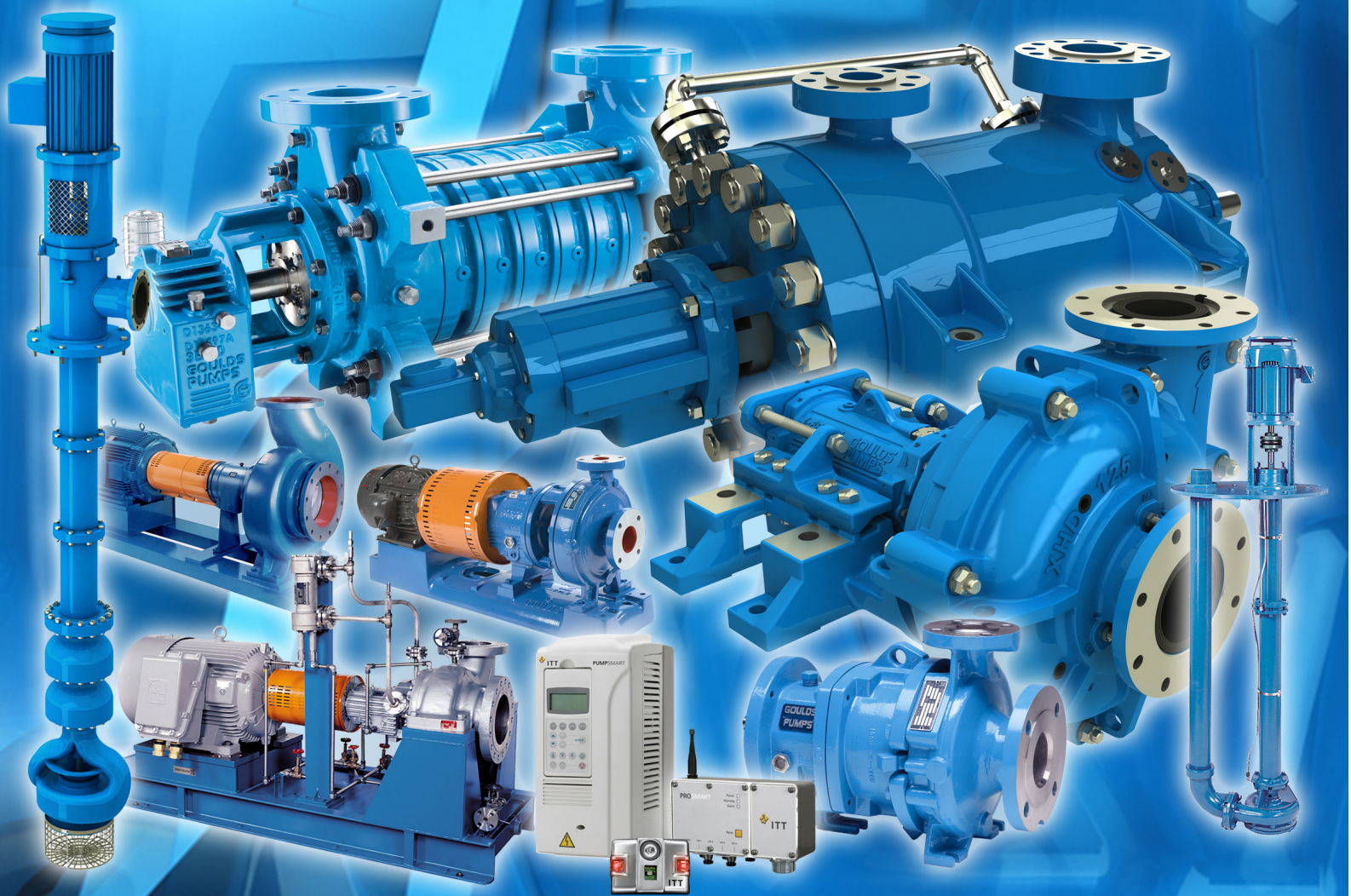
GPM10

Goulds Pumps Manual

60 Hz



ITT

GOULDS PUMPS

GPM10
Goulds Pump Manual

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Your ITT Goulds Pumps Manual

ITT Goulds Pumps is pleased to provide you with this copy of GPM10. Since the first edition was published in 1973, GPM has earned a reputation as the most complete and useful source of pump information available. We're proud of GPM and confident that you will find it to be a valuable tool for application and selection of pumps.

For the very latest pump information or to use our Pump Selection System, visit www.gouldspumps.com.

How to Use GPM

Refer to either the Table of Contents (pages 3-13), the Pump Type / Application Index (pages 14-15), or the Model Number (and description) Index (pages 16-17).

Then, simply refer to the appropriate section for details of the selected pump model. Alth13-14ough we've generally included enough information about each pump to do basic selection, you may require additional specifics such as pricing, delivery, or special constructions. No problem. Just call your nearest Goulds sales office or representative.

In addition to the product sections, a Technical Data Section is included as a useful reference for pump fundamentals and applications, mechanical and motor data, hydraulic data, properties of liquids, and conversion factors.

Safety

User safety is a major focus in the design of our products. ITT Goulds pumps will provide safe, trouble-free service when properly installed, maintained, and operated.

Safe installation, operation, and maintenance are an essential end user responsibility. Detailed Safety Warnings are included in the front of each Installation, Operation, and Maintenance manual. Understanding and adhering to these safety warnings is mandatory to ensure personnel, property, and/or the environment will not be harmed. Adherence to these warnings alone, however, is not sufficient — it is expected that the end user will also comply with industry and corporate safety standards.

Please take the time to review and understand the safe installation, operation, and maintenance guidelines outlined in our Installation, Operation, and Maintenance manuals. Current manuals are available at www.gouldspumps.com/Tools-and-Resources/Literature/Posters/ or by contacting your nearest Goulds sales representative.

Corrections?

Goulds strives to provide an accurate GPM. If you find an error, technical or typographical, we would be grateful to hear about it. A marked-up photocopy, in addition to the following information would be most helpful:

Type of Error Found: ☐ Technical ☐ Typographical Found on Page(s) _____ Section: _____

Description: _____

_____

_____

Please fax to: ITT Goulds Pumps Marketing Communications at 315-568-7759.

GPM10 Product / Service Sections

Goulds Pump Manual contains information on over 60 different Goulds and A-C models, arranged by category in nine product and service sections. Section 9 is the Technical Data Section for ease of reference and choice of the best pumping solution.

Chemical Process

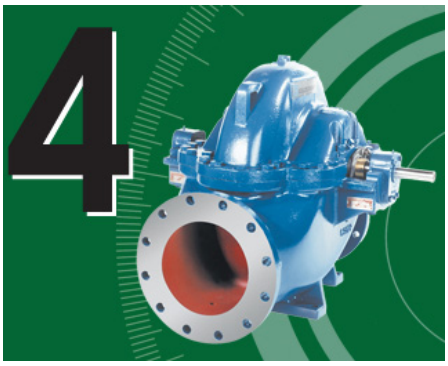
General process services, mild to severe corrosives, solids handling with minimum degradation, low flow services, elevated temperature liquids, and hazardous fluids.

Pulp & Paper/Process

Pulp & paper stock services, high capacity process services, handling fibrous/stringy materials, entrained air, non-abrasive solids and corrosives.

API Process

High temperature and high pressure process pumps for petroleum, heavy duty chemical, and gas industry services.

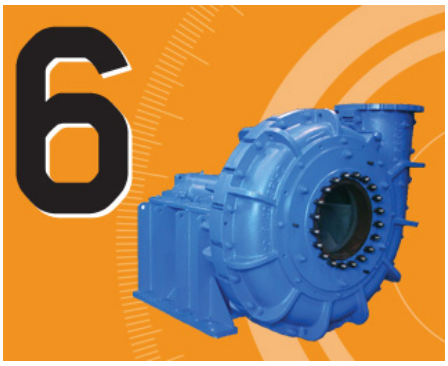


Double Suction

High capacity pumps designed for water supply in general industrial, process, marine and municipal services.

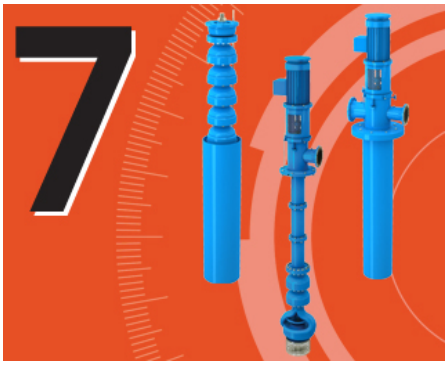
Multi-Stage

Reliable performance in demanding high pressure services such as boiler feed, cogeneration, booster, and reverse osmosis.



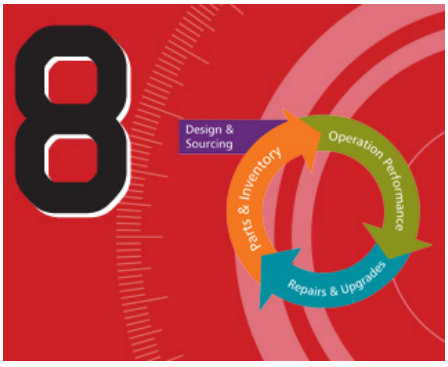
Abrasive Slurry/Solids Handling

Fine to large abrasive slurries, corrosives, large solids handling, and wastewater.



Vertical Turbine

Low to high capacity and low to high head water and process services…vertical turbine pumps in a variety of flexible configurations for clean and corrosive / erosive applications.



Plant Performance Services

Reduce total cost of pump ownership.

PumpSmart® /ProSmart®

Process Control Systems.

Technical Data Section

A useful reference for pump fundamentals and applications, mechanical and motor data, hydraulic data, properties of liquids, and conversion factors.

GPM10 Table of Contents

1 CHEMICAL PROCESS

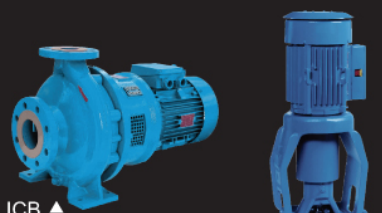
3196 *i-FRAME*™ ▶

IC ▶

▲ LF 3196 *i-FRAME*™

▲ CV 3196 *i-FRAME*™

3796 *i-FRAME*™▲


ICB ▲

3996▲

▲ HT 3196 *i-FRAME*™

ICP▲

NM 3196 *i-FRAME*™▲

3198 *i-FRAME*™▲

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
METALLIC SEALED						
3196 *i*-FRAME™	ANSI Chemical Process Pumps	7,000 (1,364)	730 (223)	700 (370)	CHEM-1A	21
IC SERIES *i*-FRAME™	ISO 5199 Chemical Process Pump for Global Industrial Process Applications	1,980 (450)	525 (160)	536 (280)	CHEM-1B	55
LF 3196 *i*-FRAME™	Low Flow ANSI Process Pumps	220 (50)	925 (282)	700 (371)	CHEM-1C	79
CV 3196 *i*-FRAME™	Recessed Impeller Pumps for Non-Clog Solids Handling	2,700 (610)	440 (134)	500 (260)	CHEM-1D	91
3796 *i*-FRAME™	Self-Priming Process Pumps	1,250 (284)	430 (131)	500 (260)	CHEM-1E	105
3996	ANSI In-Line Process Pumps	1,400 (318)	700 (213)	500 (260)	CHEM-1F	119
HT 3196 *i*-FRAME™	High Temperature Applications in the Chemical Process Industry	4,500 (1,022)	925 (282)	700 (371)	CHEM-1G	135
NON-METALLIC / LINED, SEALED						
NM 3196 *i*-FRAME™	ANSI FRP Process Pumps for Corrosive Services	800 (182)	500 (152)	200 (93)	CHEM-2A	147
3198 *i*-FRAME™	ANSI Pumps with PFA TEFLON® Lining for Severe Corrosive Services	800 (182)	450 (137)	300 (149)	CHEM-2B	163

TEFLON® is a registered trademark of DuPont.

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
MAGNETIC DRIVE - Zero Leakage Services						
3296 EZMAG	ANSI Magnetic Drive Process Pumps	700 (160)	550 (168)	535 (280)	CHEM-3A	175
3298	ANSI ETFE Lined Sealless Pumps for Chemical Services	1,200 (270)	460 (140)	250 (121)	CHEM-3B	189
SP 3298						
V 3298						
3299	ANSI PFA Lined Sealless Pumps for Severe Chemical Services	425 (96)	490 (149)	360 (182)	CHEM-3C	213
ICM/ ICMB	ISO Metal Sealless Pump for Chemical and General Services	1,760 (400)	685 (209)	536 (280)	CHEM-3D	223
SUMP PUMPS						
3171	Vertical Sump Process Pumps	3,180 (722)	344 (105)	450 (232)	CHEM-4A	239
CV 3171	Vertical Sump Process Pumps for Corrosive Slurries	1,300 (295)	230 (70)	450 (232)	CHEM-4B	255
API 3171	API VS4 Vertical Sump Pumps	3,180 (722)	525 (160)	450 (232)	CHEM-4C	265
NM 3171	Vertical Sump Process Pumps for Severe Corrosives	1,250 (284)	300 (91)	200 (93)	CHEM-4D	277
AXIAL FLOW						
AF	Axial Flow Pumps for Corrosive, Abrasives, Slurries, and Wastes	300,000 (68,000)	30 (9.1)	350 (176)	CHEM-5A	291

2 PULP & PAPER / PROCESS

3175 ▲

3180/3185 ▲

3181/3186 ▲

3500XD ▲

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
3175	Paper Stock/High Capacity Process Pumps	28,000 (6,360)	350 (107)	450 (230)	PP-1A	303
3180/3185	Paper Stock/Process Pumps	45,000 (10,220)	410 (125)	446 (230)	PP-1B	335
3181/3186	High Temperature/ High Pressure Paper Stock/Process Pumps	13,000 (3,000)	410 (125)	508 (300)	PP-1C	397
3500 XD	Medium Consistency Paper Stock Pump Systems	4,000 (900)	900 (210)	210 (100)	PP-1D	405

3 API PROCESS

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
3700	API-610 / ISO 13709 OH2 Overhung Pump High Temperature and Pressure	8,500 (1,930)	1,200 (360)	800 (425)	API-1A	417
3910	API-610 / ISO 13709 OH3 Vertical In-line Pump High Temperature and Pressure	6,000 (1,630)	750 (230)	650 (340)	API-1B	483
3600	Heavy Duty, Axially Split BB3 Between-Bearings, Multi-Stage, Pumps. API 610 / ISO 13709	8,500 (1,930)	9,000 (2,740)	400 (205)	API-1C	491
3610	API-610 / ISO 13709 BB1 Between-Bearings, Single Stage, Axially-Split, Double Suction	50,000 (11,355)	700 (215)	300 (149)	API-1D	499
3620	API-610 / ISO 13709 BB2 Between-Bearings, Single Stage, Radially-Split High Temperature and Pressure	20,000 (4,540)	1,500 (455)	850 (455)	API-1E	505
3640	API-610 / ISO 13709 BB2 Between-Bearings, Two Stage, Radially-Split High Temperature and Pressure	7,500 (1,700)	2,500 (760)	850 (455)	API-1F	547
7200CB	API 610 11th Edition / ISO 13709 2nd Edition API BB5 Barrel Multistage Pumps In-Line Diffuser Type	4,000 (910)	9,000 (2,740)	800 (425)	API-1G	557
API 3171 (VS4)	API 610 Compliant VS4 Vertical Sump	3,180 (722)	525 (160)	450 (232)	Refer to CHEM-4C	265
VIT (VS1)	API 610 Compliant VS1 Vertical Industrial Turbine Pump	70,000 (15,900)	3,500 (1,067)	500 (260)	Refer to VT-1A	815
VIC (VS6)	API 610 Compliant VS6 Vertical Industrial Can-Type Pump	70,000 (15,900)	3,500 (1,067)	500 (260)	Refer to VT-1A	819

4 DOUBLE SUCTION

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
3410	Small Capacity Horizontal Split Case, Single Stage, Double Suction Pumps	8,000 (1,817)	570 (174)	350 (177)	DS-1A	571
3409	Medium Capacity Horizontal Split Case, Single Stage, Double Suction Pumps	12,000 (2,725)	850 (259)	250 (120)	DS-1B	593
3420	Large Capacity Horizontal Split Case, Single Stage, Double Suction Pumps	65,000 (14,760)	400 (120)	275 (135)	DS-1C	605
3498	Extra Large Capacity Horizontal Split Case, Single Stage, Double Suction Pumps	225,000 (51,098)	800 (244)	275 (135)	DS-1D	625

5 MULTI-STAGE

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
3393	Radially Split, Segmented Multi-Stage Pumps	3,000 (680)	3,300 (1,000)	400 (204)	MS-1A	645
3355	Radially Split, Segmented Multi-Stage Pumps	1,500 (340)	1,640 (500)	280 (140)	MS-1B	655
3311	Radially Split, Segmented Multi-Stage Pumps	1,100 (250)	5250 (1600)	356 (180)	MS-1C	679
3316	Two-Stage, Horizontally Split Case Pumps	3,000 (681)	1,000 (305)	350 (177)	MS-1D	689
3600	Heavy Duty, Axially-Split Between-Bearings Multi-Stage Pumps	4,500 (1,000)	6,000 (1,825)	400 (205)	REFER TO API-1C	491
3935	Low Flow / High Head Diffuser Type Multi-Stage Pumps	125 (28)	2,600 (792)	400 (204)	MS-1F	701

6 ABRASIVE SLURRY/ SOLIDS HANDLING

◄ XHD

SRL -C ▲

JC ▲

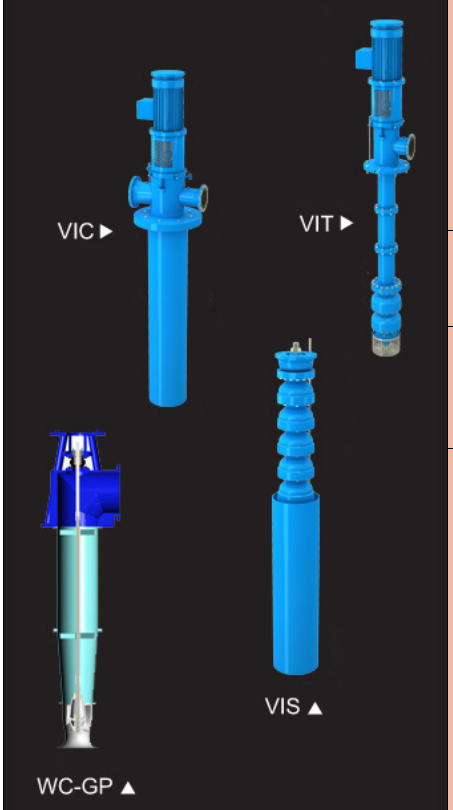
▲ 5500

◄ HS

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
XHD	Extra Heavy Duty, Lined Slurry Pump	13,000 (2,950)	280 (85)	250 (121)	AS-1A	711
SRL **SRL-C** **SRL-S**	Heavy Duty Elastomer/ Rubber Lined Slurry Pumps for Corrosive/ Abrasive Solids to max. particle clearance to $2^3/_8$ in. (60 mm)	20,000 (4,542)	164 (50)	250 (121)	AS-1B	715
SRL-XT		10,000 (2,270)	140 (42)			721
JC	Medium Duty Slurry Pumps for Corrosive/ Abrasive Slurries Solids to 2¼ in. (57 mm)	7,000 (1,600)	240 (73)	250 (121)	AS-1C	727
5500	Severe Duty, Hard Iron Slurry Pumps for Abrasive Slurries Solids to 5 in. (127 mm)	17,000 (3,861)	425 (130)	250 (121)	AS-1D	745
HS	Recessed Impeller Non-Clog Pumps For Large Solids, Corrosives, Abrasives Solids to 10 in. (254 mm)	7,000 (1,590)	140 (43)	200 (93)	AS-1E	761

Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
Trash Hog ®	Solids Handling Self-Priming Pumps Solids to 3 in. (76 mm)	6,000 (1,363)	140 (43)	225 (107)	AS-1F	773
VHS **VJC**	Vertical Cantilever Pumps for Large Solids and Abrasive Slurries Solids to 10 in. (254 mm)	7,000 (1,590)	240 (73)	200 (93)	AS-1G	783
VRS	Vertical Rubber-Lined Pumps for Abrasives and Slurries Solids to¼ in. (6 mm)	1,500 (341)	120 (37)	– –	AS-1H	793
HSU **HSUL** **JCU**	Submersible Pumps for Large, Fibrous Solids, Abrasive Slurries Solids to 6 in. (152 mm)	4,000 (910)	220 (67)	194 (90)	AS-1I	799

7 VERTICAL TURBINE, DRY PIT & HIGH CAPACITY PUMPS



Goulds Model	Description	Capacities to GPM (m^3/h)	Heads to Feet (m)	Temp. to °F (°C)	Sub-Sect.	Page
VIT	Vertical Industrial Turbine Pumps Designed to Meet Wide Range of Hydraulic Requirements and Custom User Specifications	70,000 (15,900)	3,500 (1,067)	500 (260)	VT-1A	815
VIC	Vertical Industrial Can-Type Pumps	70,000 (15,900)	3,500 (1,067)	500 (260)	VT-1A	819
VIS	Vertical Industrial Submersible Pumps	70,000 (15,900)	3,500 (1,067)	–	VT-1A	823
WC-GP	High Capacity and Higher Head Pumps	500,000 (113,562)	600 (183)	150 (65)	VT-1B	827

8 After Market

Model	Description	Sub-Sect.	Page
PRO Services	Parts & Inventory • Goulds Pumps Parts • Inventory Management • Engineered Parts - Pump Replacements Operation Performance • Field Services • Training • Control Solutions - Monitoring solutions • Reliability Engineering • Energy Performance Services Repairs & Upgrades • Rotating Equipment Repairs • Pump Upgrades • Root Cause Analysis	AF-1A	835

Model	Description	Pump Models	Power to HP (kw)	Voltage in VAC	Sub-Sect.	Page
ProSmart®	Machine Health Monitoring	All	All	All	AF-1B	843
Pump-Smart®	Pump System Control & Protection	All	1,000 (745)	208 (690)	AF-1C	851

9 TECHNICAL DATA

TECH	Centrifugal Pump Fundamentals	TECH-A	862
	Pump Application Guide	TECH-B	878
	Water Data	TECH-C	910
	Properties of Liquids	TECH-D	921
	Paper Stock	TECH-E	948
	Mechanical Data	TECH-F	959
	Motor Data	TECH-G	968
	Conversion Factors	TECH-H	979
	Basic Troubleshooting	TECH-I	990
	Miscellaneous Pump Information	TECH-J	992

Index

Pump Type/Application

Pump Type/Application		Goulds Models
Abrasive Slurry	Light to Medium Duty	AF, CV 3196, HS, HSU, HSUL, JC
	Heavy Duty	5500, AF, JCU, SRL, SRL-C, SRL-S,SRL-XT, VJC, VRS
ANSI (Dimension)		3196, LF 3196, NM 3196, 3198, 3296, 3298, 3299, 3996, V 3298
API		3600, 3610, 3620, 3640, 3700, 3910, 7200CB, VIT, VIC, API 3171
Axial Flow		AF
Close-Coupled		3298, 3299, V 3298, SP 3298, ICMB, ICB
Double Suction		3409, 3410, 3420, 3498, 3610, 3620
Fan Pumps		(See Double Suction)
Fire Pumps		3409, 3410, VIT
High Capacity (Process)		3175, 3180/85, 3181, 3186, AF
High Pressure (Heads 1000 feet [305 m] and greater)		3311, 3316, 3355, 3620, 3640, 3600, 3700, 3935, VIC, VIT, 3393
High Temperature (500° F [260° C] and greater)		3181/3186, 3196, HT 3196, LF 3196, 3296, 3620, 3640, 3700/3710, 3910, 7200CB, ICP, ICMP, VIT, VIC
In-line		V 3298, 3910, 3996
ISO (Dimension)		IC, ICM, ICMB, ICMP, ICP, ICB
Lined		3198, 3298, SP 3298, V 3298, 3299, SRL, SRL-C, VRS
Low Flow		LF 3196, 3935, IC, 3700
Magnetic Drive		3296, 3298, SP 3298, V 3298, 3299, ICM
Mining		3409, 3410, 3196, 3298, 3180, 5500, AF, IC, JC, JCU, HS, HSU, HSUL, SRL, SRL-C, SRL-S, SRL-XT, Trash Hog, VIC, VIS, VIT, VHS, VJC, VRS
Multi-Stage		3311, 3316, 3355, 3600, 3640, 3935, 7200CB, 3393
Non-Metallic		NM 3196, NM 3171, 3198, 3298, SP 3298, V 3298, 3299, SRL, SRL-C

Pump Type / Application

Pump Type/Application	Goulds Models
Paper Stock	3175, 3180/85, 3181/86, 3500XD
Process Monitoring and Control Systems	ProSmart®, PumpSmart®
Recessed Impeller (Vortex)	CV 3171, CV 3196, HS, HSU, HSUL, VHS
Sealless	(See Magnetic Drive) 3171, CV 3171, NM 3171
Self-Priming	SP 3298, 3796, Trash Hog
Sewage and Sludge	CV 3171, HS, HSU, HSUL, NSW, NSY, SSE, SSF, Trash Hog, VHS, WSY
Slurry	(See Abrasive Slurry)
Solids Handling (Large Non-Abrasive)	CV 3171, 3175, 3180/85, 3181/86, CV 3196, 3500XD, HS, HSU, HSUL, VHS
Submersible	VIS (See Sump)
Sump (Submersible)	HSU, HSUL, JCU
Vertical Cantilever	VHS, VJC, VRS
Vertical Dry Pit	3171
Vertical (Non-Metallic)	NM 3171
Vertical (Submerged Bearing)	3171, CV 3171, NM 3171
Vertical Sump	3171, CV 3171, NM 3171, VJC, VHS, VRS
Vertical Turbine	VIC, VIC-API, VIT, VIS, VMF, WC-GP
Vertically-Mounted Double Suction	3409, 3410(v), 3498
Water Pumps (General Service)	3171, 3196, 3409, 3410, 3420, 3498, IC, ICB, 3180/3185, Trash Hog
Water Pumps (High Capacity)	3409, 3410, 3420, 3498, AF, 3180/3185

Model Number / Section Number Index

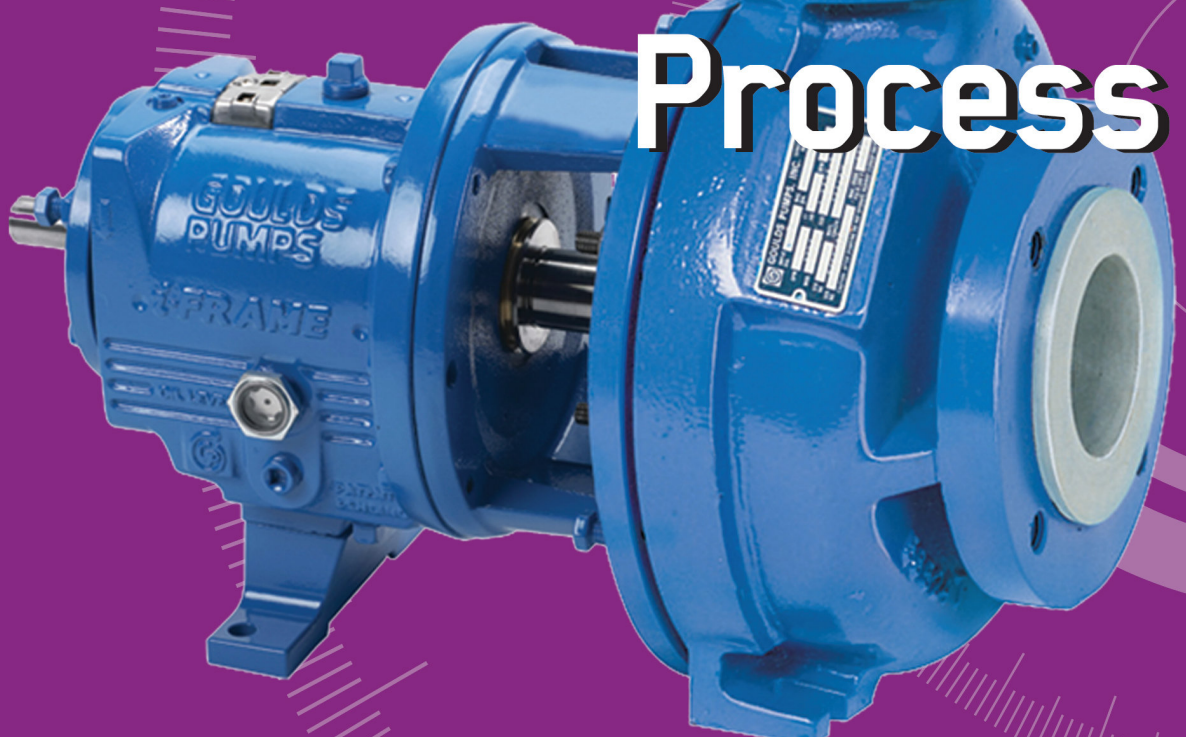
Goulds Model	Section	Page
3171 Vertical Sump Process Pump	**CHEM-4A**	239
3175 Paper Stock / High Capacity Process Pumps	**PP-1A**	303
3180 Paper Stock / Process Pumps	**PP-1B**	335
3181 High Temperature/ High Pressure Paper Stock / Process Pumps	**PP-1C**	397
3185 Paper Stock / Process Pumps	**PP-1B**	335
3186 High Temperature / High Pressure Paper Stock / Process Pumps	**PP-1C**	397
3196 ANSI Chemical Process Pumps	**CHEM-1A**	21
3198 ANSI Pumps with PFA Teflon® Lining for Severe Corrosive Services	**CHEM-2B**	163
3296 EZMAG ANSI Metal Magnetic Drive Process Pumps for Zero Leakage Services	**CHEM-3A**	175
3298 ANSI ETFE Multi-Duty Sealless Pumps for Chemical Services	**CHEM-3B**	189
3299 ANSI Heavy Duty PFA Lined Sealless Pumps for Chemical Services	**CHEM-3C**	213
3311 Radially Split, Segmented Multi-Stage Pumps	**MS-1C**	679
3316 Two-Stage, Horizontally Split Case Pumps	**MS-1D**	689
3355 Multi-Stage Pumps	**MS-1B**	655
3393 High Pressure, Multistage Ring Section Pump	**MS-1A**	645
3409 High Capacity, Single Stage Double Suction Pumps	**DS-1B**	593
3410 Single Stage Double Suction Pumps	**DS-1A**	571
3420 High Capacity Single Stage Double Suction Pumps	**DS-1C**	605
3498 High Capacity Single Stage Double Suction Pumps	**DS-1D**	625
3500XD Medium Consistency Paper Stock Pump Systems	**PP-1D**	405
3600 API-610 BB3 Between Bearings, Multi-Stage	**API-1C**	491
3610 API-610 BB1 Between Bearings, Single Stage, Axially-Split, Double Suction	**API-1D**	499
3620 API-610 BB2 Between Bearings, Single Stage Radially-Split	**API-1E**	505
3640 API-610 BB2 Between Bearings, Two-Stage Radially-Split	**API-1F**	547
3700 API-610 OH2 Overhung, High Temperature High Pressure	**API-1A**	417
3796 Self-Priming Process Pumps for a Range of Industry Services	**CHEM-1E**	105
3910 API-610 OH3 Vertical In-Line, High Temperature, High Pressure	**API-1B**	483
3935 Low Flow / High Head Diffuser Type Multi-Stage Pumps	**MS-1F**	701
3996 ANSI In-Line Process Pumps	**CHEM-1F**	119
5500 Severe Duty Abrasive Slurry Pumps	**AS-1D**	745
7200CB API 610 BB5 Barrel Multistage, In-Line Diffuser Type	**API-1G**	557
AF Axial Flow Pumps for Corrosive, Abrasives, Slurries, and Wastes	**CHEM-5A**	291
API 3171 API VS4 Vertical Sump Pumps	**CHEM-4C**	265
CV 3171 Vertical Sump Process Pumps for Non-Clog Solids Handling	**CHEM-4B**	255
CV 3196 Recessed Impeller Pumps for Non-Clog Solids Handling	**CHEM-1D**	91
HS Recessed Impeller Non-Clog Pumps for Large Solids, Corrosives, Abrasives	**AS-1E**	761
HSU Submersible Pumps with Agitator for Abrasive Solids	**AS-1L**	799
HSUL Submersible Pumps with Agitator for Abrasive Solids	**AS-1L**	799
HT 3196 High Temperature Applications in the Chemical Process Industry	**CHEM-1G**	135
IC / ICB / ICP ISO 5199 Cehmical Process Pumps for Global Industrial Process Applications	**CHEM-1B**	55
ICM / ICMB ISO 5199 / ISO 15783 Sealless Chemical Process Pumps Designed for Global Process Applications	**CHEM-3D**	223

Goulds Model	Section	Page
JC Medium Duty Slurry Pumps for Corrosive / Abrasive Slurries	**AS-IC**	727
JCU Submersible Pumps for Abrasive Solids	**AS-1L**	799
LF 3196 Low Flow ANSI Process Pumps	**CHEM-1C**	79
NM 3171 Non-metallic Vertical Sump Process Pumps Designed for Severe Corrosive Services	**CHEM-4D**	277
NM 3196 ANSI FRP Process Pumps for Corrosive Services	**CHEM-2A**	147
PumpSmart® Process Control Systems	**AF-1C**	851
ProSmart® Process Control Systems	**AF-1B**	843
SP 3298 ETFE Self-Priming Sealless Pumps Designed for Chemical Services	**CHEM-3B**	189
SRL Single Stage Rubber Lined Pumps for Corrosive/ Abrasive Slurries	**AS-1B**	715
SRL-C Single Stage Thick Rubber Lined Pumps for Corrosive/Abrasive Slurries	**AS-1B**	715
SRL-S Single Stage Rubber Lined Pumps for Corrosive/Abrasive Slurries with entrained air, froth and stringy solids	**AS-1B**	715
SRL-XT Single Stage Rubber Lined Pumps for Corrosive/ Abrasive Slurries	**AS-1B**	721
Trash Hog® Solids Handling Self-Priming Pumps	**AS-1F**	773
V 3298 ANSI Vertical ETFE Multi-Duty Sealless Pumps for Chemical Services	**CHEM-3B**	189
VHS Vertical Cantilever Pumps for Large Solids, Abrasive Slurries	**AS-1G**	783
VIC Vertical Industrial Can Type Pumps	**VT-1A**	819
VIS Vertical Industrial Submersible Pumps	**VT-1A**	823
VIT Vertical Industrial Turbine Pumps Designed to Meet Wide Range of Hydraulic Requirements and Custom Specifications of the User	**VT-1A**	815
VJC Vertical Cantilever Pumps for Large Solids, Abrasive Slurries	**AS-1G**	783
VRS Vertical Cantilever	**AS-1H**	793
WC-GP High Capacity and Higher Head Pumps	**VT-1B**	827
XHD Extra Heavy Duty, Lined Slurry Pump	**AS-1A**	711

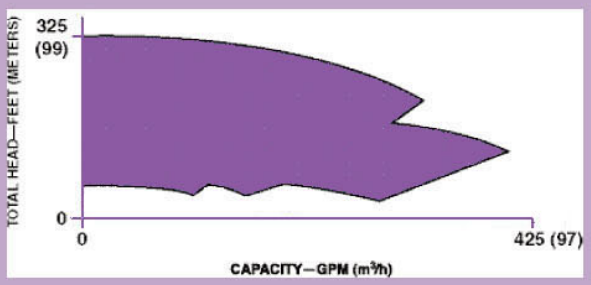
NOTES

1

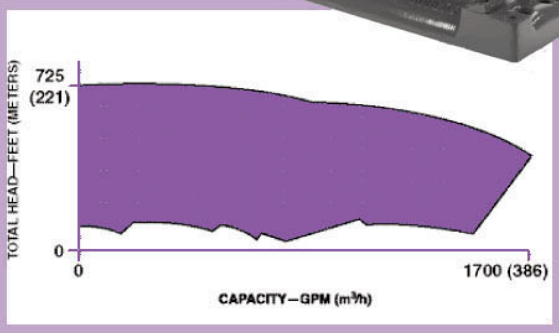
Chemical Process



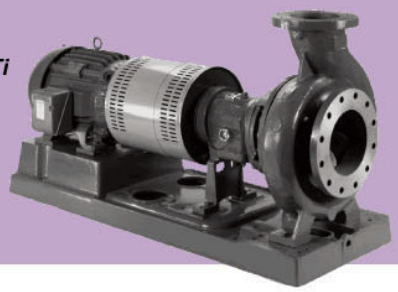
Model 3196 *STi*
5 ANSI Pumps

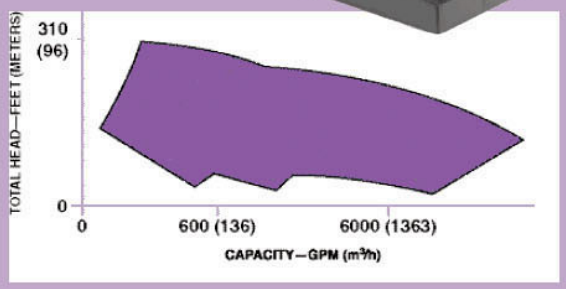


Model 3196 *MTi*
15 ANSI Pumps



Model 3196 *XLTi*
9 ANSI Pumps





Goulds Model 3196 *i-FRAME™*

Chemical Process Pumps Designed for Total Range of Industry Services

- Capacities to 7000 GPM (1364 m^3/h)
- Heads to 730 feet (223 m)
- Temperatures to 700°F (371° C)
- Pressures to 375 PSIG (2586 kPa)

Outstanding Features for Outstanding Performance

Extended Pump Life

- Fully Open Impeller
- Engineered Seal Chambers
- *i-FRAME™* Power Ends
- Engineered Pump Mounting Systems

Ease of Maintenance

- Back Pull-Out Design
- External Impeller Adjustment
- Maximum Interchangeability
- Optional C-Face Motor Adapter

Optimum Hydraulic Performance

- Fully Open Impeller
- Full 50/60 Hz Coverage
- 29 Sizes
- Pump Selection Software

Safety

- Heavy Duty Casings
- Hydrostatic Testing of Pressure Retaining Components
- ANSI B15.1 Coupling Guard
- Ductile Iron Frame Adapter
- Optional Shaft Guard

Proven Performance

Every day in over 1,000,000 installations, Goulds process pumps prove why they are the industry standard for performance. Users in chemical, petrochemical, pulp & paper, primary metals, food & beverage and general industries know they can make no better choice than the best.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3196 *i-FRAME™* Process Pumps

Featuring *i-ALERT™* Patented Monitoring

i-ALERT™ CONDITION MONITOR

(U.S. Patent 8,154,417)
Constantly measures vibration and temperature at the thrust bearing. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

HEAVY DUTY SHAFT AND BEARINGS

Rigid shaft designed for minimum deflection at seal faces—less than 0.002 in. (.05 mm). Bearings sized for 10-year average life under tough operating conditions. Available with or without shaft sleeve.

CASING

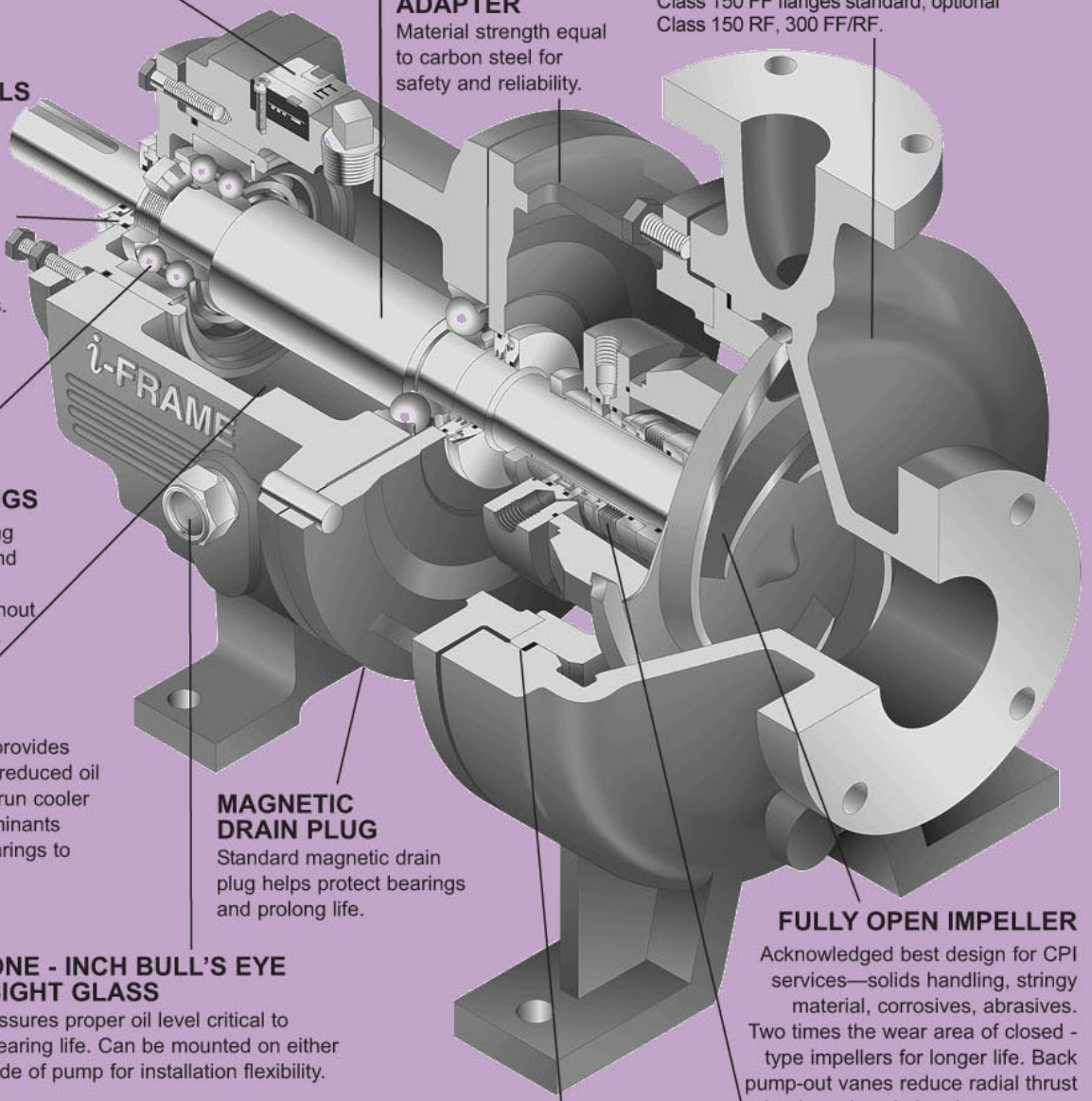
- Bonus casing thickness: Class 150 pumps feature Class 300 wall thickness as standard; increased reliability and maximized casing life.
- Top centerline discharge for air handling, self-venting.
- Back pull-out design for ease of maintenance.
- Integral casing feet prevent pipe load misalignment — maximized seal and bearing life.
- Serrated flanges standard for positive sealing against leakage. Meets ANSI B16.5 requirements. Class 150 FF flanges standard, optional Class 150 RF, 300 FF/RF.

DUCTILE IRON FRAME ADAPTER

Material strength equal to carbon steel for safety and reliability.

INPRO VBXX-D HYBRID LABYRINTH SEALS

Prevents premature bearing failure caused by lubricant contamination or loss of oil. Stainless steel rotors for optimal performance in corrosive environments.



PREMIUM SEVERE-DUTY THRUST BEARINGS

Premium bearings using improved tolerances and cleaner steel provide reduced assembled runout and longer bearing life.

OPTIMIZED OIL SUMP DESIGN

Increased oil capacity provides better heat transfer for reduced oil temperature. Bearings run cooler and last longer. Contaminants directed away from bearings to magnetic drain plug.

MAGNETIC DRAIN PLUG

Standard magnetic drain plug helps protect bearings and prolong life.

ONE - INCH BULL'S EYE SIGHT GLASS

Assures proper oil level critical to bearing life. Can be mounted on either side of pump for installation flexibility.

FULLY OPEN IMPELLER

Acknowledged best design for CPI services—solids handling, stringy material, corrosives, abrasives. Two times the wear area of closed - type impellers for longer life. Back pump-out vanes reduce radial thrust loads and seal chamber pressure.

CONTINUOUS PERFORMANCE

Original flow, pressure and efficiency are maintained by simple external adjustment resulting in long-term energy and repair parts savings.

i-FRAME™ POWER END

Designed for reliability and extended pump life, backed with a 5-year warranty.

POSITIVE SEALING

Fully confined gasket at casing joint protects alignment fit from liquid, makes disassembly easier.

SEALING FLEXIBILITY

Wide range of sealing arrangements available to meet service conditions. Engineered seal chambers improve lubrication and heat removal (cooling) of seal faces for extended seal life and pump uptime.

Before Selecting A Process Pump. . .

Consider the Four Design Features For Extended Pump Performance

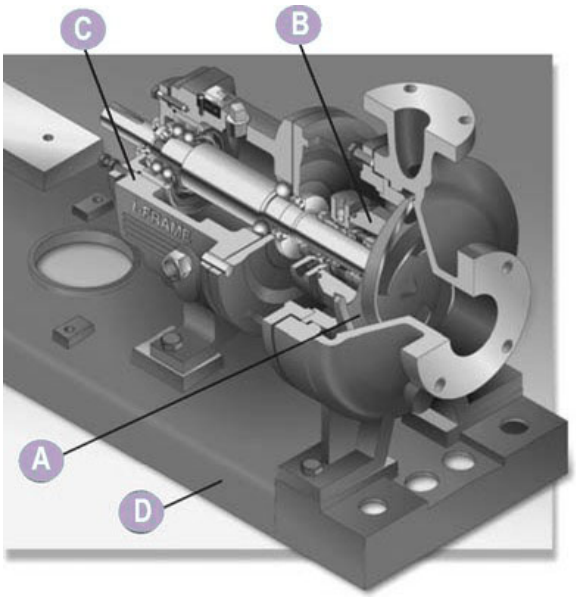
In order to select a chemical process pump wisely, consideration must be given to design features that provide long-term reliable performance. The pump must be designed for optimum shaft seal and bearing life to prevent the failure of these two primary causes of pump downtime.

A **IMPELLER**
Must be designed for long-term, maintainable performance and minimum hydraulic loads for maximum reliability.

B **SEAL CHAMBER**
Must be designed for favorable seal environment—proper heat dissipation and lubrication of seal faces. The design must also be able to handle tough services: liquids containing solids, air or vapors.

C **POWER END** Must be designed for optimum bearing life, effective oil cooling, minimum shaft deflection. Onboard condition monitoring provides early warning of potential failures, before they occur.

D **BASEPLATE**
Must be rigid, and able to withstand forces and moments of plant piping systems.

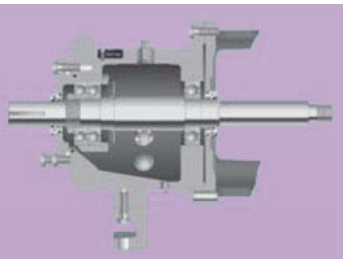


FULLY OPEN IMPELLER

Best design for the Chemical Process Industries services. Ideally suited for corrosives and abrasives, handles solids and stringy fibers with ease. Allows for simple restoration of clearances when wear takes place. Back pump-out vanes reduce pressure on the shaft seal, reduce axial thrust on the bearings.

ENGINEERED SEAL CHAMBERS

BigBore™ and TaperBore™ PLUS seal chambers allow seals to run cooler with better face lubrication. Keep solids, air and vapors away from the seal faces for extended seal life.



i-FRAME **™ POWER ENDS**

Patented design maximizes reliability and MTBF (Mean Time Between Failure). Severe-duty bearings increase bearing life 2-5 times, while onboard condition monitor gives visible indication of general pump health. Backed by a five-year standard warranty.

PUMP MOUNTING SYSTEM

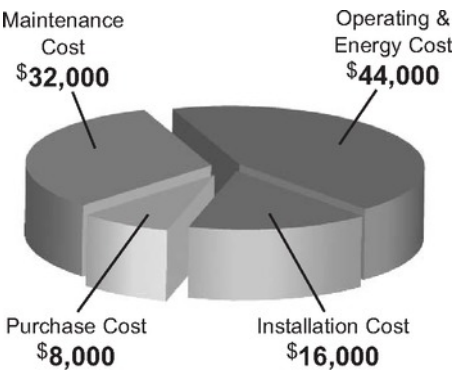
Critical for reliability. . .rigid baseplate prevents distortion, maintaining pump/motor alignment; corrosion resistant in severe environments. Designed for low vibration and to withstand pipe loads. Meets total range of plant requirements, easier installation and maintenance.

Consider the Total Cost Of Ownership

Consider the fact that over a 20-year ANSI pump life, 92% of the total costs are maintenance, operation and installation. Only 8% is the initial pump purchase cost.

Select a process pump that maximizes reliability (low maintenance cost), has long-term maintainable hydraulic performance (low operating cost) and is installed on a rigid baseplate.

Energy and maintenance costs during the life of a process pump can be more than 10 times its purchase price.



Fully Open Impeller

Acknowledged Best Design for CPI Services

The open impeller is the acknowledged best design for process services. It is ideally suited for corrsives/erosives, liquids containing solids and stringy materials. The most reliable pumps feature open impellers as standard.

Open Impeller Enclosed-type Impeller

See The Difference

Remarkably, Goulds had performance in mind when the Model 3196 standard dimension process pump was developed in 1959. Of timely significance was the decision to feature a fully open impeller rather than an enclosed type.

There are three excellent reasons why:

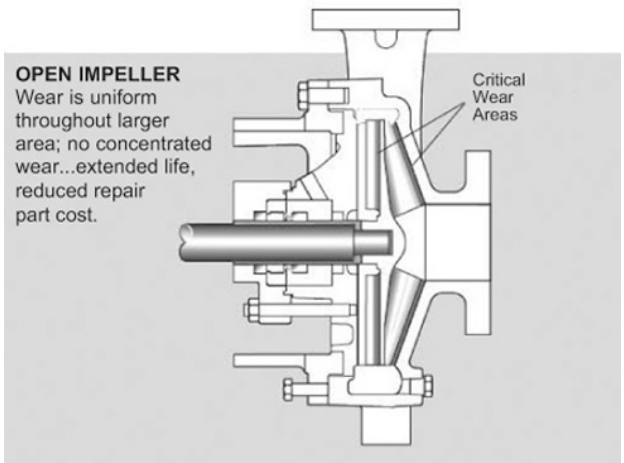
1. Greater wear area for longer life
2. Renewable performance for reduced repair costs
3. Minimum hydraulic loads for maximum mechanical reliability

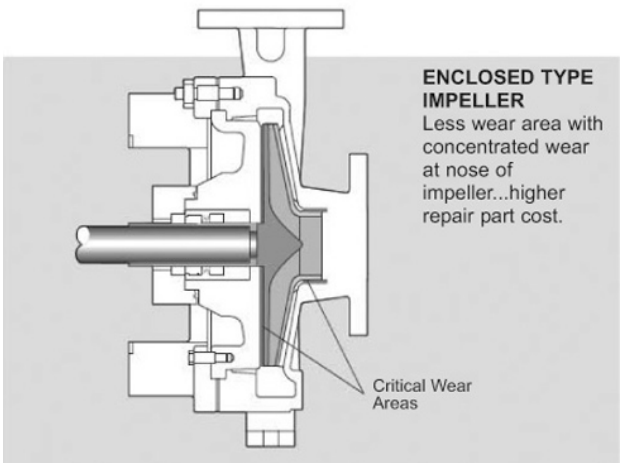
---

1 Two Times More Wear Area

Longer Life, Reduced Repair Costs

The most critical wear areas of a pump are the casing and stuffing box/seal chamber clearances. At a given wear rate, the larger wear area means longer life.





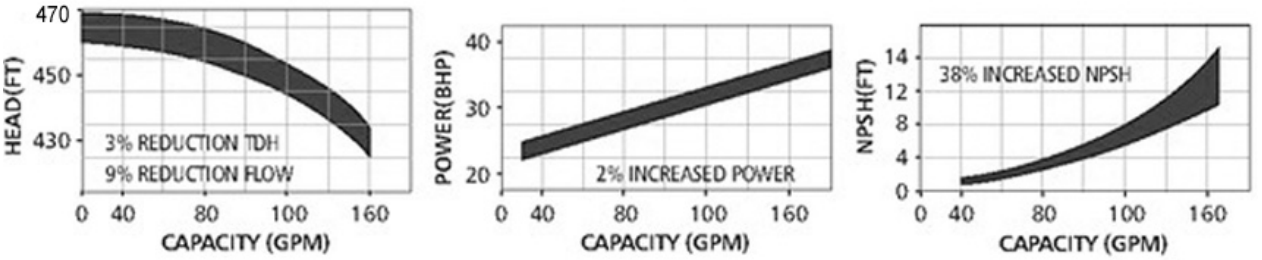
Wear Area Calculation (10 inch dia. impeller)
Area Wear Surface = $\pi r^2 = \pi(5)^2 = 79$ in^2
Total Wear Area (Front & Back) = 2 x 79 = 158 in^2

Area Nose Ring = $2\pi rW = 2 \times \pi \times (.9)\ (.9) = 5$ in^2
Area Back Cover = $\pi r^2 = \pi(5)^2 = 79$ in^2
Total Wear Area = 5 + 79 = 84 in^2

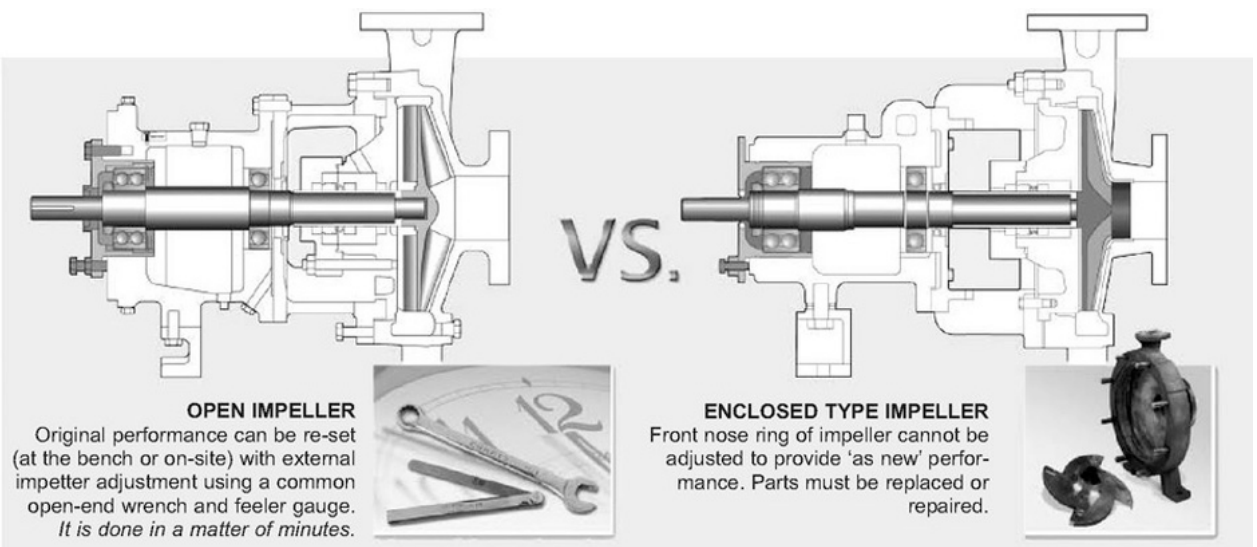
2 Maintained High Performance

Long Pump Life

It is common knowledge that as a pump wears, the performance decreases. Goulds open impeller can be adjusted, simply and quickly, to compensate for wear and renew performance. The enclosed type impeller cannot be adjusted. Performance renewal requires new or repaired casing and impeller.



Typical reduction in performance due to wear (.010 inch per year) on any ANSI pump.



OPEN IMPELLER
Original performance can be re-set (at the bench or on-site) with external impetter adjustment using a common open-end wrench and feeler gauge. *It is done in a matter of minutes.*

ENCLOSED TYPE IMPELLER
Front nose ring of impeller cannot be adjusted to provide 'as new' performance. Parts must be replaced or repaired.

3 Minimum Hydraulic Loads

Extended Seal and Bearing Life

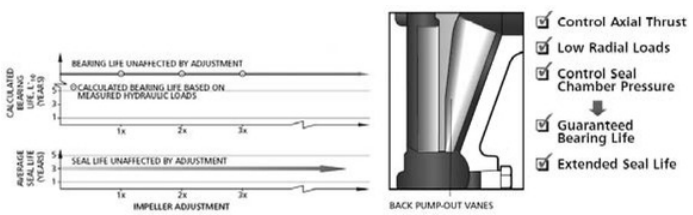
Goulds open impeller is engineered to assure minimum radial and axial thrust loads; controlled clearances between front and back of impeller minimize radial loads; back pump-out vanes control and reduce axial thrust. Bearing life is guaranteed.

Engineered for Long Life

Back vane height/angle and shroud design are engineered to minimize hydraulic loads throughout the life of the pump. Bearing life is guaranteed.

As the open impeller is adjusted and performance renewed, back pump-out vanes control axial thrust.

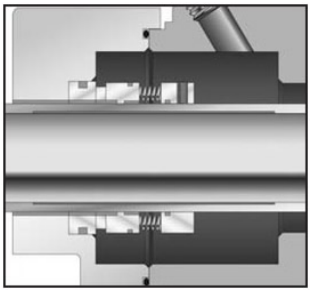
Bearing and seal life are maintained - unaffected by adjustment.



Engineered Seal Chambers

Extended Seal Life and Lower Maintenance Costs

SEAL ENVIRONMENT IS CRITICAL FOR EXTENDED SEAL LIFE



The number one cause of pump downtime is failure of the shaft seal. These failures are normally the result of an unfavorable seal environment such as improper heat dissipation (cooling), poor lubrication of the seal faces, or seals operating in liquids containing solids, air or vapors.

Goulds engineered seal chambers are designed to provide the best seal environment for any sealing arrangement.

Enlarged bore seal chambers (BigBore™ and TaperBore™ PLUS) with increased radial clearance between the mechanical seal and seal chamber provide better circulation of liquid to and from seal faces. Improved lubrication and heat removal extend seal life and pump uptime.

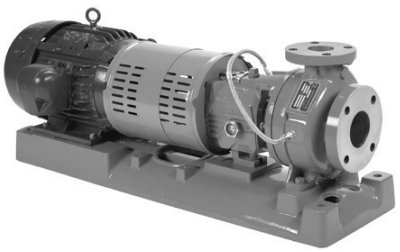
The bottom line is lower maintenance costs.

Engineered Seal Chamber Selection Guide

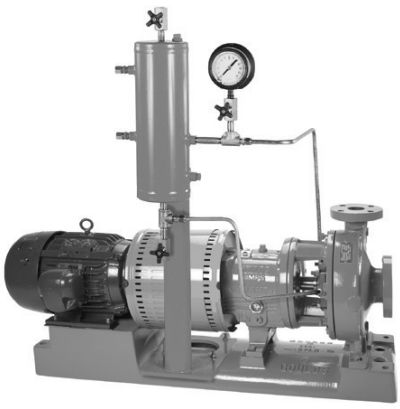
A	Ideally Suited	TYPE 1 **Standard Bore** *Designed for packing. Also accommodates mechanical seals.*	TYPE 2 **BigBore™** *Enlarged chamber for increased seal life through improved lubrication and cooling.*	TYPE 3 **TaperBore™ PLUS** *Lower seal face temperatures, self-venting and draining. Solids and vapors circulated away from seal faces.*	TYPE 4 **Jacketed TaperBore™ PLUS** *Maintains proper temperature control (heating or cooling) of seal environment.*	TYPE 5 **Jacketed BigBore™** *Maintains proper temperature control (heating or cooling) of seal environment.*
B	Acceptable					
C	Not Recommended					
Service						
Water-Based Liquids with Flush		A	A	A	A	A
Entrained Air or Vapor		C	B	A	A	B
Solids 0-10%, no Flush		C	C	A	A	C
Solids Greater than 10% with Flush		B	A	C	C	A
Paper Stock 0-5%, no Flush		C	C	A	-	-
Paper Stock 0-5%, with Flush		B	A	-	-	-
Slurries 0-5%, no Flush		C	C	A	A	C
High Boiling Point Liquids, no Flush		C	C	A	A	C
Temperature Control		C	C	C	A	A
Self-Venting and Draining		C	B	A	A	C
Seal Face Heat Removal		C	A	A	A	A
Molten or Polymerized Liquid, no Flush		C	C	C	A	A
Molten or Polymerized Liquid with Flush		C	C	C	A	A

Seal Flush Plans

All ANSI B73.1 seal flush and cooling plans are available to control emission levels and meet seal installation requirements. Goulds can also provide other special arrangements of user preference.

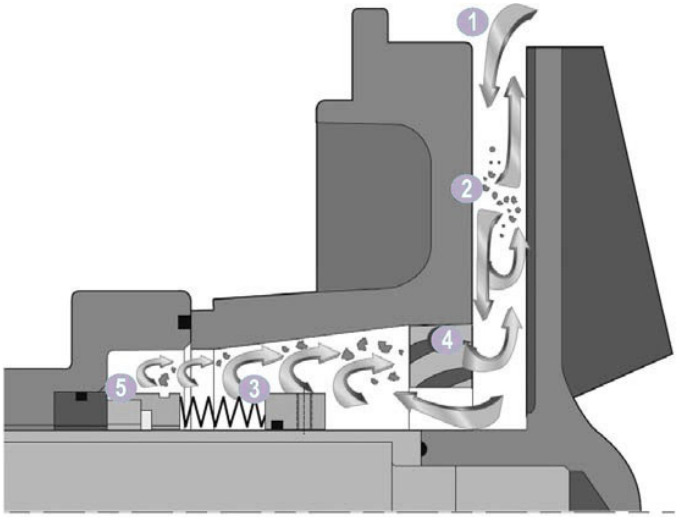


CPI PLAN 7311
By-pass flush lubricates single seal faces.



CPI PLAN 7353
Pressurized circulation lubricates double seal faces.

Goulds TaperBore™ *PLUS*



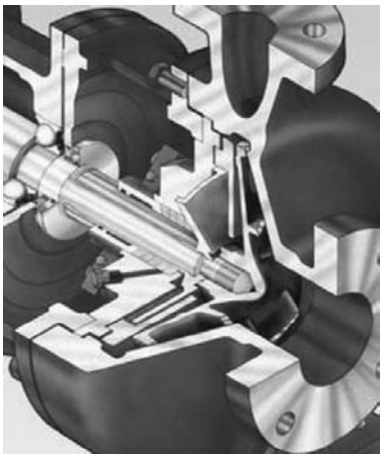
How It Works

The unique flow path created by the Vane Particle Ejector directs solids away from the mechanical seal, not towards the seal as with other tapered bore designs. And, the amount of solids entering the bore is minimized. Air and vapors are also efficiently removed. On services with or without solids, air or vapors, Goulds TaperBore™ PLUS is the effective solution for extended seal and pump life and lower maintenance costs.

1. Solids/liquid mixture flows toward mechanical seal/seal chamber.
2. Turbulent zone. Some solids continue to flow toward shaft. Other solids are forced back out by centrifugal force (generated by back pump-out vanes).
3. Clear liquid continues to move toward mechanical seal faces. Solids, air, vapors flow away from seal.
4. Low pressure zone created by Vane Particle Ejector. Solids, air, vapor liquid mixture exit seal chamber bore.
5. Flow in TaperBore™ PLUS seal chamber assures efficient heat removal (cooling) and lubrication. Seal face heat is dissipated. Seal faces are continuously flushed with clean liquid.

Dynamic Seal

Eliminate Sealing Problems, Reduce Maintenance Costs



On tough pumping services, especially corrosives and slurries, mechanical seals require outside flush and constant, costly attention. Even then, seal failures are common, resulting in downtime. Goulds offers a solution: The Dynamic Seal which, simply by fitting a repeller between the stuffing box cover and impeller, eliminates the need for a mechanical seal

BENEFITS OF DYNAMIC SEAL:

- Eliminate use of seal water
- Eliminate pumpage contamination and product dilution
- Reduce utility cost
- Eliminate problems associated with piping from a remote source
- Eliminate need to treat seal water
- Considerably less expensive than a slurry mechanical seal

Stuffing Box Cover Repeller Repeller Plate

Goulds Patented *i-FRAME™* Power Ends

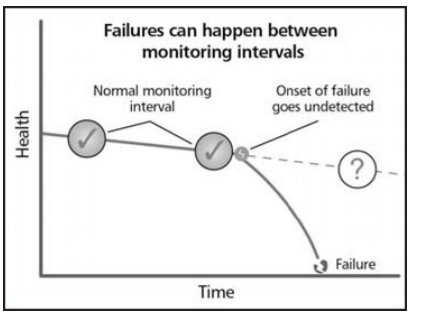
Extended Pump Life Through Intelligent Design

Goulds ***i-FRAME*** Power Ends are the result of 160 years of design experience, customer interaction, and continuous improvement. Customers get extended Mean Time Between Failure (MTBF) and lower life cycle costs (LCC)...guaranteed!

1 *i-ALERT™* CONDITION MONITOR

The heart of the *i-FRAME*, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

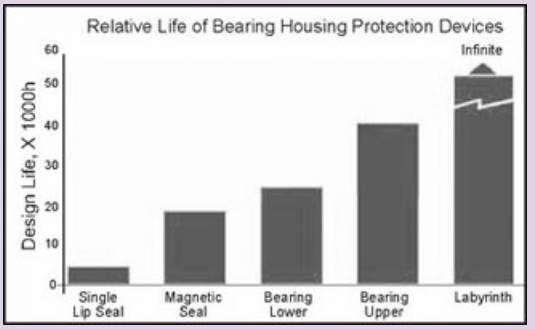
A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



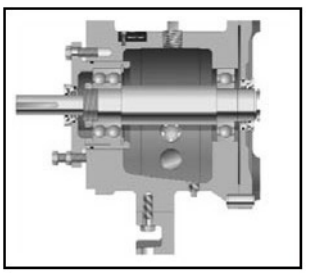
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

2 INPRO VBXX-D HYBRID BEARING ISOLATORS

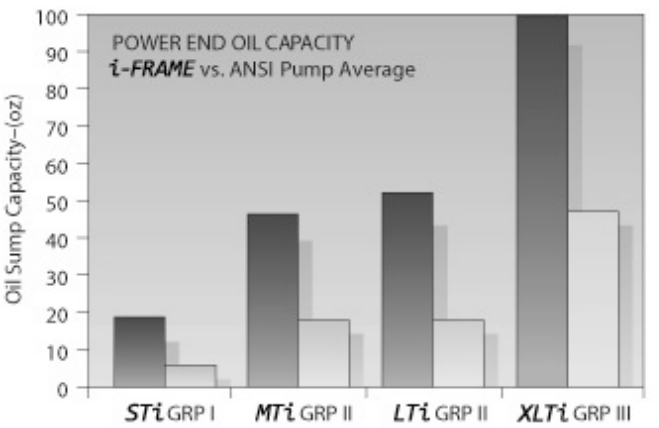
Most bearings fail before reaching their potential life. They fail for a variety of reasons, including contamination of the lubricant. INPRO VBXX-D has long been considered the industry standard in bearing lubricant protection. The ***i-FRAME*** now improves upon that design by offering stainless steel rotors, for maximum protection against contaminants and the corrosive effects of seal leakage or environmental conditions. These seals are non-contacting and do not wear.



3 OPTIMIZED OIL SUMP DESIGN



Internal sump geometry is optimized for longer bearing life. Sump size increased by 10%-20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.



Larger *Means Cooler*
GOULDS
Industry Average

4 SHAFT AND BEARINGS ENGINEERED FOR MAXIMUM RELIABILITY

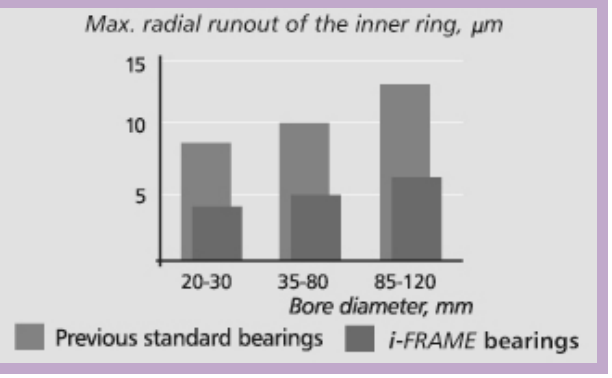
The rugged shaft and bearing combination maintains shaft deflection of less than 0.002 inches at all operating points. The result is longer seal and bearing life.

Premium severe-duty thrust bearings increase bearing fatigue life.

- High purity steels have fewer inclusions than standard steel – better grain structure and wear resistance.
- Heat treatment of bearing elements to SO stabilizaion levels provides superior thermal stability for increased service life.
- Bearing Balls are manufactured to at least one ISO grade above standard (ISO P5 for ring running accuracy and ISO P6 for dimensions). The result is reduced vibration and noise for improved shaft guidance.

Every 3196 ***i-FRAME***™ Power End is engineered and manufactured for optimal pump performance and increased MTBF.

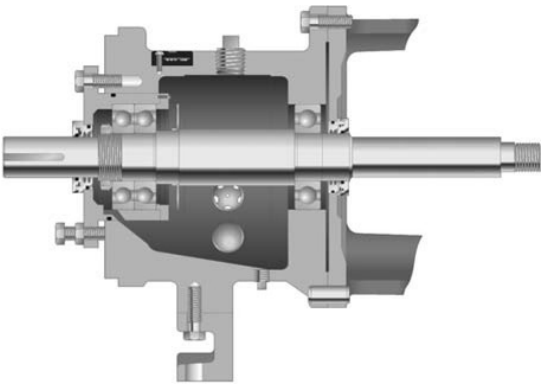
ANSI B73.1 Shaft Specification	Meets	Exceeds
Diameter Tolerance		✓
Surface Finish		✓
Runout	✓	
Deflection		✓



5 *LTi* POWER END FOR HIGH LOAD APPLICATIONS

Increased L'10 Bearing Life 150% to 200% on the Toughest Applications

Ideal for tough conditions when a power end is pushed beyond ANSI limits: operating at low flows and higher heads, pumping high specific gravity liquids, fluctuating process conditions, overhung belt drive. Oversized shaft and bearing assembly significantly expands the limits for long, trouble-free bearing and seal life. On high load applications, the *LTi* power end improves bearing life 150%-200%; oil operating temperature reduced by 45°F (25° C).



FLINGER/CHANNEL OIL LUBRICATION SYSTEM

Provides 30% increased L'10 life; 15°F (8°C) reduced oil temperature.

OVERSIZED SHAFT

With duplex thrustbearings provide increased L'10 by 40%.

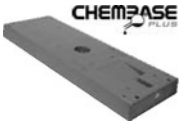
DUPLEX THRUST BEARINGS

Duplex thrust bearings (40°/40° angular contact) with machined brass cages, are ideally sized for high load applications.

Our Guarantee We are so confident that the ***i-FRAME***™ is the most reliable Power End in the industry, that we are proud to offer a standard 5-year warranty on every ***i-FRAME*** ANSI Process Pump.

Baseplate Mounting Systems

Goulds offers a complete range of pump mounting systems to meet plant requirements; make installation and maintenance easier.

						
Baseplate Selection Guide	**CAMBER TOP CAST IRON** Preferred standard of process industries. Rigid and corrosion resistant, it is the best value in the industry today.	**CHEMBASE PLUS™** Polymer concrete construction provides exceptional rigidity & corrosion resistance. ANSI 1991 dimensional.	**FABRICATED STEEL** An economical choice that meets ANSI/ASME B73.1 dimensional requirements.	**ENHANCED FEATURE FABRICATED STEEL** Upgraded ANSI baseplate designed to maximize pump operation life and ease installation. Meets API-minded chemical pump users' toughest requirements.	**ADVANTAGE** Heavy duty PIP compliant fabricated steel baseplate.	**POLYSHIELD ANSI COMBO** Heavy duty polymer concrete combination baseplate and foundation.
PLANT REQUIREMENTS						
Corrosion Resistance (mild/moderate)	■	■	■	■	■	■
Corrosion Resistance (severe)		■			□	■
Machined Pump and Motor Pads	■		■	■	■	□
Circular Grout Holes (4 in. min.)	■	■	■	■	■	■
Vent Holes (1 in. min.)	■					■
Vent Holes (1/2 in. min.)		■		■	■	
Non-Overhang				■	■	
Full Drain Rim				■	■	
Built-in Drain Pan (under pump)		■				■
Drain Pan Under Pump	□		□		■	■
Baseplate Leveling Screws		□		□	□	
Motor Alignment Adjusters	□	□	□	□	□	□
Lifting Feature				■	■	
Continuous Welding Used				■	■	
Flexibly Mounted	□	□	□			
Spring-Loaded*			□			
Available in 304 and 316 SS			□	□	□	
ANSI B73.1-1991 Conformance		■	■	■		
API-610 Conformance					□	
PIP RESP 002 Conformance		■			■	

■ **STANDARD** □ **OPTIONAL** * Engineered option - requires special baseplate

Bonus Interchangeability

i-FRAME™ Power Ends Fit 7 Different Process Pumps

Minimize inventory, reduce downtime.

3196 *i-FRAME* Process Pumps

CV 3196 *i-FRAME* Non-Clog Process Pumps

HT 3196 *i-FRAME* High Temperature Process Pumps

LF 3196 *i-FRAME* Low Flow ANSI Process Pumps

3198 *i-FRAME* PFA TEFLON®-Lined Process Pumps

3796 *i-FRAME* Self-Priming Process Pumps

NM 3196 *i-FRAME* Non-Metallic Process Pumps

Options

Goulds offers a variety of options to meet process requirements.

High and Low Temperature Capability

Options are readily available for high and low temperature applications or where pumpage temperature must be controlled.

HEAT JACKET

Economical clamp-on jacket provides practical method of heating or cooling the casing. Excellent heat transfer characteristics. Easy to install or remove for pump servicing.

JACKETED SEAL CHAMBER

Maintains proper temperature control of sealing environment. Ideal for maintaining temperature for services such as molten sulphur and polymerizing liquids. Available in BigBore™ and TaperBore™ designs.

BEARING FRAME FINNED COOLER

Directly cools oil for lower bearing operating temperature. Requires minimum cooling water. Corrosion resistant construction. Recommended for temperatures over 350°F (177°C) when using conventional oil. When synthetic oil is used, pump can run up to 450°F without cooling. Above 450°F add for high temperature option.

HIGH TEMPERATURE FEATURES

[For operation to 700°F (371°C)]

- Jacketed Stuffing Box/Seal Chamber
- Finned Cooler
- 316 Stainless Steel Shaft
- Graphite Impeller O-ring
- Graphite Casing Gasket

Other Features for Safety Reliability

C-FACE ADAPTER

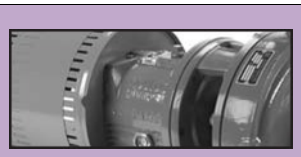
i-FRAME™ Power Ends accommodate optional C-Face motor adapter - simplifies pump/motor alignment.

3196CC (Close Coupled)

Certain sizes of the 3196 are available in a close coupled configuration which saves space, requires less maintenance and needs no alignment.

CENTERLINE-MOUNTED CASING

For high temperature services (500° to 700° F/260° to 370°C).



ANSI COUPLING GUARD

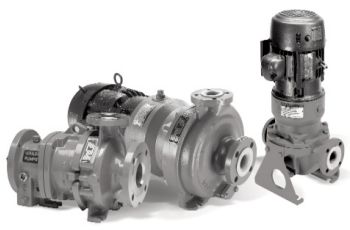
Meets all requirements of ANSI B15.1 specifications.

SHAFT GUARD

When a guard around all rotating shaft parts is required.

Sealless Solutions

Not all process pump applications can be sealed with optimum reliability. Goulds ANSI dimensional magnetic drive sealless process pumps are perfect solutions to mechanical seal or environmental sealing problems. The 3296 EZMAG metal magnetic drive process pump has a revolutionary bearing cartridge design for maximum reliability and ease of maintenance. For tough corrosive services Goulds also offers ETFE® and PFA-lined magnetic drives available in horizontal, vertical or self-priming configurations to meet all your process needs.



Model 3296 EZMAG | Model 3298 | Model V3298

Construction Details All dimensions in inches and (mm).

		STi	MTi	LTi	XLTi
Shaft	Diameter at Impeller	.75 (19)	1 (25)	1.25 (32)	1.5 (38)
	Diameter in Stuffing Box/Seal Chamber				
	(Less Sleeve)	1.375 (35)	1.75 (45)	2.125 (54)	2.5 (64)
	(With Sleeve)	1.125 (29)	1.5 (38)	1.875 (48)	2 (51)*
	Diameter Between Bearings	1.5 (38)	2.125 (54)	2.5 (64)	3.125 (79)
	Diameter at Coupling	.875 (22)	1.125 (29)	1.875 (48)	2.375 (60)
	Overhang	6.125 (156)	8.375 (213)	8.375 (213)	9.969 (253)
	Maximum Shaft Deflection	0.002 (0.05)			
	Shaft Deflection Index (L^3/D^4)				
	(With Sleeve)	143	116	48	62
	(Less Sleeve)	64	63	29	25
Sleeve	O.D. thru Stuffing Box/Seal Chamber	1.375 (35)	1.75 (45)	2.125 (54)	2.5 (64)*
Bearings	Radial	6207	6309	6311	6313
	Thrust	3306	3309	7310	3313
	Bearing Span	4.125 (105)	6.75 (171)	6.875 (164)	9.25 (235)
BigBore™ Seal Chamber	Bore	2.875 (73)	3.5 (89)	3.875 (98)	4.75 (120)*
Stuffing Box	Bore	2 (51)	2.5 (64)	2.875 (73)	3.375 (86)*
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)	5.6 (4.2)	14 (10.5)**
Temperature	Maximum Liquid Temperature— Oil/Grease Lubrication without Cooling	350° F (177° C)			
	Maximum Liquid Temperature— Oil Lubrication with High Temp. Option	700°F (370° C)			
Casing	Corrosion Allowance	.125 (3)			

*17 inch sizes have 21⁄4 inch (57) shaft diameters in stuffing box/seal chamber with sleeve. Shaft sleeve O.D. is 23⁄4 inches (70) for packing and 21⁄2 inches (64) for mechanical seals. Seal chamber bore is 43⁄4 inches (121). Stuffing box bore is 35⁄8 inches (92).
**17 inch sizes power limit per 100 RPM is 20HP (15kW).

Process Industry Practices (PIP) Compliance

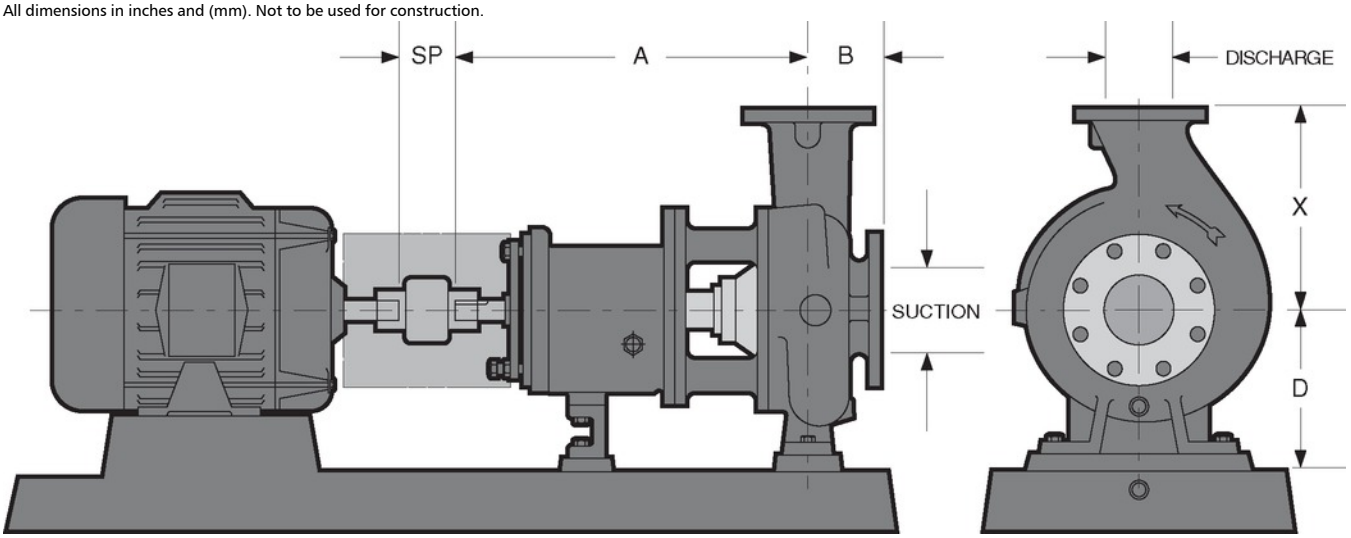
The standard design features of Goulds 3196 (ANSI B73.1M) and 3996 (ANSI B73.2M) pumps meet ASME/ANSI standards. In addition, both models can be manufactured to comply with PIP Specifications for application of horizontal and vertical in-line ANSI process pumps.

Model 3196 meets B73.1M and RESP73H

Model 3996 meets B73.2M and RESP73V

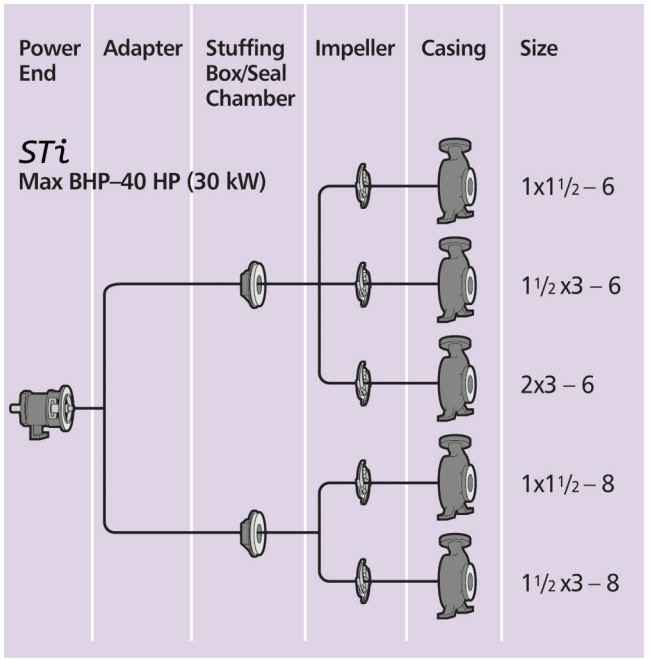
Dimensions Model 3196 *i-FRAME™*

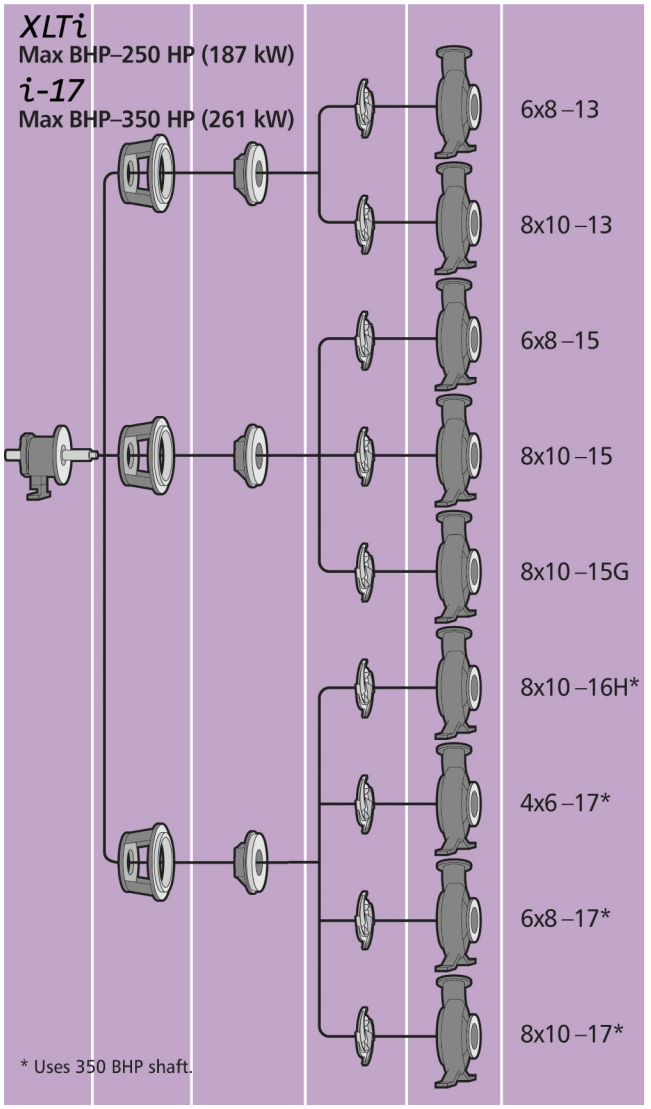
All dimensions in inches and (mm). Not to be used for construction.

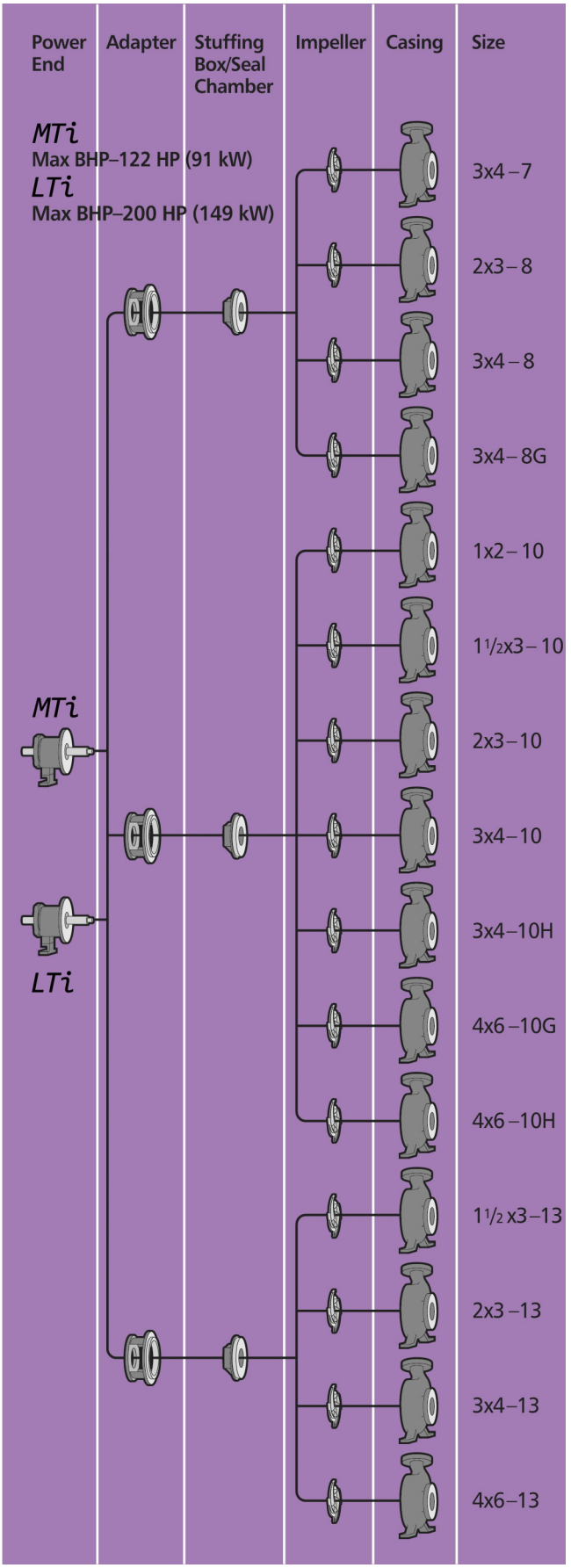


DIMENSIONS											
Group	Pump Size	ANSI Designation	Discharge Size	Suction Size	X	A	B	D	SP	Bare Pump Weight Lbs. (kg)	
STi	1x1½-6	AA	1	1½	6.5 (165)	13.5 (343)	4 (102)	5.25 (133)	3.75 (95)	84	(38)
	1½x3-6	AB	1½	3						92	(42)
	2x3-6		2	3						95	(43)
	1x1½-8	AA	1	1½						100	(45)
	1½x3-8	AB	1½	3						108	(49)
MTi/ LTi	3x4-7	A70	3	4	11 (280)	19.5 (495)	4 (102)	8.25 (210)	3.75 (95)	220	(100)
	2x3-8	A60	2	3	9.5 (242)					220	(91)
	3x4-8	A70	3	4	11 (280)					220	(100)
	3x4-8G	A70	3	4							
	1x2-10	A05	1	2	8.5 (216)					200	(91)
	1½x3-10	A50	1½	3						220	(100)
	2x3-10	A60	2	3	9.5 (242)					230	(104)
	3x4-10	A70	3	4	11 (280)					265	(120)
	3x4-10H	A40	3	4	12.5 (318)	19.5 (495)	4 (102)	10 (254)		275	(125)
	4x6-10G	A80	4	6	13.5 (343)					305	(138)
	4x6-10H	A80	4	6							
	1½x3-13	A20	1½	3	10.5 (267)					245	(111)
	2x3-13	A30	2	3	11.5 (292)					275	(125)
	3x4-13	A40	3	4	12.5 (318)					330	(150)
	4x6-13	A80	4	6	13.5 (343)					405	(184)
XLT-i	6x8-13	A90	6	8	16 (406)	27.875 (708)	6 (152)	14.5 (368)	5.25 (133)	560	(254)
	8x10-13	A100	8	10	18 (457)					670	(304)
	6x8-15	A110	6	8						610	(277)
	8x10-15	A120	8	10	19 (483)					740	(336)
	8x10-15G	A120	8	10						710	(322)
	8x10-16H	A120	8	10						850	(385)
	4x6-17		4	6	16 (406)					650	(295)
	6x8-17		6	8	18 (457)					730	(331)
	8x10-17		8	10	19 (483)					830	(376)

Modular Interchangeability





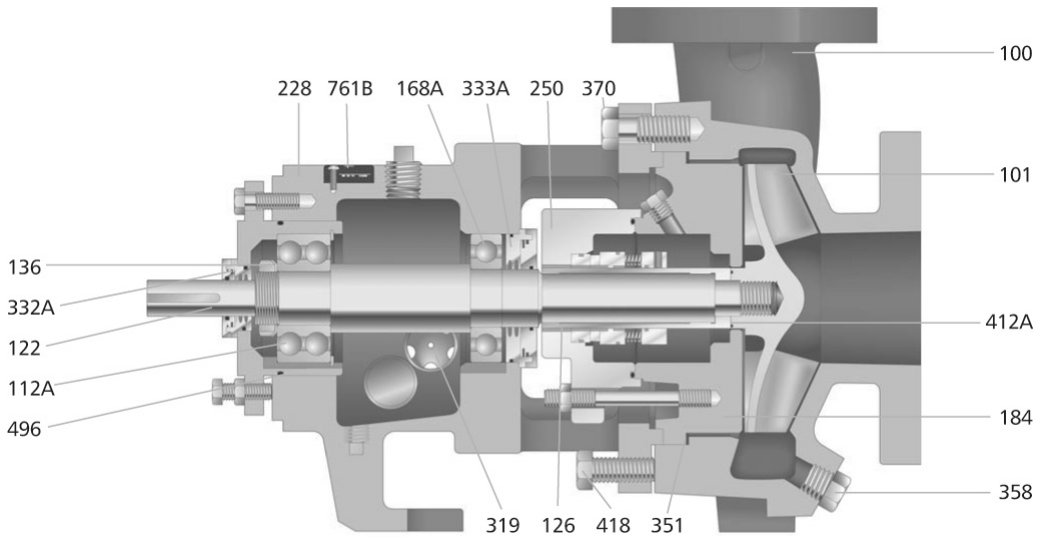


Parts List and Materials of Construction

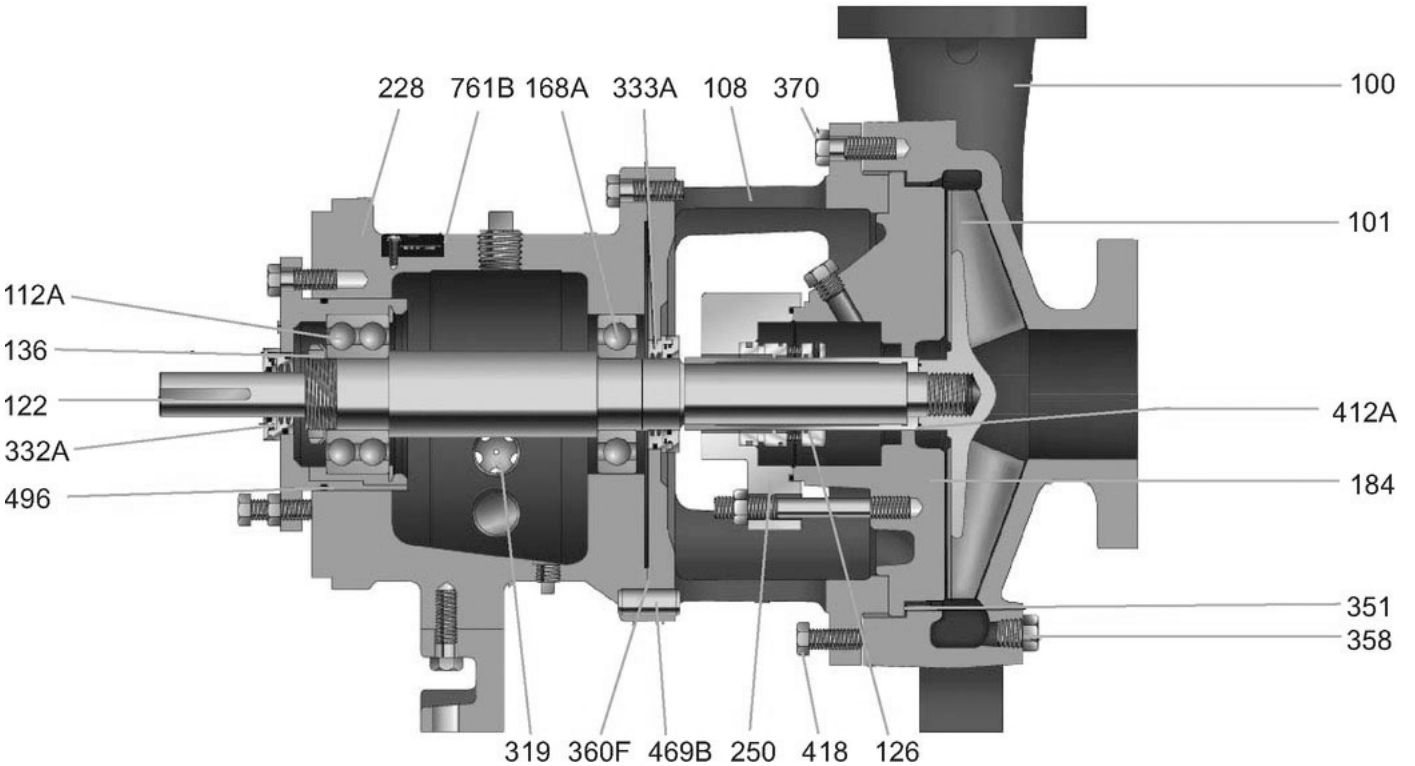
		Material							
Item Number	**Part Name**	**Ductile Iron**	**316SS**	**CD4MCu**	**Alloy 20**	**Monel**	**Nickel**	**Hastelloy B & C**	**Titanium**
100	Casing	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
101	Impeller	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
105	Lantern Ring	Glass-Filled TEFLON*							
106	Stuffing Box Packing	TEFLON* Impregnated Fibers							
108	Frame Adapter	Ductile Iron							
112A	Thrust Bearing	Double Row Angular Contact**							
122	Shaft—Less Sleeve (Optional)	316SS			Alloy 20	Monel	Nickel	Hastelloy	Titanium
122	Shaft—With Sleeve	SAE4140				316SS			
126	Shaft Sleeve	316SS		Alloy 20		Monel	Nickel	Hastelloy	Titanium
136	Bearing Locknut and Lockwasher	Steel							
168A	Radial Bearing	Single Row Deep Groove							
184	Stuffing Box Cover (Packed Box)	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
184	Seal Chamber (Mechanical Seal)	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
228	Bearing Frame	Cast Iron (Ductile Iron for *STi* Group)							
250	Gland	316SS		Alloy 20		Monel	Nickel	Hastelloy	Titanium
262	Repeller/Sleeve (Dynamic Seal Option)	CD4MCu			Alloy 20	Monel	Nickel	Hastelloy	Titanium
264	Gasket, Cover-to-Backplate (Dynamic Seal)	TEFLON*							
370H	Stud/Nut, Cover-to-Adapter	304SS							
319	Oil Sight Glass	Glass/Steel							
332A	INPRO ® VBXX-D Labyrinth Oil Seal (Outboard)	Stainless Steel/Bronze							
333A	INPRO ® VBXX-D Labyrinth Oil Seal (Inboard)	Stainless Steel/Bronze							
351	Casing Gasket	Aramid Fiber with EPDM Rubber							
358	Casing Drain Plug (Optional)	Steel	316SS	Alloy 20		Monel	Nickel	Hastelloy	Titanium
360F	Gasket, Frame-to-Adapter	Buna							
360C	Gasket, Bearing End Cover	Cellulose Fiber with Binder							
370	Cap Screw, Adapter-to-Casing	Steel							
412A	O-ring, Impeller	Glass-Filled TEFLON*							
418	Jacking Bolt	304SS							
444	Backplate (Dynamic Seal Option)	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
469B	Dowel Pin, Frame-to-Adapter	Steel							
496	O-ring, Bearing Housing	Buna Rubber							
761B	***i-ALERT*** Condition Monitor	Stainless Steel/Epoxy							

*E.I. DuPont reg. trademark
** *LTi* Power End features standard Duplex Angular Contact: Optional *STi, MTi, XLT-i*
Other Alloys Available: 316L, 317, 317L, 254SMO, Zirconium, etc.

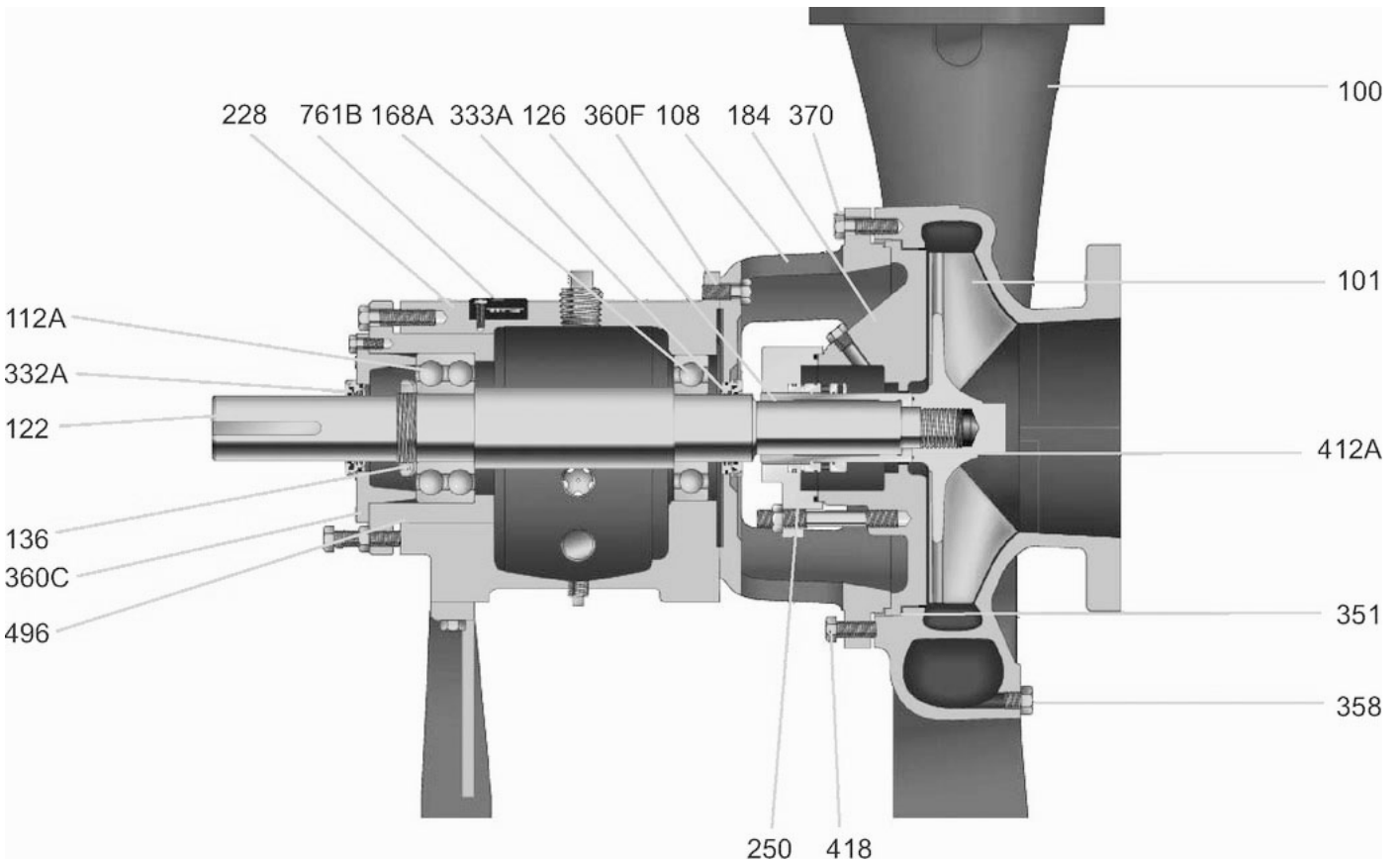
Sectional View Model 3196 *STi*



Model 3196 *MTi/LTi*

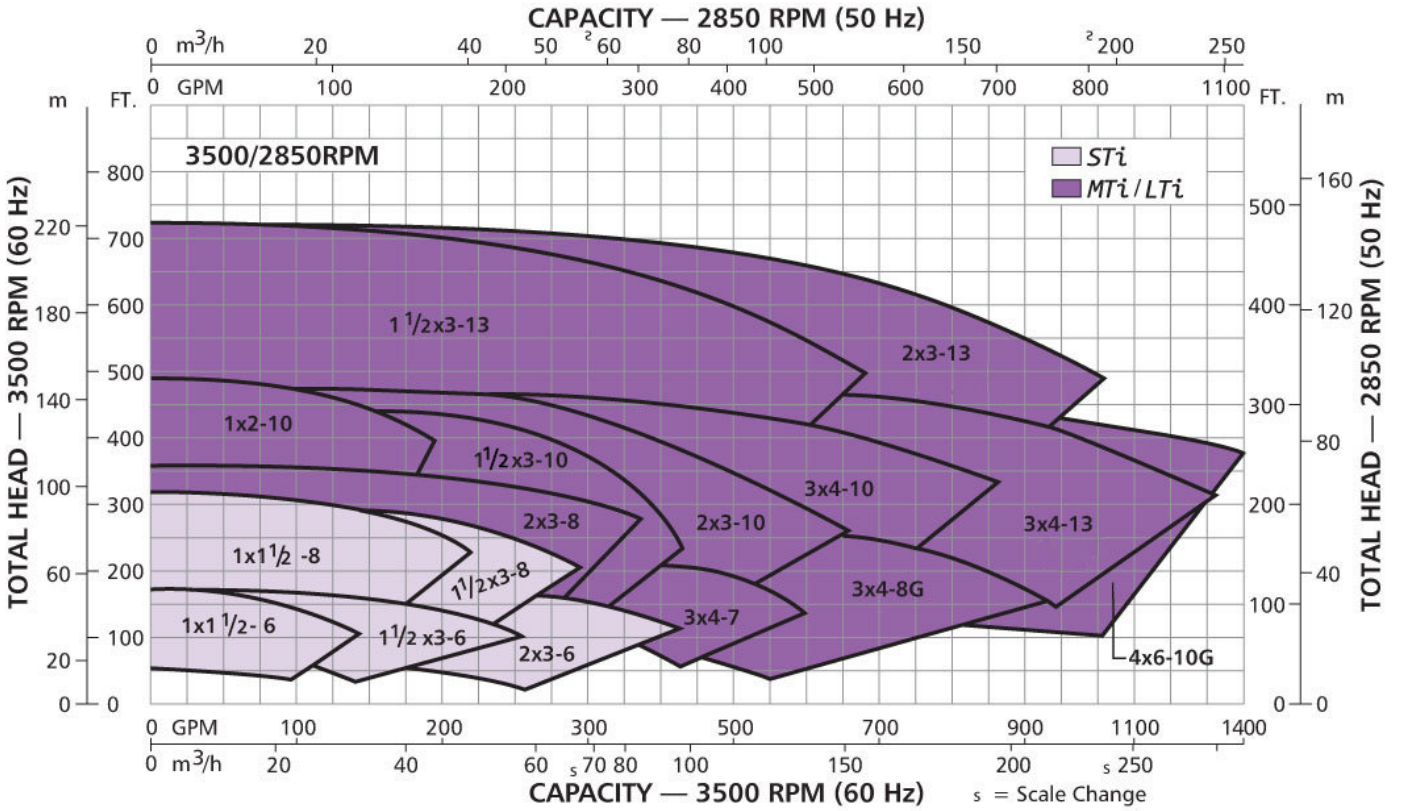


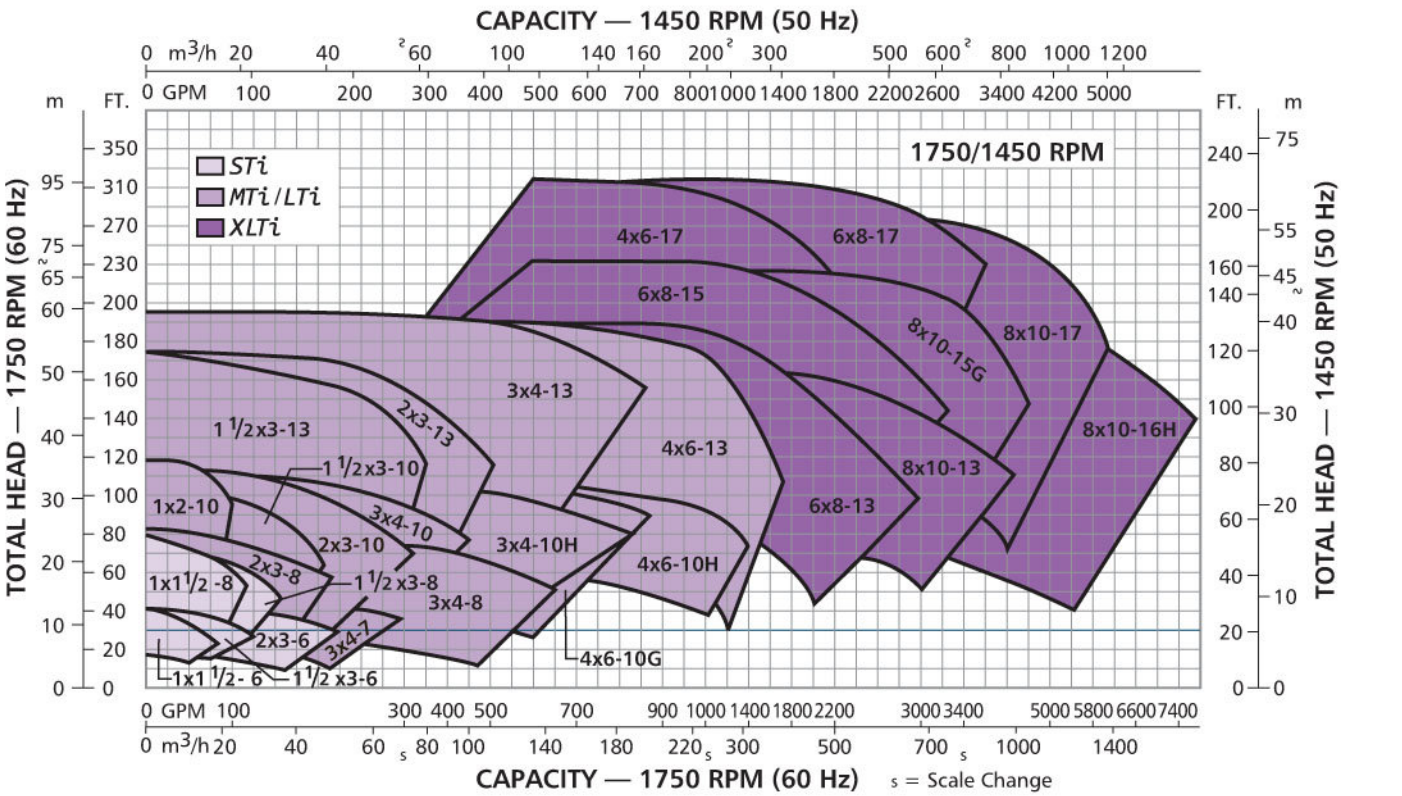
Model 3196 *XLT-i/i-17*



Hydraulic Coverage

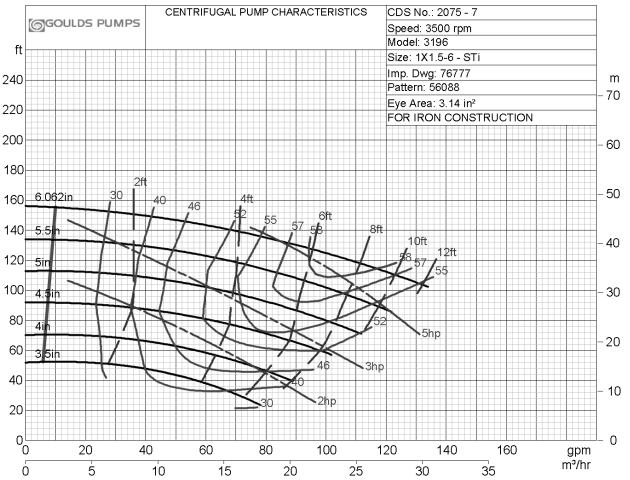
Model 3196 *i-FRAME™*



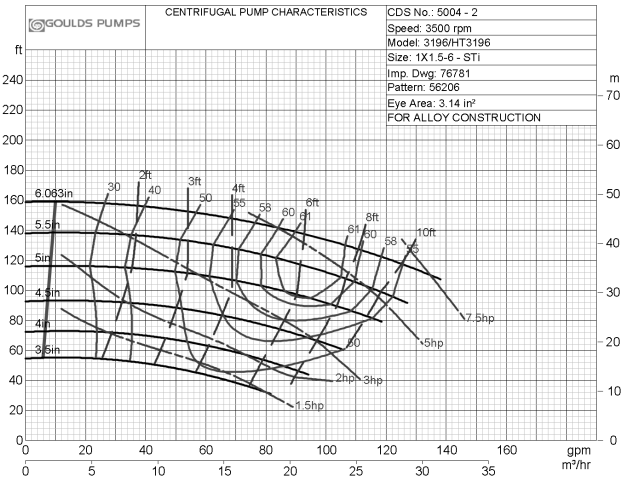


NOTES

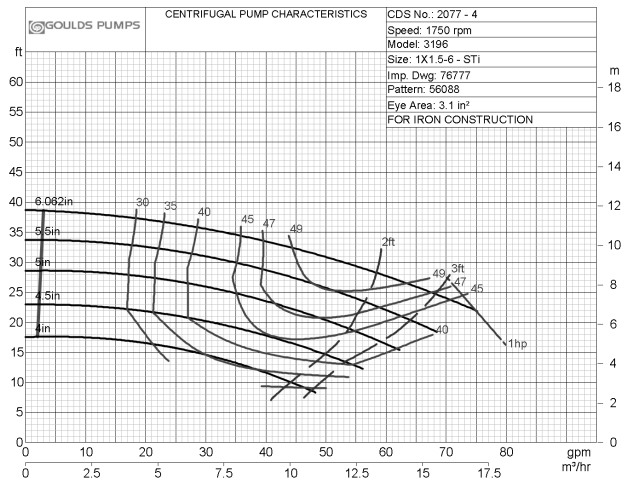
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



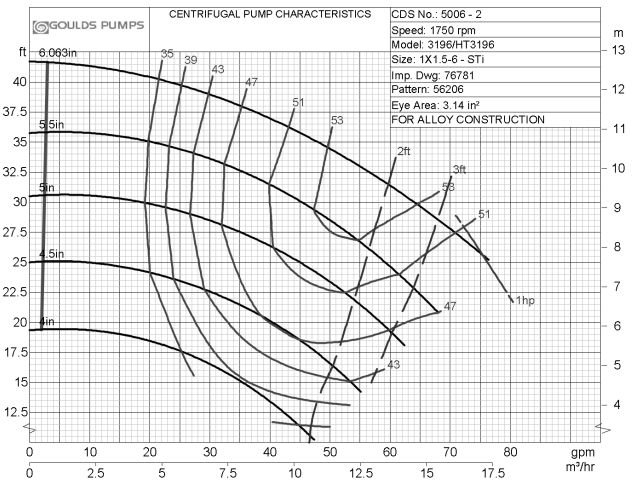
1X1.5-6 **3500rpm**



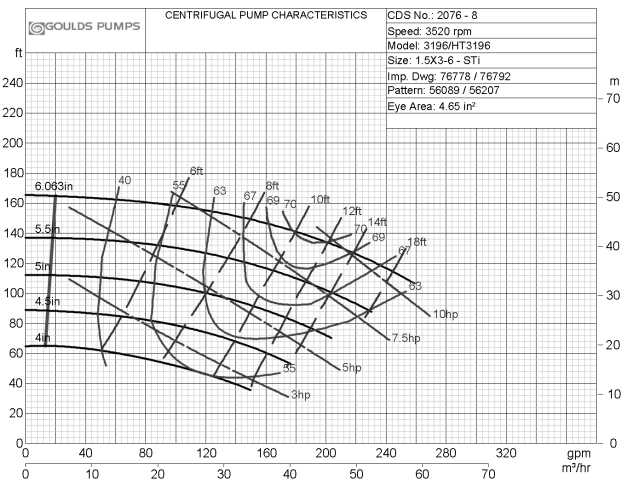
1X1.5-6 **3500rpm**



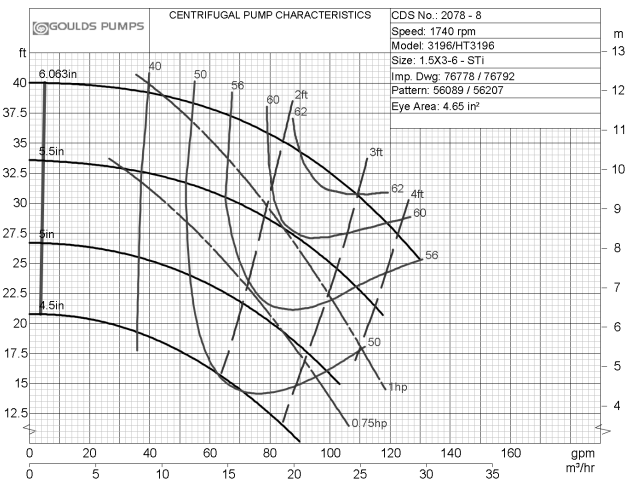
1X1.5-6 **1750rpm**



1X1.5-6 **1750rpm**



1.5X3-6 **3520rpm**

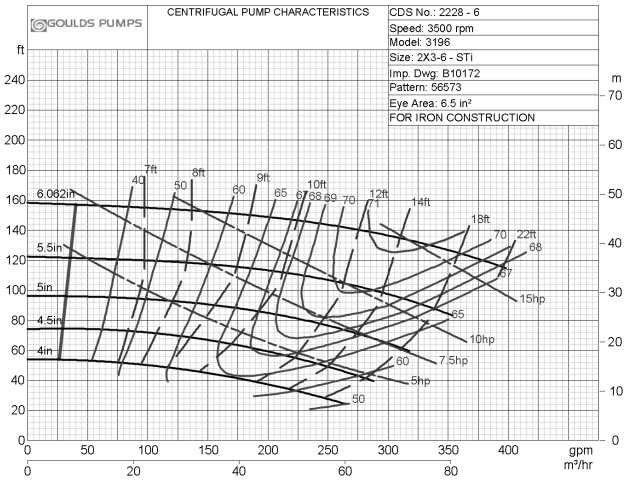


1.5X3-6 **1740rpm**

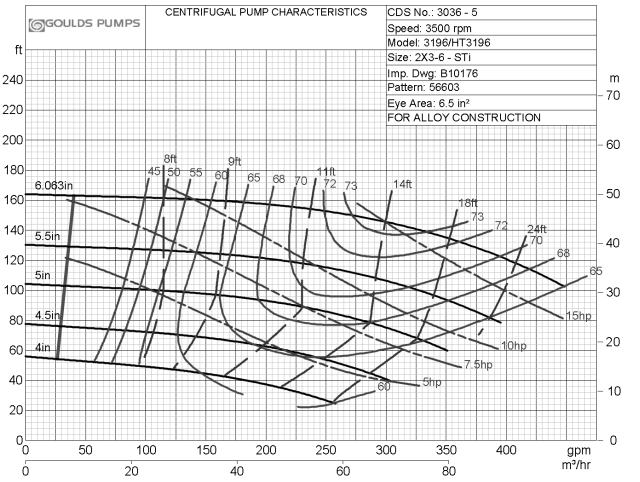
60Hz Curves

Model 3196

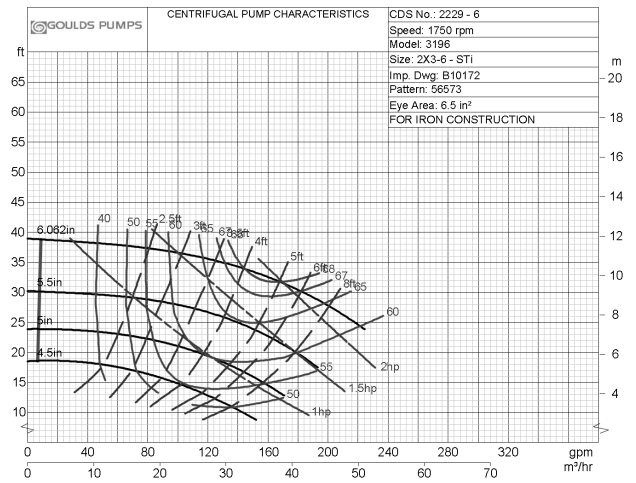
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



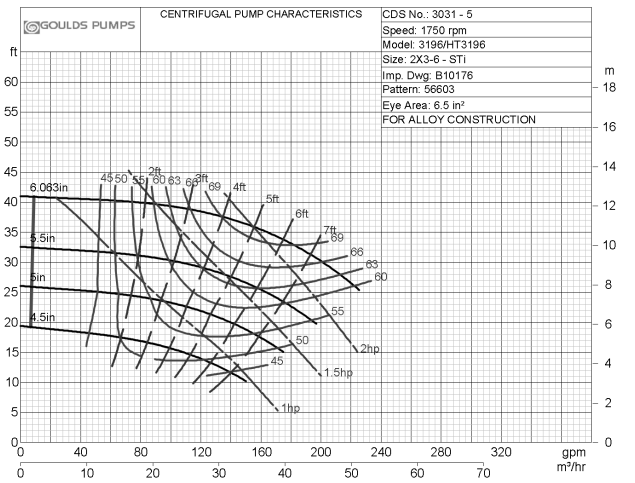
2X3-6 **3500rpm**



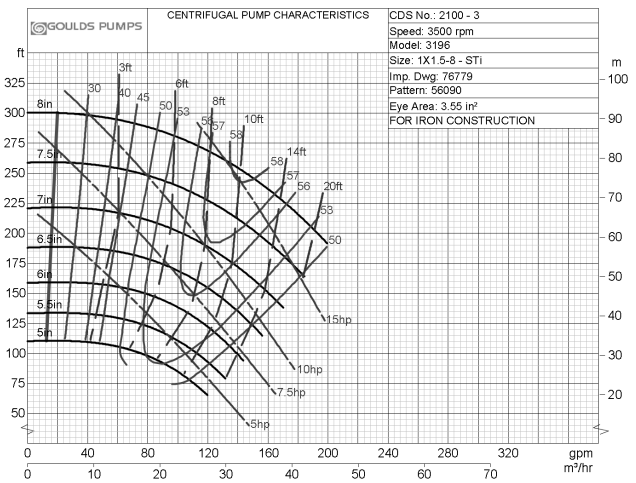
2X3-6 **3500rpm**



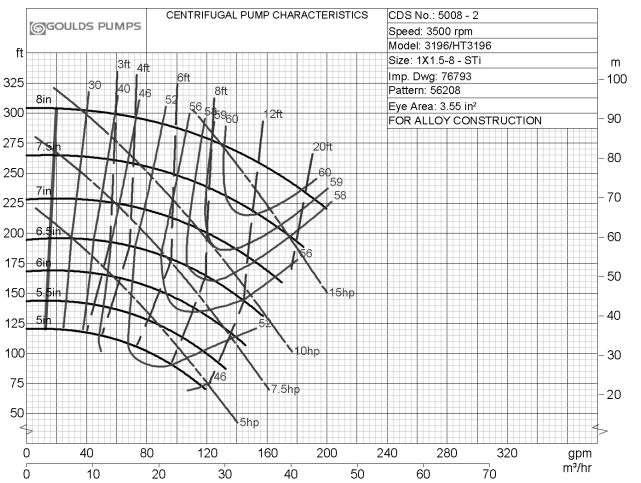
2X3-6 **1750rpm**



2X3-6 **1750rpm**

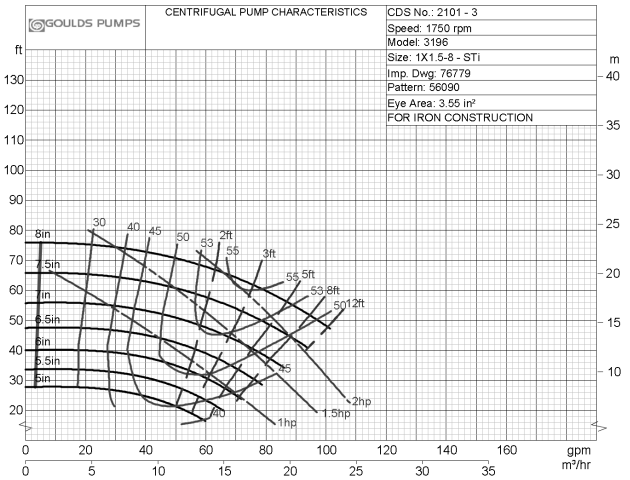


1X1.5-8 **3500rpm**

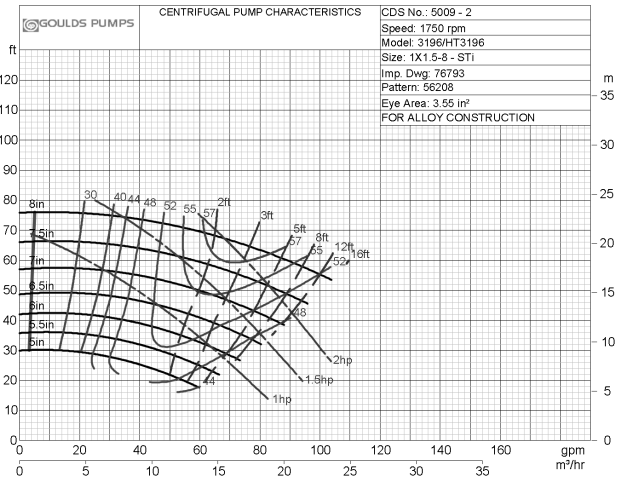


1X1.5-8 **3500rpm**

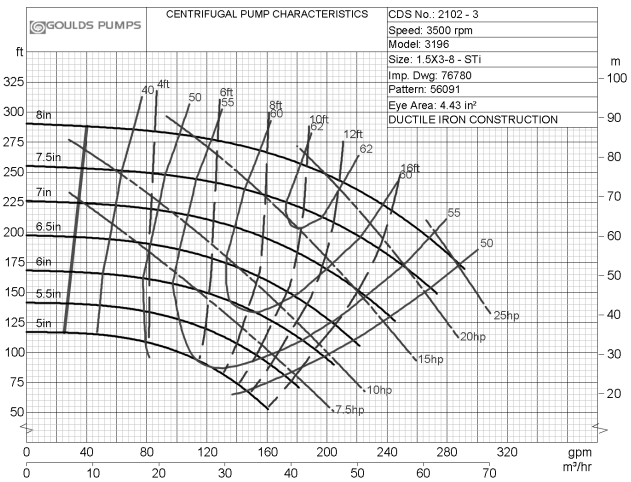
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



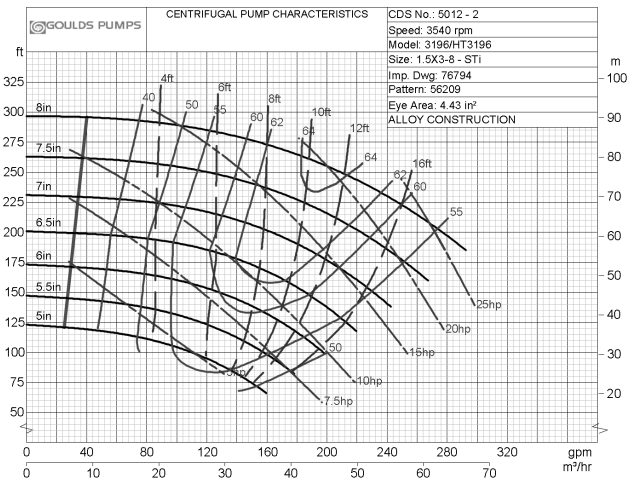
1X1.5-8 **1750rpm**



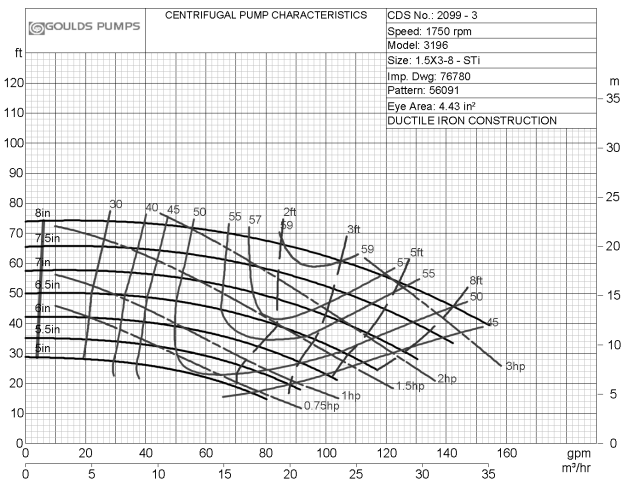
1X1.5-8 **1750rpm**



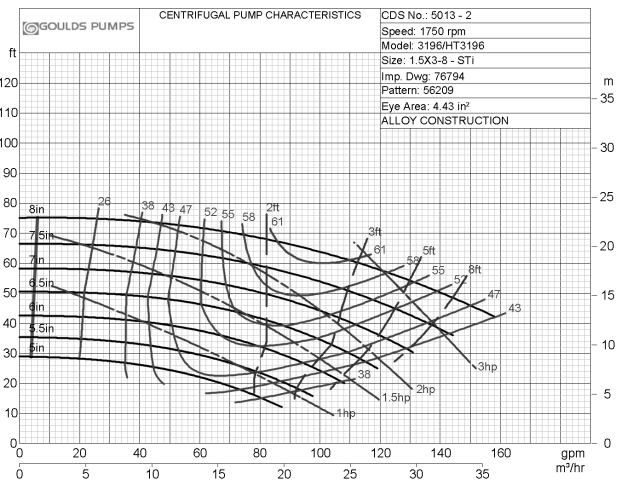
1.5X3-8 **3500rpm**



1.5X3-8 **3540rpm**



1.5X3-8 **1750rpm**

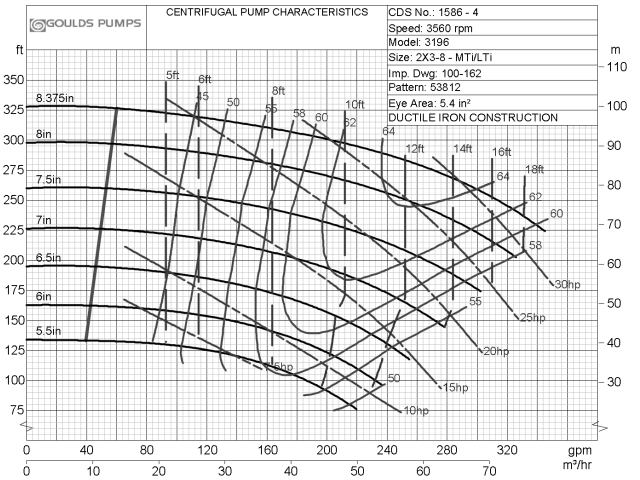


1.5X3-8 **1750rpm**

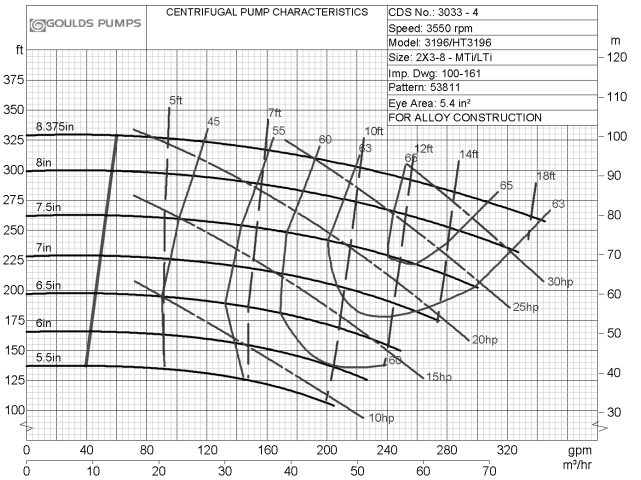
60Hz Curves

Model 3196

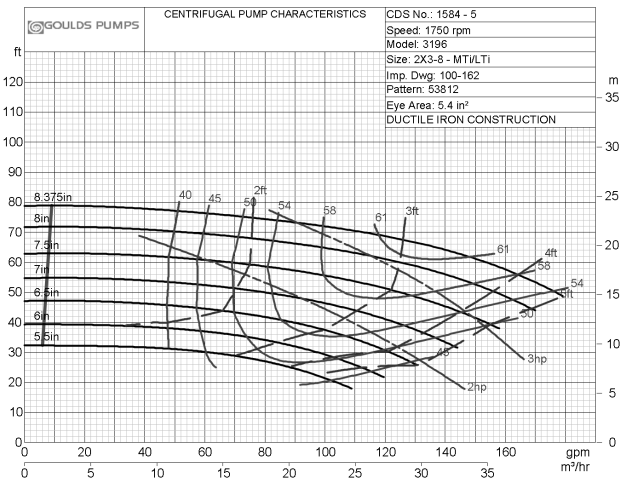
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



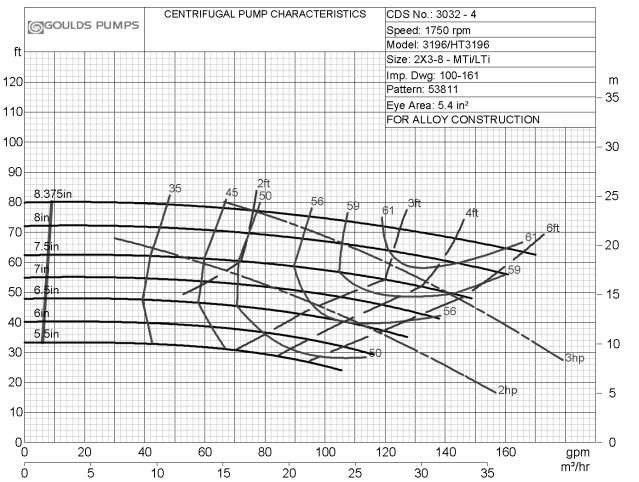
2X3-8 **3560rpm**



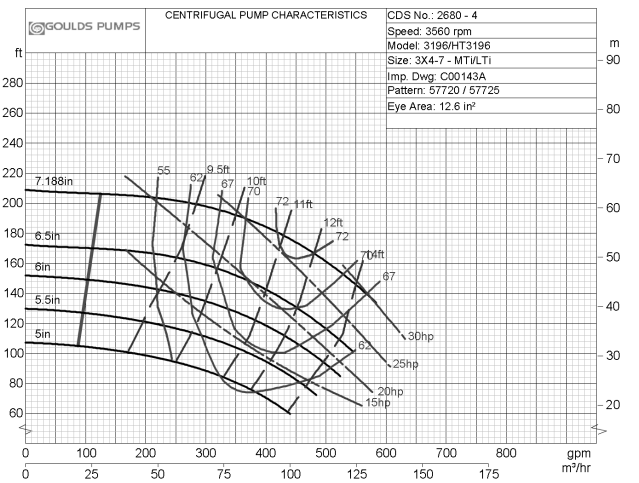
2X3-8 **3550rpm**



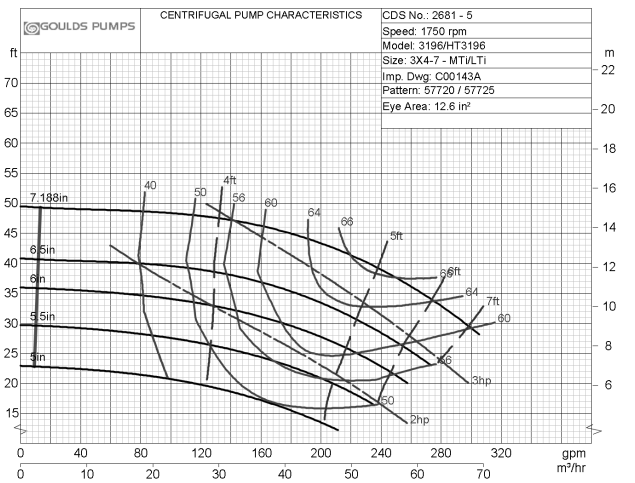
2X3-8 **1750rpm**



2X3-8 **1750rpm**

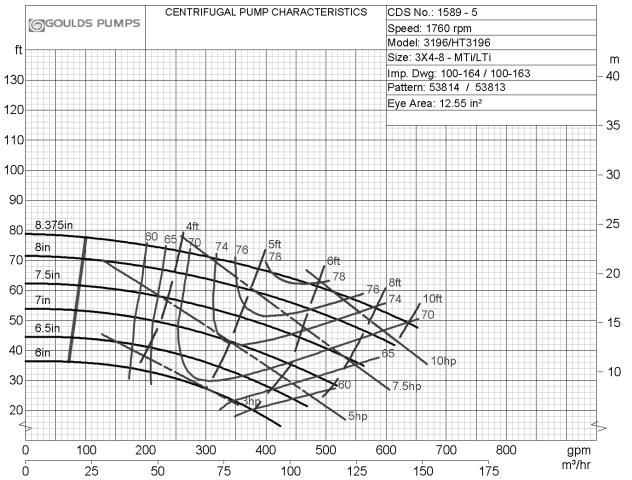


3X4-7 **3560rpm**

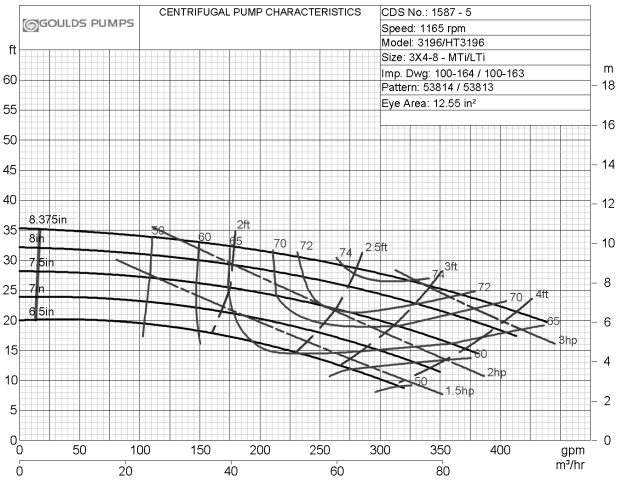


3X4-7 **1750rpm**

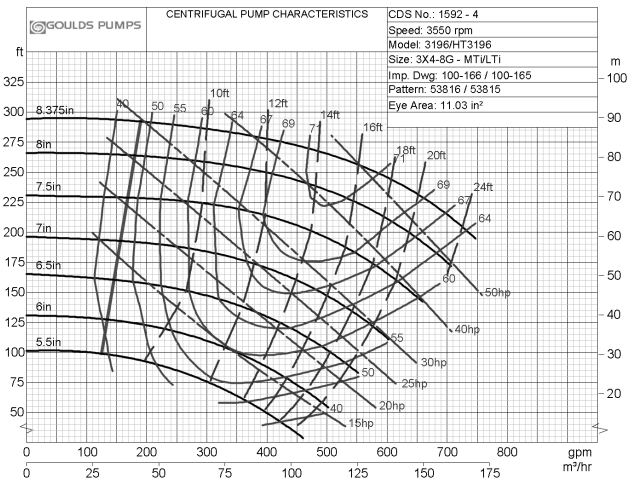
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



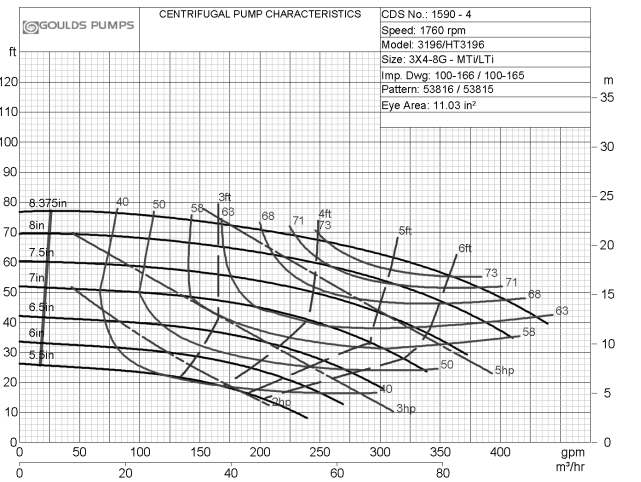
3X4-8 **1760rpm**



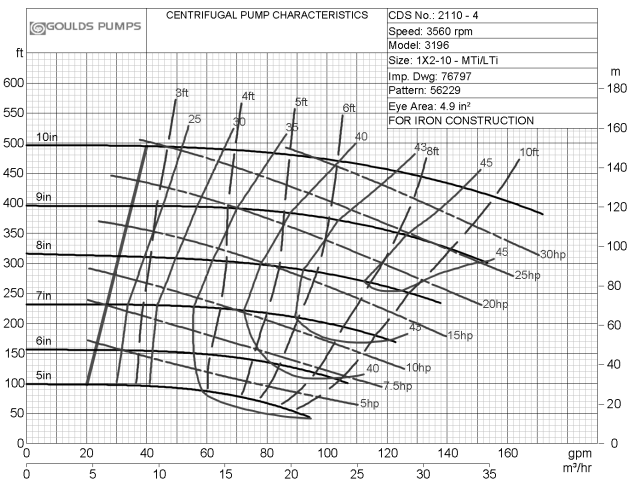
3X4-8 **1165rpm**



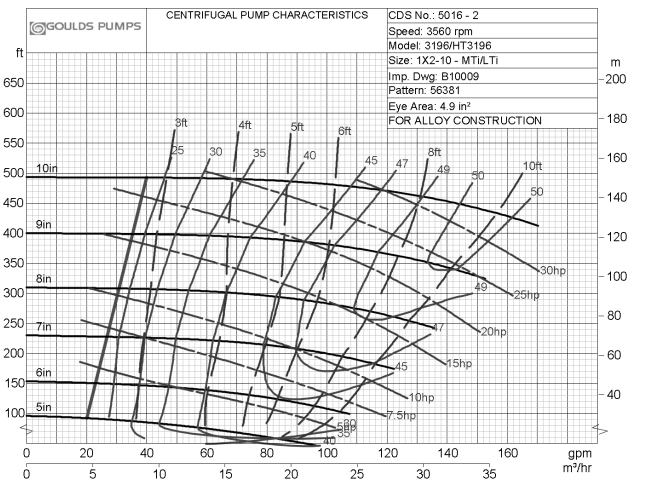
3X4-8G **3550rpm**



3X4-8G **1760rpm**



1X2-10 **3560rpm**



1X2-10 **3560rpm**

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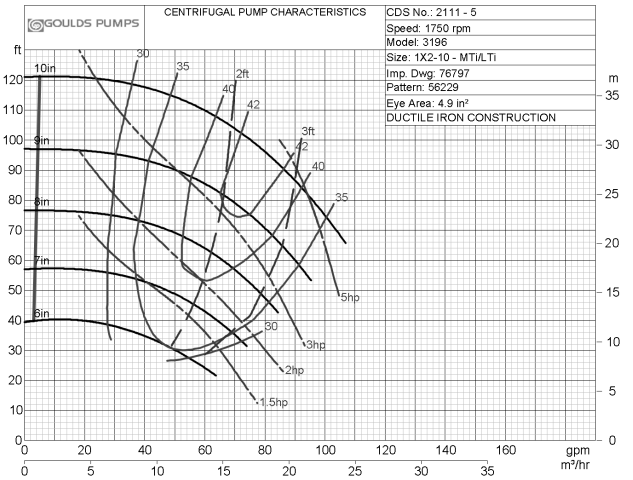
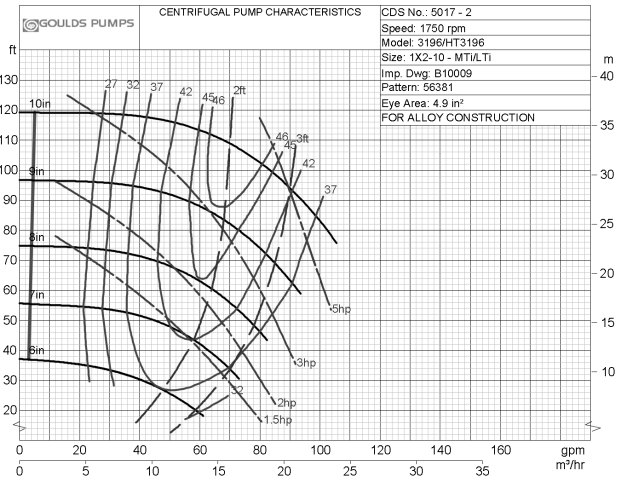
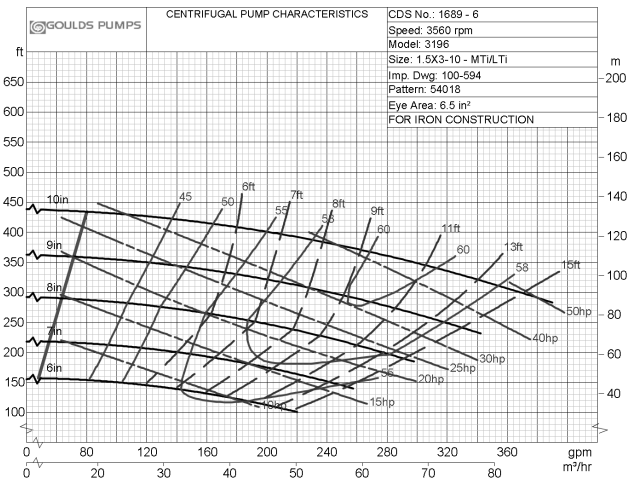


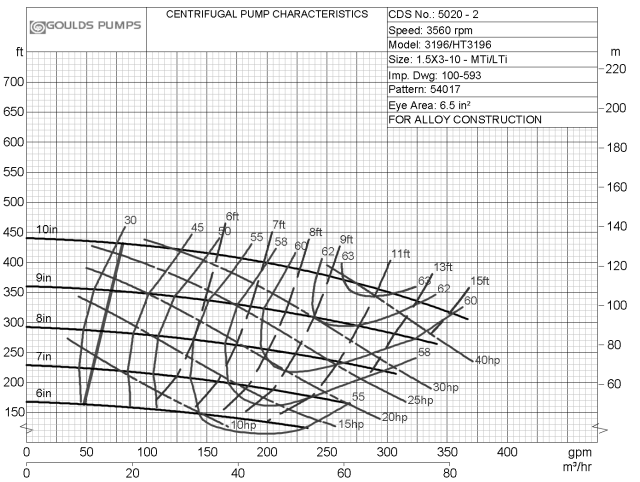
1X2-10 **1750rpm**



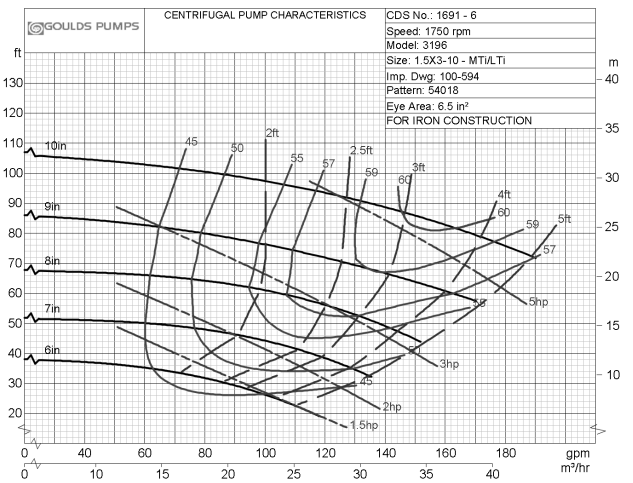
1X2-10 **1750rpm**



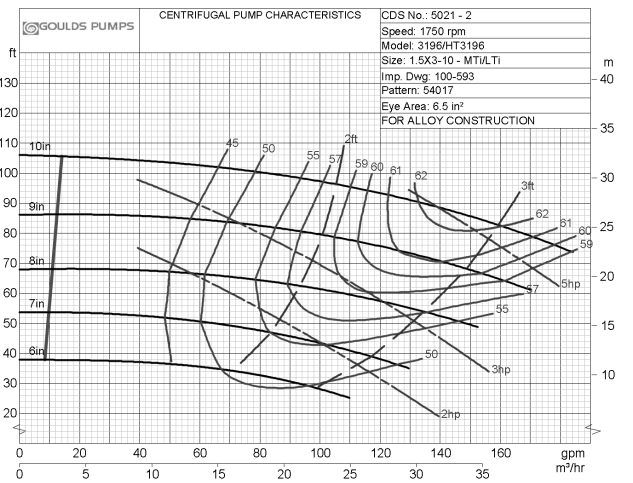
1.5X3-10 **3560rpm**



1.5X3-10 **3560rpm**



1.5X3-10 **1750rpm**



1.5X3-10 **1750rpm**

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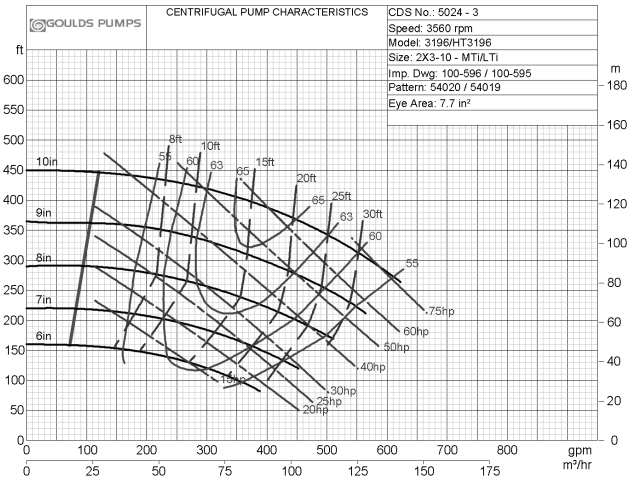
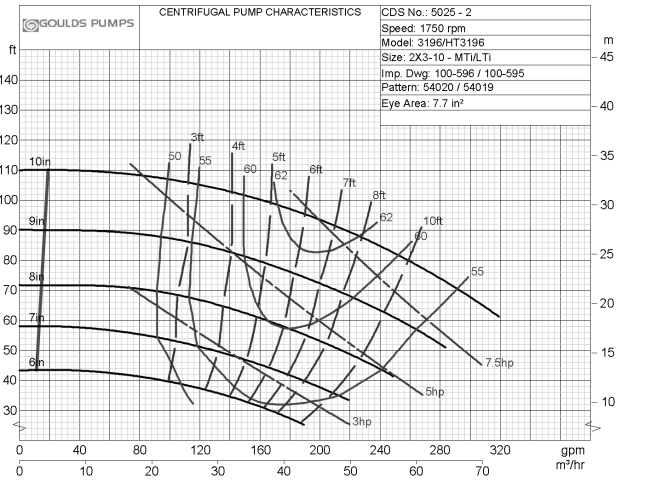
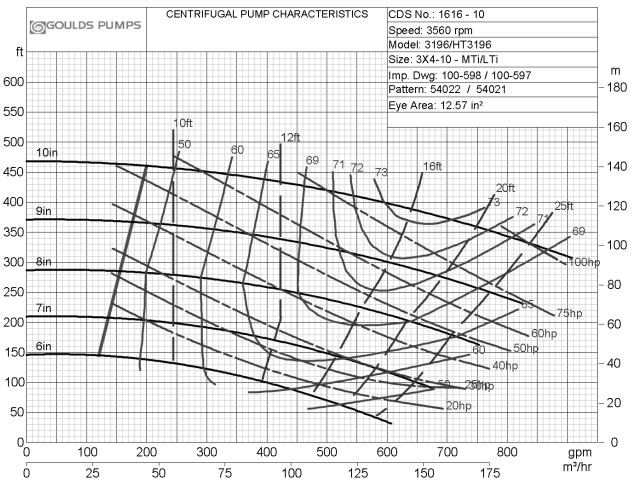


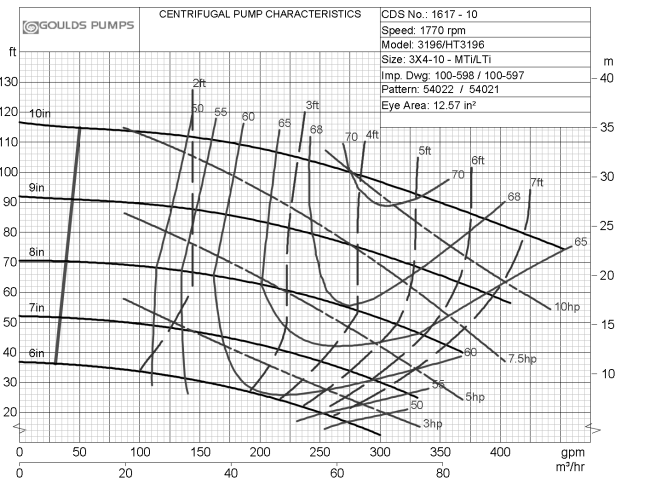
2X3-10 **3560rpm**



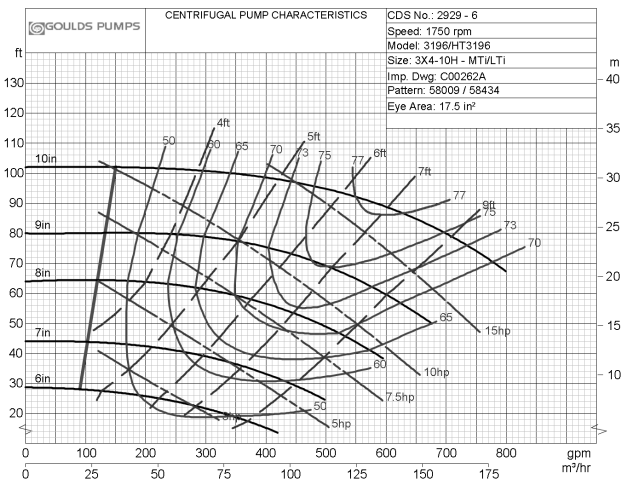
2X3-10 **1750rpm**



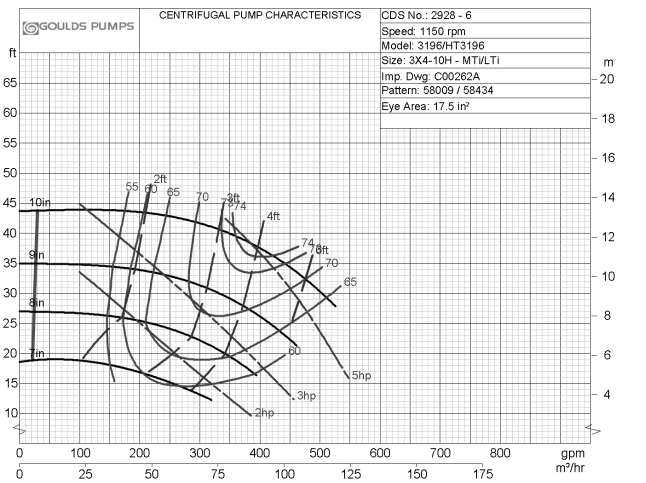
3X4-10 **3560rpm**



3X4-10 **1770rpm**



3X4-10H **1750rpm**



3X4-10H **1150rpm**

60Hz Curves

Model 3196

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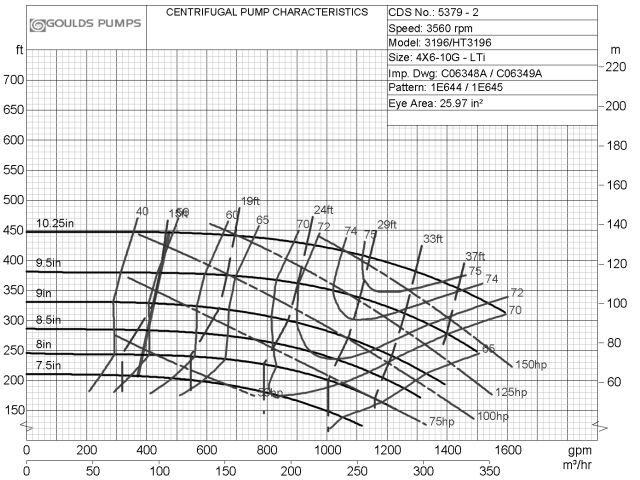
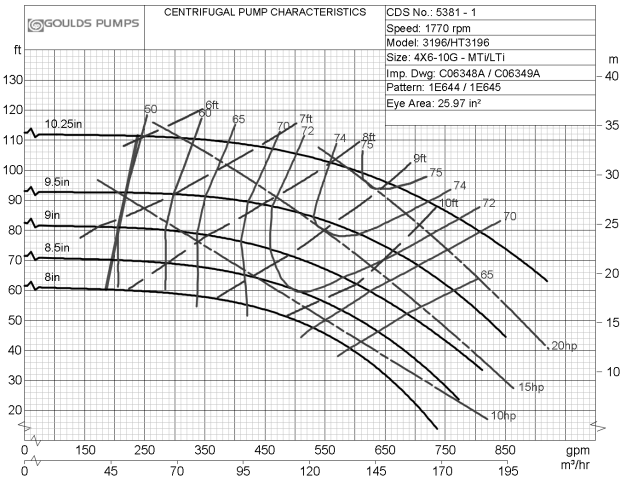
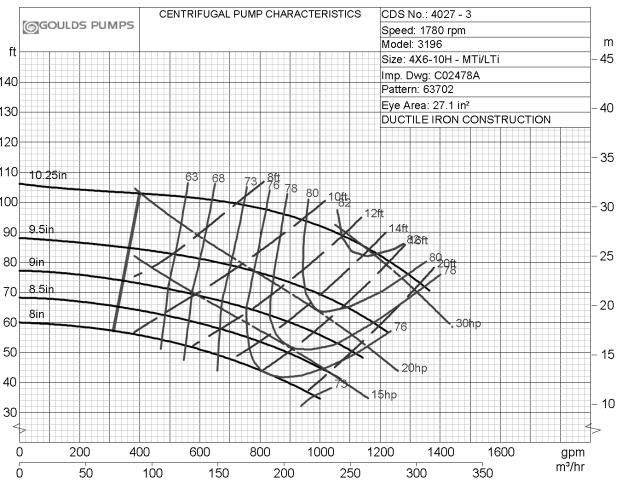


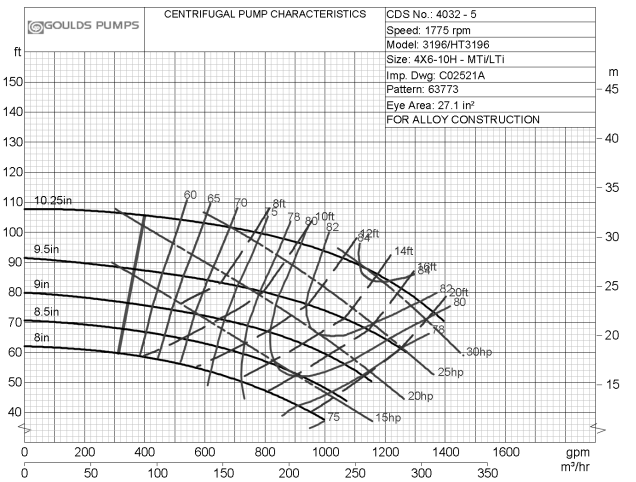
4X6-10G **3560rpm**



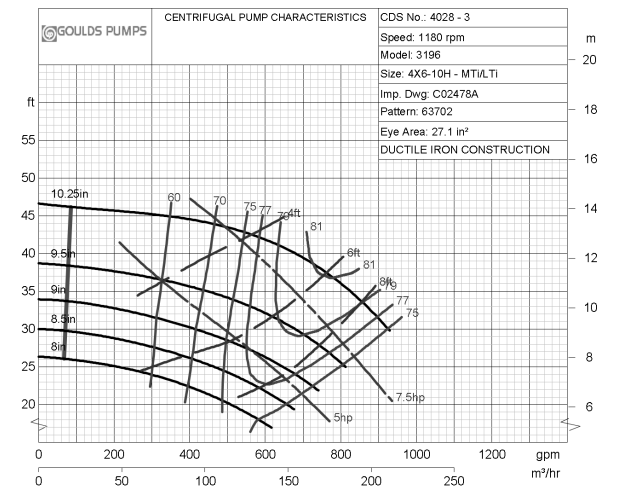
4X6-10G **1770rpm**



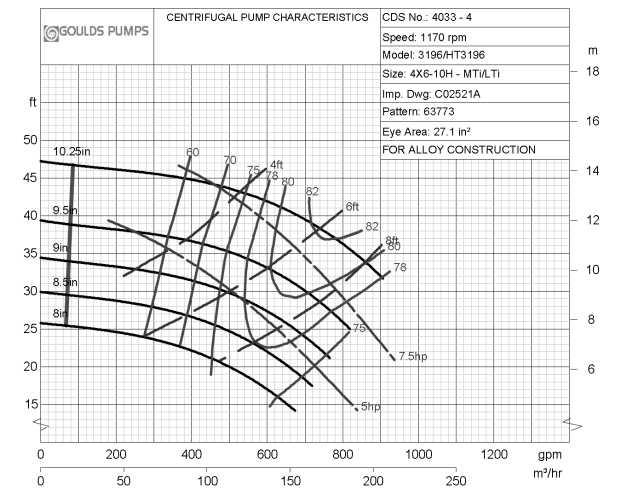
4X6-10H **1780rpm**



4X6-10H **1775rpm**



4X6-10H **1180rpm**



4X6-10H **1170rpm**

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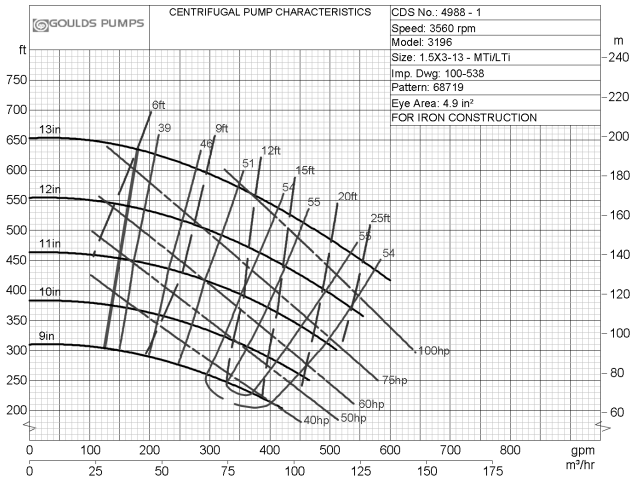
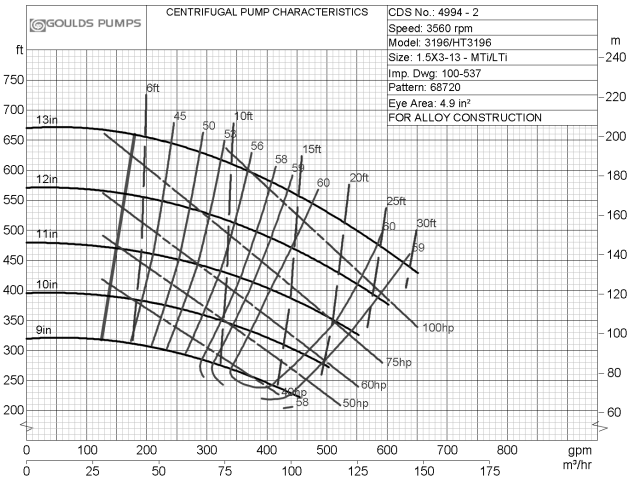
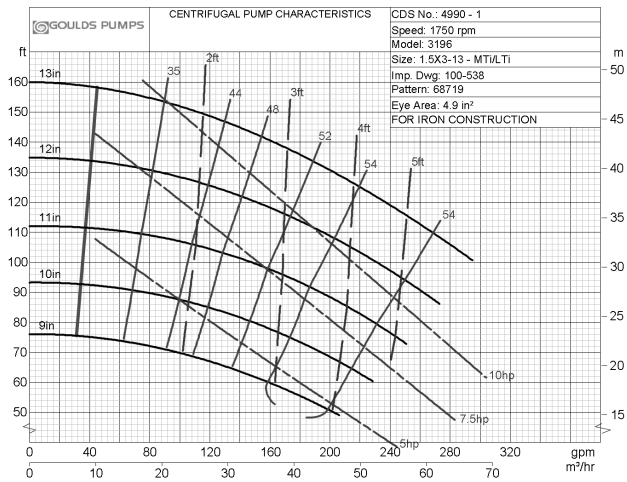


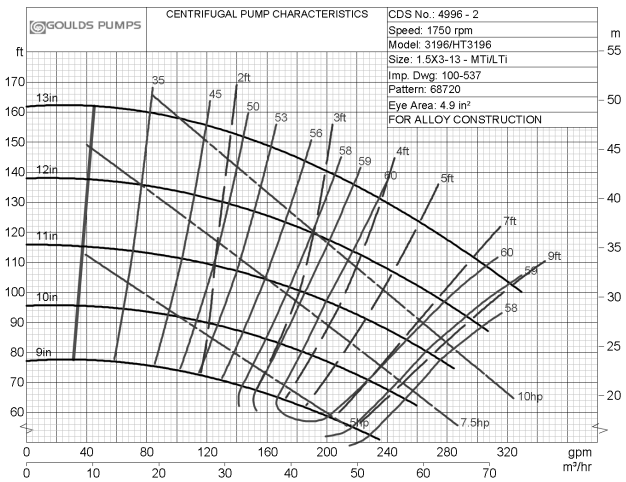
1.5X3-13 **3560rpm**



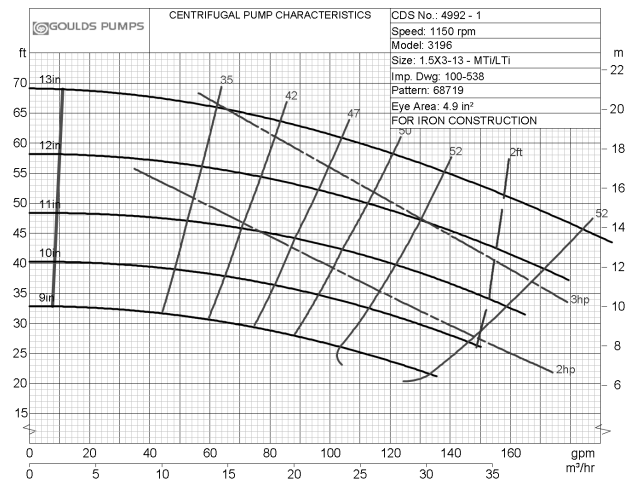
1.5X3-13 **3560rpm**



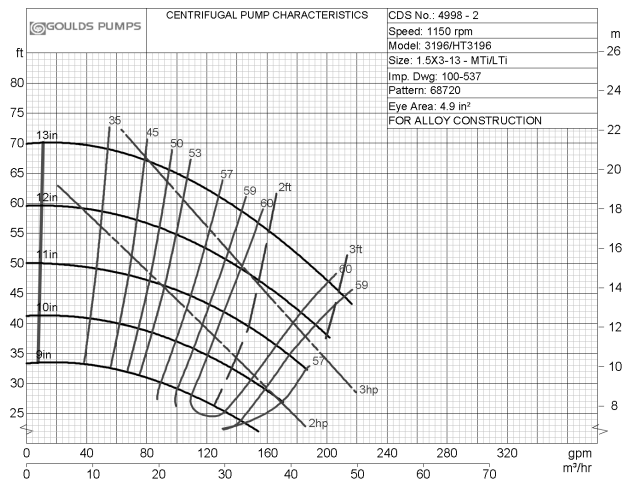
1.5X3-13 **1750rpm**



1.5X3-13 **1750rpm**



1.5X3-13 **1150rpm**



1.5X3-13 **1150rpm**

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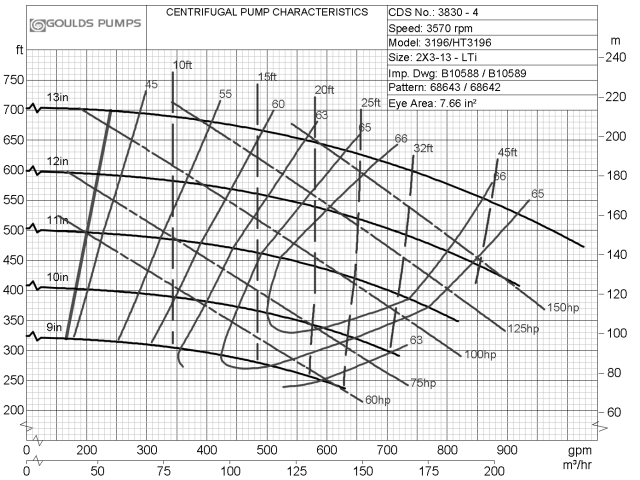
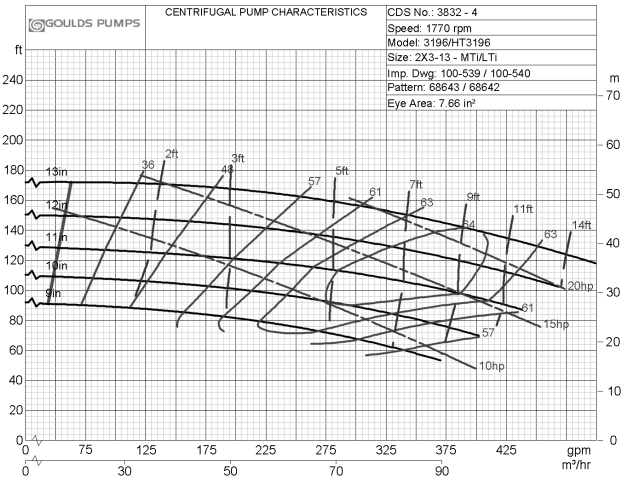
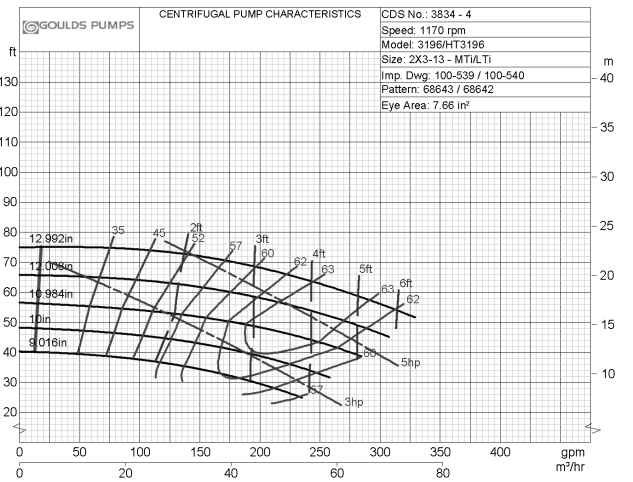


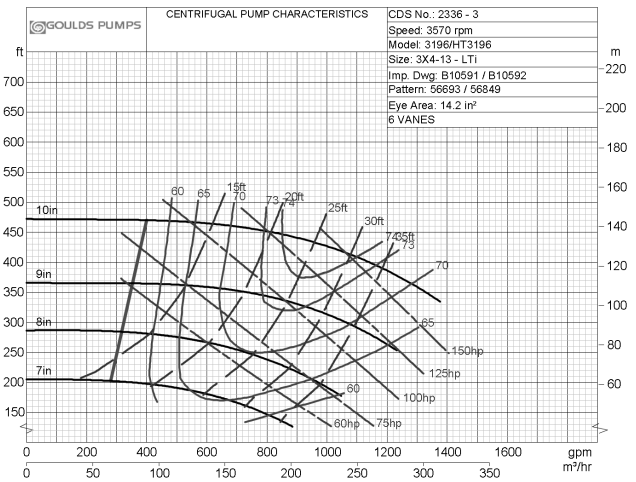
2X3-13 **3570rpm**



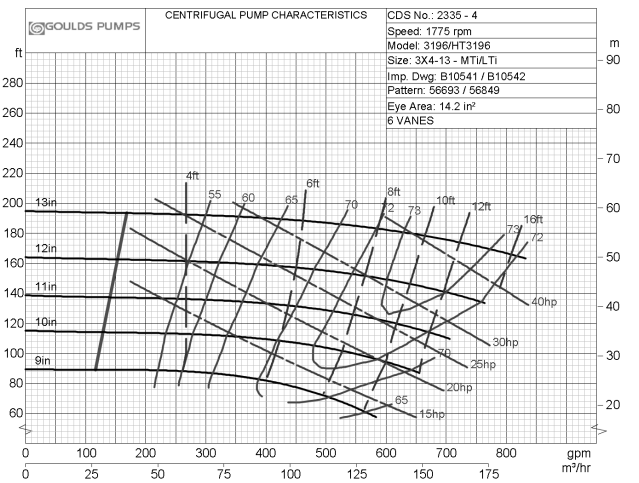
2X3-13 **1770rpm**



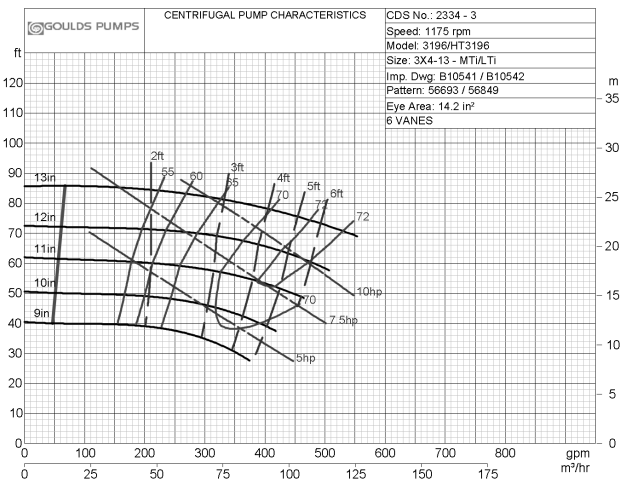
2X3-13 **1170rpm**



3X4-13 **3570rpm**

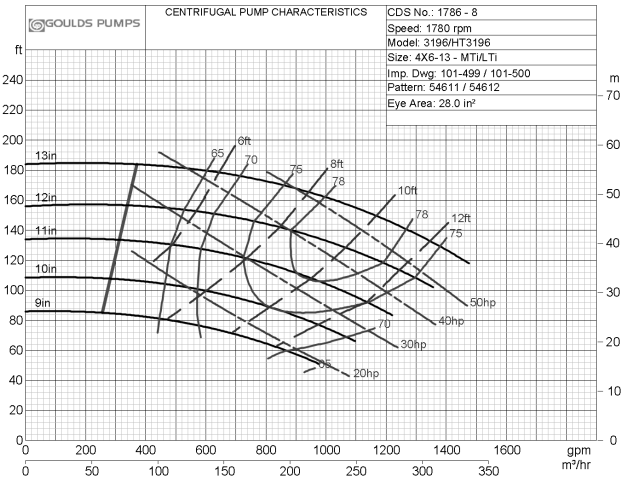


3X4-13 **1775rpm**

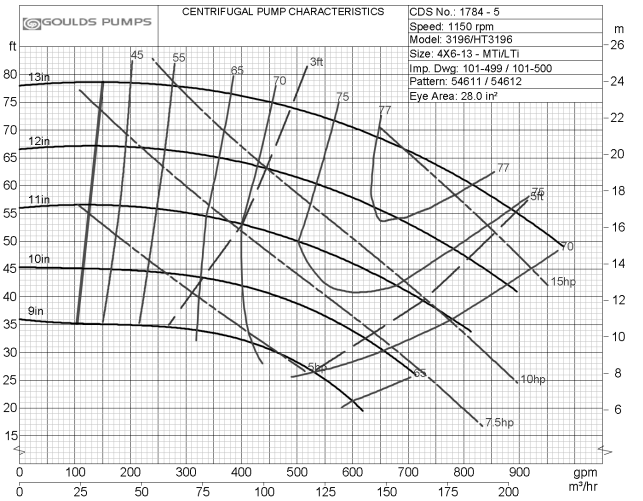


3X4-13 **1175rpm**

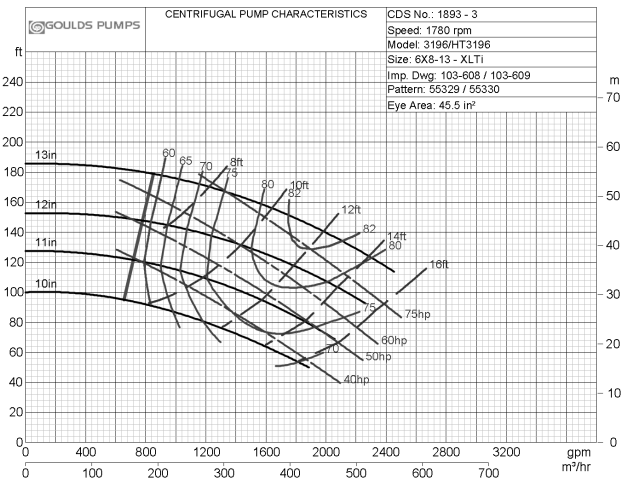
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



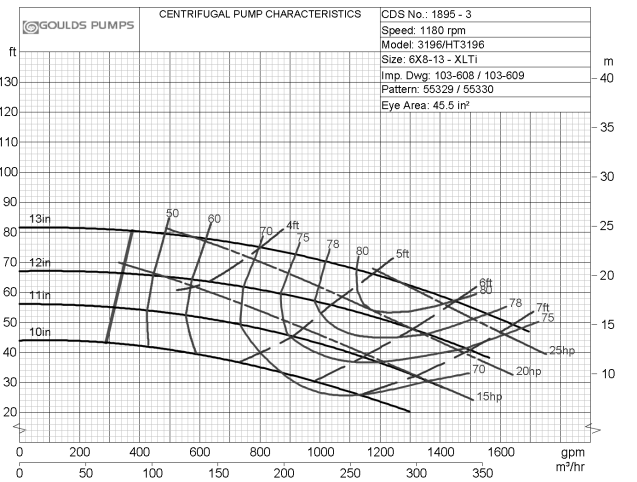
4X6-13 **1780rpm**



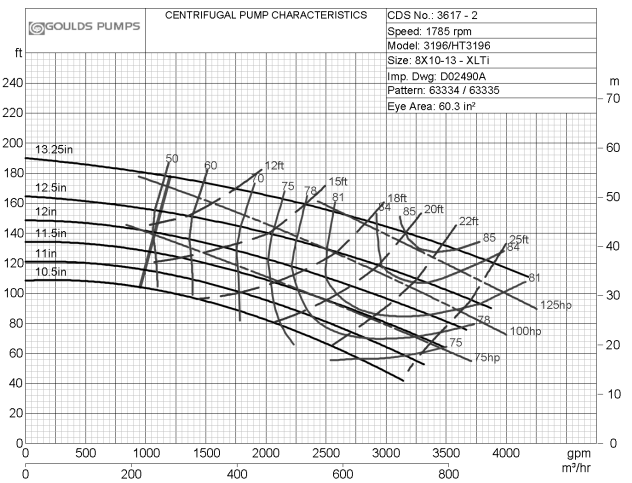
4X6-13 **1150rpm**



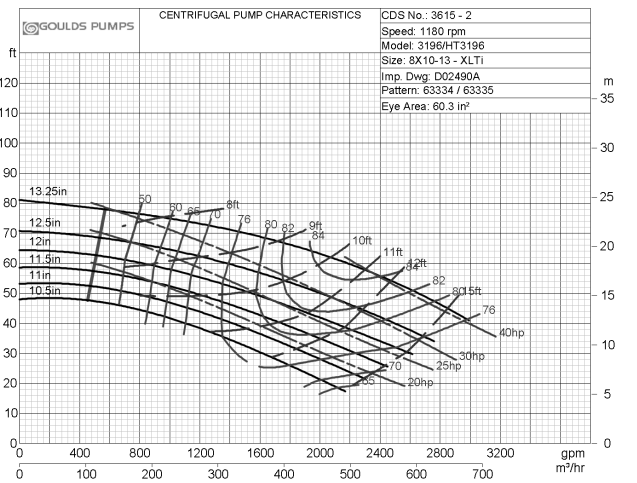
6X8-13 **1780rpm**



6X8-13 **1180rpm**



8X10-13 **1785rpm**

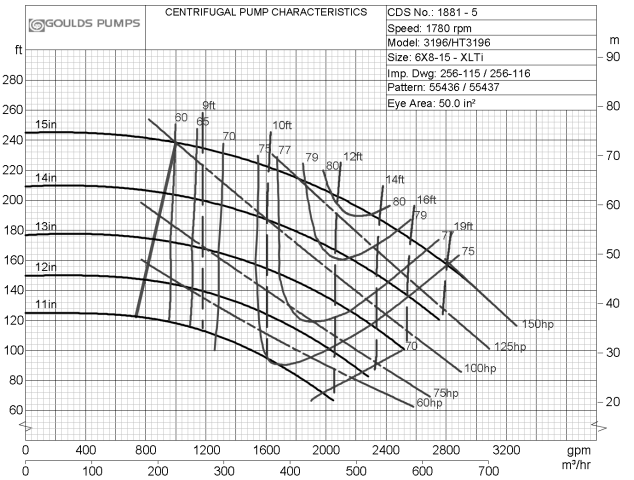


8X10-13 **1180rpm**

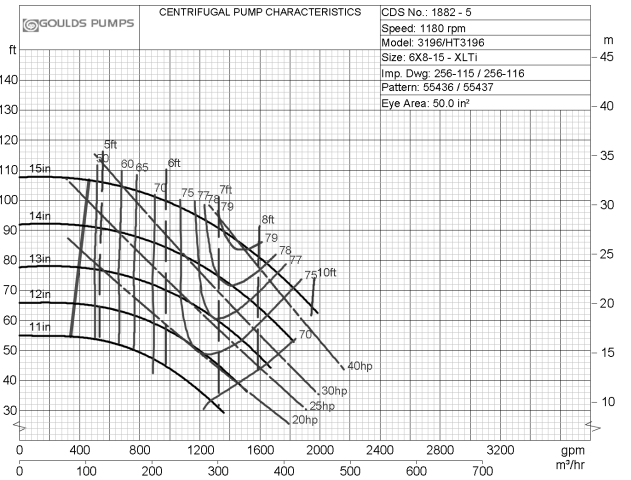
60Hz Curves

Model 3196

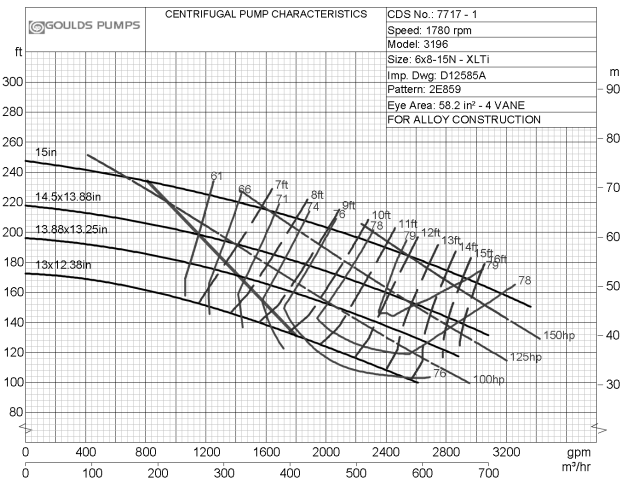
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



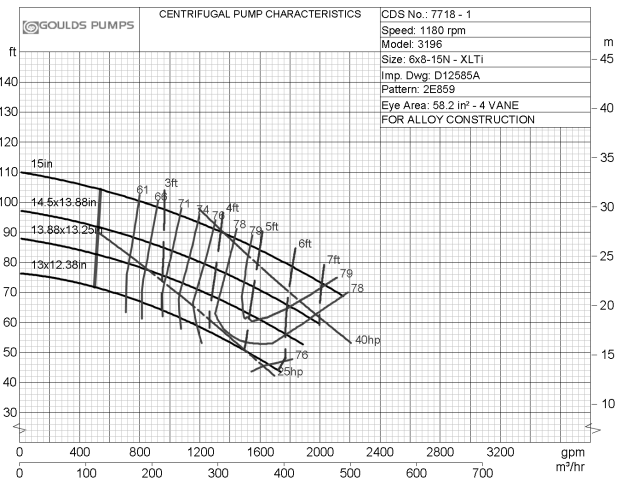
6X8-15 **1780rpm**



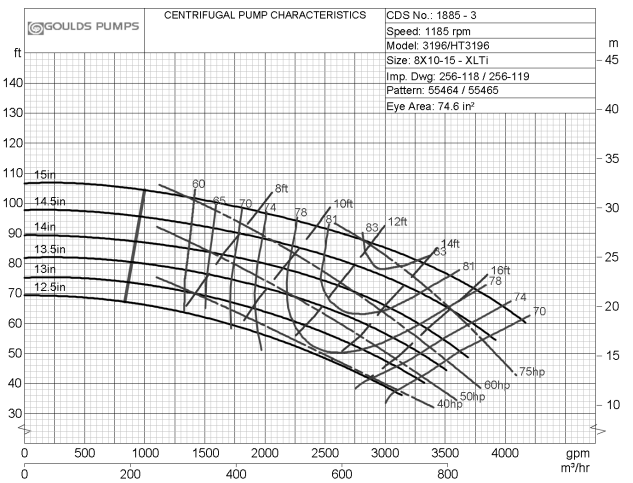
6X8-15 **1180rpm**



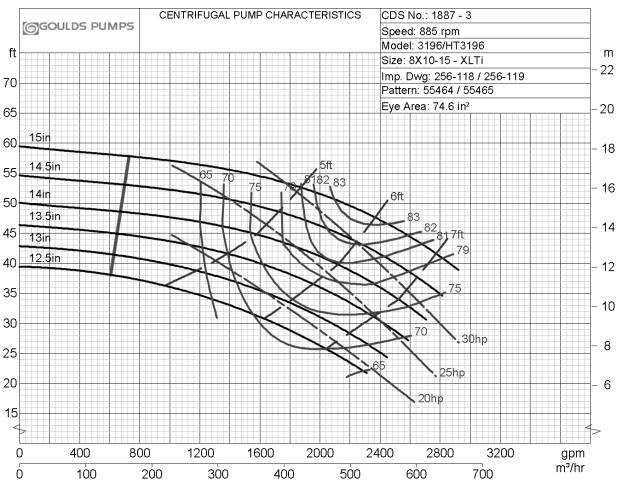
6x8-15N **1780rpm**



6x8-15N **1180rpm**

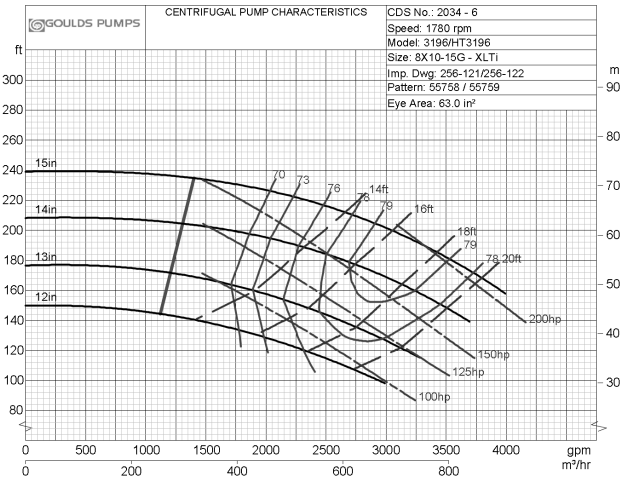


8X10-15 **1185rpm**

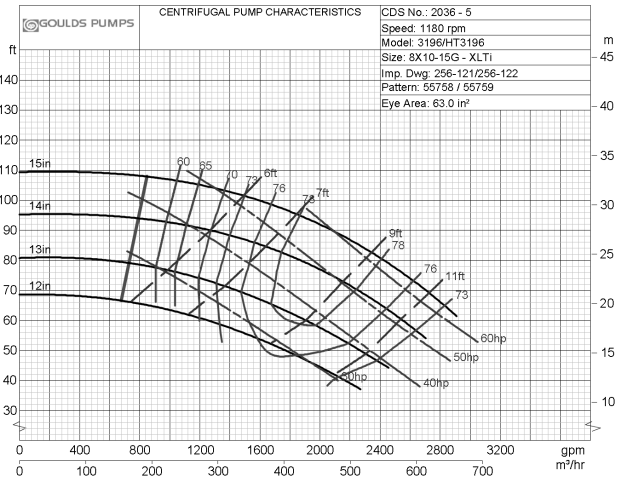


8X10-15 **885rpm**

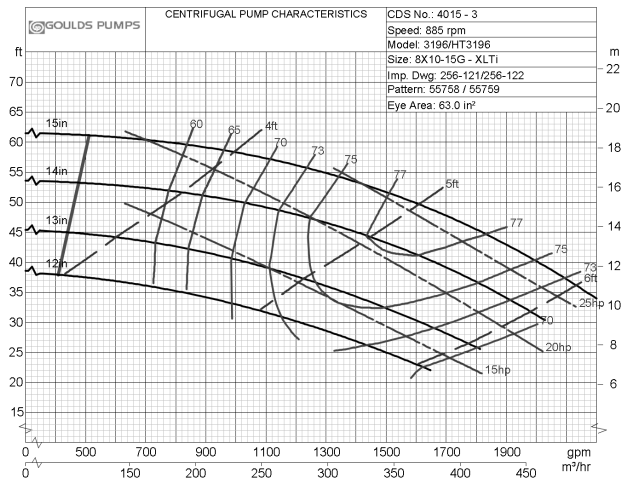
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



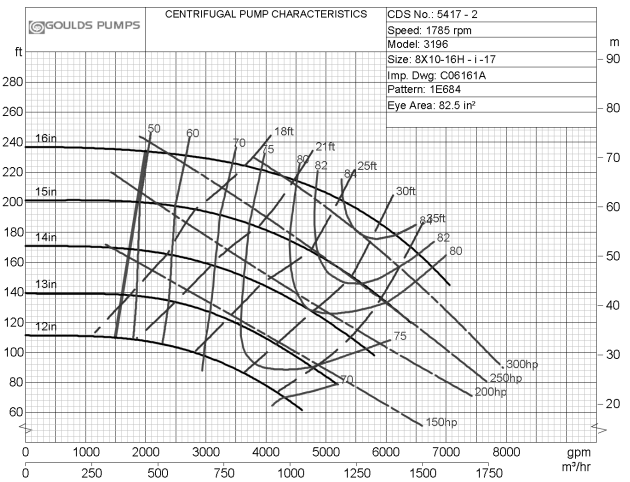
8X10-15G **1780rpm**



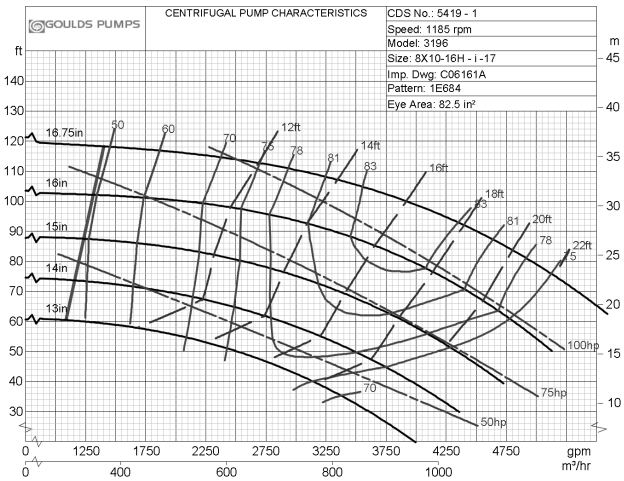
8X10-15G **1180rpm**



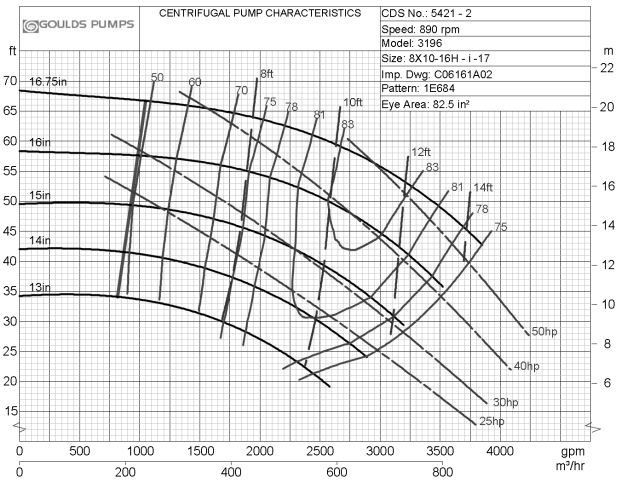
8X10-15G **885rpm**



8X10-16H **1785rpm**



8X10-16H **1185rpm**



8X10-16H **890rpm**

60Hz Curves

Model 3196

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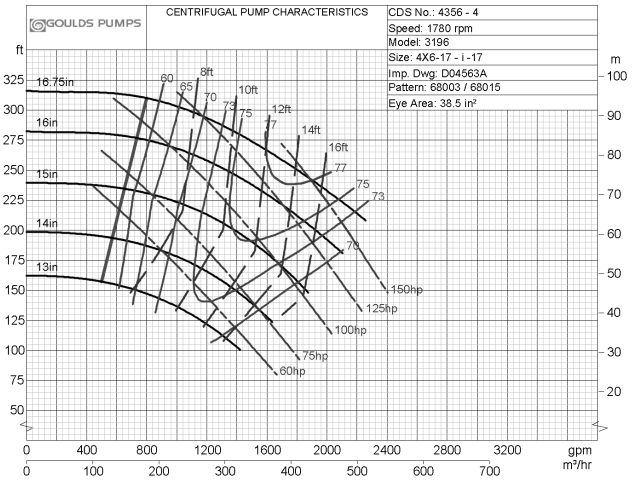
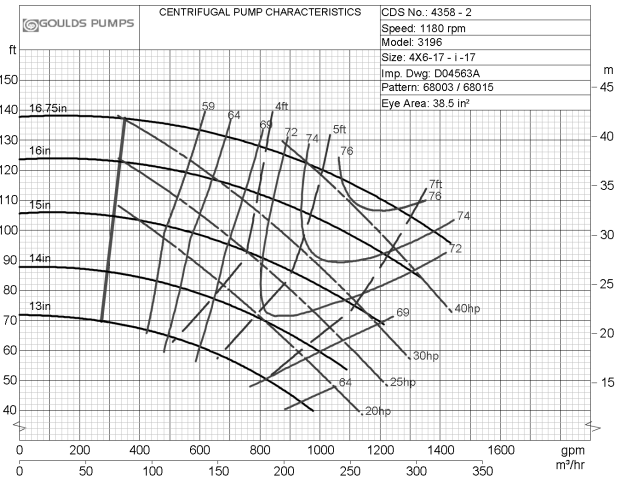
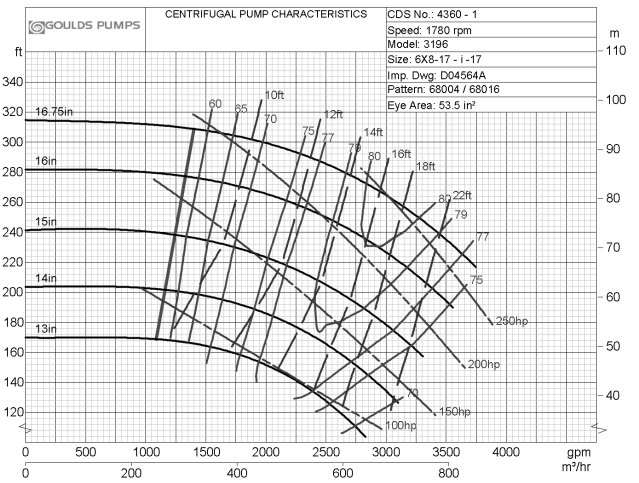


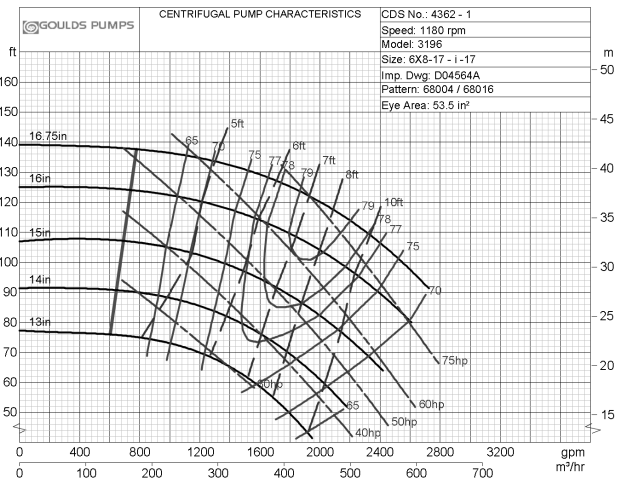
4X6-17 **1780rpm**



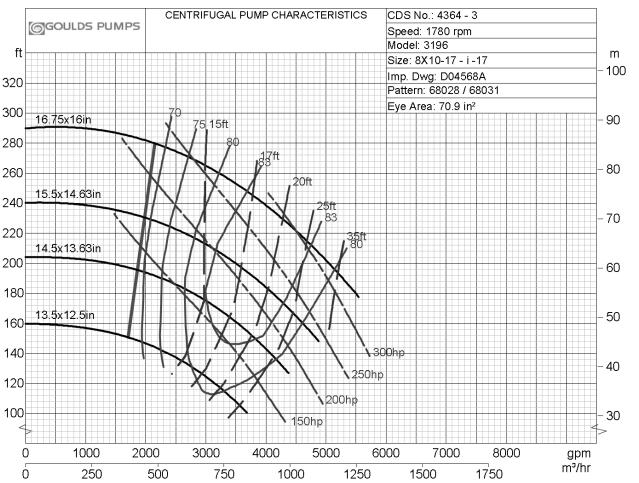
4X6-17 **1180rpm**



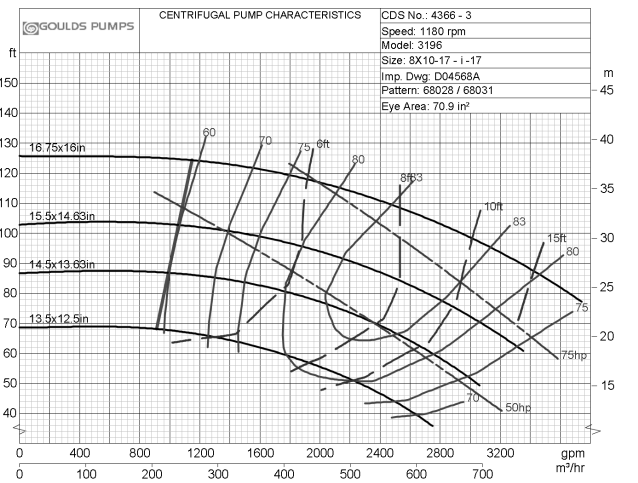
6X8-17 **1780rpm**



6X8-17 **1180rpm**



8X10-17 **1780rpm**



8X10-17 **1180rpm**

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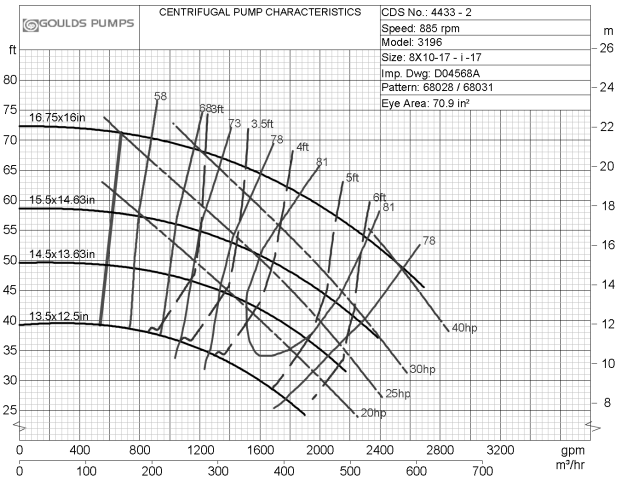
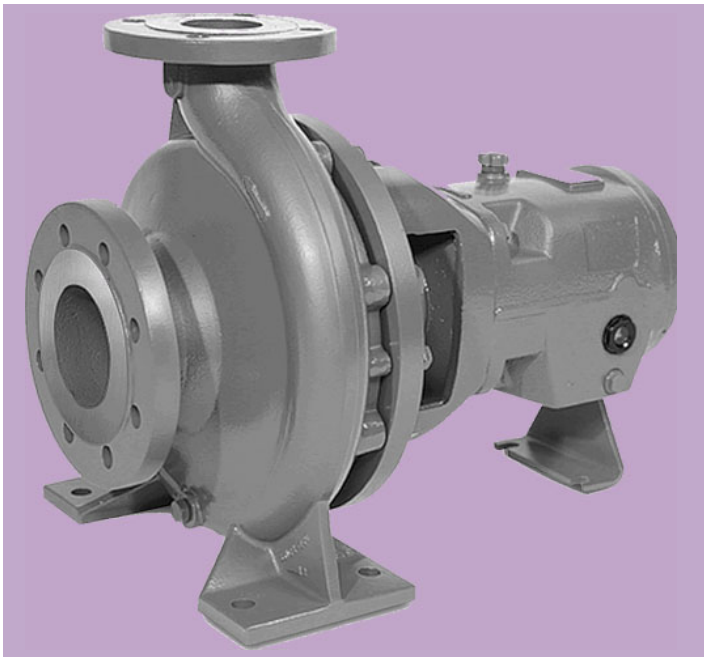


8X10-17 **885rpm**

NOTES



ISO Chemical Process Pumps for Worldwide Applications

Goulds IC Series

Worldwide Solutions for Process Pumping and Controls

Reducing Pump Life Cycle Costs

Goulds Pumps IC family of ISO chemical process pumps is designed in accordance with ISO 5199 and ISO 2858, making it ideal for worldwide chemical or industrial process applications. The IC pump range includes:

- 34 hydraulic sizes
- Flows up to 450 m^3/h (1980 GPM)
- Heads up to 160 m (525 feet)
- Temperatures from -40°C to 280°C (-40°F to 530°F)
- Pressures up to 25 Bar (360 PSI)

The IC series represents over 150 years of process pump experience to define a solution which truly reduces your pumping **Life Cycle Cost** . Utilizing a modular design, the IC pump offers broad hydraulic coverage while minimizing the number of pump components for reduced maintenance and inventory cost.

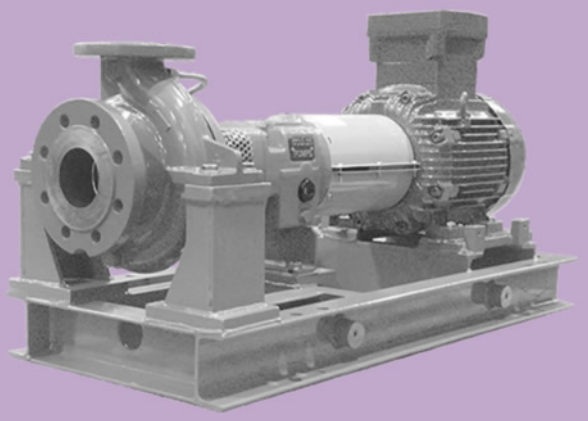
The IC series consists of multiple pump configurations, which have been engineered by ITT hydraulic specialists from Goulds Pumps, to meet both the pumping and environmental needs of customers in the Process Industry. Included in the range is:

- IC - 16 Bar, mechanically sealed version for most process fluid pumping.
- ICP - 25 Bar, centerline mounted unit for high pressure applications.
- ICB - compact, close-coupled design for economical, space-saving service.
- ICM - magnetic drive, sealless arrangement for the handling of hazardous or sensitive liquids.

ITT Goulds proven pump hydraulic designs utilize precision cast, enclosed impeller for maximum efficiency, low NPSH and reduced hydraulic loads. In addition, all mechanically sealed pumps have been engineered with our patented Cyclone Seal Chamber, a feature proven to provide the optimum sealing environment for extended seal life, critical in reducing Life Cycle Cost.

The IC series is available in a comprehensive range of materials which include ductile iron, 316 Stainless Steel, Duplex Stainless Steel, Alloy 20, Hastelloy B and C, and Titanium.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.



Goulds ICP Series

Goulds ICP Series

High Pressure and High Temperature

The ICP is a heavy duty chemical process pump designed for extreme temperatures (-40°C to 280°C) and pressures to 25 Bar. Centerline mounted casing controls thermal growth and maintains pump alignment for extended seal life. Complies with ISO 5199.

Specifications

- Capacities to 450 m^3/h (1980 USgpm)
- Heads to 150 m (492 feet)
- Temperature Range -40°C to 280°C (-40°F to 535°F)
- Pressures to 25 Bar (363 PSIG)
- Materials - Carbon Steel (1.0619), Stainless Steel (1.4408), Duplex Stainless Steel (1.4517), Hastelloy C (2.4811)

Goulds ICB Series

Goulds ICB Series

Close-coupled, Economical Installation

The ICB close-coupled chemical process pump provides an economical, space-saving design, which simplifies installation and reduces costs. Precise alignment eliminates the multiple craft installation costs.

No baseplate. No flexible coupling. Floor space utilisation is maximized. Complies with ISO 2858. Available on all frame 24, 32 and 42 pump sizes.

Specifications

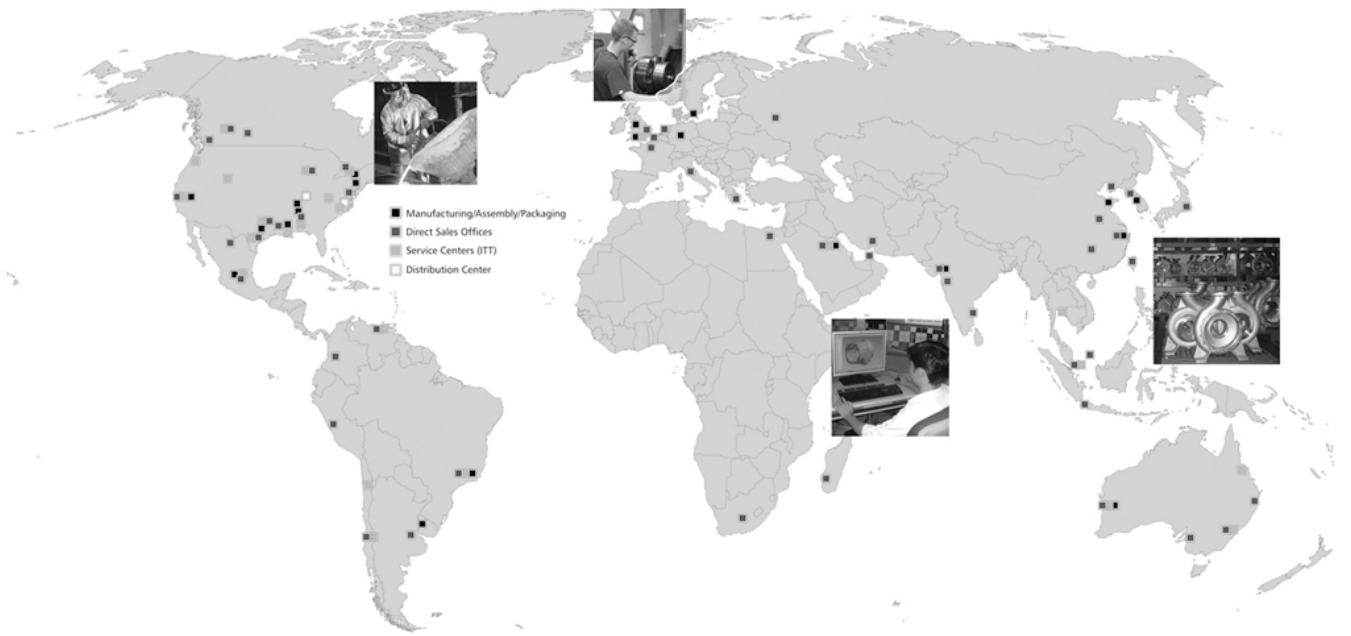
- Capacities to 340 m^3/h (1490 USgpm)
- Heads to 160 m (525 feet)
- Temperature Range -40°C to 140°C (-40°F to 280°F)
- Pressures to 16 Bar (235 PSIG)
- Materials - Ductile Iron (0.7043), Stainless Steel (1.4408), Duplex Stainless Steel (1.4517)

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

ITT Industrial Process Global Presence

The IC family of products has a complete world-wide presence.

With manufacturing, engineering, sales and inventory in multiple regions, this product can support your needs everywhere in the world. You can rest assured that we will support your industrial pump requirements, even if you specify and order the pump in one country and need to install it on the other side of the world.

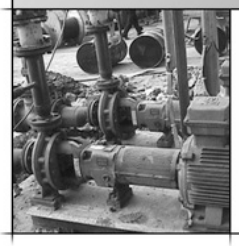


ITT 125 Countries | 110+ Distributors/Agents | **3,200** Employees

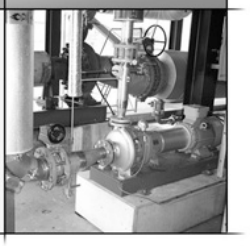
IC and ICM Plant Engineering Product of the Year

Plant Services MRO Product of the Year

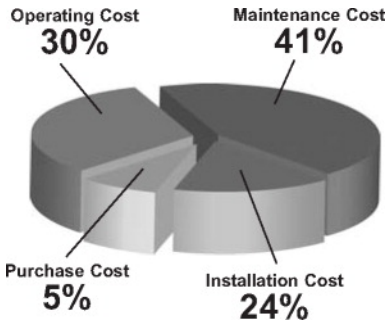
IC Pumps installed in a chemical plant in Western Europe on reactor water with mixed chemical stream.



ICM mag-drive pump installed in Western Europe on chemical service.



Long-term Reliable Performance Means Lower Life-Cycle Costs.

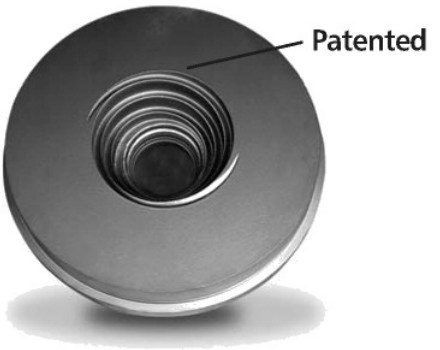


When selecting a chemical process pump, look for the design features that help lower maintenance costs as well as operating and installation costs. Design features that maximize reliability and ensure long-term maintainable hydraulic performance help lower the "total cost" of pump ownership. In a typical process pump, over a 20 year pump life, *95% of the total costs are maintenance, operation and installation costs.*

Only 5% is the initial pump cost.

The Keys to Reliable Performance

The "Cyclone" Seal Chamber and a Heavy Duty Bearing Frame.



FACT:

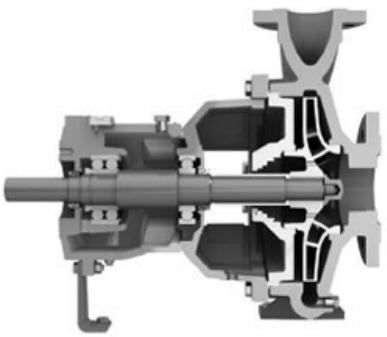
The number one cause of pump downtime is failure of the shaft seal. Typically, seal failures are the result of an unfavorable seal environment such as poor heat dissipation, poor lubrication or operation in the presence of solids or vapors.

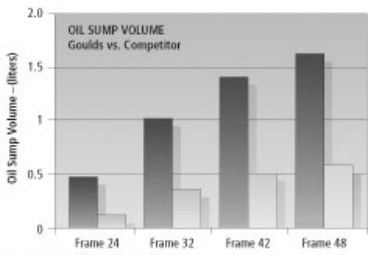
Patented cyclone seal chamber design maximizes seal life.

- A tapered bore design enhanced with a helical groove removes suspended solids away from mechanical seal components resulting in extended seal life.
- Increased radial clearance and volume provides improved cooling for extended seal life.
- Seal venting design eliminates a build-up of vapors in the seal area.
- Patented design has been rigorously tested for reliable results.

Optimized Oil Sump Design

Internal sump geometry is optimized for longer bearing life. Sump size increased by 10% -20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.





FACT:

The second largest cause of pump downtime is bearing failures. Over 90% of all pump bearing failures are the result of inadequate or contaminated lubrication.

Rigid bearing frame extends pump life.

- Large capacity oil sump results in cooler, cleaner oil. The Model IC ISO chemical pump has the largest oil sump in its class!
- Heavy duty bearing sized for L_{10} bearing life in excess of 17,500 hours.
- Rigid, stainless steel shaft resists corrosion while maintaining shaft deflections below 0.05mm.
- Double lip oil seals maintain clean oil sump.
- O-ring seal between frame and lantern ensures clean oil environment.

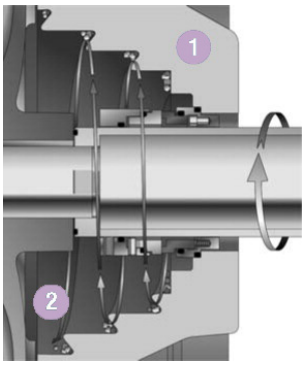
Shaft Sealing Solutions

Engineered to Extend Seal Life and Lower Maintenance Costs

Based on over 150 years of providing pumping solutions to the Chemical Process Industry, ITT Industries can provide a shaft sealing system that best meets your application requirements. Key to our shaft sealing program is placing the best shaft sealing solution in the best operating environment for long life and reduced maintenance and operating costs.

Patented Cyclone Seal Chamber Design

At the heart of our program is the patented cyclone seal chamber that not only provides the optimum seal environment in the presence of solids and vapors, but also improves maintainability and reduces installation cost by eliminating seal flush piping.



Here's how it works:

1. Cast helical ribs act as a barrier to particles traveling within the inward boundary layer flow found on the tapered walls of the seal chamber.
2. Once caught in the grooves of the helical ribs, the "cyclone-like" rotational velocity created by the impeller carry particles out of the seal chamber away from the seal.

Solids removal is key to prevent seal and seal chamber wear as well as clogging of the mechanical seal for guaranteed reliability.

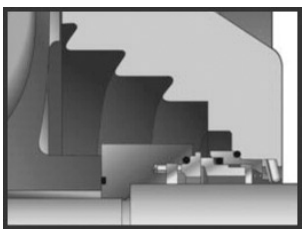
Maximum seal flexibility

Because selecting the best seal for the application is key to extended pump reliability, seal chambers for the Model IC pump have been designed in accordance with ISO 3069 to support the use of a wide range of seals.

The shaft sealing arrangements possible include the use of any DIN 24960L 1K compliant seal arranged in single, single with quench, double (back-to-back) or tandem configurations. Sealing with cartridge type seals is also possible for customers seeking to obtain further reductions in downtime and maintenance costs.

Proprietary mechanical seal

Also available is a propriety mechanical seal engineered for optimum performance when installed in the cyclone seal chambers. Our mechanical seals feature balanced seal faces installed in a stationary spring design that has been integrated with the pump shaft sleeve. This arrangement extends seal reliability and reduces customer costs.



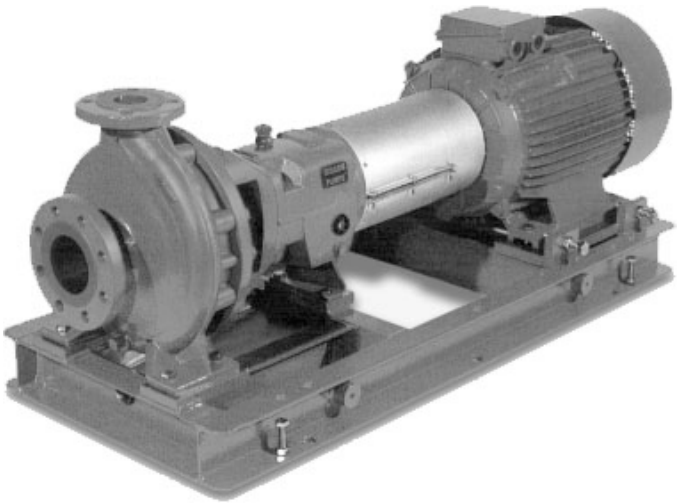
GS11 Single Mechanical Seal

Benefits of our mechanical seal design

- Eliminates shaft sleeve fretting for extended seal life.
- Balanced design reduces face loading.
- Springs are located external to the pumpage which helps reduce seal clogging and corrosion.
- Unitized shaft sleeve and seal simplify installation and reduce spare parts.

Goulds Engineered Pump Mounting Systems

Proper installation and alignment are two key elements to maximize pump reliability. There are multiple mounting systems for the Model IC series. Simple to install, they provide a mounting platform resistant to corrosion and distortion while maintaining pump alignment and dampening the effect of harmful vibrations.

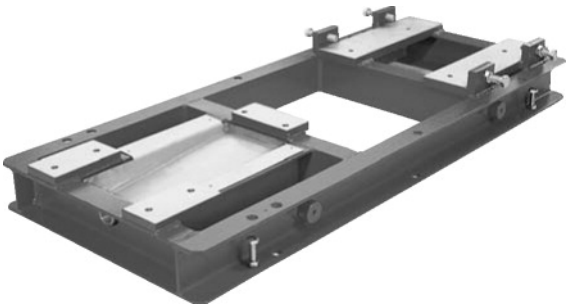


Standard Baseplate Design

- Rigid fabricated steel design.
- Machined pump and motor mounting surfaces make final alignments quick and accurate.
- Dimensions conform to ISO 3661 for easy installation.
- Suitable for grouted and ungrouted applications.
- Optional drip pan with 1″ drain connection.
- Available in stilt mounted arrangement.

Feature Baseplate Design

- Structurally reinforced for maximum torsional and axial stiffness.
- Machined pump and motor mounting surfaces.
- Complies with ISO 3661.
- Includes value-added features:
  - Stainless steel drip pan with 1″ drain.
  - Motor adjustment screws.
  - Vertical leveling screws.
  - Earthing lug.

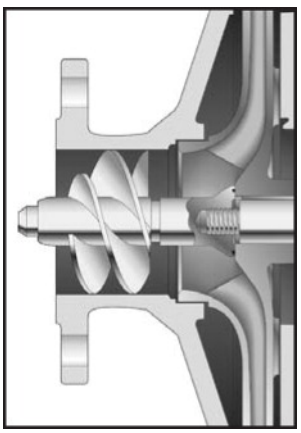


Standard Options

Designed for Flexibility to Meet Customer Needs

Suction Inducer

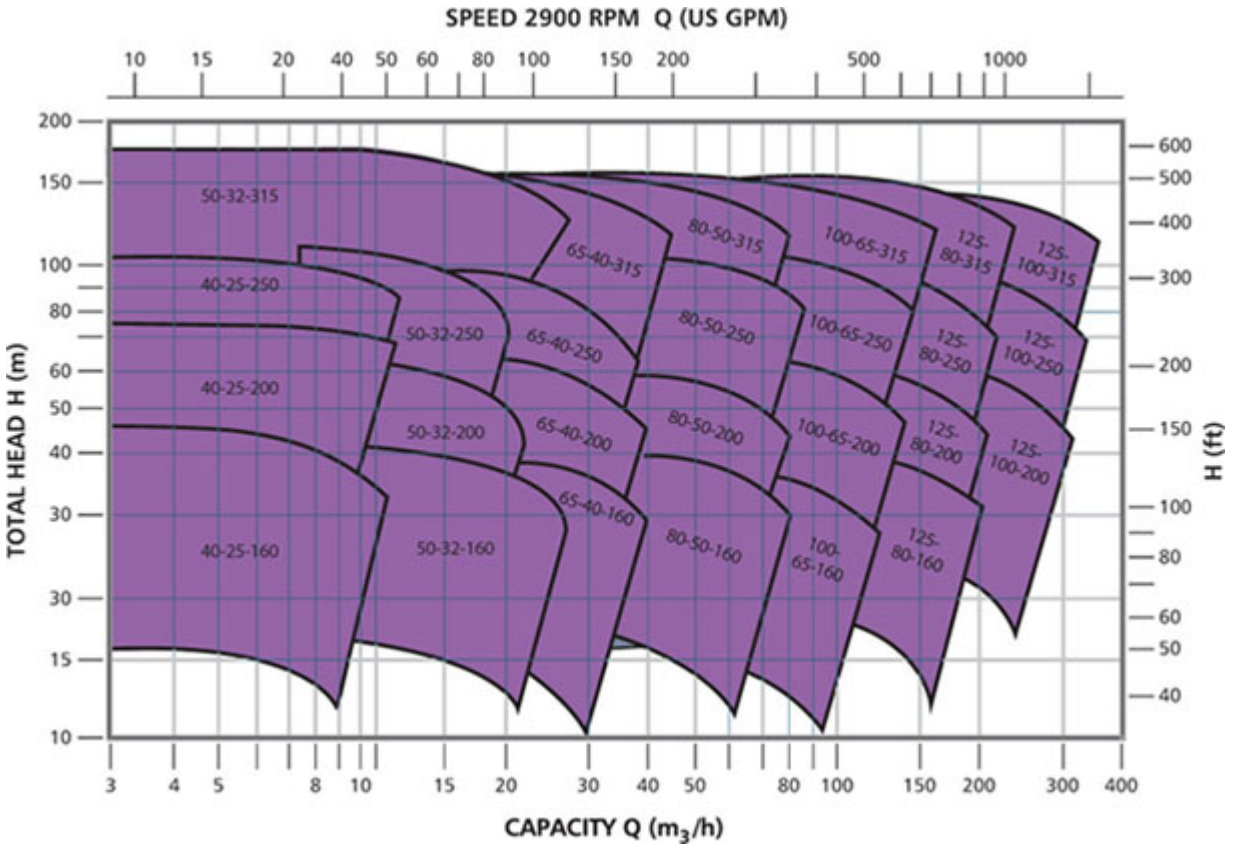
All sizes of the Model IC ISO chemical pump can be supplied with an optional suction inducer which can extend the operating range of the pump by improving the inlet flow into the impeller resulting in reductions of NPSHr. Inducers provide a more economical pumping solution as smaller, faster pumps can often be used. In addition, inducers can help eliminate cavitation caused by intermittent process conditions and entrained gas or vapor.

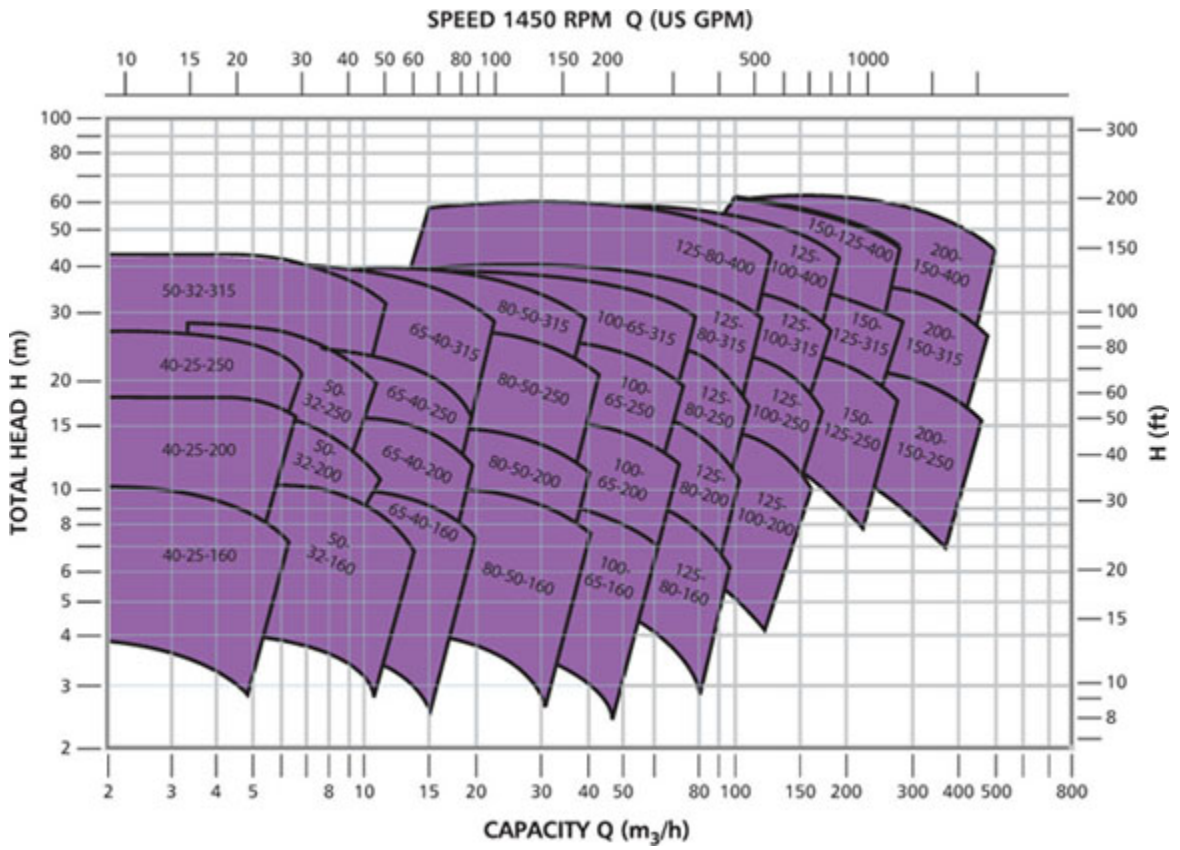


Inducer benefits:

- Reduces NPSHr by 35-50% – ideal for marginal NPSH applications.
- Allows for use of smaller, faster pumps – reducing costs.
- Eliminates pumping problems on services with entrained gas.
- No compromise to pump operating range.
- All sizes available in stainless steel and higher constructions.
- Proven design with over 30 years of application experience.

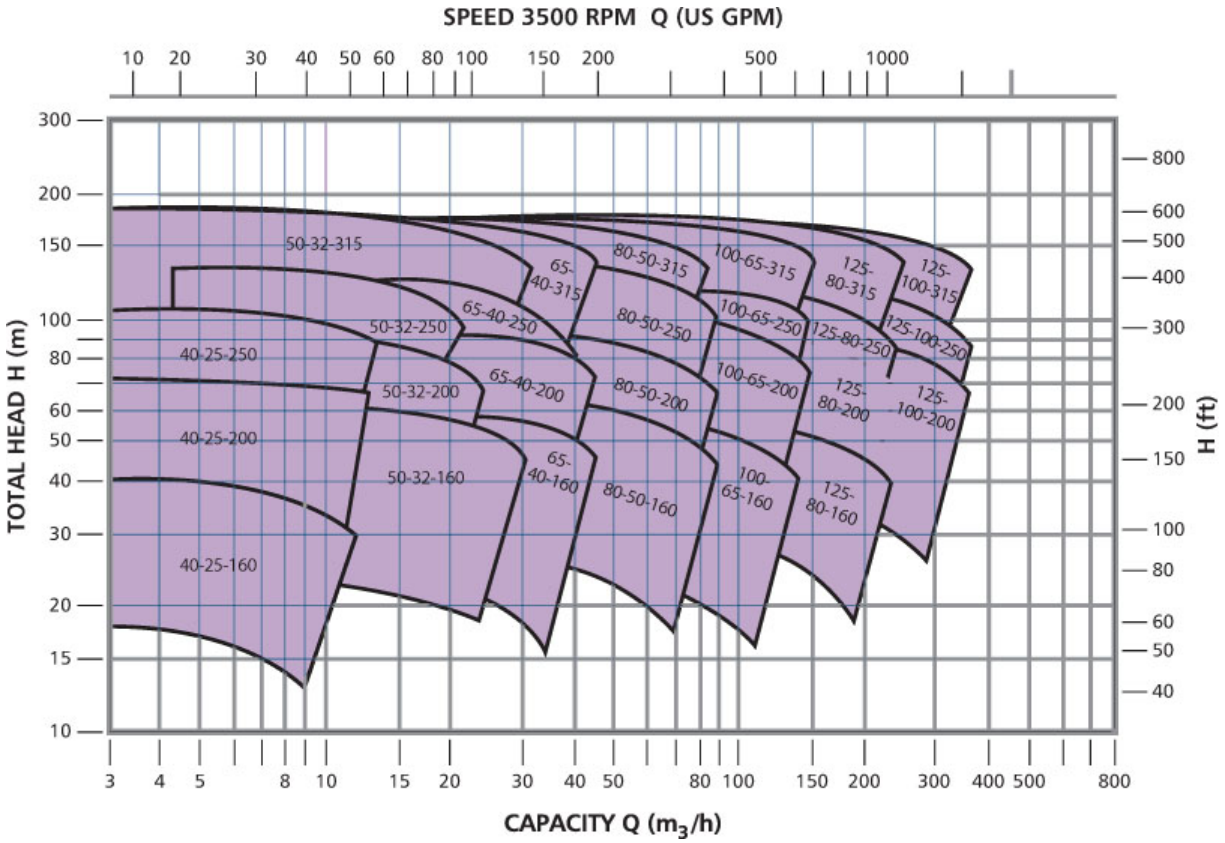
IC Series Hydraulic Coverage 50Hz Performance

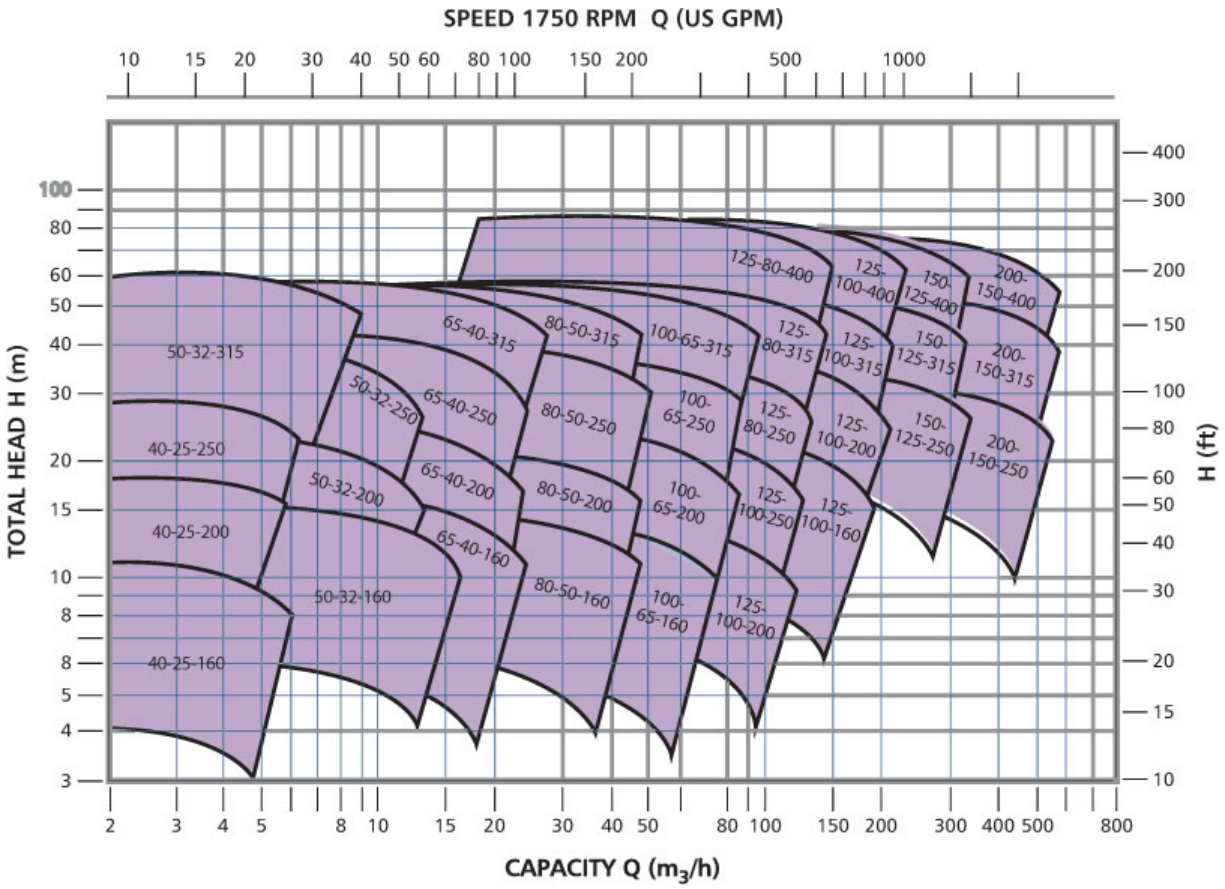




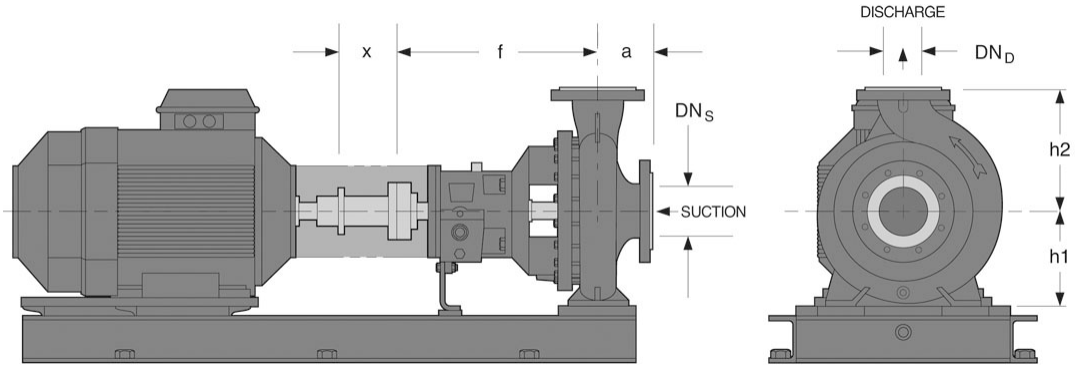
Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

IC Series Hydraulic Coverage 60Hz Performance





Dimensions IC Series



DIMENSIONS									
		Flanges							Bare Pump
Pump Size	Frame	DNs	DNd	a	f	h1	h2	X	weights
40-25-160	24	40	25	80	385	132	160	100	42
40-25-200	24	40	25	80	385	160	180	100	50
40-25-250	32	40	25	175	500	180	225	100	79
50-32-160	24	50	32	80	385	132	160	100	43
50-32-200	24	50	32	80	385	160	180	100	52
50-32-250	32	50	32	100	500	180	225	100	85
50-32-315	32	50	32	210	500	200	250	100	111
65-40-160	24	65	40	80	385	132	160	100	44
65-40-200	24	65	40	100	385	160	180	100	57
65-40-250	32	65	40	100	500	180	225	100	85
65-40-315	32	65(1)	40(1)	125	500	200	250	100	121
80-50-160	24	80	50	100	385	160	180	100	48
80-50-200	24	80	50	100	385	200	100	100	57
80-50-250	32	80	50	125	500	180	225	100	87
80-50-315	32	80(1)	50(1)	125	500	225	280	100	126
100-65-160	32	100	65	100	500	160	200	100	74
100-65-200	32	100	65	100	500	180	200	140	79
100-65-250	32	100	65	125	500	200	250	140	98
100-65-315	42	100(1)	65(1)	125	530	225	280	140	150
125-80-160	32	125	80	125	500	180	225	140	81
125-80-200	32	125	80	125	500	180	250	140	87
125-80-250	32	125	80	125	500	225	280	140	109
125-80-315	42	125(1)	80(1)	125	530	250	315	140	162
125-80-400	42	125	80	140	530	280	355	140	201
125-100-200	32	125	80	125	500	200	280	140	93
125-100-250	42	125	100	140	530	225	280	140	130
125-100-315	42	125(1)	100(1)	140	530	250	315	140	174
125-100-400	42	125	100	140	530	280	355	140	215
150-125-250	42	150	125	140	530	250	355	140	143
150-125-315	42	150	125	140	530	280	355	140	195
150-125-400	42	150	125	140	530	315	400	140	246
200-150-250	42	200	150	160	530	280	375	180	152
200-150-315	48	200	150	160	670	315	400	180	262
200-150-400	48	200	150	160	670	315	450	180	303

Dimensions in mm

Dimensions subject to change without notice

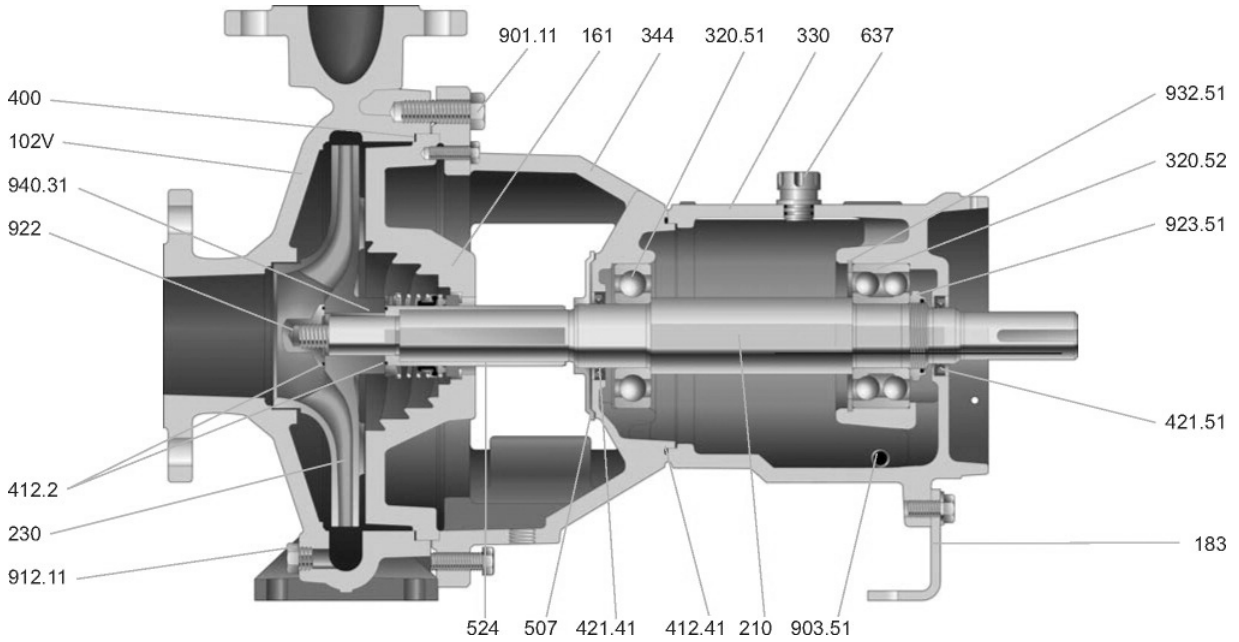
Flange drilling in accordance with ISO 7001/EN 27001 PN16 except where noted

(1)-Flanges drilled PN25

Detailed pump dimensions in accordance with ISO 2858/EN22858

Detailed baseplate dimensions in accordance with ISO 3661/EN23661

MATERIAL SPECIFICATIONS			
Cast Material Standards			
		Approximate Equivalent Standards	
	IC Series Standard	DIN	ASTM
Cast Iron	EN-GJL-250	0.6025	A48, Class 35B
Ductile Iron	EN-GJS-400-18-LT	0.7043	A395, grade 60-40-18
Stainless Steel	1.4408	1.4408	A743, CF-8M
Duplex SS	1.4517	1.4517	A744 CD4-MCu
Alloy 20	1.4536	1.4536	A743 CN-7M
Hastelloy C	2.4686	2.4811	A494 N-12MV
Hastelloy B	2.4810	2.4810	A494CX 2MV
Titanium	3.7031	3.7031	B367 Grade 2



Parts List and Materials of Construction

		MATERIAL					
Item Number	**Part Name**	**DI/316SS (VL)**	**316SS (VV)**	**Duplex (WW)**	**Alloy 20 (AA)**	**Hastelloy (BB/CC)**	**Titanium (TT)**
102V	Casing	DI/316SS	316SS	Duplex SS	Alloy 20	Hastelloy	Titanium
161	Seal Chamber/Stuffing Box Cover	DI/316SS	316SS	Duplex SS	Alloy 20	Hastelloy	Titanium
183	Support Foot	Carbon Steel					
210	Shaft	Stainless Steel (1.4021)					
230	Impeller	316SS		Duplex SS	Alloy 20	Hastelloy	Titanium
320.51	Radial Bearing	Single Row, Ball Bearing					
320.52	Thrust Bearing	Double Row Angular Contact Ball Bearing					
330	Bearing Bracket	Cast Iron					
344	Lantern	Ductile Iron					
400	Case Gasket	Non-Asbestos Aramid Fiber					
412.21	O-ring, Shaft Sleeve & Impeller Nut	Teflon					
412.41	O-ring Bearing Bracket	Buna					
421.41	Oil Seal, Inboard	Lip Seal (Buna & Steel)					
421.51	Oil Seal, Outboard	Lip Seal (Buna & Steel)					
507	Flinger	Noryl 66					
524	Shaft Sleeve	316L (1.4404)		Duplex SS	Alloy 20	Hastelloy	Titanium
637	Oil Vent	Steel					
901.11	Casing Bolts, Hex Cap Screw	Stainless Steel (A2)					
903.51	Drain Plug	Steel Magnetic Tipped					
912.11	Case Drain Plug	316SS			Alloy 20	Hastelloy	Titanium
922	Impeller Nut	Duplex SS			Alloy 20	Hastelloy	Titanium
923.51	Bearing Lock Nut	Steel/Nylon					
932.51	Snap Ring/Circlip	Carbon Steel					
940.31	Impeller Key	Carbon Steel					

Other Parts Not Shown						
236	Inducer (optional)	Duplex SS (1,4462)		Alloy 20	Hastelloy	Titanium
452	Packing Gland	316ss				
458	Lantern Ring	Glass Filled PTFE				
461	Packing	PTFE Impregnated				
502.11	Wear Ring (optional)	316ss (1.4410)	DuplexSS	Alloy 20	Hastelloy	Titanium
642	Oil Level Sight Glass	Glass/Plastic				

NOTES

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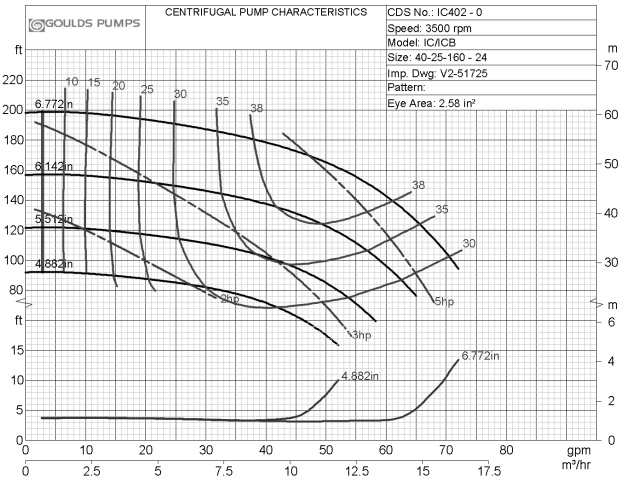
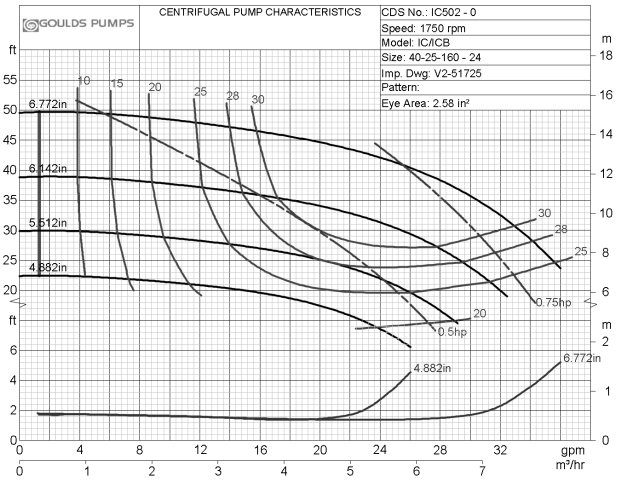
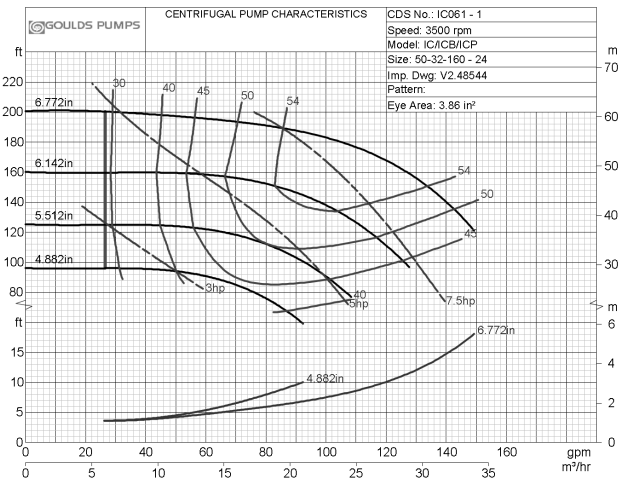


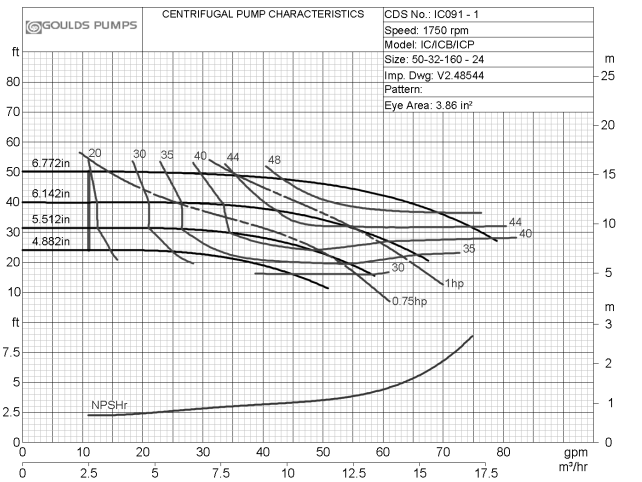
40-25-160 **3500rpm**



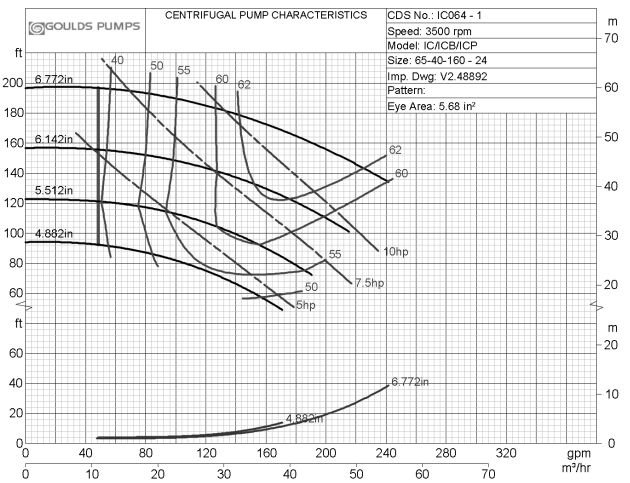
40-25-160 **1750rpm**



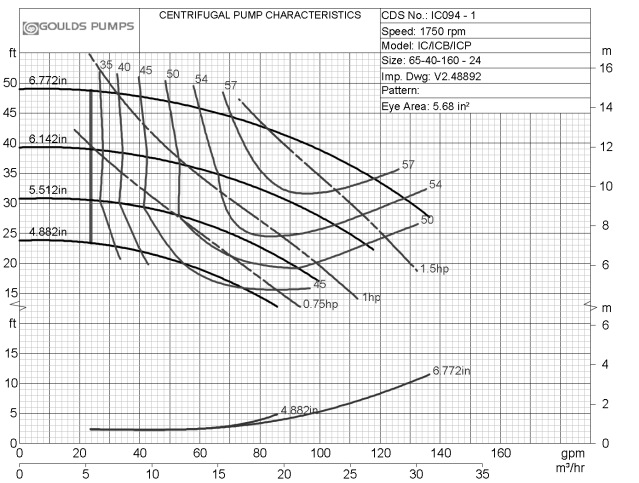
50-32-160 **3500rpm**



50-32-160 **1750rpm**



65-40-160 **3500rpm**



65-40-160 **1750rpm**

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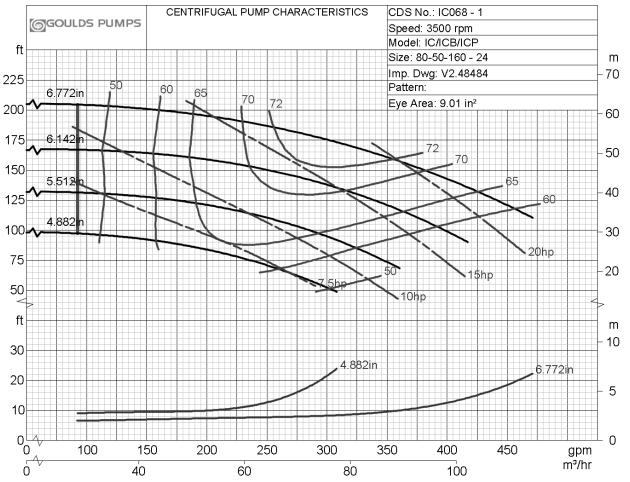
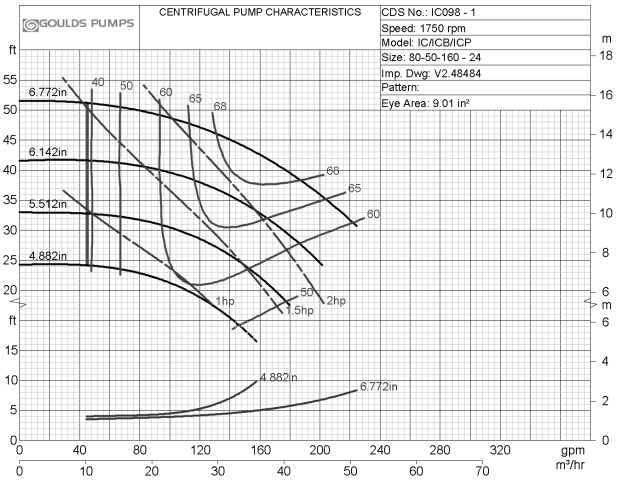
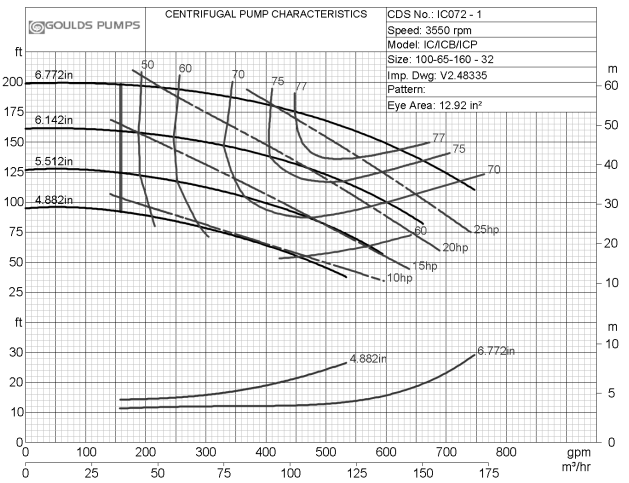


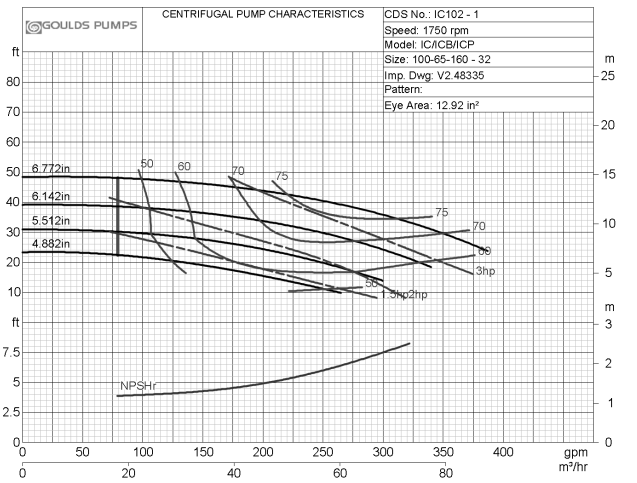
80-50-160 **3500rpm**



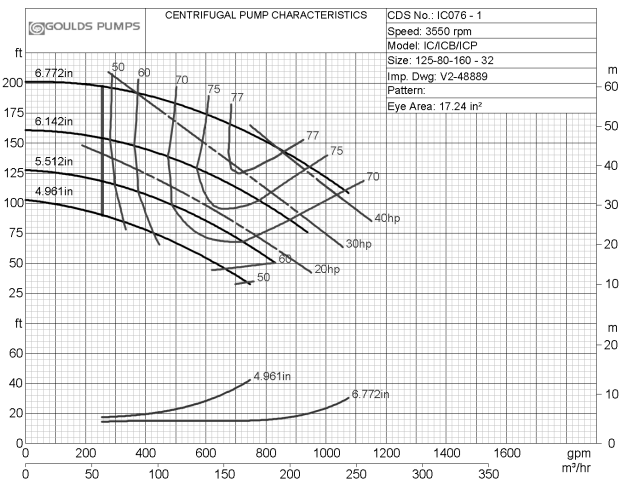
80-50-160 **1750rpm**



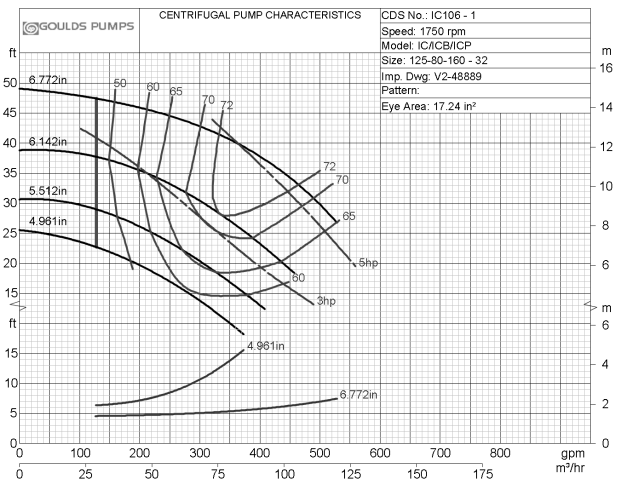
100-65-160 **3550rpm**



100-65-160 **1750rpm**



125-80-160 **3550rpm**



125-80-160 **1750rpm**

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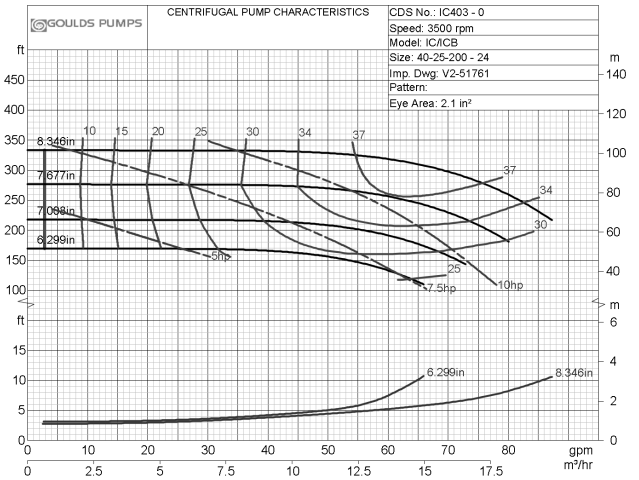
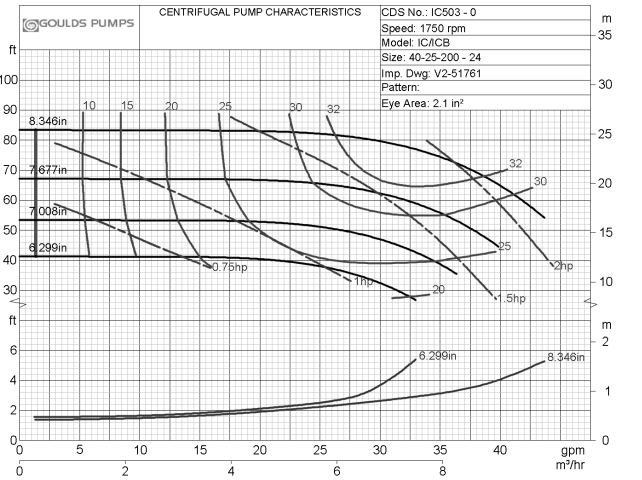
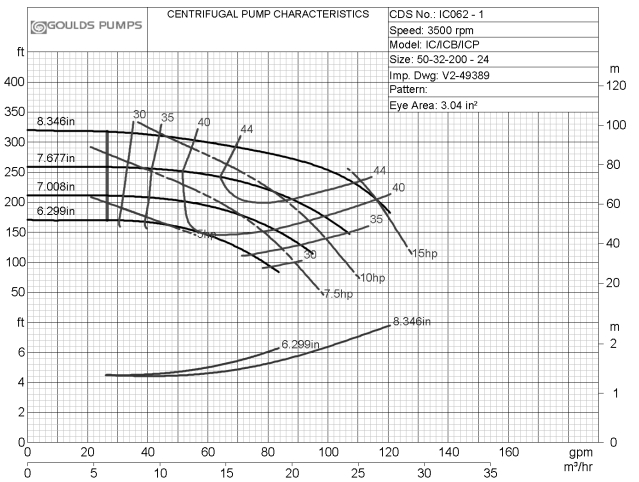


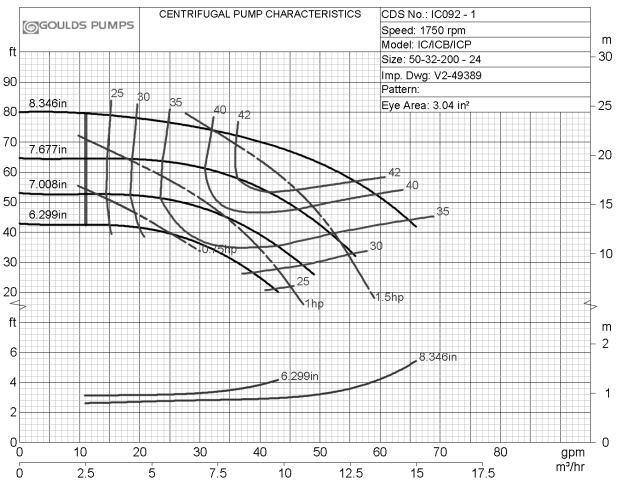
40-25-200 **3500rpm**



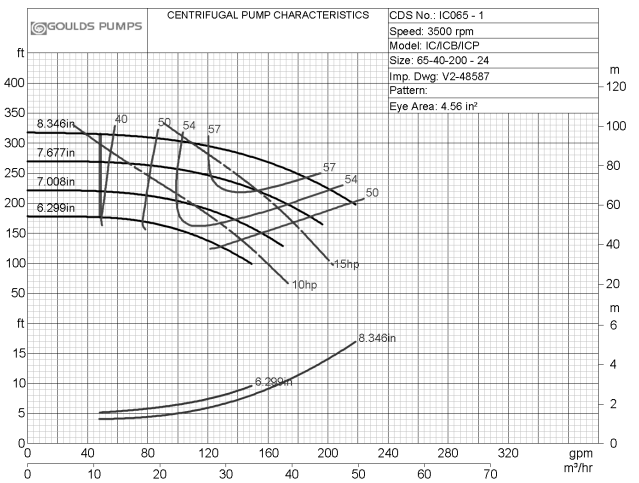
40-25-200 **1750rpm**



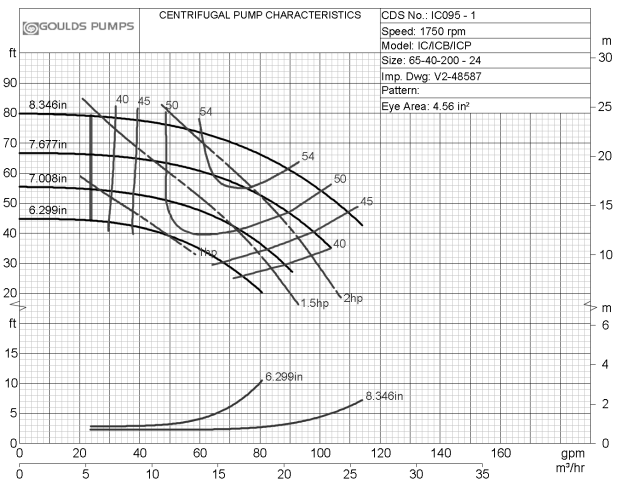
50-32-200 **3500rpm**



50-32-200 **1750rpm**



65-40-200 **3500rpm**



65-40-200 **1750rpm**

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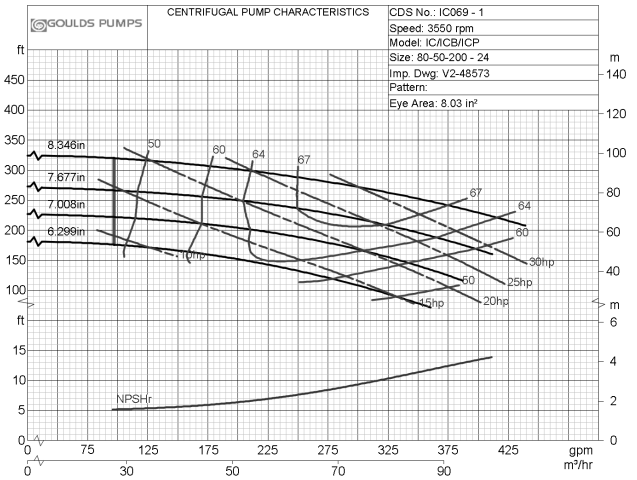
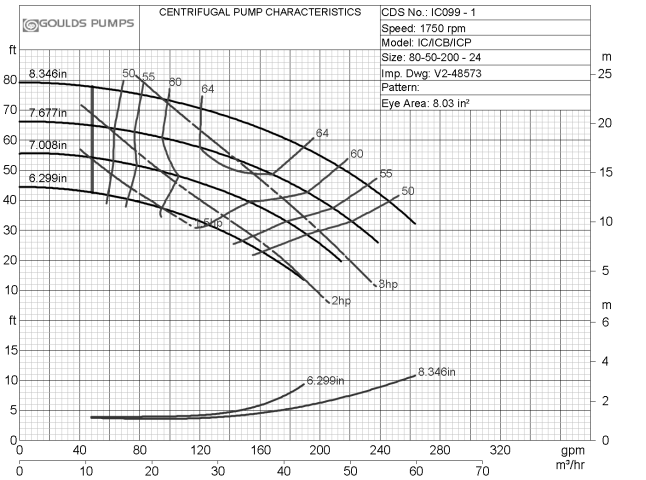
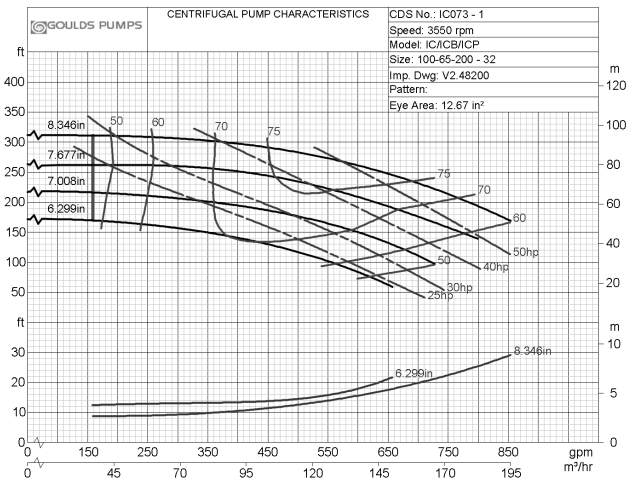


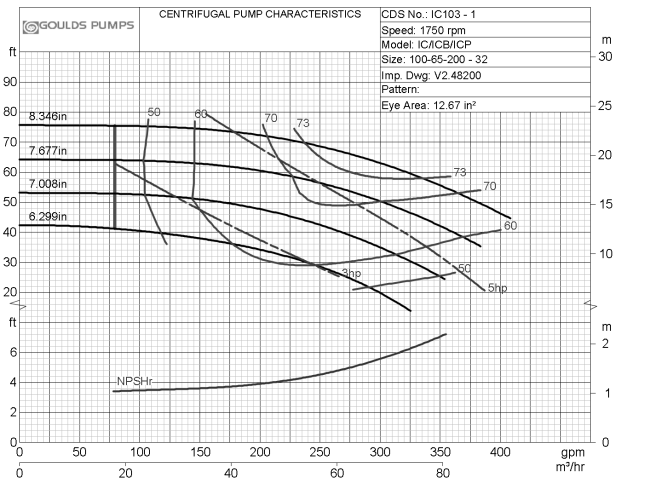
80-50-200 **3550rpm**



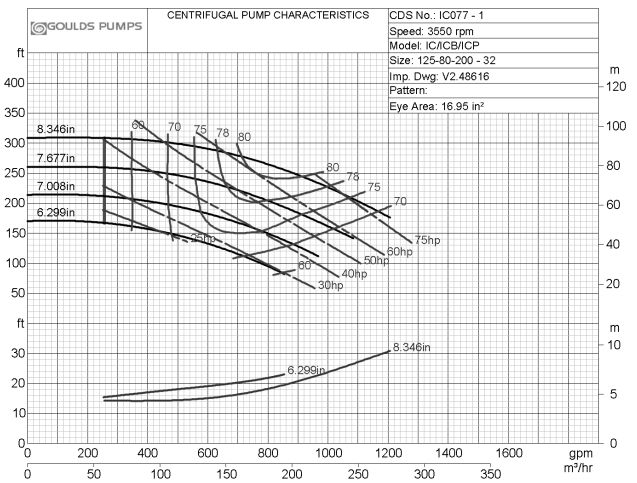
80-50-200 **1750rpm**



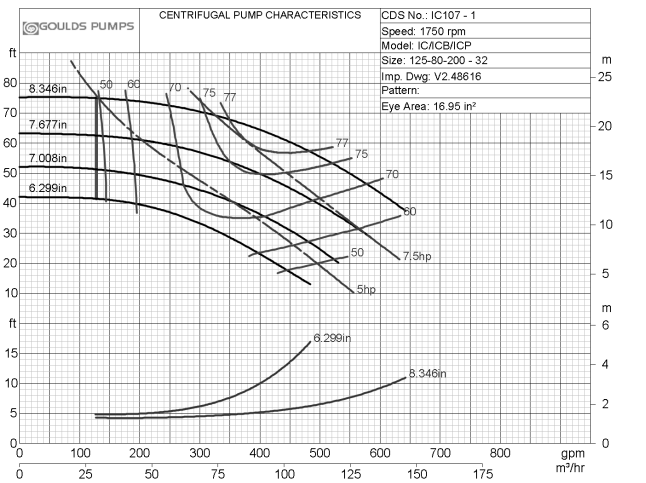
100-65-200 **3550rpm**



100-65-200 **1750rpm**



125-80-200 **3550rpm**



125-80-200 **1750rpm**

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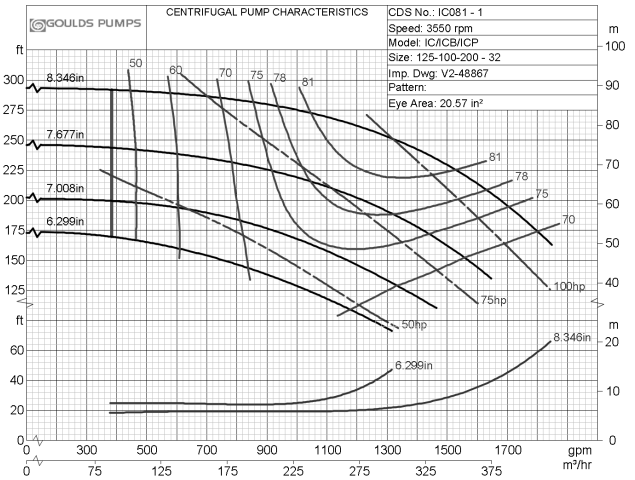
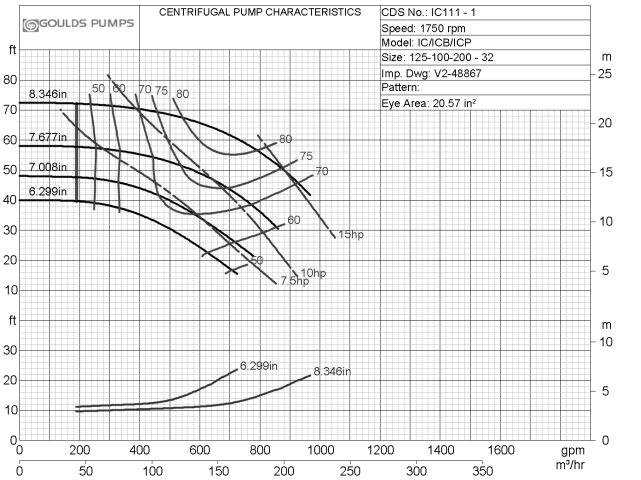
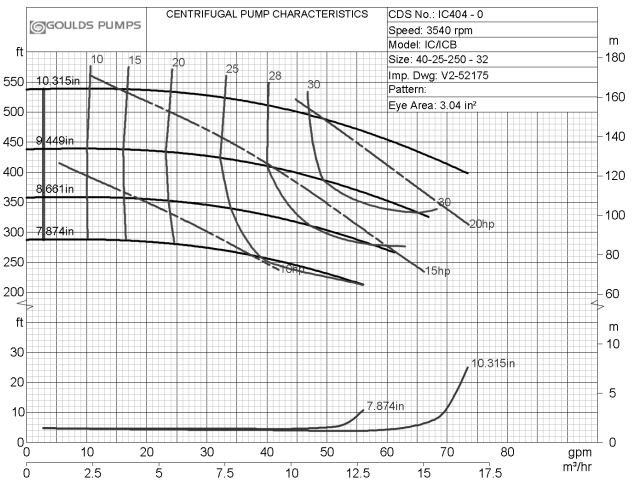


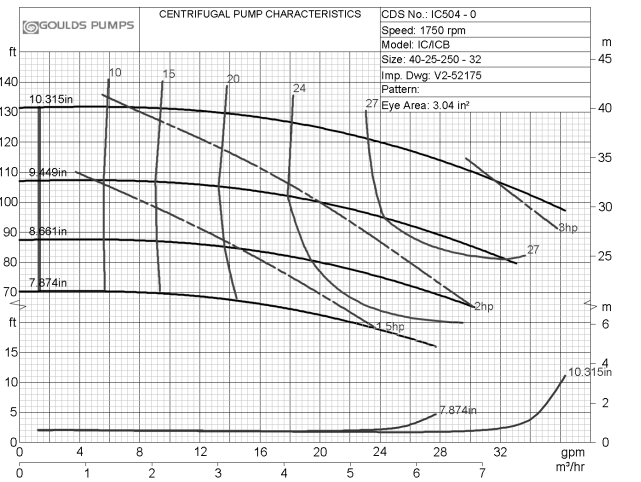
125-100-200 **3550rpm**



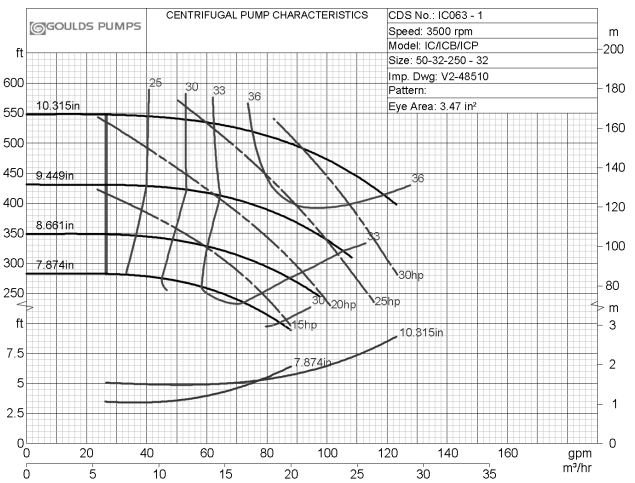
125-100-200 **1750rpm**



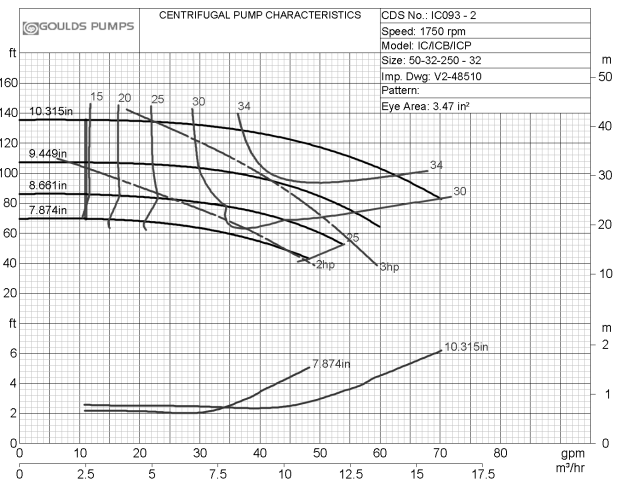
40-25-250 **3540rpm**



40-25-250 **1750rpm**

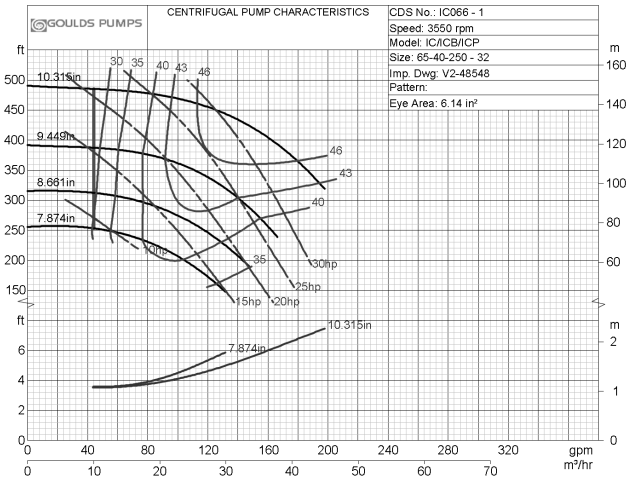


50-32-250 **3500rpm**

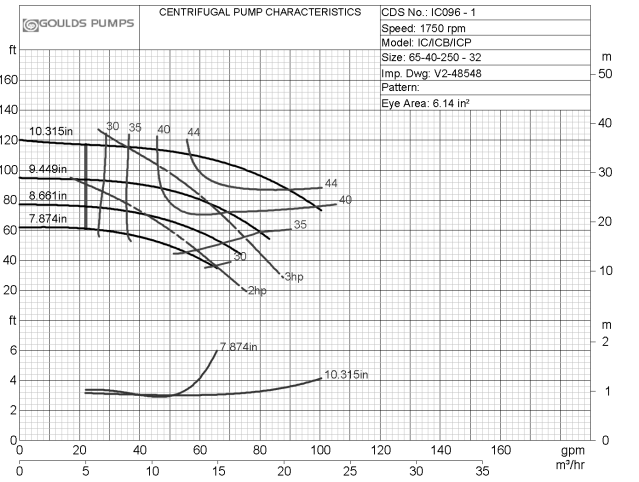


50-32-250 **1750rpm**

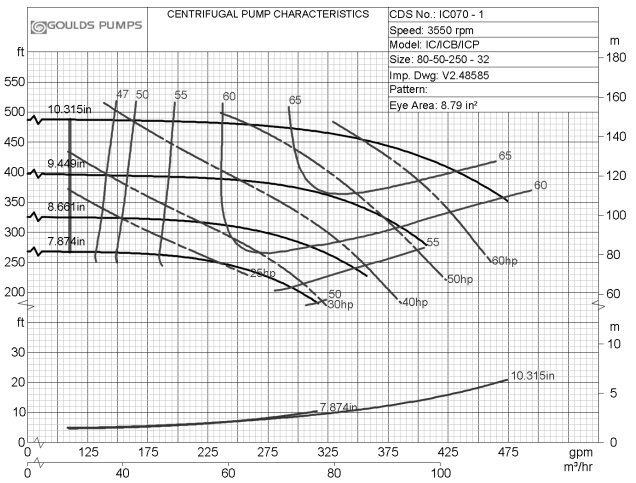
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



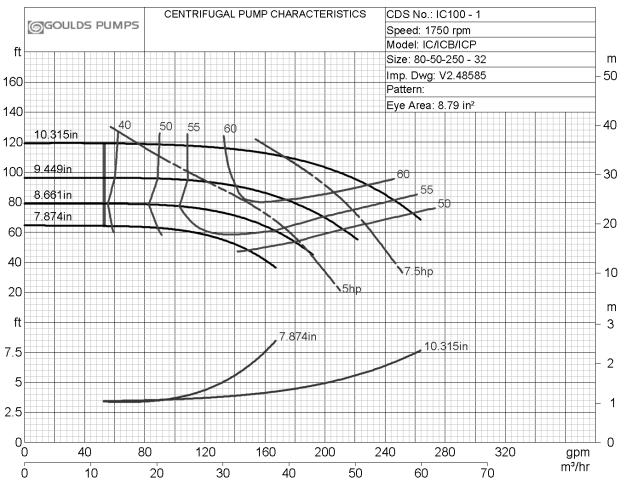
65-40-250 **3550rpm**



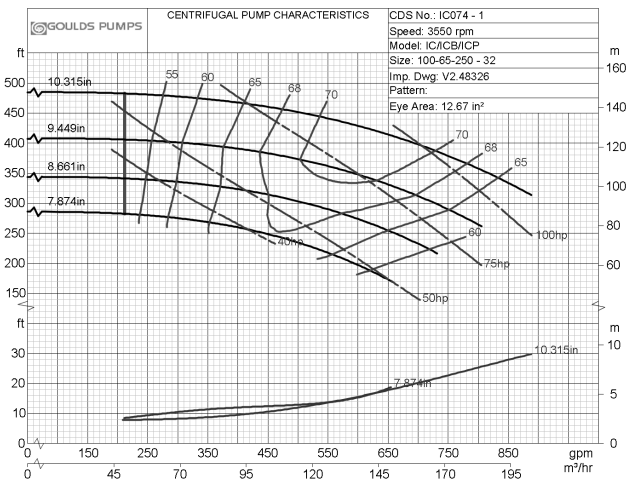
65-40-250 **1750rpm**



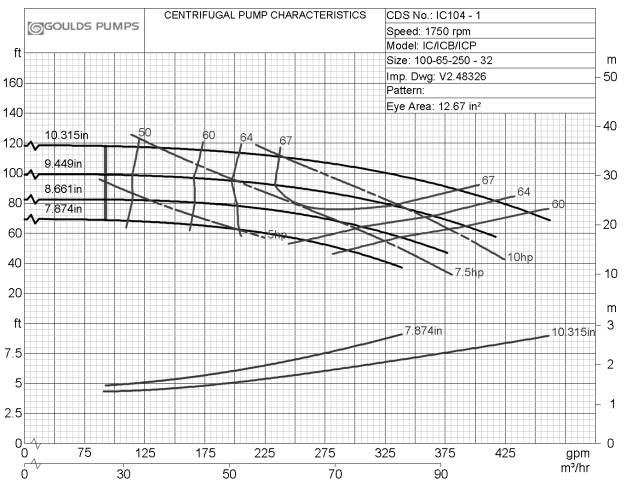
80-50-250 **3550rpm**



80-50-250 **1750rpm**

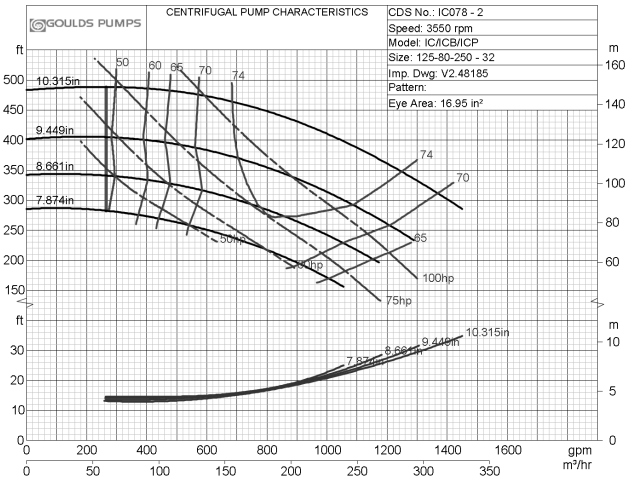


100-65-250 **3550rpm**

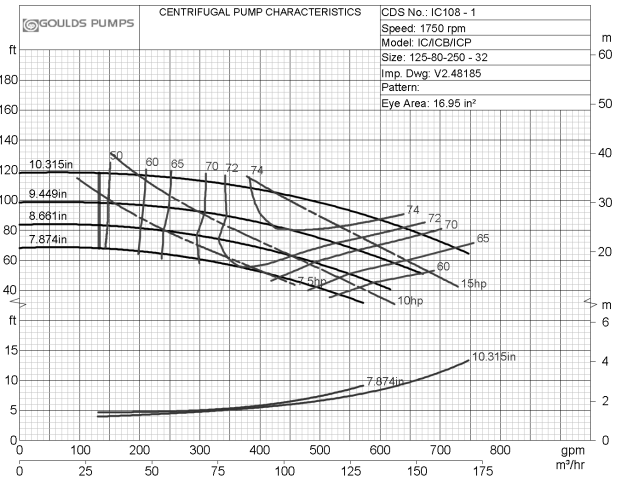


100-65-250 **1750rpm**

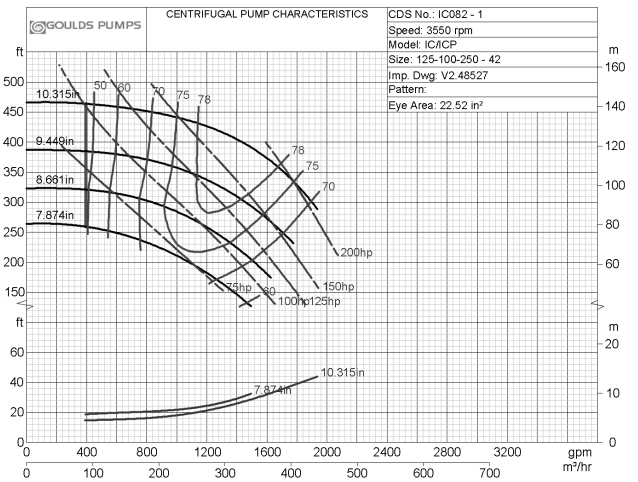
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



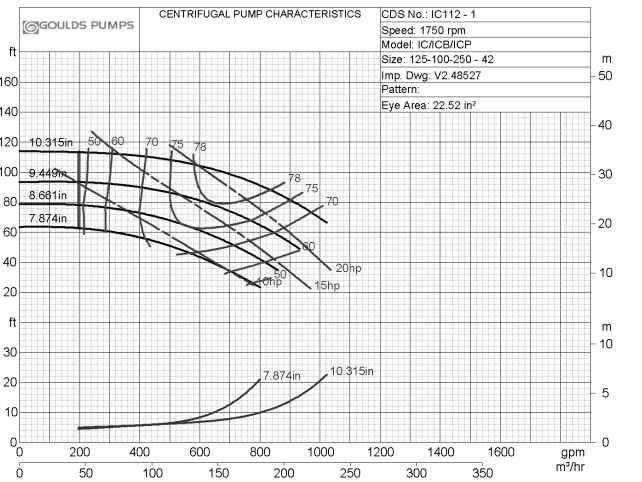
125-80-250 **3550rpm**



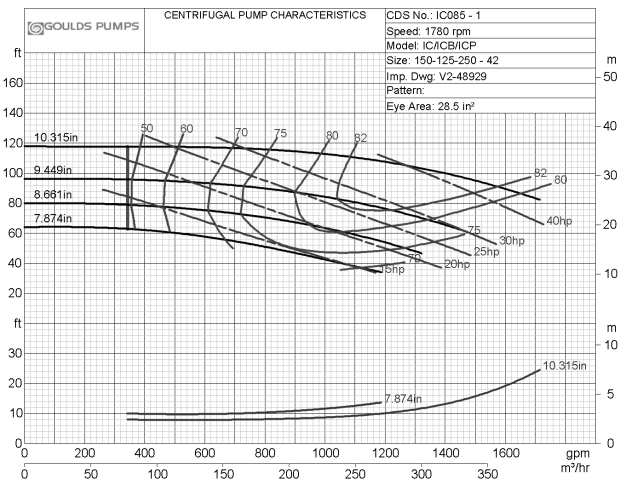
125-80-250 **1750rpm**



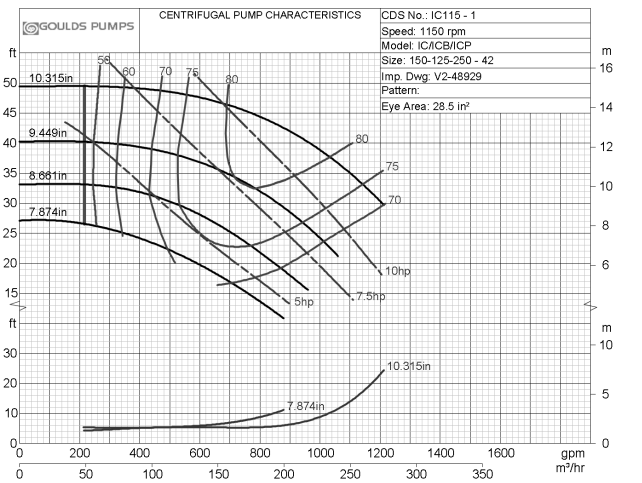
125-100-250 **3550rpm**



125-100-250 **1750rpm**

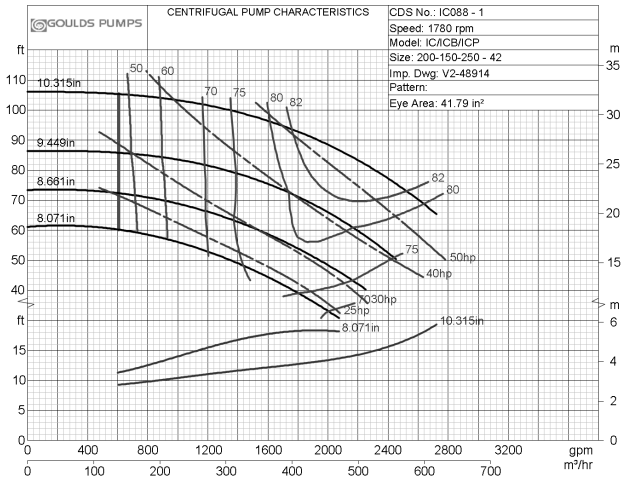


150-125-250 **1780rpm**

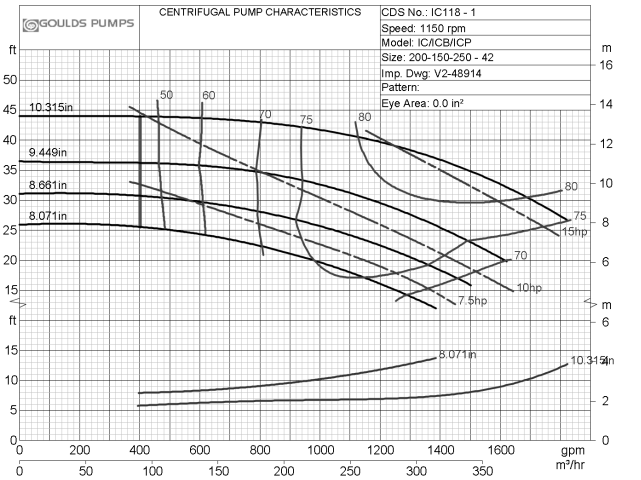


150-125-250 **1150rpm**

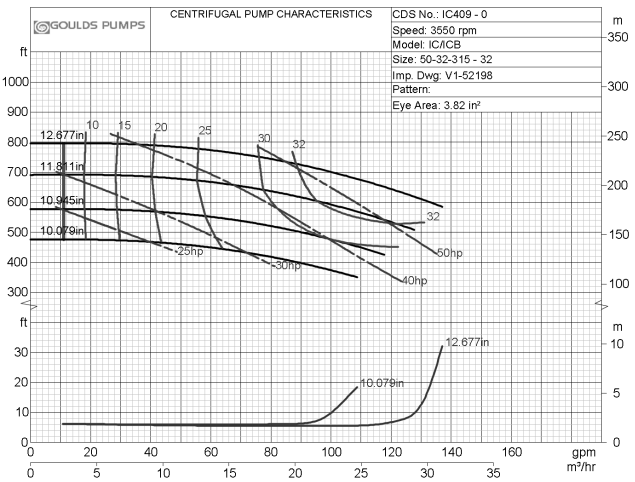
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



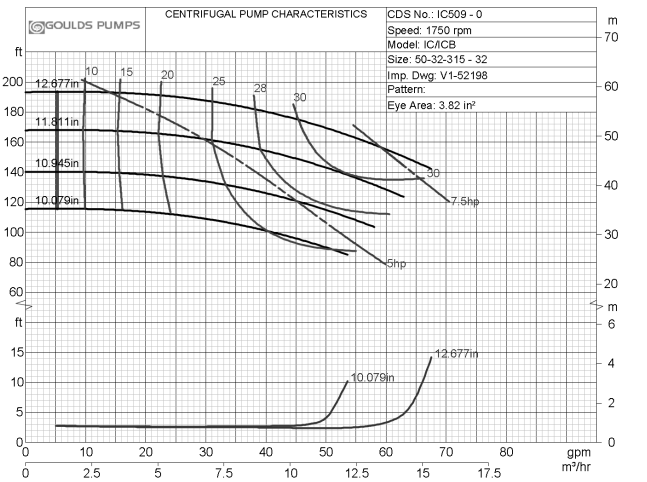
200-150-250 **1780rpm**



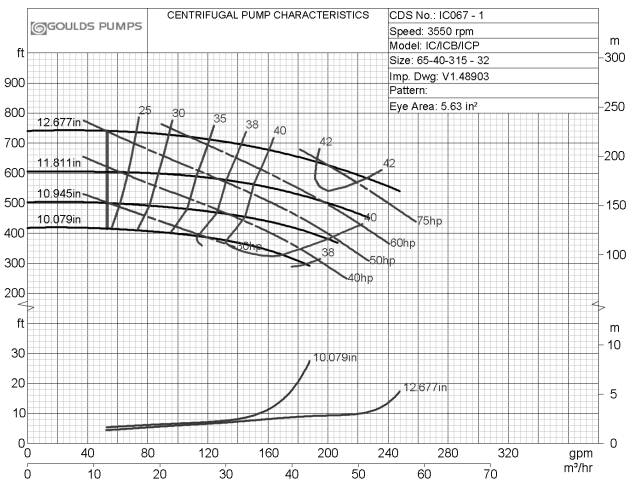
200-150-250 **1150rpm**



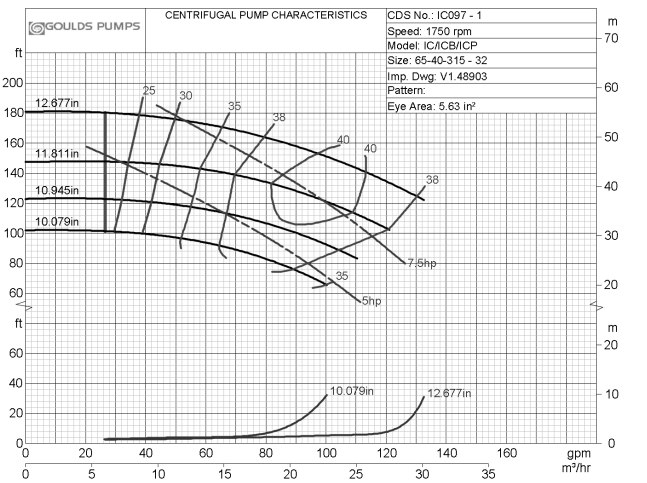
50-32-315 **3550rpm**



50-32-315 **1750rpm**

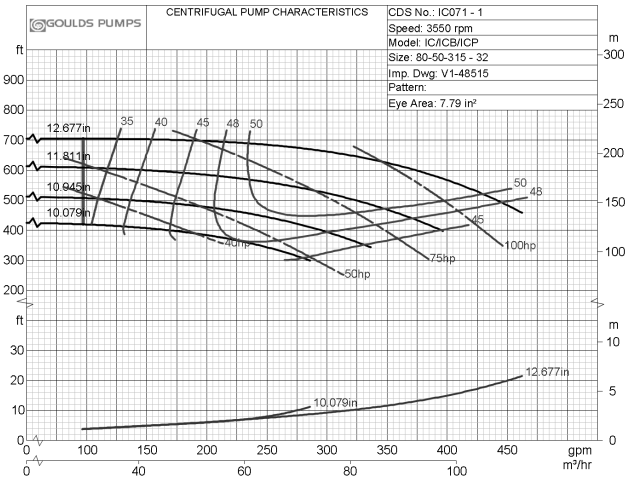


65-40-315 **3550rpm**

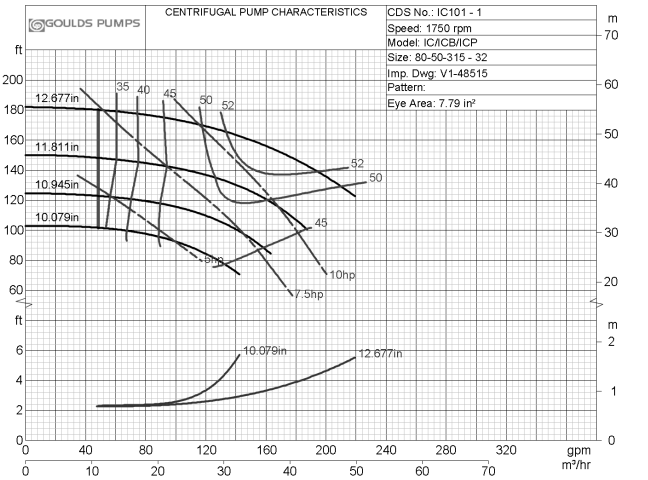


65-40-315 **1750rpm**

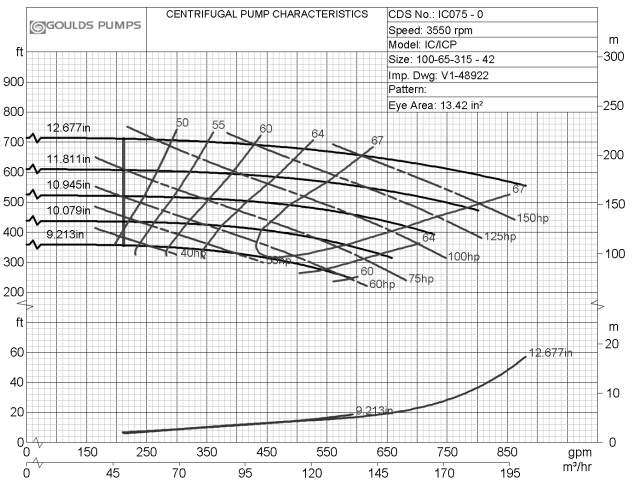
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



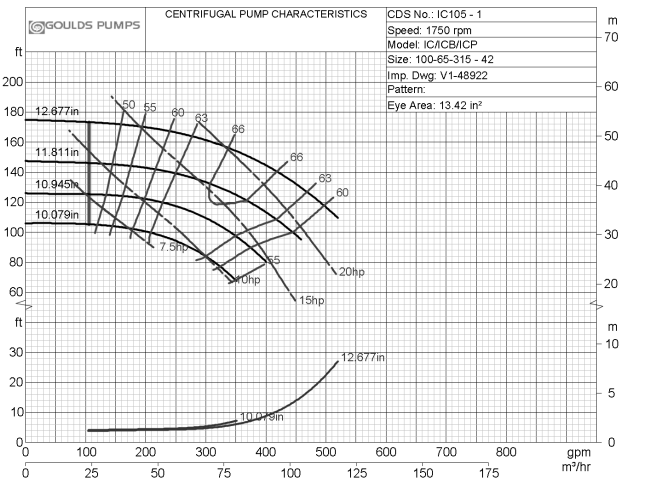
80-50-315 **3550rpm**



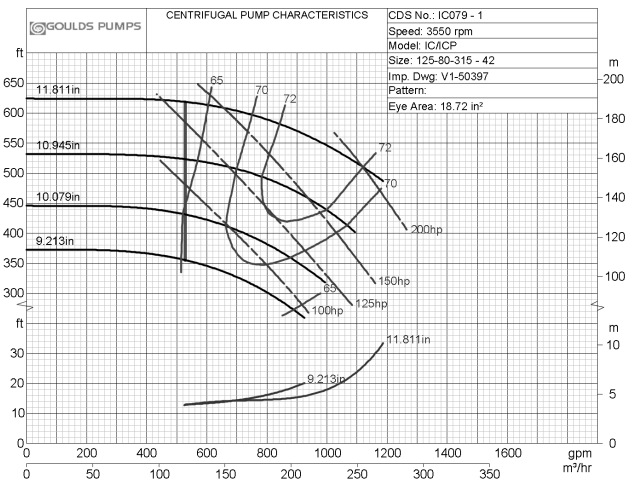
80-50-315 **1750rpm**



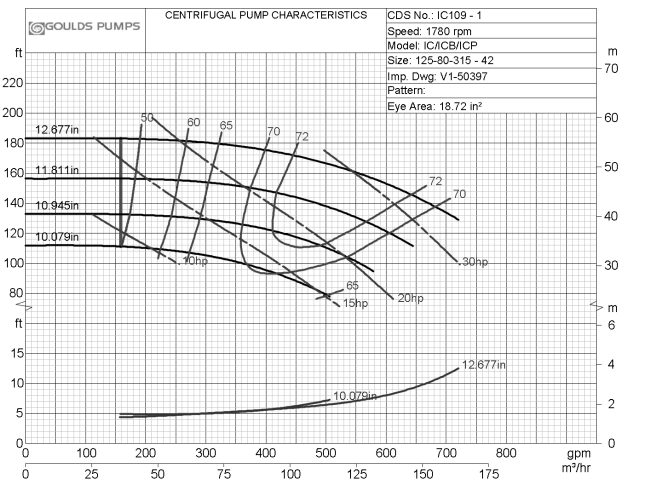
100-65-315 **3550rpm**



100-65-315 **1750rpm**

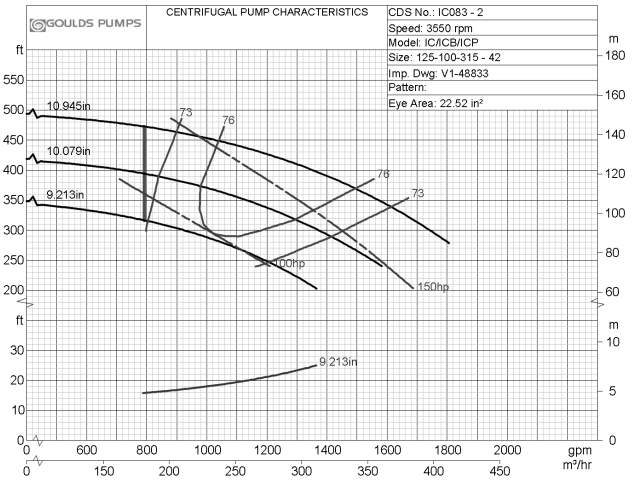


125-80-315 **3550rpm**

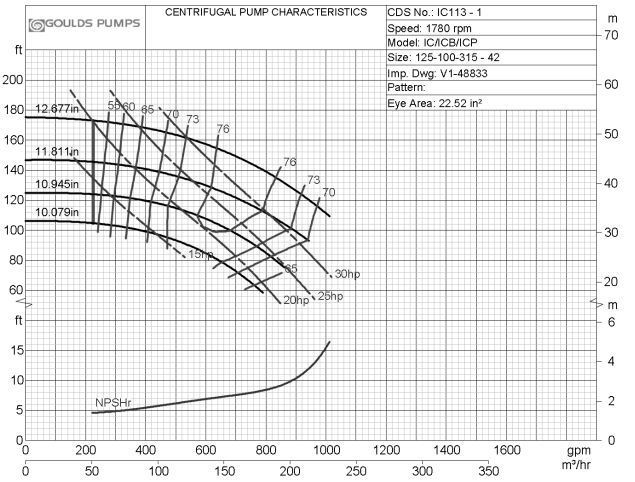


125-80-315 **1780rpm**

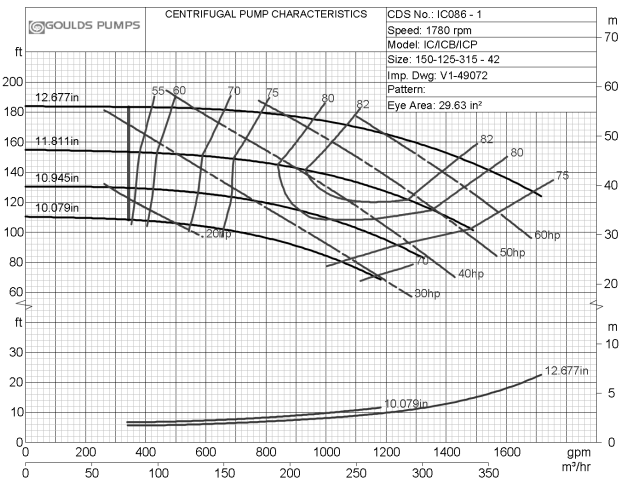
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



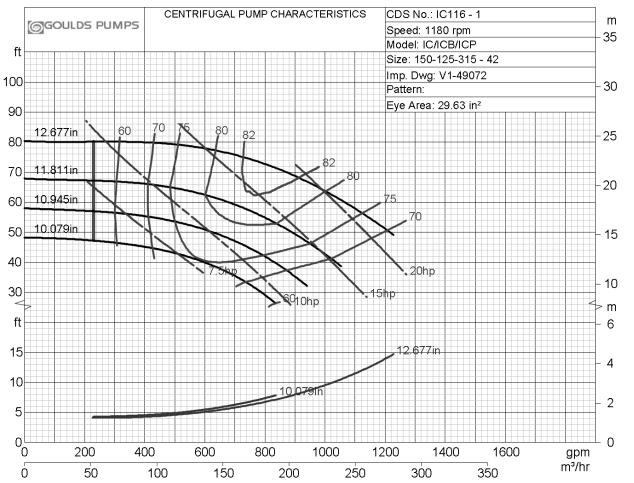
125-100-315 **3550rpm**



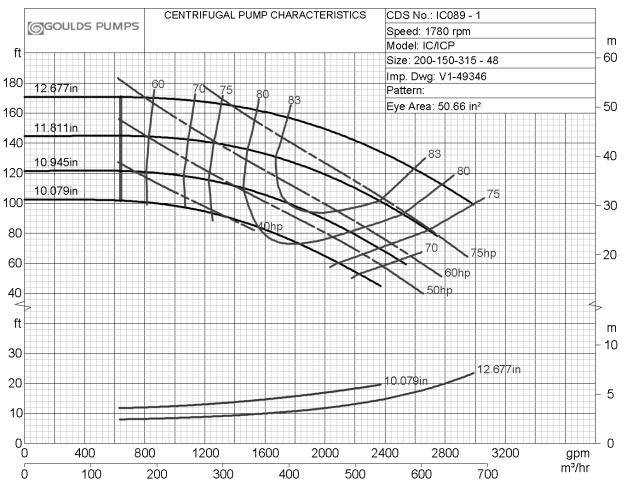
125-100-315 **1780rpm**



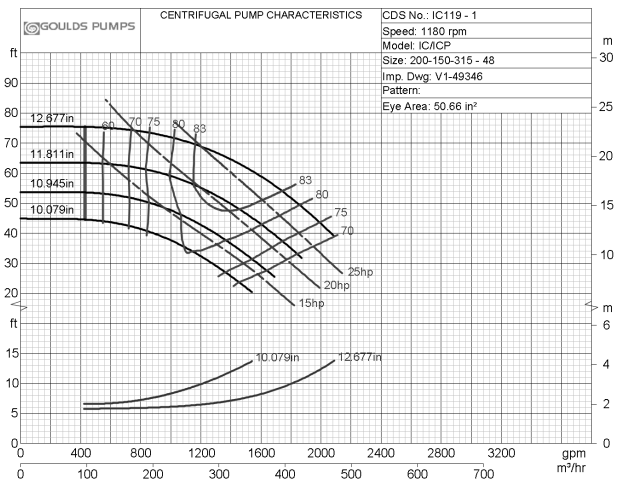
150-125-315 **1780rpm**



150-125-315 **1180rpm**

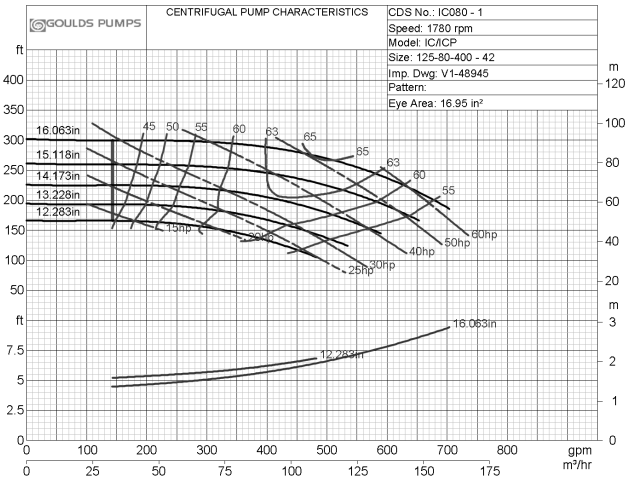


200-150-315 **1780rpm**

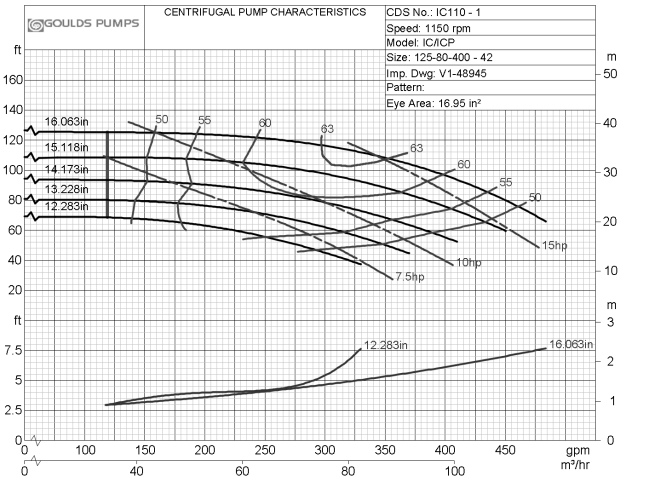


200-150-315 **1180rpm**

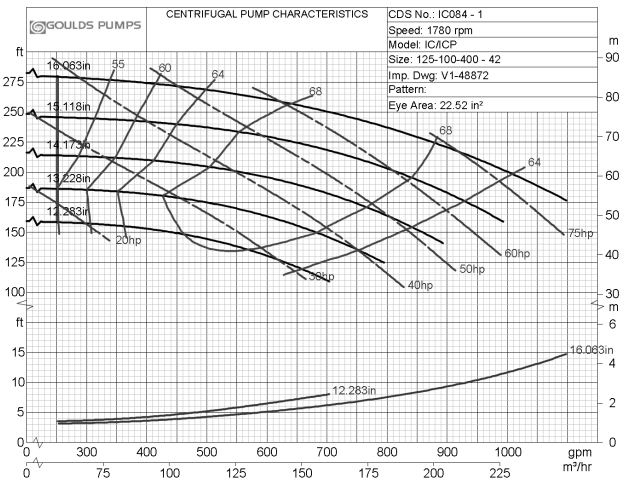
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



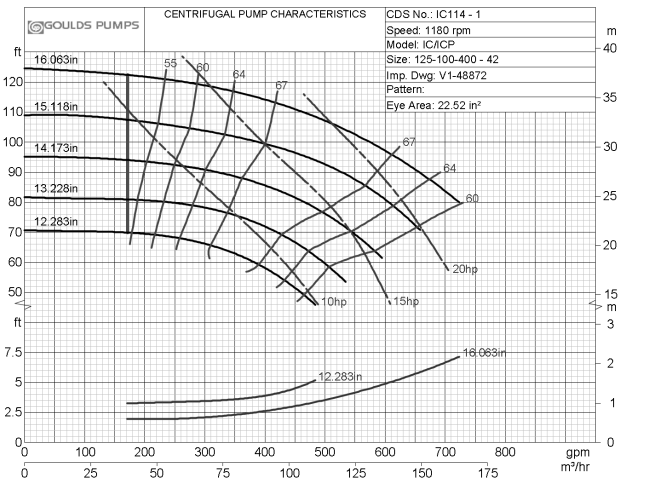
125-80-400 **1780rpm**



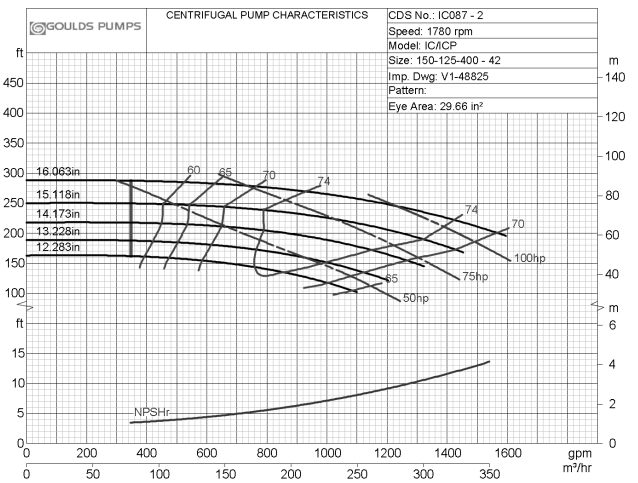
125-80-400 **1150rpm**



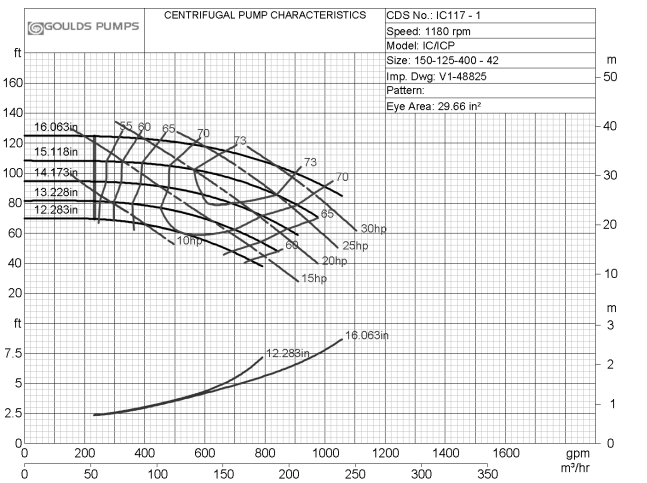
125-100-400 **1780rpm**



125-100-400 **1180rpm**



150-125-400 **1780rpm**

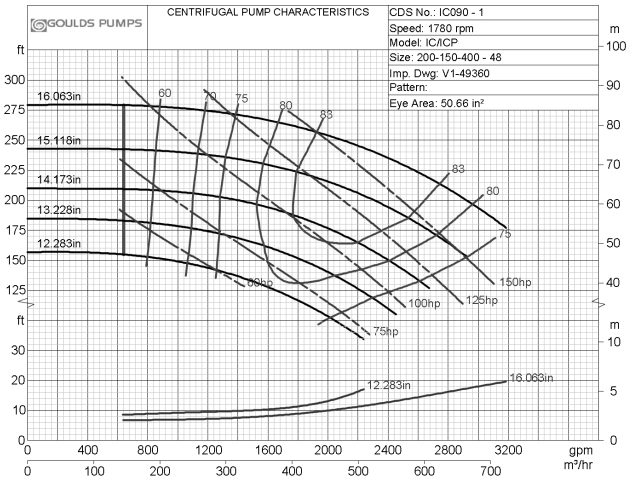


150-125-400 **1180rpm**

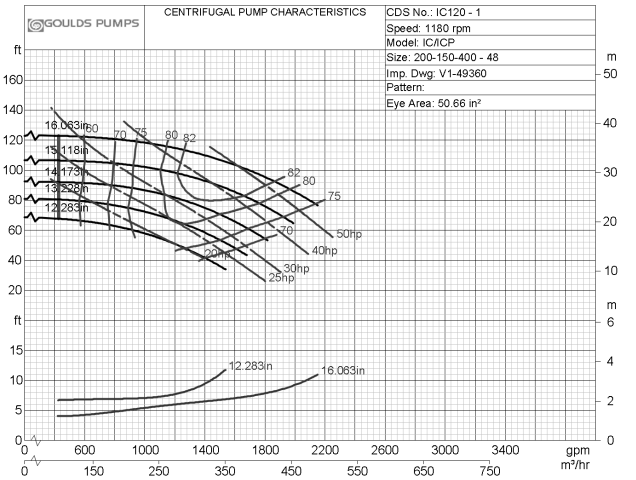
60Hz Curves

Model IC

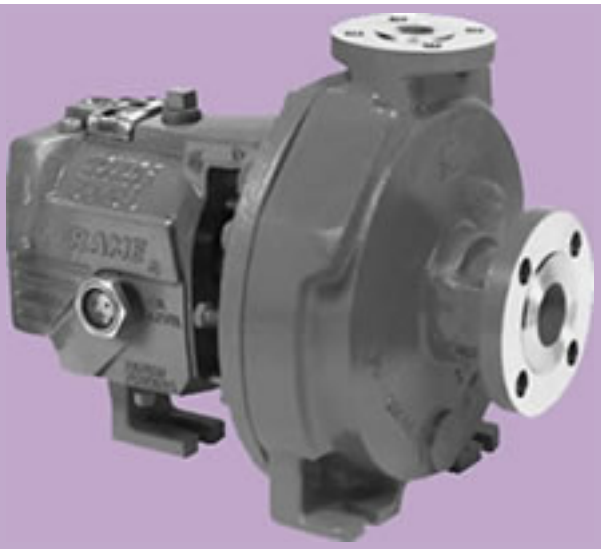
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



200-150-400 **1780rpm**



200-150-400 **1180rpm**



Model LF 3196 *i*-FRAME *STi* (1×1½-4, 1×1½-8)

The LF 3196 *i-FRAME* process pump line is specifically designed to provide superior performance for low flow services of the Chemical Process industries.

Model LF 3196 *i-FRAME MTi/LTi* (1×2-10 *MTi/LTi*, 1½×3-13 *LTi*)

Goulds Model LF 3196 *i-FRAME™*

Low Flow ANSI Process Pumps Designed for Total Range of Industry Services

- Capacities to 220 GPM (50 m^3/h)
- Heads to 925 feet (282 m)
- Temperatures to 700° F (371° C)
- Pressures to 450 PSIG (3102 kPa)

Performance Features for Low Flow Services

Extended Pump Life

- Concentric (Circular) Casing
- Radial Vane Impeller
- TaperBore™/BigBore™ Seal Chambers
- ***i-FRAME***™ Power Ends
- Optional Centerline Mounted Casings

Ease of Maintenance

- Back Pull-out Design
- Parts Interchangeable with Goulds Model 3196
- External Impeller Adjustment
- Easy Retrofit

Safety

- ANSI B15.1 Coupling Guard
- Ductile Iron Frame Adapter
- Raised Face Flanges
- Optional Shaft Guard

Applications

- Specialty Chemicals
- Batch Chemical Process
- Reactor Feed
- Seal Water
- Shower Service
- Boiler Feed
- Condensate
- High Pressure Process
- Column Bottoms
- Hot Oil
- Column Reflux

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model LF 3196 *i-FRAME™ Low Flow* ANSI Process Pumps

Design Features for Total Range of Industry Services

INPRO VBXX-D HYBRID LABYRINTH SEALS
Prevents premature bearing failure caused by lubricant contamination or loss of oil. Stainless steel rotors for optimal performance in corrosive environments.

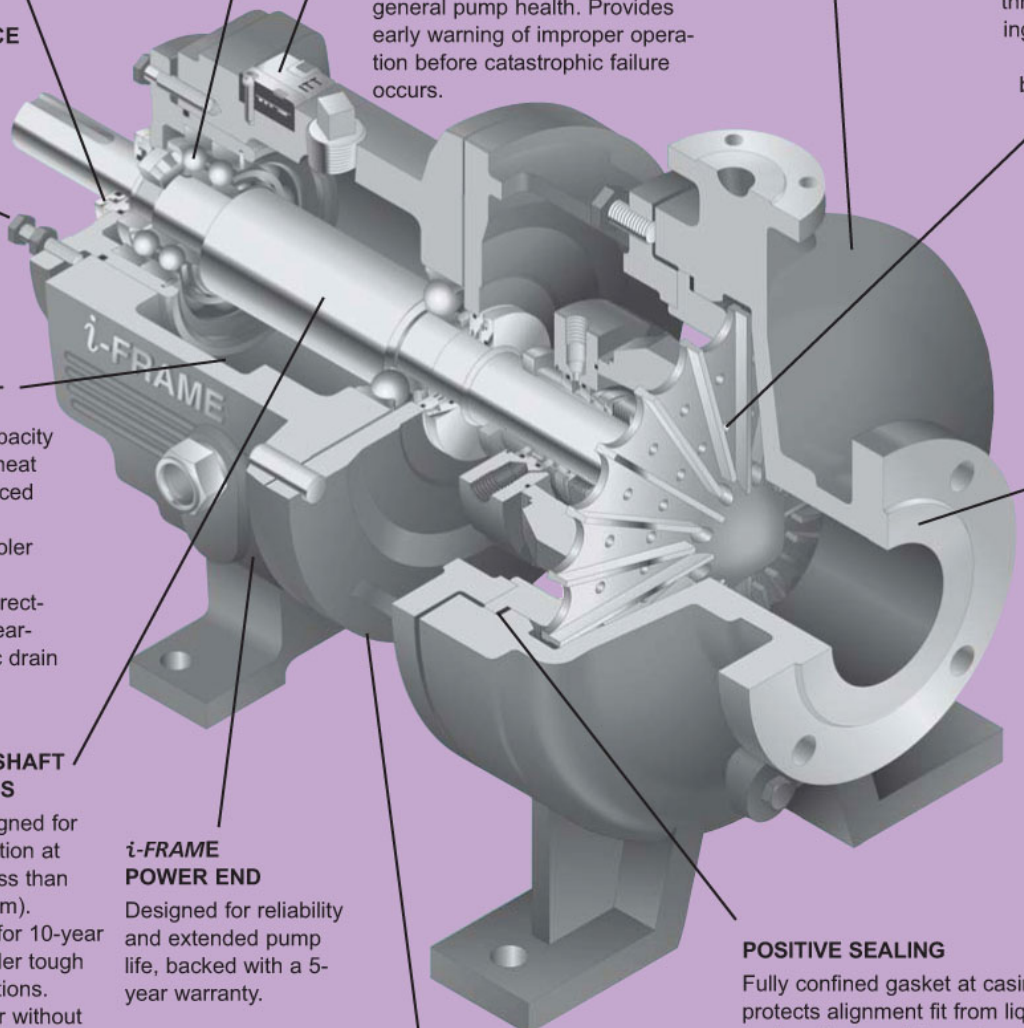
PREMIUM SEVERE-DUTY THRUST BEARINGS
Increase bearing fatigue life by 2-5X that of conventional bearing steels.

***i-ALERT* CONDITION MONITOR (U.S. Patent 8,154,417)**
Constantly measures vibration and temperature at the thrust bearing. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

CIRCULAR VOLUTE CASING
Reduces radial loads during low flow operation. Mechanical seal and bearings last longer. Fully machined discharge and volute provide maximum efficiency and precise control of hydraulics at low flows.

GOULDS LOW FLOW IMPELLER
Multiple open radial vanes reduce pulsations, vibration and vane stress. Full shroud for superior vane strength when operating at extreme low flows. Balance holes reduce axial thrust, minimize stuffing box/seal chamber pressure for longer bearing and seal life.

CONTINUOUS PERFORMANCE
Original flow, pressure and efficiency are maintained by simple external adjustment resulting in long-term energy and repair parts savings.



OPTIMIZED OIL SUMP DESIGN
Increased oil capacity provides better heat transfer for reduced oil temperature. Bearings run cooler and last longer. Contaminants directed away from bearings to magnetic drain plug.

RAISED FACE FLANGES
Serrated for positive sealing against leakage. Meets ANS0I B16.5 requirements.Class 150 RF standard. Class 300 RF optional. (13 in. casing—300 RF flanges standard.)

HEAVY DUTY SHAFT AND BEARINGS
Rigid shaft designed for minimum deflection at seal faces — less than 0.002 in. (.05 mm). Bearings sized for 10-year average life under tough operating conditions. Available with or without shaft sleeve.

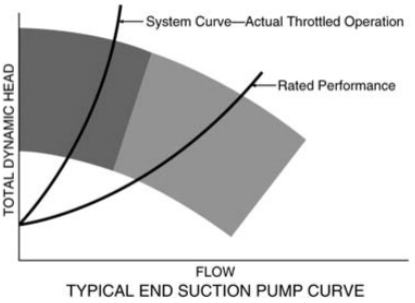
***i-FRAME* POWER END**
Designed for reliability and extended pump life, backed with a 5-year warranty.

POSITIVE SEALING
Fully confined gasket at casing joint protects alignment fit from liquid, makes disassembly easier.

MAGNETIC DRAIN PLUG
Standard magnetic drain plug helps protect bearings and prolong life.

Goulds LF 3196 *i-FRAME™*

Designed for Low Flow Services

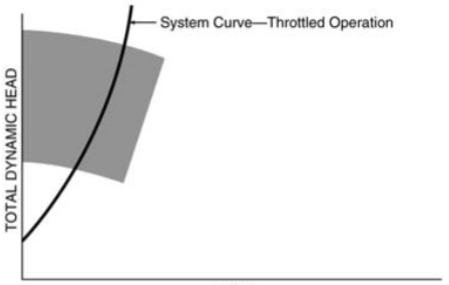


TYPICAL END SUCTION PUMP CURVE

Not All End Suction Pumps are Designed for Low Flows

Many users throttle pumps to attain desired low flow performance. Because these pumps are not designed to operate continuously in this range, the resultant higher radial loads and increased shaft deflection lead to premature bearing and mechanical seal failure. Unscheduled downtime and higher maintenance costs are the consequence.

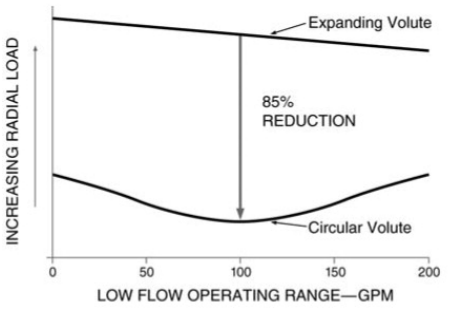
- Off Design Operation Range
- Recommended Operation Range



LF 3196 PUMP CURVE

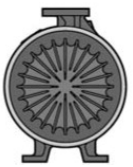
LF 3196 *i-FRAME* Designed Specifically for Trouble-Free Operation At Low Flows

Goulds LF 3196 ***i-FRAME*** concentric (circular volute) casing and open radial vane impeller are designed to eliminate hydraulic and mechanical problems at throttled low flows.



LOW FLOW OPERATING RANGE—GPM

EXPANDING VOLUTE PUMP


LF 3196 *i-FRAME* CIRCULAR VOLUTE

Reduced Radial Loads for Optimum Reliability

Radial loads are reduced by as much as 85% compared to end suction expanding volute pumps at low flows. Bearing, mechanical seal and overall pump life are optimized.

Maximum Interchangeability

Low Flow Retrofit

Pump Replacement

Since the LF 3196 ***i-FRAME*** meets ANSI dimensional standards, retrofitting ANSI pumps not designed for operation at low flows is easy. Simply replace the troublesome pump with the equivalent ANSI size LF 3196 ***i-FRAME*** .

Pump Retrofit

The LF 3196 *i-FRAME* uses all Goulds Model 3196 parts except casing and impeller. An LF 3196 retrofit kit easily converts a 3196 to LF 3196 *i-FRAME*.

Goulds Patented *i-FRAME™* Power Ends

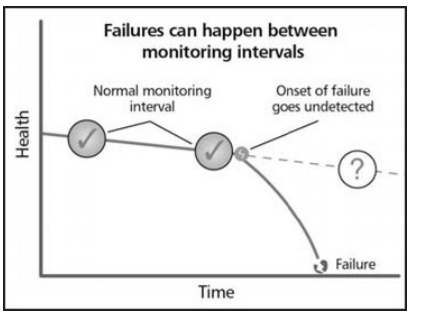
Extended Pump Life Through Intelligent Design

Goulds ***i-FRAME*** Power Ends are the result of 160 years of design experience, customer interaction, and continuous improvement. Customers get extended Mean Time Between Failure (MTBF) and lower life cycle costs (LCC)...guaranteed!

1 *i-ALERT™* CONDITION MONITOR

The heart of the *i-FRAME*, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

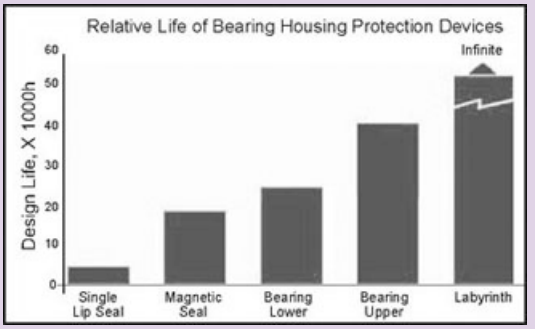
A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



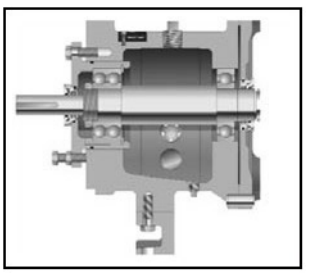
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

2 INPRO VBXX-D HYBRID BEARING ISOLATORS

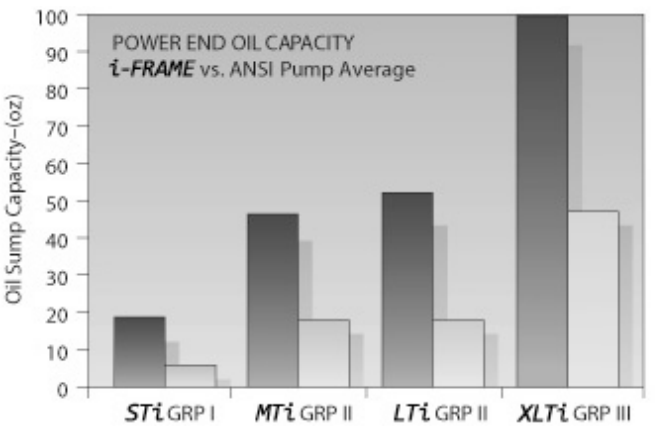
Most bearings fail before reaching their potential life. They fail for a variety of reasons, including contamination of the lubricant. INPRO VBXX-D has long been considered the industry standard in bearing lubricant protection. The ***i-FRAME*** now improves upon that design by offering stainless steel rotors, for maximum protection against contaminants and the corrosive effects of seal leakage or environmental conditions. These seals are non-contacting and do not wear.



3 OPTIMIZED OIL SUMP DESIGN



Internal sump geometry is optimized for longer bearing life. Sump size increased by 10%-20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.



Larger *Means Cooler*
GOULDS
Industry Average

4 SHAFT AND BEARINGS ENGINEERED FOR MAXIMUM RELIABILITY

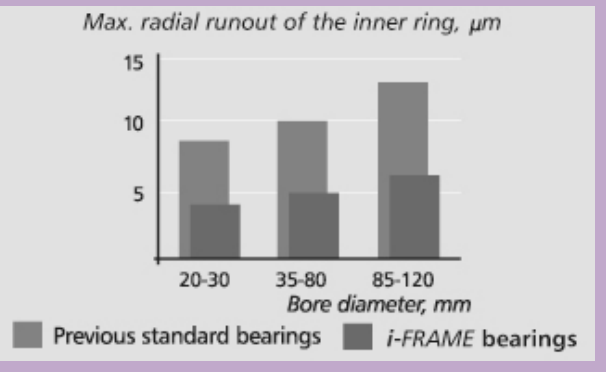
The rugged shaft and bearing combination maintains shaft deflection of less than 0.002 inches at all operating points. The result is longer seal and bearing life.

Premium severe-duty thrust bearings increase bearing fatigue life.

- High purity steels have fewer inclusions than standard steel – better grain structure and wear resistance.
- Heat treatment of bearing elements to SO stabilizaion levels provides superior thermal stability for increased service life.
- Bearing Balls are manufactured to at least one ISO grade above standard (ISO P5 for ring running accuracy and ISO P6 for dimensions). The result is reduced vibration and noise for improved shaft guidance.

Every 3196 ***i-FRAME***™ Power End is engineered and manufactured for optimal pump performance and increased MTBF.

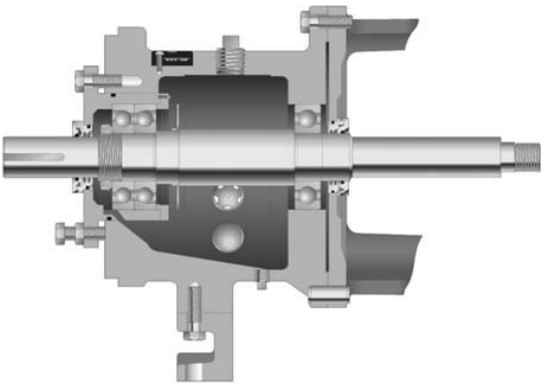
ANSI B73.1 Shaft Specification	Meets	Exceeds
Diameter Tolerance		✓
Surface Finish		✓
Runout	✓	
Deflection		✓



5 *LTi* POWER END FOR HIGH LOAD APPLICATIONS

Increased L'10 Bearing Life 150% to 200% on the Toughest Applications

Ideal for tough conditions when a power end is pushed beyond ANSI limits: operating at low flows and higher heads, pumping high specific gravity liquids, fluctuating process conditions, overhung belt drive. Oversized shaft and bearing assembly significantly expands the limits for long, trouble-free bearing and seal life. On high load applications, the *LTi* power end improves bearing life 150%-200%; oil operating temperature reduced by 45°F (25° C).



FLINGER/CHANNEL OIL LUBRICATION SYSTEM

Provides 30% increased L'10 life; 15°F (8°C) reduced oil temperature.

OVERSIZED SHAFT

With duplex thrustbearings provide increased L'10 by 40%.

DUPLEX THRUST BEARINGS

Duplex thrust bearings (40°/40° angular contact) with machined brass cages, are ideally sized for high load applications.

Our Guarantee We are so confident that the ***i-FRAME***™ is the most reliable Power End in the industry, that we are proud to offer a standard 5-year warranty on every ***i-FRAME*** ANSI Process Pump.

Parts List and Materials of Construction

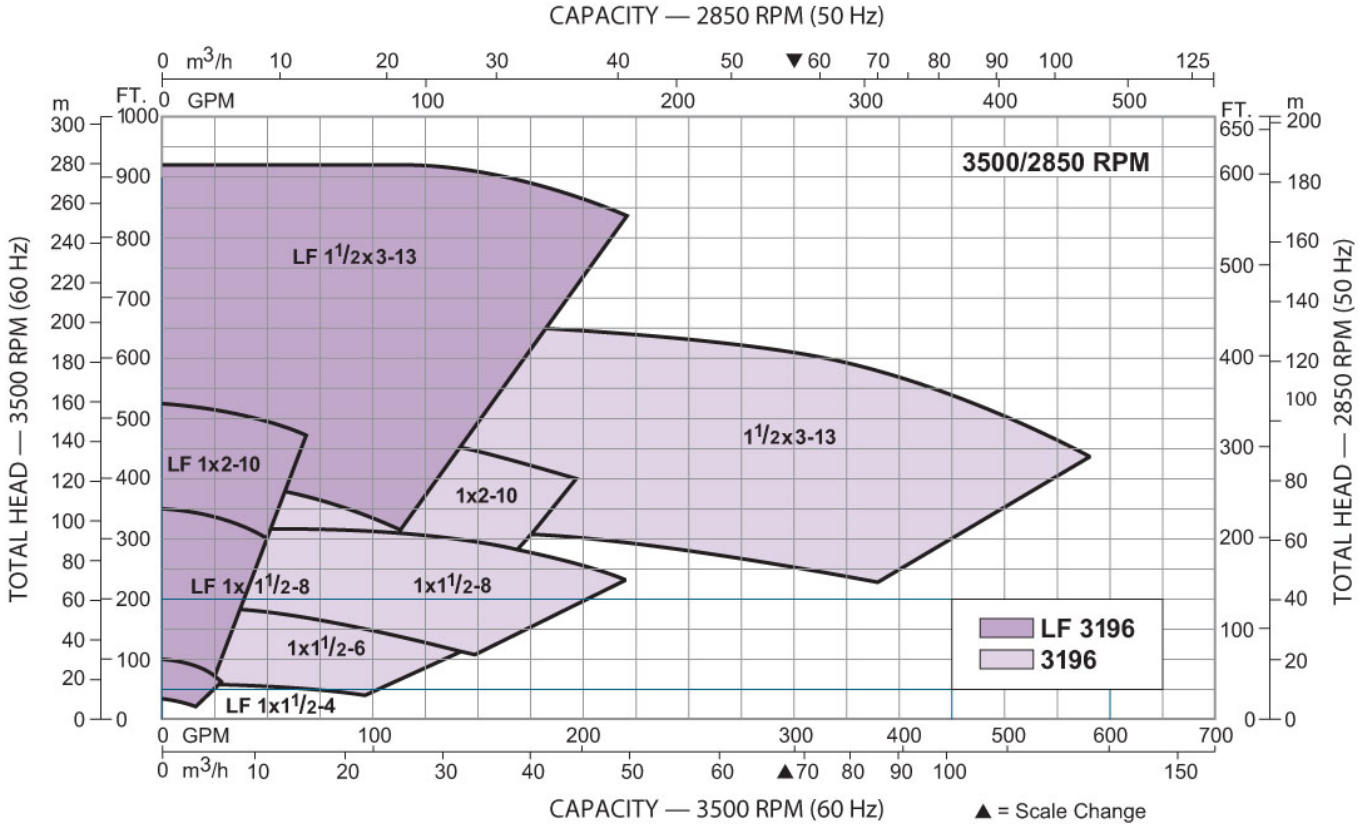
Item Number	Part Name	Material				
		Ductile Iron/316SS Trim	316SS	CD4MCu	Alloy 20	Hastelloy B & C
100	Casing	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy
101	Impeller	316SS	316SS	CD4MCu	Alloy 20	Hastelloy
105	Lantern Ring (Not Illustrated)	Glass-Filled Teflon*				
106	Stuffing Box Packing (Not Illustrated)	Teflon* Impregnated Fibers				
108	Frame Adapter	Ductile Iron				
112	Thrust Bearing	Double Row Angular Contact Conrad**				
122	Shaft—Less Sleeve (Optional)	SAE4140	316SS		Alloy 20	Hastelloy
122	Shaft—With Sleeve	SAE4140				316SS
126	Shaft Sleeve	316SS		Alloy 20		Hastelloy
136	Bearing Locknut and Lockwasher	Steel				
168	Radial Bearing	Single Row Deep Groove				
184	Stuffing Box Cover (Packed Box)	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy
184M	Seal Chamber (Mechanical Seal)	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy
228	Bearing Frame	Cast Iron (Ductile Iron for STX Group)				
250	Gland	316SS		CD4MCu	Alloy 20	Hastelloy
262	Repeller/Sleeve (Dynamic Seal Option)	CD4MCu			Alloy 20	Hastelloy
264	Gasket, Cover-to-Backplate (Dynamic Seal)	Teflon*				
265A	Stud/Nut, Cover-to-Adapter	304 SS				
319	Oil Sight Glass	Glass/Steel				
332A	Inpro ® vbxx-d Labyrinth Oil Seal (Outboard)	Stainless Steel/Bronze				
333A	Inpro ® vbxx-d Labyrinth Oil Seal (Inboard)	Stainless Steel/Bronze				
351	Casing Gasket	Aramid Fiber with EPDM Rubber				
358A	Casing Drain Plug (Optional)	Steel	316SS	CD4MCu	Alloy 20	Hastelloy
360	Gasket, Frame-to-Adapter	Buna				
370	Cap Screw, Adapter-to-Casing	Steel	304SS			
418	Jacking Bolt	304SS				
444	Backplate (Dynamic Seal Option)	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy
469B	Dowel Pin	Steel				
496	O-ring, Bearing Housing	Buna Rubber				
496A	O-ring, Impeller	Glass-Filled Teflon*				
761B	***i-ALERT*** Condition Monitor	Stainless Steel/Epoxy				

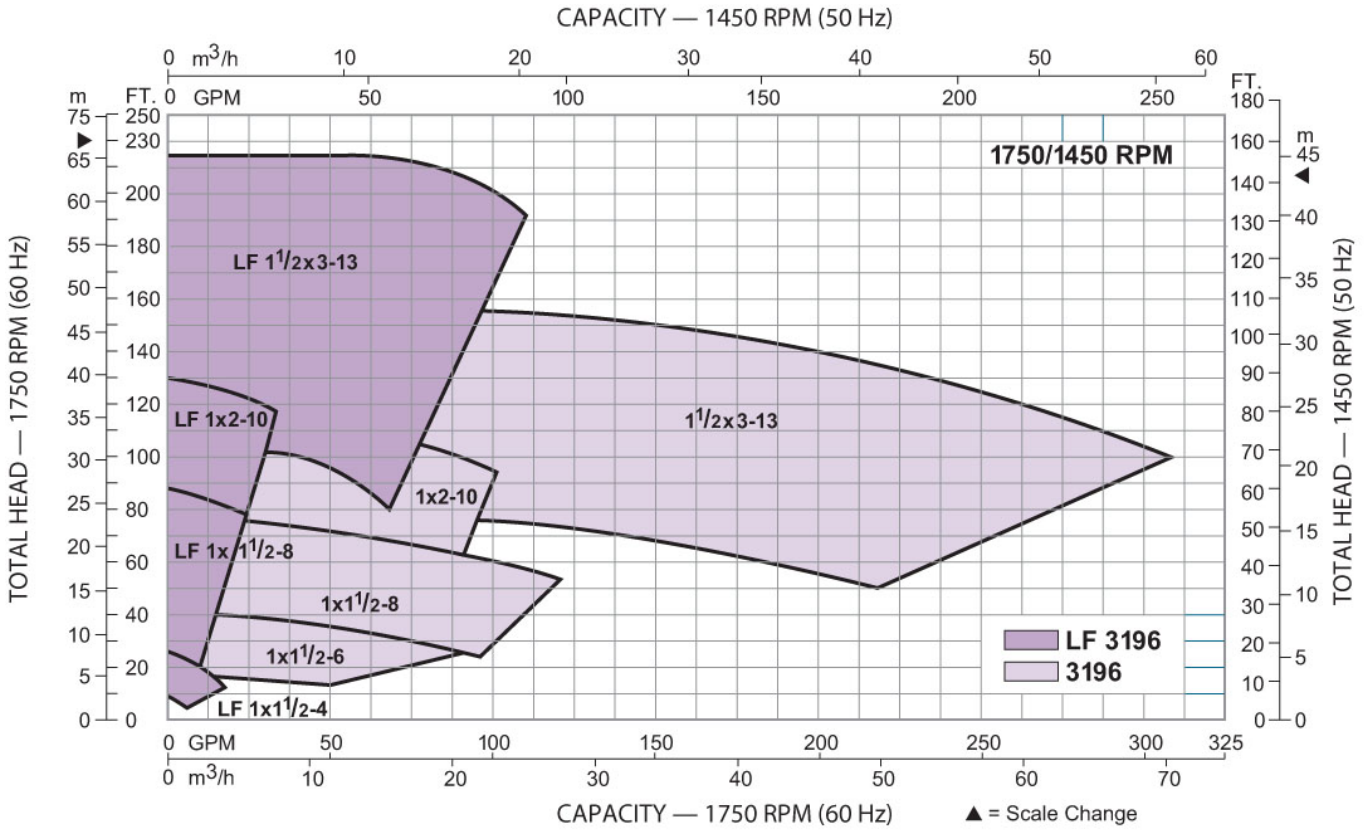
*E.I. DuPont reg. trademark ** ***LTi*** Power End features Duplex Angular Contact

Construction Details All dimensions in inches and (mm).

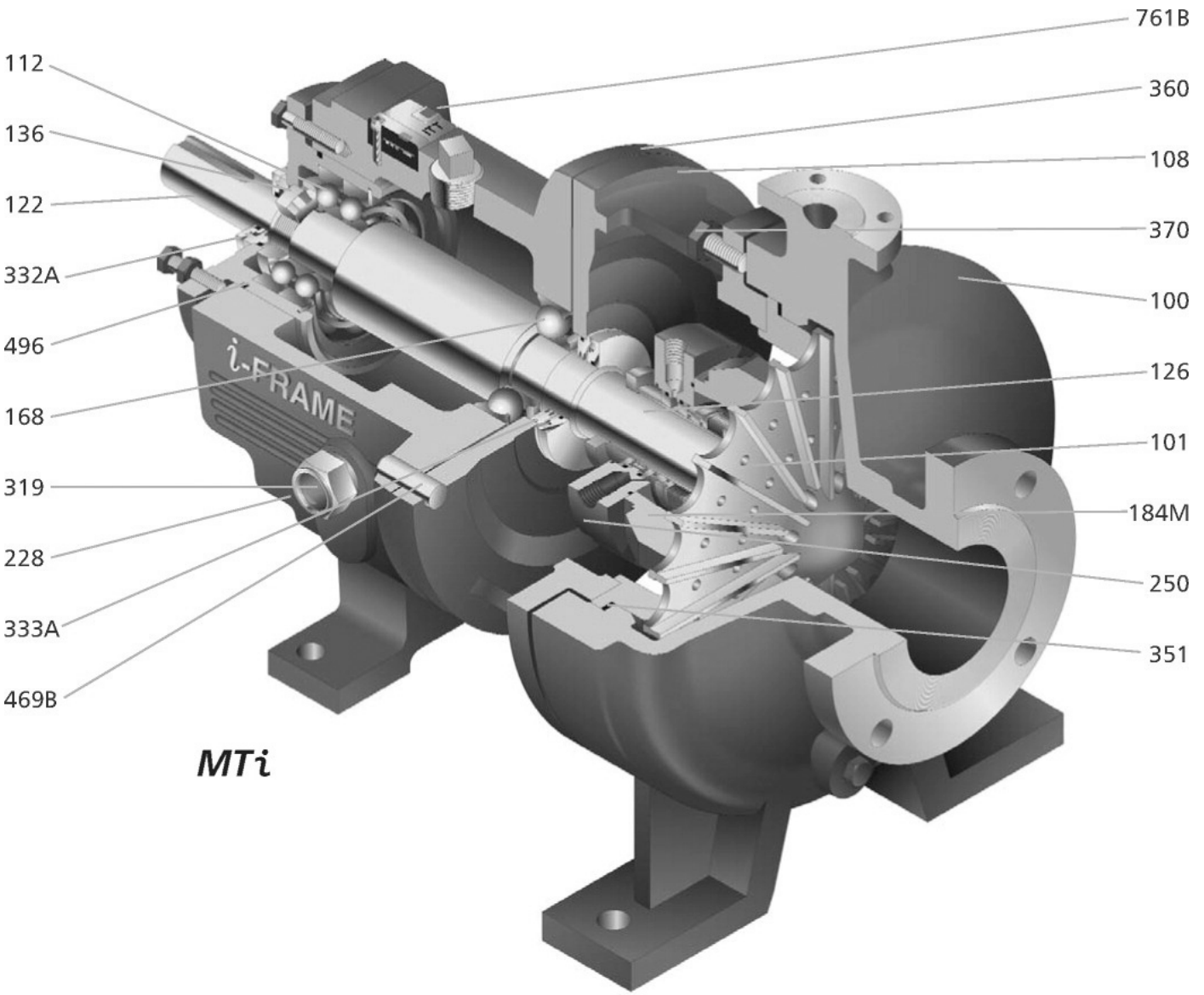
		STi	*MTi*	*LTi*
Shaft	Diameter at Impeller	.75 (19)	1 (25)	1.25 (32)
	Diameter in Stuffing Box/Seal Chamber			
	(Less Sleeve)	1.375 (35)	1.75 (45)	2.125 (54)
	(With Sleeve)	1.125 (29)	1.5 (38)	1.875 (48)
	Diameter Between Bearings	1.5 (38)	2.125 (54)	2.5 (64)
	Diameter at Coupling	.875 (22)	1.125 (29)	1.875 (48)
	Overhang	6.125 (156)	8.375 (213)	8.375 (213)
	Maximum Shaft Deflection	0.002 (0.05)		
Sleeve	O.D. thru Stuffing Box/Seal Chamber	1.375 (35)	1.75 (45)	2.125 (54)
Bearings	Radial	6207	6309	6311
	Thrust	3306	3309	7310
	Bearing Span	4.125 (105)	6.75 (171)	6.875 (164)
BigBore™ Seal Chamber	Bore	2.875 (73)	3.5 (89)	3.875 (98)
Stuffing Box	Bore	2 (51)	2.5 (64)	2.875 (73)
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)	5.6 (4.2)
Maximum Liquid Temperature	Oil/Grease Lubrication without Cooling	350° F (177° C)		
	Oil Lubrication with Finned Cooler	500° F (260° C)		
	Oil Lubrication with	700° F (371° C)		
	High Temperature Option			
Casing	Corrosion Allowance	.125 (3)		

Hydraulic Coverage Model LF 3196 *i-FRAME*™

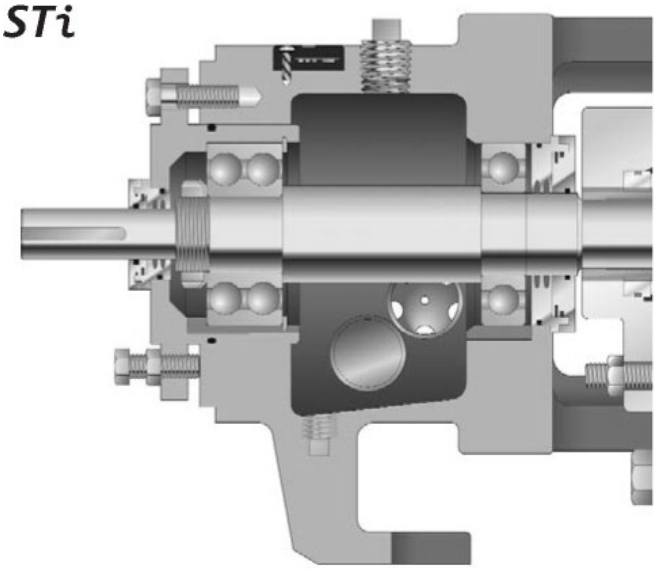




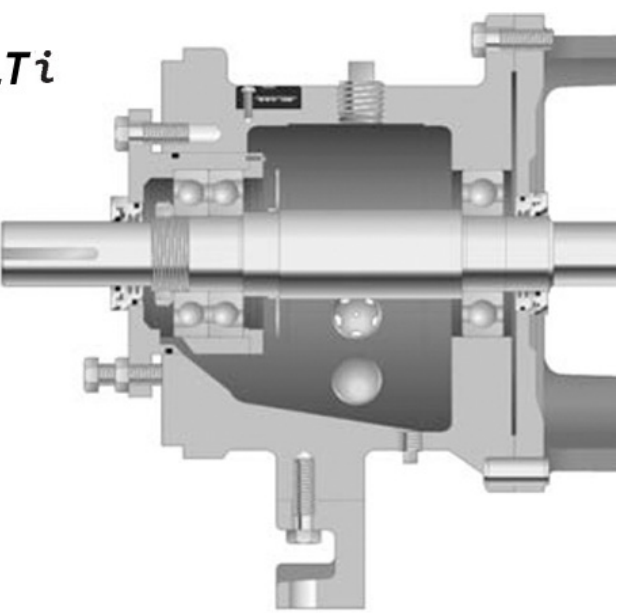
Sectional View Model LF 3196 *i-FRAME™*



STi

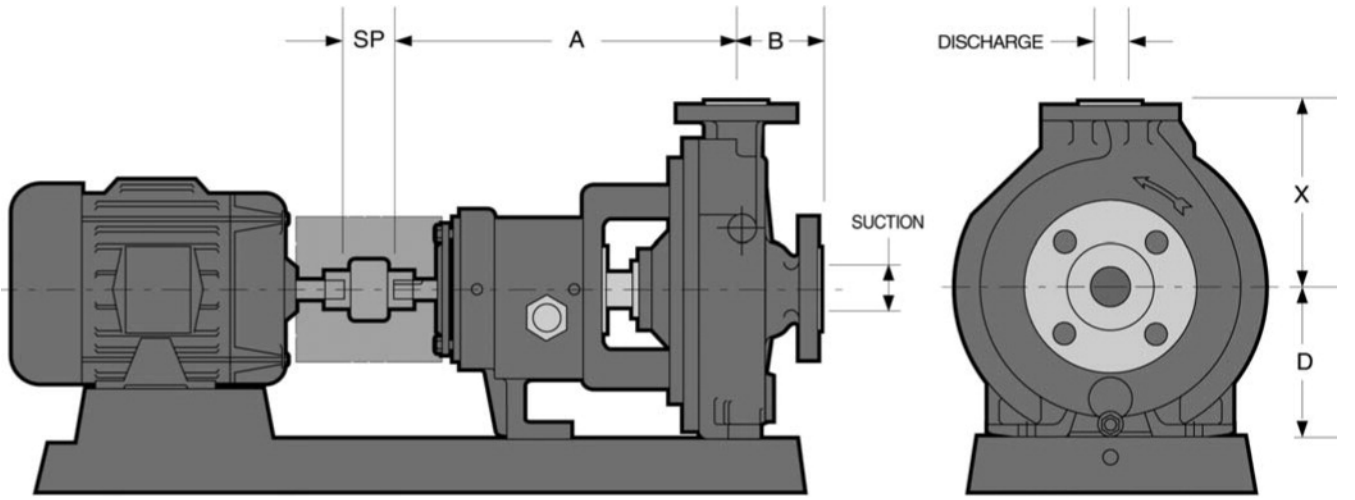


LTi



Dimensions Model LF 3196 *i-FRAME™*

All dimensions in inches and (mm). Not to be used for construction.



DIMENSIONS										
Group	**Pump Size**	**ANSI Designation**	**Discharge Size**	**Suction Size**	**X**	**A**	**B**	**D**	**SP**	**Bare Pump Weight Lbs. (kg)**
STi	1×1½-4	AA	1	1½	6.5 (165)	13.5 (343)	4.0 (102)	5.25 (133)	3.75 (95)	84 (38)
	1×1½-8	AA	1	1½	6.5 (165)	13.5 (343)	4.0 (102)	5.25 (133)	3.75 (95)	100 (45)
MTi	1×2-10	A05	1	2	8.5 (216)	19.5 (495)	4.0 (102)	8.25 (210)	3.75 (95)	200 (91)-*MTi* 245 (111)-*LTi*
LTi	1½×3-13	A20	1½	3	10.5 (267)	19.5 (495)	4.0 (102)	10.0 (254)	3.75 (95)	285 (129)

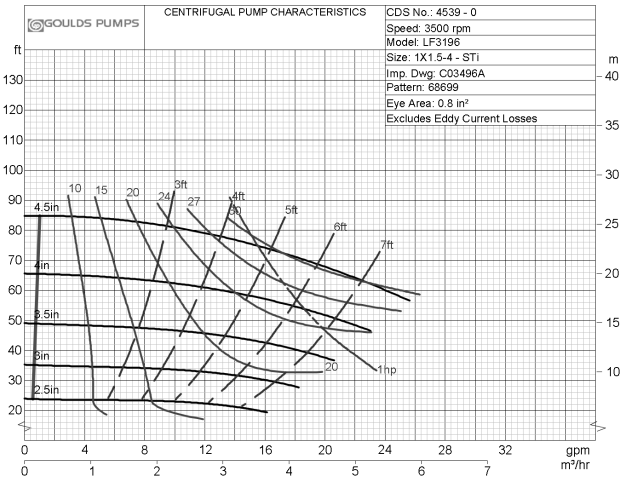
High Temperature LF 3196 *i-FRAME™*

For high temperature services (500˚-700˚F/ 260˚-370˚C), the LF 3196 ***i-FRAME*** is furnished with the following standard features:

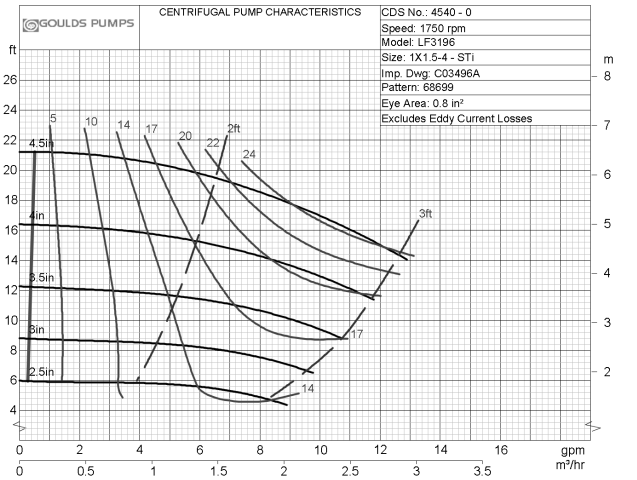
- Centerline-mounted casing
- Graphite casing gasket
- Graphite impeller O-ring
- Jacketed stuffing box
- High temperature bolting
- Stainless steel shaft
- Finned oil cooler

NOTES

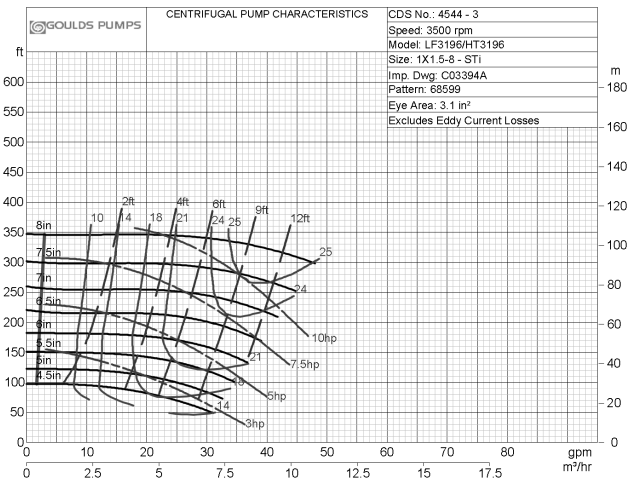
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



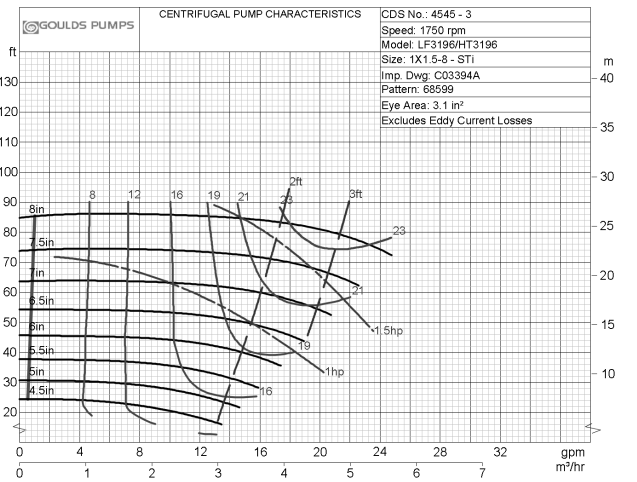
1X1.5-4 **3500rpm**



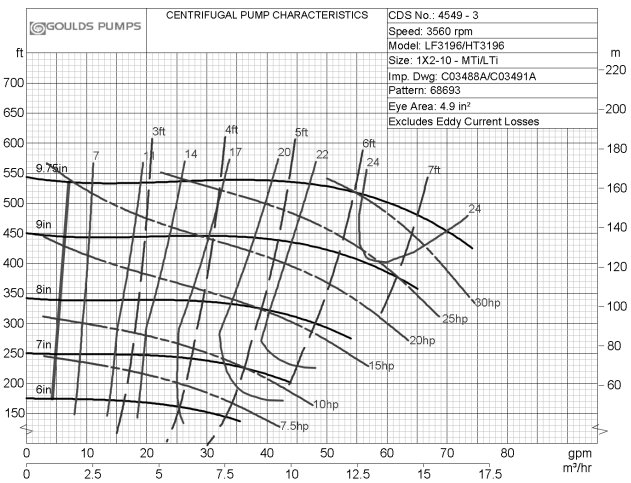
1X1.5-4 **1750rpm**



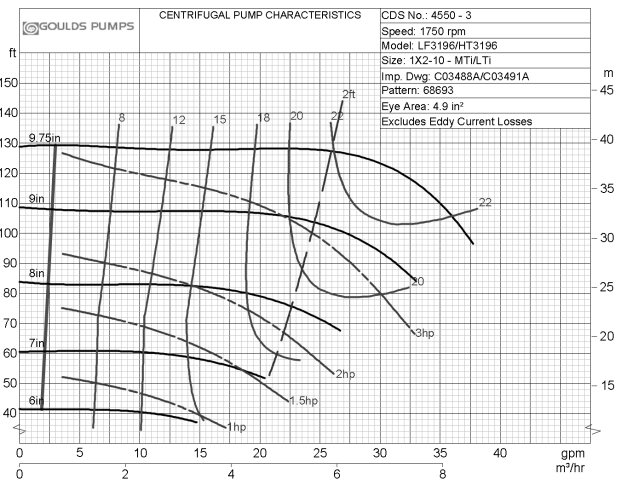
1X1.5-8 **3500rpm**



1X1.5-8 **1750rpm**



1X2-10 **3560rpm**

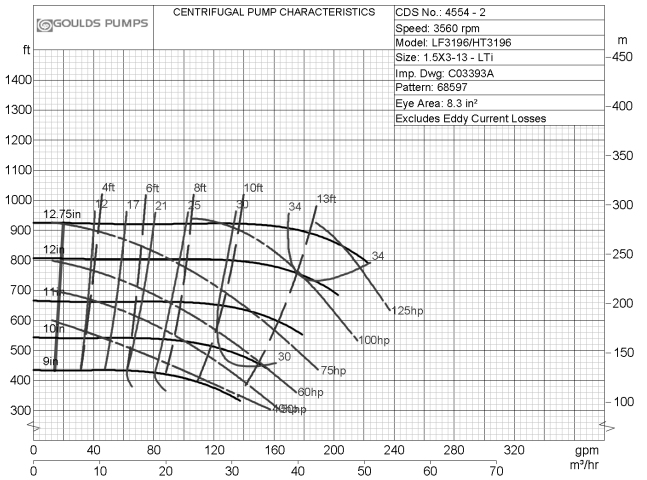


1X2-10 **1750rpm**

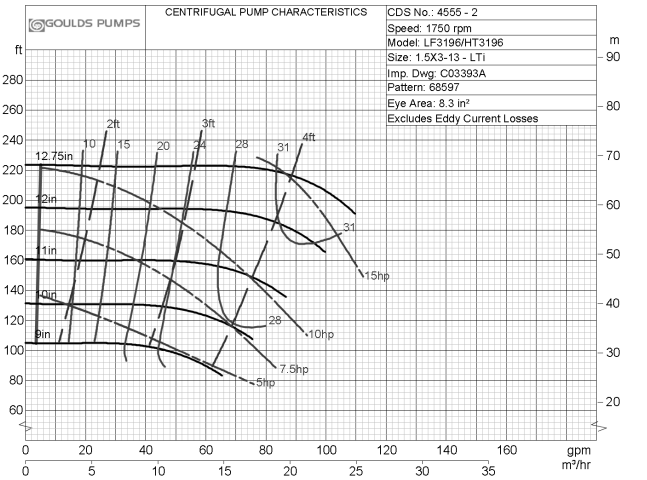
60Hz Curves

Model LF3196/HT3196

The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



1.5X3-13 **3560rpm**



1.5X3-13 **1750rpm**

Goulds Model CV 3196 *i-FRAME™*

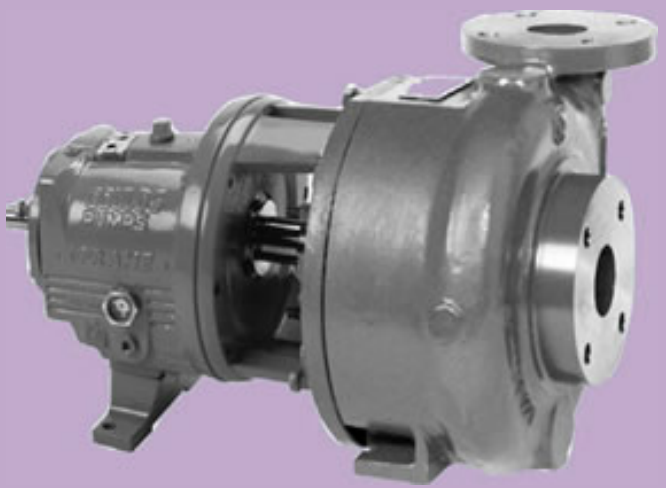
Recessed Impeller Process Pumps Designed for Non-Clog Solids Handling

- Capacities to 2700 GPM (610 m^3/h)
- Heads to 440 feet (134 m)
- Temperatures to 500°F (260°C)
- Pressures to 285 PSIG (1965 kPa)

Model CV 3196 *i-FRAME STi*

(2 × 2 - 8)

The CV 3196 *i-FRAME*™ is designed specifically to provide superior performance for process services containing solids. Goulds concentric volute casing with recessed open impeller provides non-clogging capability with minimal solids degradation. In addition, the CV 3196 can handle liquids entrained with air or gas.



Model CV 3196 *i-FRAME™ MTi/LTi*

(2 × 2 - 10, 3 × 3 - 10, 2 × 3 - 13, 3 × 4 - 13)

Model CV 3196 *LTi* (4 × 6 - 13)

Model CV 3196 *XLT-i* (6 × 8 15)

Performance Features for Solids Handling Services

Extended Pump Life

- Concentric volute casing for non-clog, minimum wear
- Recessed impeller for minimum solids degradation
- TaperBore™ / BigBore™ seal chambers
- ***i-FRAME***™ power ends

Ease of Maintenance

- Back pull-out design
- Most parts interchangeable with Goulds Model 3196 ***i-FRAME***™
- External impeller adjustment
- Easy retrofit

Safety

- ANSI B15.1 coupling guard
- Ductile iron frame adapter

Applications

- Filter slurries
- Latex
- Polystyrene beads
- Crystal suspensions
- Screen rejects
- Hydropulper pump
- Sodium chlorate slurry
- Fruit and vegetable suspensions
- Dye liquor
- Fibrous wastewater
- Long fibre white water
- Primary cleaner pump

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

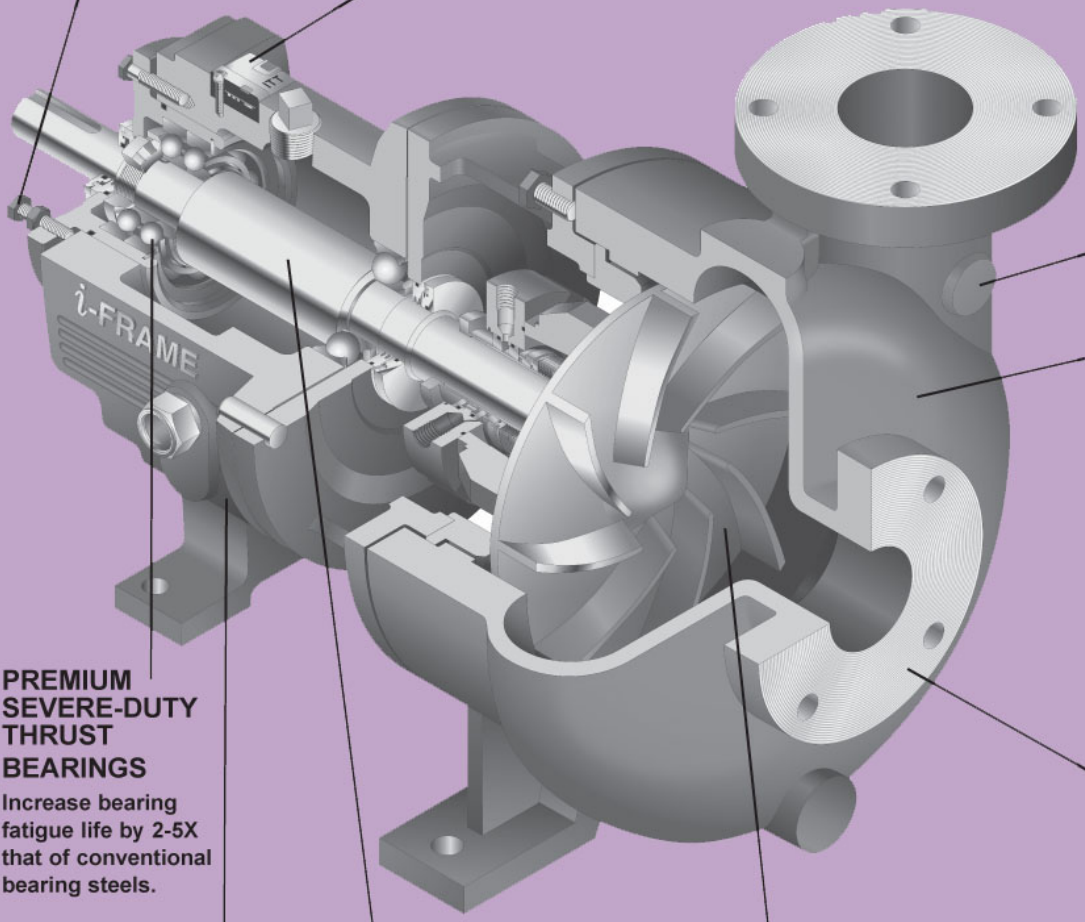
Model CV 3196 *i-FRAME™ Non-Clog* Process Pumps

Design Features for Wide Range of Solids Handling Services

CONTINUOUS PERFORMANCE
Original flow, pressure and efficiency are maintained by simple external adjustment resulting in long-term energy and repair parts savings.

i-ALERT™ CONDITION MONITORING
(U.S. Patent 8,154,417)
Constantly measures vibration and temperature at the thrust bering. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

OPTIONAL FLUSH AND DRAIN CONNECTION
Provide capability to clean impeller and casing without distrubing piping. Scheduled maintenance is easy.



NON-CLOG CIRCULAR CASING
Large open passageways prevent clogging when handling bulky, stringy or fibrous liquids.Circular volute reduces radial loads during low flow operation.

PREMIUM SEVERE-DUTY THRUST BEARINGS
Increase bearing fatigue life by 2-5X that of conventional bearing steels.

SERRATED FLANGES
For positive sealing against leakage. Meets ANSI B16.5 requirements. Class 150 FF standard.

i-FRAME™ POWER END
Designed for reliability and extended pupm life, back with a 5-year warranty.

HEAVY DUTY SHAFT AND BEARINGS
Rigid shaft designed for minimum deflection at seal faces - less than .002 in. (.05 mm). Bearings sized for 10 year average life under tough operating conditions. Available with or without shaft sleeve.

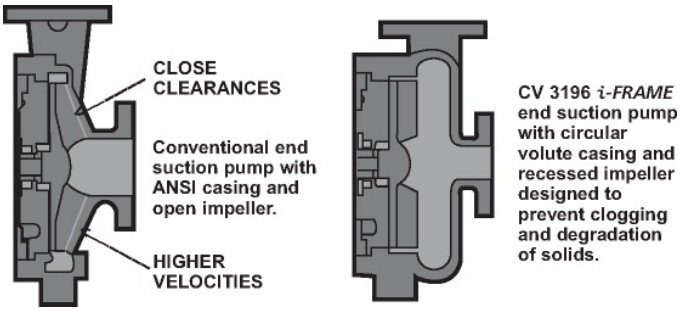
RECESSED IMPELLER
Since impeller is recessed from casing, velocities are low and solids contact with impeller is reduced. Wear rate, solids degradation and shearing of liquid are minimized. Liquids containg significant entrained air or gas can also be pumped.

Goulds Model CV 3196 *i-FRAME™*

Designed for Solids Handling Applications

Not All Pumps Are Designed to Handle Certain Bulky/Fibrous or Shear Sensitive Solids

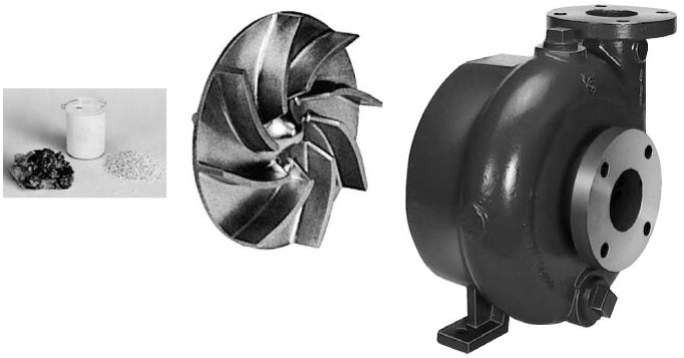
Conventional end suction pumps have close clearances between impeller and casing to maintain efficiency and performance. However, when handling certain bulky, fibrous solids, they can clog. In addition, high velocities in the casing cause increased wear, and can degrade or shear pumpage.



CV 3196 *i-FRAME™* Designed Specifically For Non-Clog Pumping With Minimum Solids Degradation

Since the induced flow or vortex impeller is recessed from the casing, velocities are low, and solids contact with the impeller is reduced, wear rate, solids degradation and shearing of liquid are minimized.

The casing design is well suited to handling solids in liquid suspension. Anything that can exit the discharge will pass through the pump.

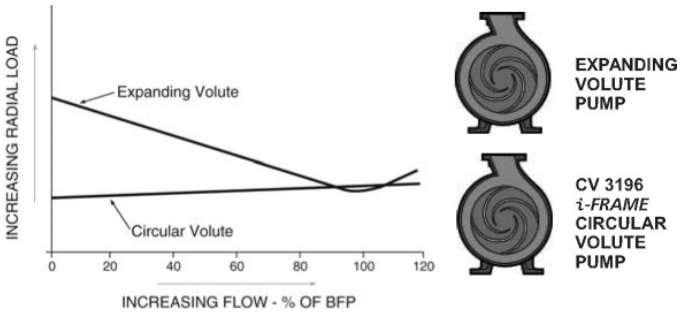


Reduced Radial Loads

Trouble-Free Operation At Low Flows

Many users throttle pumps to attain desired low flow performance. Because most pumps are not designed to operate continuously in this range, the resultant higher radial loads and increased shaft deflection lead to premature bearing and mechanical seal failure.

An added benefit of recessed impeller pumps is reliable operation at low flows. The CV 3196 ***i-FRAME*** uses a concentric casing which reduces radial loads by as much as 85% compared to end suction expanding volute pumps at low flows. Bearing, seal and overall pump life are optimized.



Easy Replacement or Retrofit

PUMP REPLACEMENT

Since the CV 3196 ***i-FRAME*** foot mounting dimensions are the same as ANSI pumps, replacing ANSI pumps not designed to handle solids is simple…the inadequate pump is easily replaced by the appropriate size Model CV 3196 ***i-FRAME***.

PUMP RETROFIT

The CV 3196 uses all Goulds Model 3196 ***i-FRAME*** parts except casing and impeller, making pump retrofit and upgrade easy and economical.

A CV 3196 *i-FRAME* retrofit kit (casing and impeller) easily converts an existing 3196.

Parts List and Materials of Construction

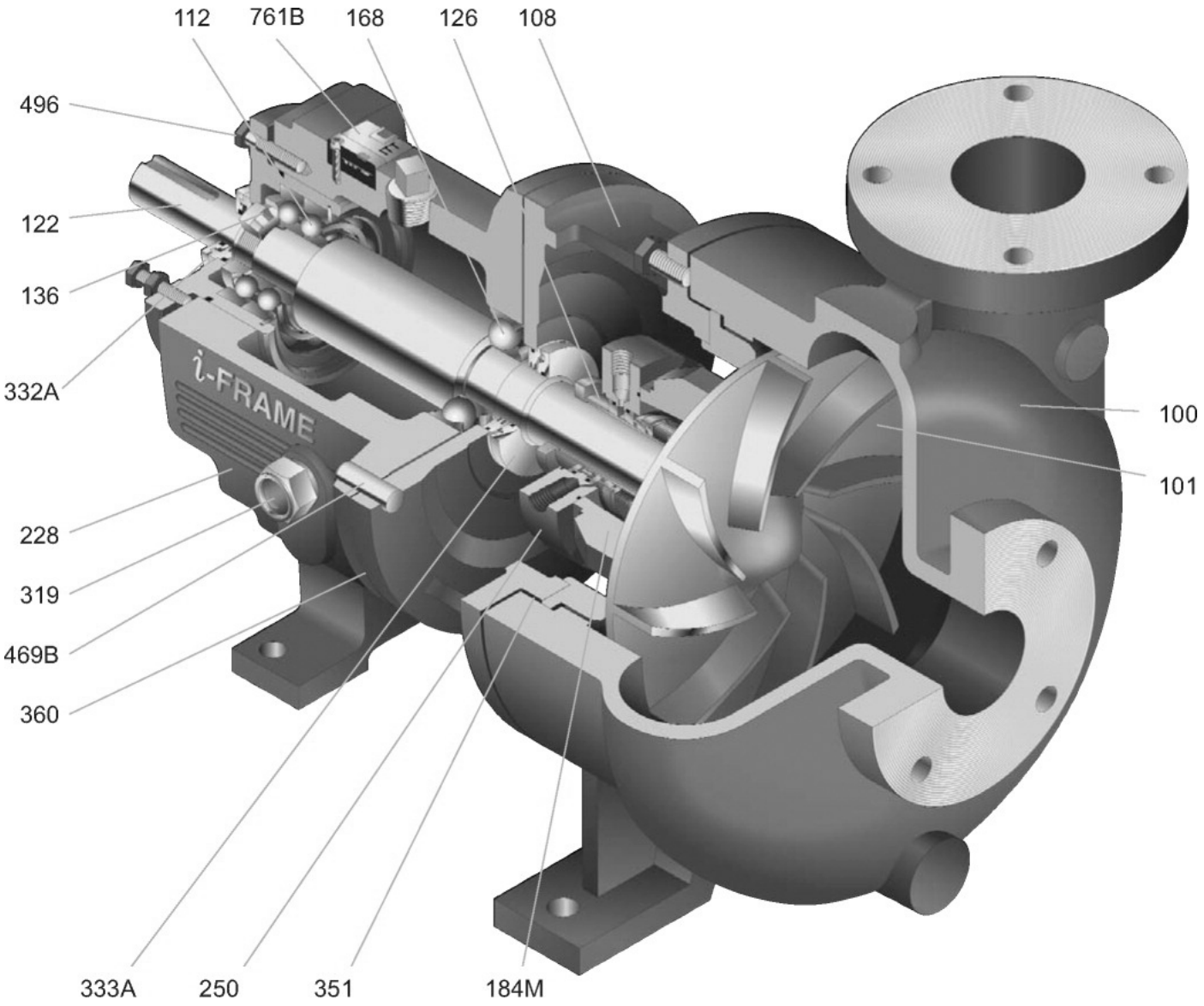
Item Number	Part Name	Material			
		Ductile Iron/CD4MCuN Trim	CD4MCuN	Alloy 20	Hastelloy B & C
100	Casing	Ductile Iron	CD4MCuN	Alloy 20	Hastelloy
101	Impeller	CD4MCuN	CD4MCuN	Alloy 20	Hastelloy
105	Lantern Ring (Not Illustrated)	Glass-Filled Teflon*			
106	Stuffing Box Packing (Not Illustrated)	Teflon* Impregnated Fibers			
108	Frame Adapter	Ductile Iron			
112	Thrust Bearing	Double Row Angular Contact Conrad**			
122	Shaft—Less Sleeve (Optional)	SAE4140	316SS	Alloy 20	Hastelloy
122	Shaft—With Sleeve	SAE4140			316SS
126	Shaft Sleeve	316SS	Alloy 20		Hastelloy
136	Bearing Locknut and Lockwasher	Steel			
168	Radial Bearing	Single Row Deep Groove			
184	Stuffing Box Cover (Packed Box)	Ductile Iron	CD4MCuN	Alloy 20	Hastelloy
184M	Seal Chamber (Mechanical Seal)	Ductile Iron	CD4MCuN	Alloy 20	Hastelloy
228	Bearing Frame	Cast Iron (Ductile Iron for STX Group)			
250	Gland	316SS	CD4MCuN	Alloy 20	Hastelloy
262	Repeller/Sleeve (Dynamic Seal Option)	CD4MCuN		Alloy 20	Hastelloy
264	Gasket, Cover-to-Backplate (Dynamic Seal)	Teflon*			
265A	Stud/Nut, Cover-to-Adapter	304SS			
319	Oil Sight Glass	Glass/Steel			
332A	INPRO ® Labyrinth Oil Seal (Outboard)	Stainless Steel / Bronze			
333A	INPRO ® Labyrinth Oil Seal (Inboard)	Stainless Steel / Bronze			
351	Casing Gasket	Aramid Fiber with EPDM Rubber			
358A	Casing Drain Plug (Optional)	Steel	Alloy 20	Alloy 20	Hastelloy
360	Gasket, Frame-to-Adapter	Buna			
370	Cap Screw, Adapter-to-Casing	Steel	304SS		
412A	O-ring, Impeller	Glass-Filled Teflon*			
418	Jacking Bolt	304SS			
444	Backplate (Dynamic Seal Option)	Ductile Iron	CD4MCuN	Alloy 20	Hastelloy
469B	Dowel Pin	Steel			
496	O-ring, Bearing Housing	Buna Rubber			
761B	*i - ALERT* Condition Monitor	Stainless Steel / Epoxy			

*E.I. DuPont Reg. Trademark ***LTi* Power End features Duplex Angular Contact

Construction Details All dimensions in inches and (mm).

		STi	*MTi*	*LTi*	*XLTi*
Shaft	Diameter at Impeller	.75 (19)	1 (25)	1.25 (32)	1.5 (38)
	Diameter in Stuffing Box/Seal Chamber				
	(Less Sleeve)	1.375 (35)	1.75 (45)	2.125 (54)	2.5 (64)
	(With Sleeve)	1.125 (29)	1.5 (38)	1.875 (48)	2 (51)
	Diameter Between Bearings	1.5 (38)	2.125 (54)	2.5 (64)	3.125 (79)
	Diameter at Coupling	.875 (22)	1.125 (29)	1.875 (48)	2.375 (60)
	Overhang	6.125 (156)	8.375 (213)	8.375 (213)	9.969 (253)
	Maximum Shaft Deflection	0.002 (0.05)			
Sleeve	O.D. thru Stuffing Box/Seal Chamber	1.375 (35)	1.75 (45)	2.125 (54)	2.5 (64)
Bearings	Radial	6207	6309	6311	6313
	Thrust	3306	3309	7310 BECBM	3313
	Bearing Span	4.125 (105)	6.75 (171)	6.875 (164)	9.25 (235)
BigBore™ Seal Chamber	Bore	2.875 (73)	3.5 (89)	3.875 (98)	4.75 (121)
Stuffing Box	Bore	2 (51)	2.5 (64)	2.875 (73)	3.375 (86)
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)	6.6 (4.9)	14.0 (10.5)
Maximum Liquid Temperature	Oil/Grease Lubrication without Cooling	350° F (177° C)			
	Oil Lubrication with Finned Cooler	500° F (260° C)			
Casing	Corrosion Allowance	.125 (3)			

Sectional View **Model CV 3196 *i-FRAME™***



Bonus Interchangeability

i-FRAME™ Power Ends Fit 7 Different Process Pumps

Minimize inventory, reduce downtime.

3196 *i-FRAME*
Process Pumps

CV 3196
i-FRAME
Non-Clog
Process Pumps

HT 3196
i-FRAME
High Temperature
Process Pumps

LF 3196
i-FRAME
Low Flow ANSI
Process Pumps

3198 *i-FRAME*
PFA TEFLON®-Lined
Process Pumps

3796 *i-FRAME*
Self-Priming
Process Pumps

NM 3196
i-FRAME
Non-Metallic
Process Pumps

Goulds Patented *i-FRAME™* Power Ends

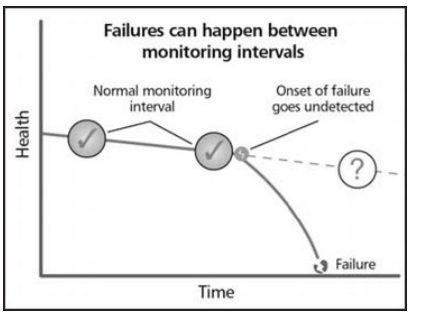
Extended Pump Life Through Intelligent Design

Goulds ***i-FRAME*** Power Ends are the result of 160 years of design experience, customer interaction, and continuous improvement. Customers get extended Mean Time Between Failure (MTBF) and lower life cycle costs (LCC)...guaranteed!

1 *i-ALERT™* CONDITION MONITOR

The heart of the *i-FRAME*, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

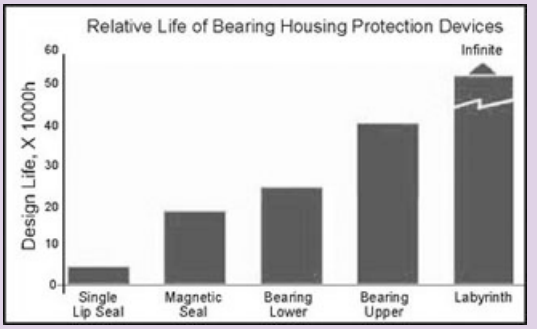
A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



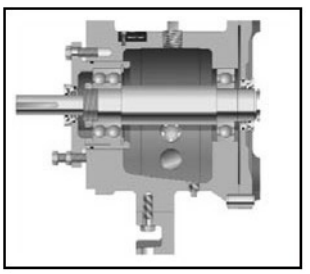
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

2 INPRO VBXX-D HYBRID BEARING ISOLATORS

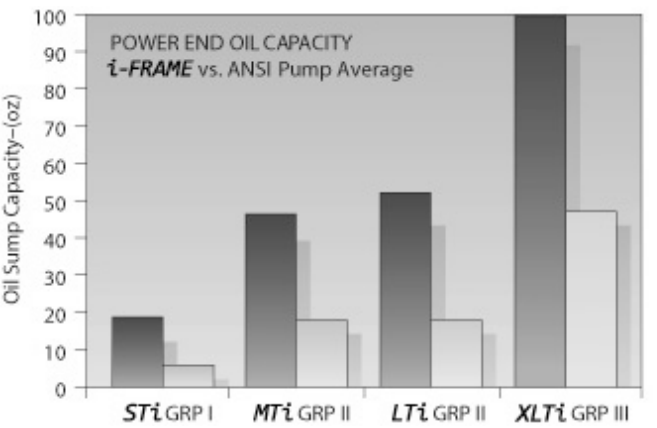
Most bearings fail before reaching their potential life. They fail for a variety of reasons, including contamination of the lubricant. INPRO VBXX-D has long been considered the industry standard in bearing lubricant protection. The ***i-FRAME*** now improves upon that design by offering stainless steel rotors, for maximum protection against contaminants and the corrosive effects of seal leakage or environmental conditions. These seals are non-contacting and do not wear.



3 OPTIMIZED OIL SUMP DESIGN



Internal sump geometry is optimized for longer bearing life. Sump size increased by 10%-20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.



Larger *Means Cooler*
GOULDS
Industry Average

4 SHAFT AND BEARINGS ENGINEERED FOR MAXIMUM RELIABILITY

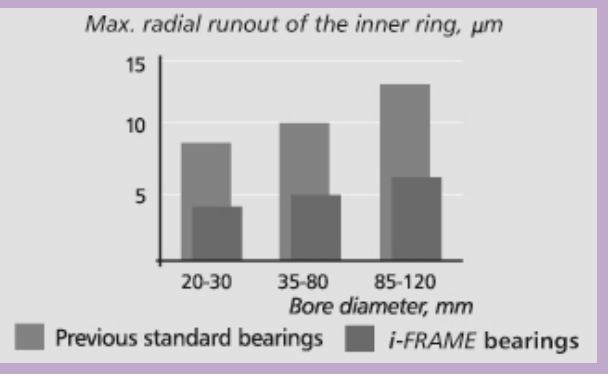
The rugged shaft and bearing combination maintains shaft deflection of less than 0.002 inches at all operating points. The result is longer seal and bearing life.

Premium severe-duty thrust bearings increase bearing fatigue life.

- High purity steels have fewer inclusions than standard steel – better grain structure and wear resistance.
- Heat treatment of bearing elements to SO stabilizaion levels provides superior thermal stability for increased service life.
- Bearing Balls are manufactured to at least one ISO grade above standard (ISO P5 for ring running accuracy and ISO P6 for dimensions). The result is reduced vibration and noise for improved shaft guidance.

Every 3196 ***i-FRAME***™ Power End is engineered and manufactured for optimal pump performance and increased MTBF.

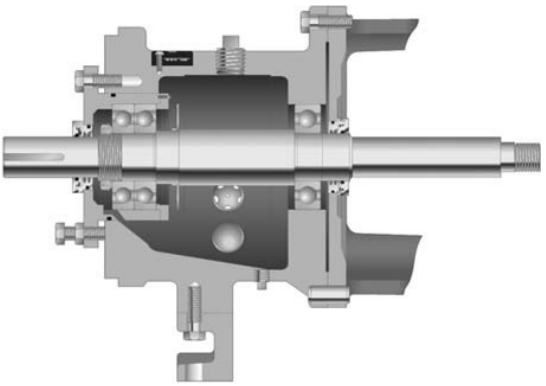
ANSI B73.1 Shaft Specification	Meets	Exceeds
Diameter Tolerance		✓
Surface Finish		✓
Runout	✓	
Deflection		✓



5 *LTi* POWER END FOR HIGH LOAD APPLICATIONS

Increased L'10 Bearing Life 150% to 200% on the Toughest Applications

Ideal for tough conditions when a power end is pushed beyond ANSI limits: operating at low flows and higher heads, pumping high specific gravity liquids, fluctuating process conditions, overhung belt drive. Oversized shaft and bearing assembly significantly expands the limits for long, trouble-free bearing and seal life. On high load applications, the *LTi* power end improves bearing life 150%-200%; oil operating temperature reduced by 45°F (25° C).



FLINGER/CHANNEL OIL LUBRICATION SYSTEM

Provides 30% increased L'10 life; 15°F (8°C) reduced oil temperature.

OVERSIZED SHAFT

With duplex thrustbearings provide increased L'10 by 40%.

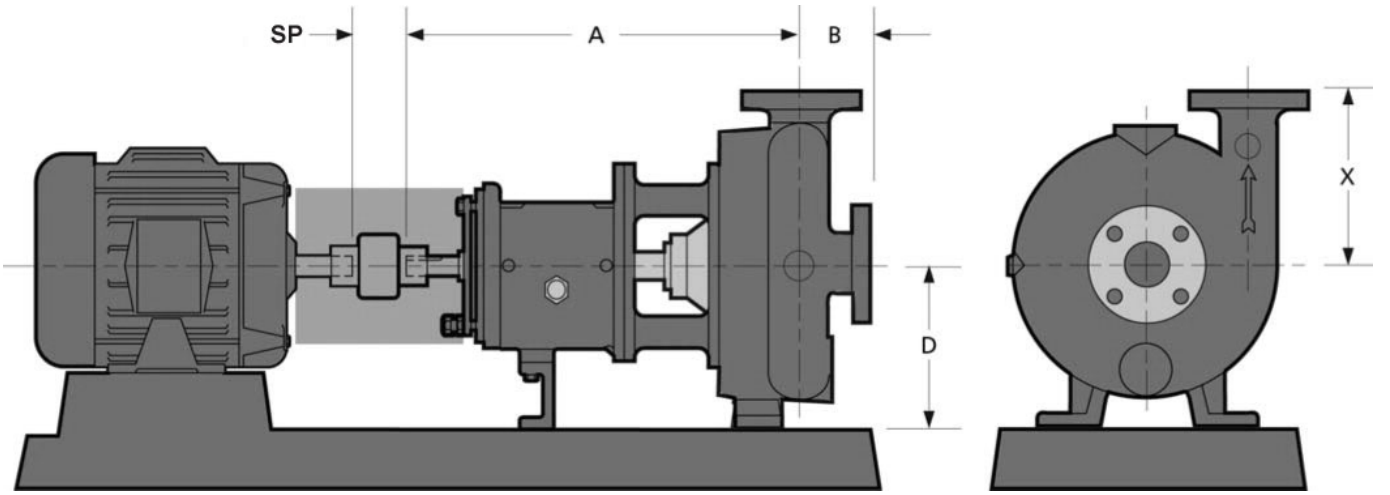
DUPLEX THRUST BEARINGS

Duplex thrust bearings (40°/40° angular contact) with machined brass cages, are ideally sized for high load applications.

Our Guarantee We are so confident that the ***i-FRAME***™ is the most reliable Power End in the industry, that we are proud to offer a standard 5-year warranty on every ***i-FRAME*** ANSI Process Pump.

Dimensions Model CV 3196 *i-FRAME™*

All dimensions in inches and (mm). Not to be used for construction.



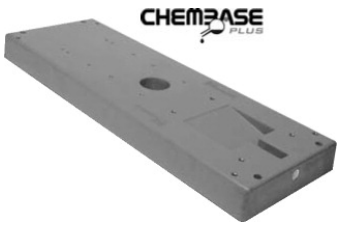
DIMENSIONS							
Group	Size	A	B	D	X	SP	Bare Pump Weight Lbs. (kg)
STi	2×2-8	15.38 (391)	2.75 (70)	5.25 (133)	6.50 (165)	3.75 (95)	140 (65)
MTi / LTi	2×2-10	21.75 (552)	3.50 (89)	8.25 (210)	8.50 (216)	3.75 (95)	260 (120)
	3×3-10	22.50 (572)	4.25 (108)	8.25 (210)	9.00 (229)	3.75 (95)	280 (125)
	2×3-13	22.38 (568)	4.12 (105)	10.00 (254)	10.50 (267)	3.75 (95)	360 (165)
	3×4-13	22.81 (579)	4.12 (105)	10.00 (254)	10.50 (267)	3.75 (95)	410 (185)
LTi	4×6-13	23.13 (588)	4.75 (121)	10.00 (254)	11.50 (292)	3.75 (95)	430 (194)
XLTi	6×8-15	32.5 (826)	6.5 (165)	14.5 (368)	14.00 (356)	5.25 (133)	486 (219)

Baseplate Mounting Options

Goulds offers a complete range of mounting systems to meet plant reliability requirements and to make alignment and maintenance easier.

CAMBER TOP CAST IRON

Rigid and corrosion resistant, it is preferred by many plants.



CHEMBASE PLUS™

Polymer concrete construction provides exceptional rigidity & corrosion resistance. ANSI 1991 dimensional.

FABRICATED STEEL

Economical baseplate that meets ANSI/ASME B73.1M current edition dimensional requirements.

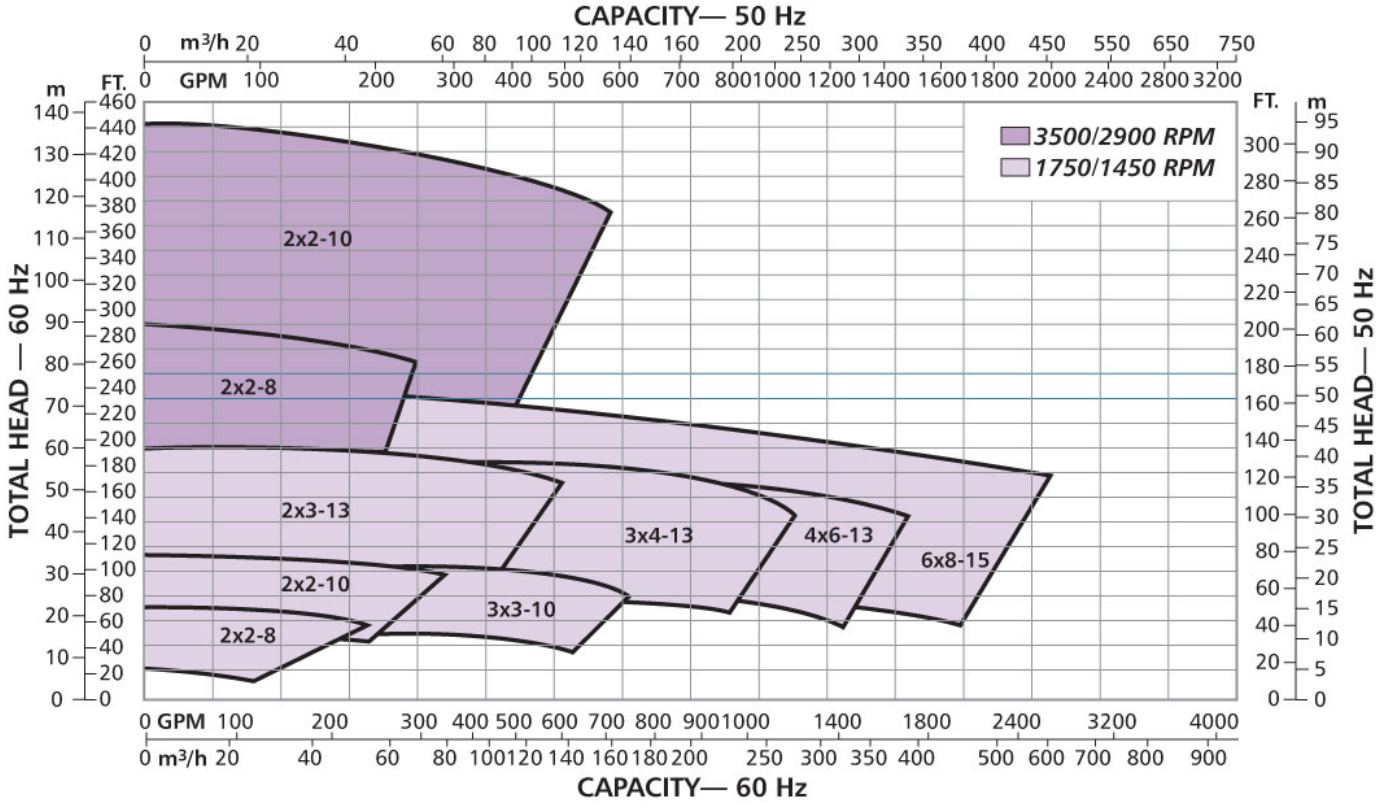
ENHANCED FEATURE FABRICATED STEEL

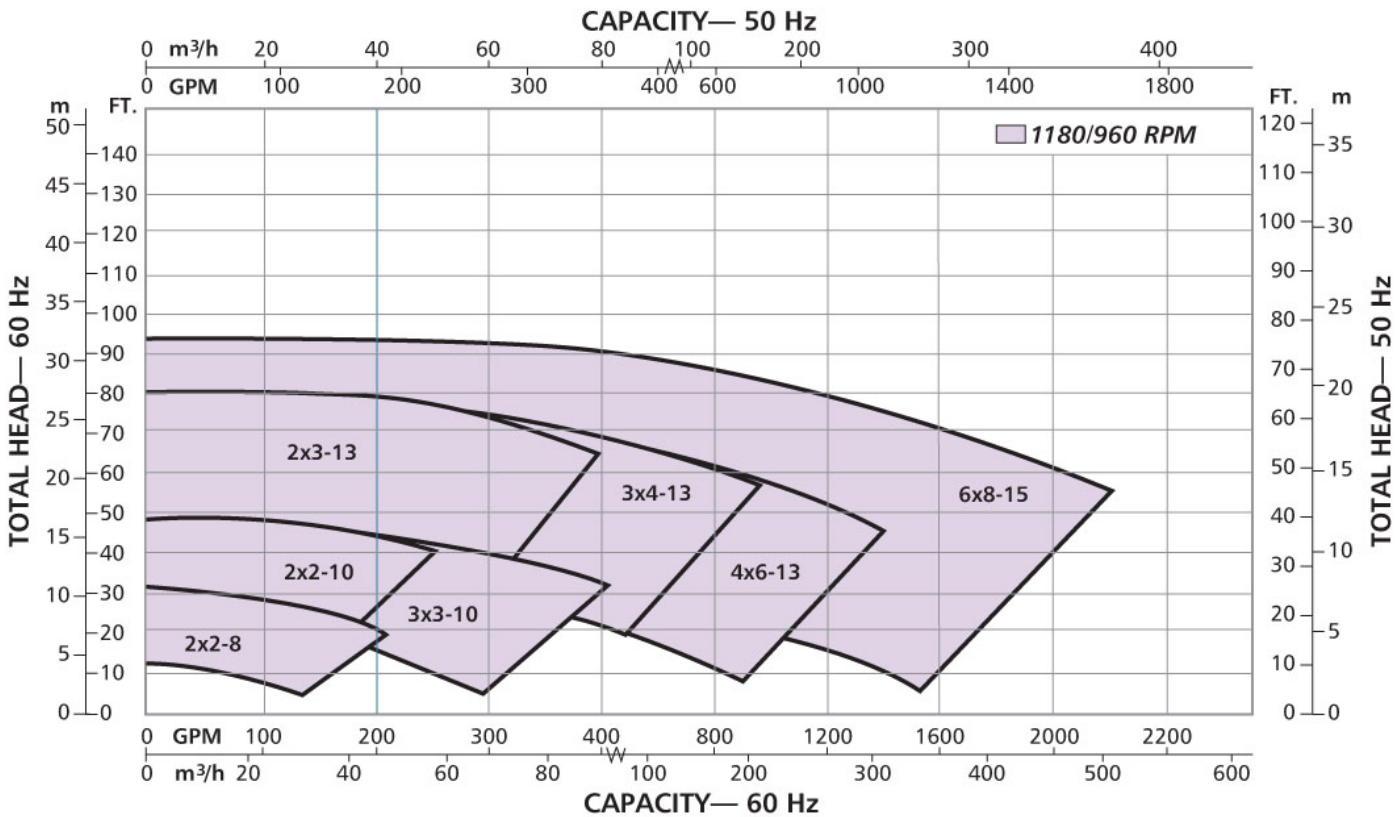
Upgraded ANSI baseplate designed to maximize pump operation life and ease installation by meeting API-minded chemical pump users' toughest requirements.

Member of Hydraulic Institute

Refer to section CHEM-1A (Model 3196) for Baseplate Selection Guide.

Hydraulic Coverage Model CV 3196 *i-FRAME™*





NOTES

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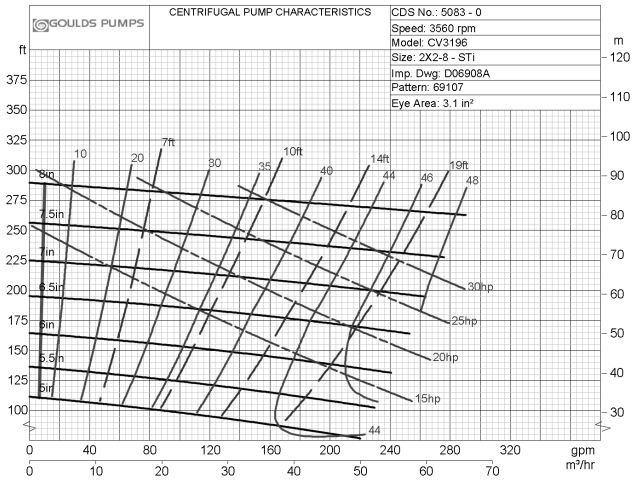
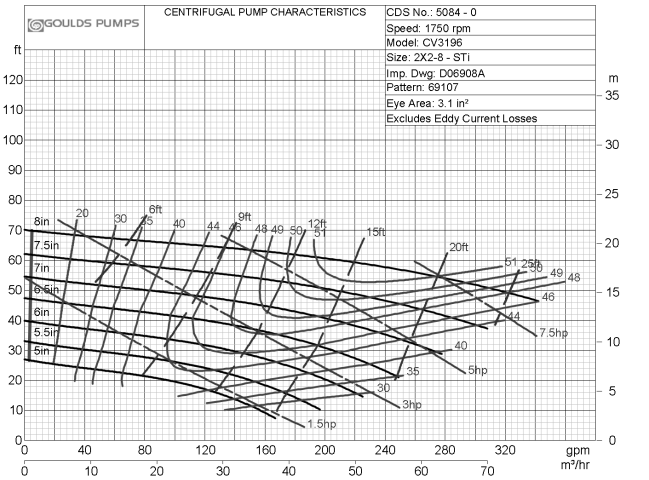
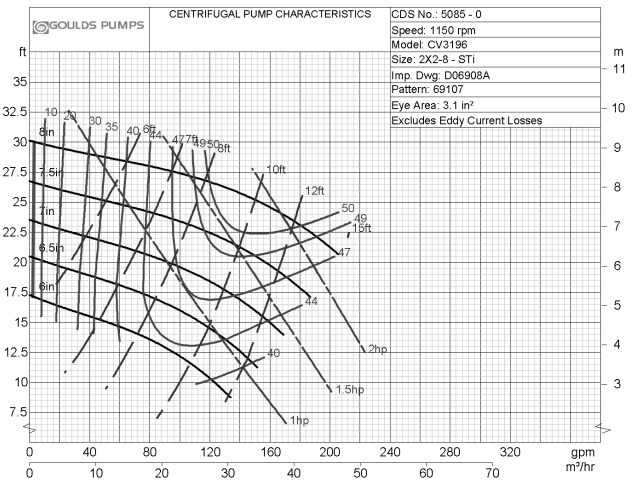


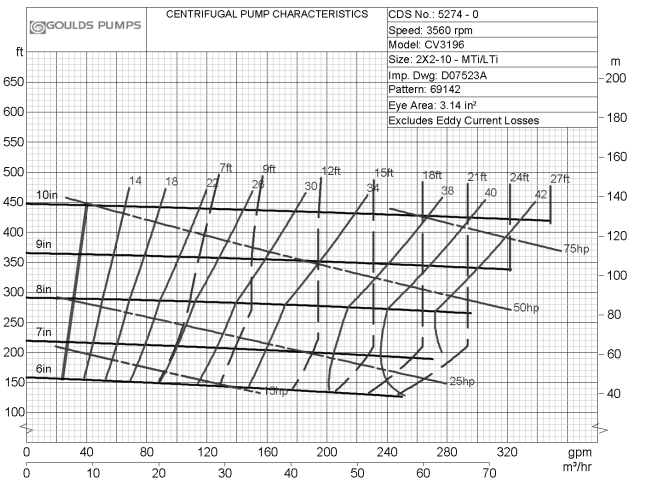
2X2-8 **3560rpm**



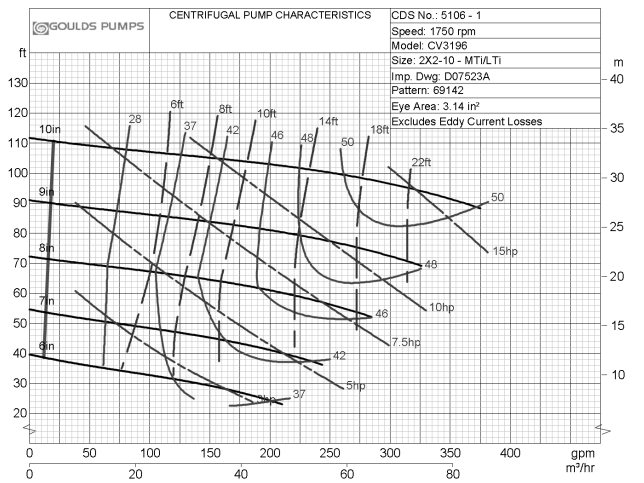
2X2-8 **1750rpm**



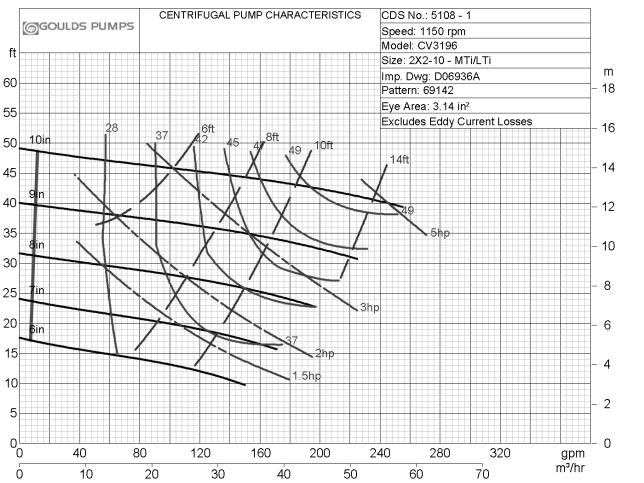
2X2-8 **1150rpm**



2X2-10 **3560rpm**



2X2-10 **1750rpm**



2X2-10 **1150rpm**

60Hz Curves

Model CV3196

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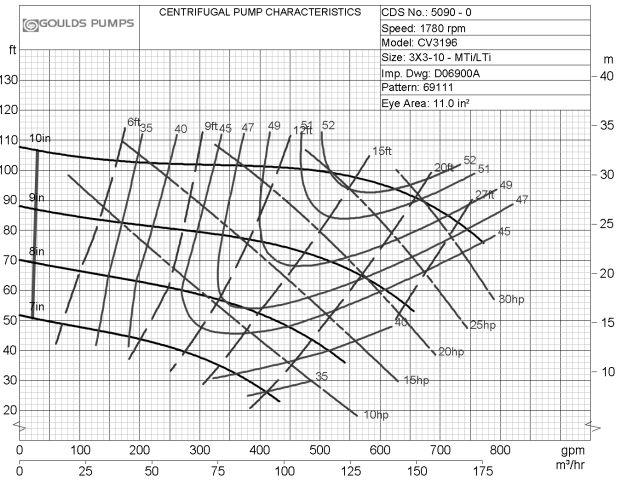
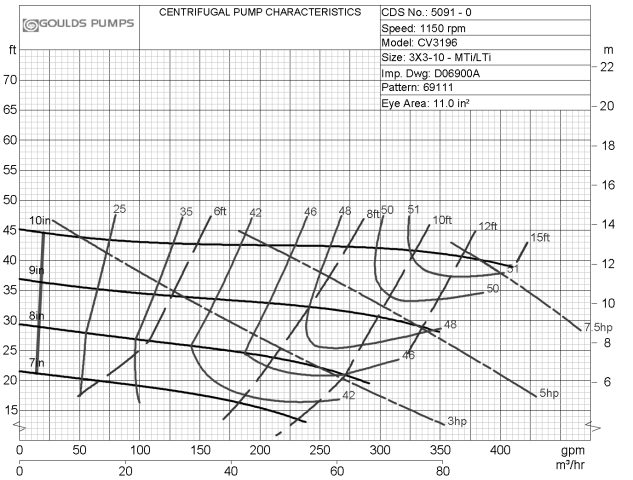
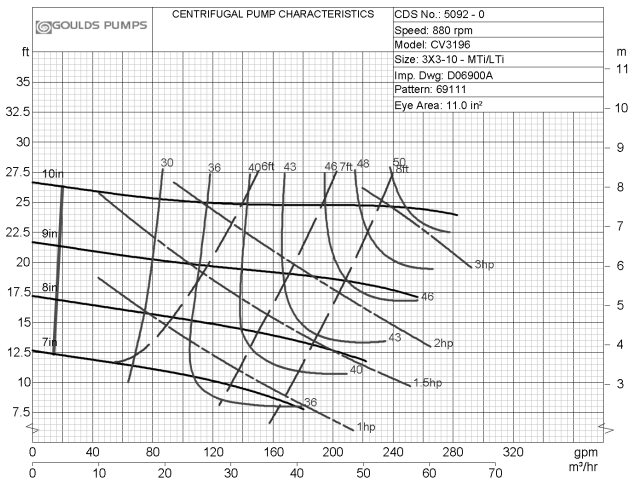


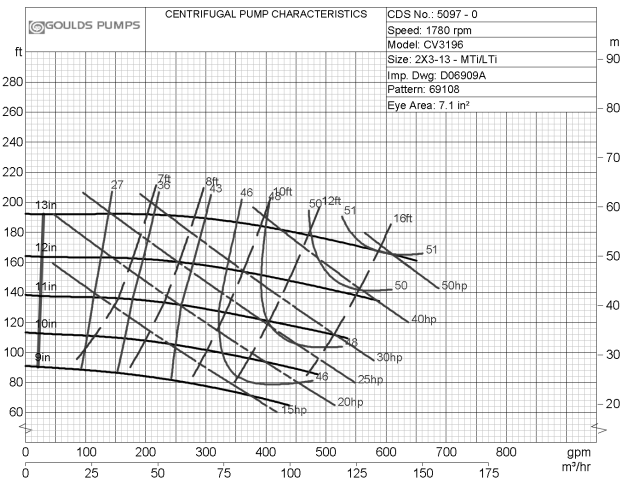
3X3-10 **1780rpm**



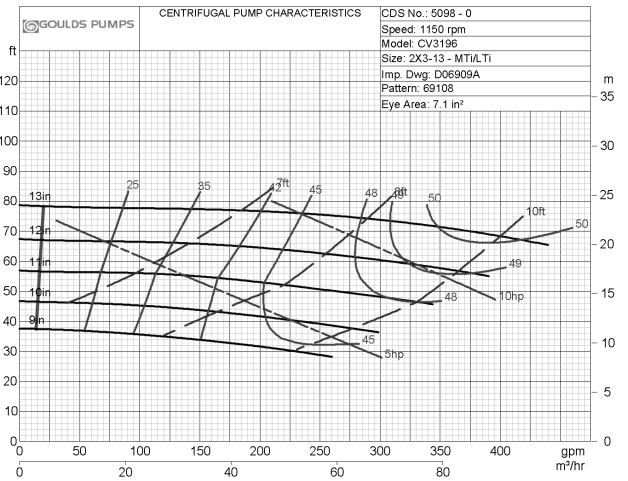
3X3-10 **1150rpm**



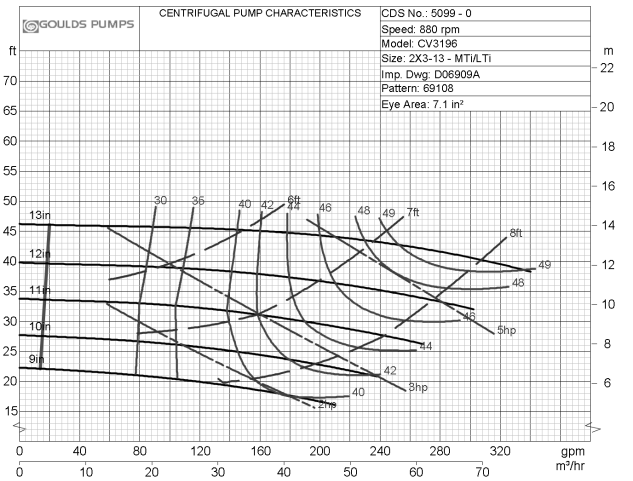
3X3-10 **880rpm**



2X3-13 **1780rpm**



2X3-13 **1150rpm**



2X3-13 **880rpm**

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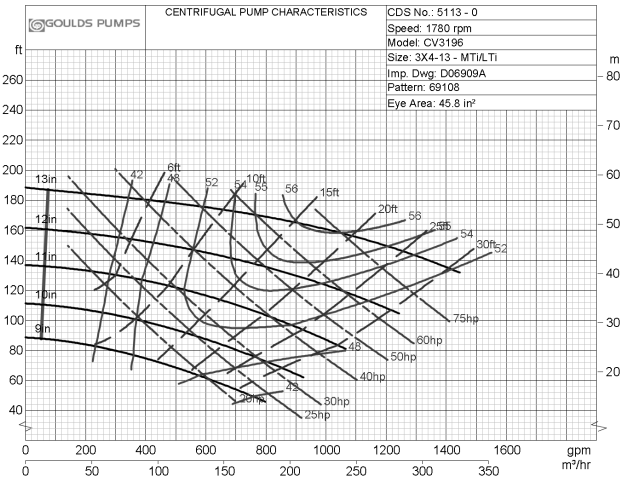
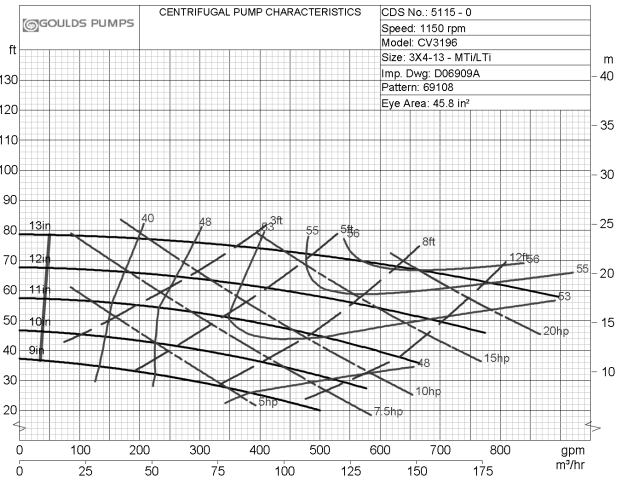
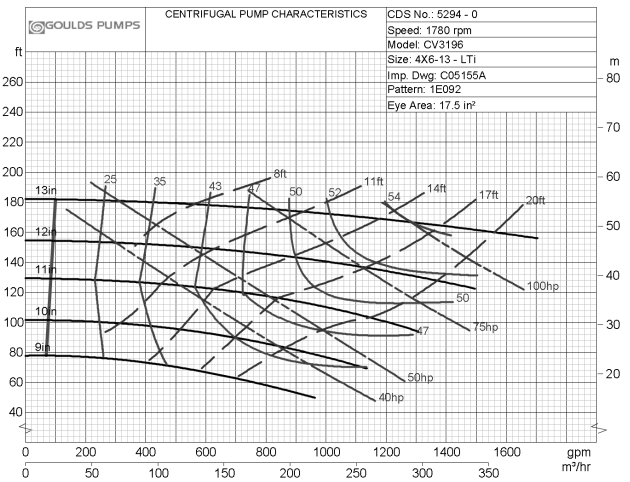


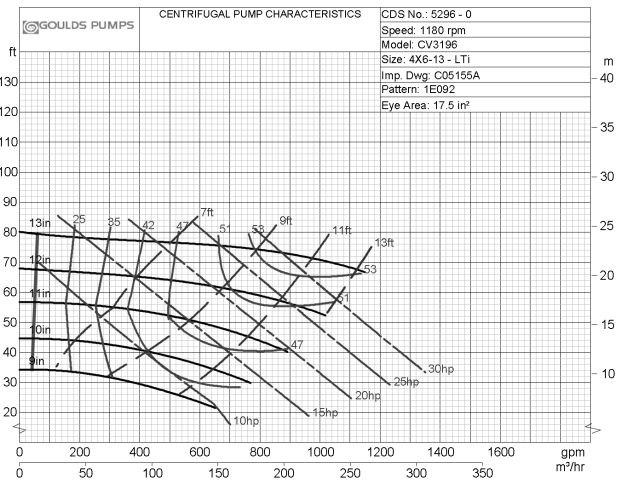
3X4-13 **1780rpm**



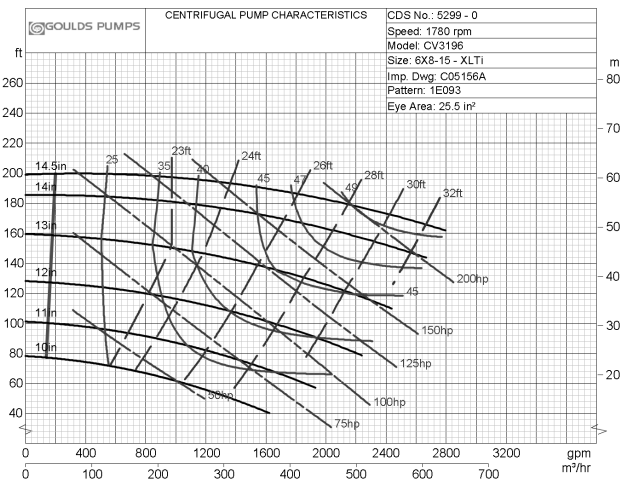
3X4-13 **1150rpm**



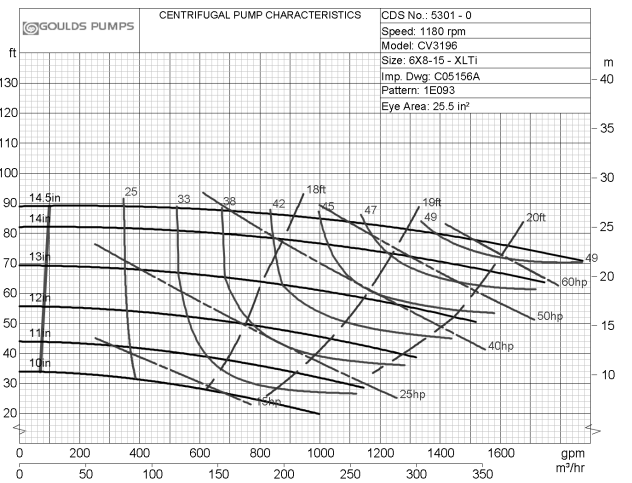
4X6-13 **1780rpm**



4X6-13 **1180rpm**



6X8-15 **1780rpm**



6X8-15 **1180rpm**

NOTES

Model 3796 *i-FRAME STi*

(1×1½-6, 1½×1½-8)

Goulds Model 3796 *i-FRAME*™ process pump line is specifically designed to provide superior performance for self-priming services of the Chemical Process Industries.

Model 3796 *i-FRAME MTi*

(2×2-10, 3×3-10, 4×4-10, 3×3-13, 4×4-13, 6×6-13)

Goulds Model 3796 *i-FRAME*™

Self-Priming Process Pumps with Patented Intelligent Monitoring

- Capacities to 1,250 GPM (284 m^3/h)
- Heads to 430 feet (131 m)
- Temperatures to 500° F (260° C)
- Pressures to 375 PSIG (2,586 kPa)
- Effective static lift to 20 feet (6 m)

Performance Features for Self-Priming Services

Extended Pump Life

- One-piece casing with integral priming and air separation (no external priming chamber or air separator required)
- No suction check valve required
- Rapid priming time
- Positive retention of pumpage under siphon conditions
- Self-purge of vapors
- *i-FRAME*™ Power Ends

Ease of Maintenance

- Back pull-out design (one craft maintenance)
- Parts interchangeable with Goulds Model 3196
- External impeller adjustment
- Easy retrofit

Safety

- ANSI B15.1 coupling guard
- Ductile iron frame adapter
- Fully serrated flanges

Applications

- Industrial Sump
- Mine Dewatering
- Chemical Transfer
- Bilge Water Removal
- Coal Pile Drainage
- Tank Car Unloading
- Filter Systems v Petroleum Transfer
- Column Bottoms and Reflux

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3796 *i-FRAME™* Self-Priming Process Pumps

Featuring *i-FRAME* Patented Intelligent Monitoring

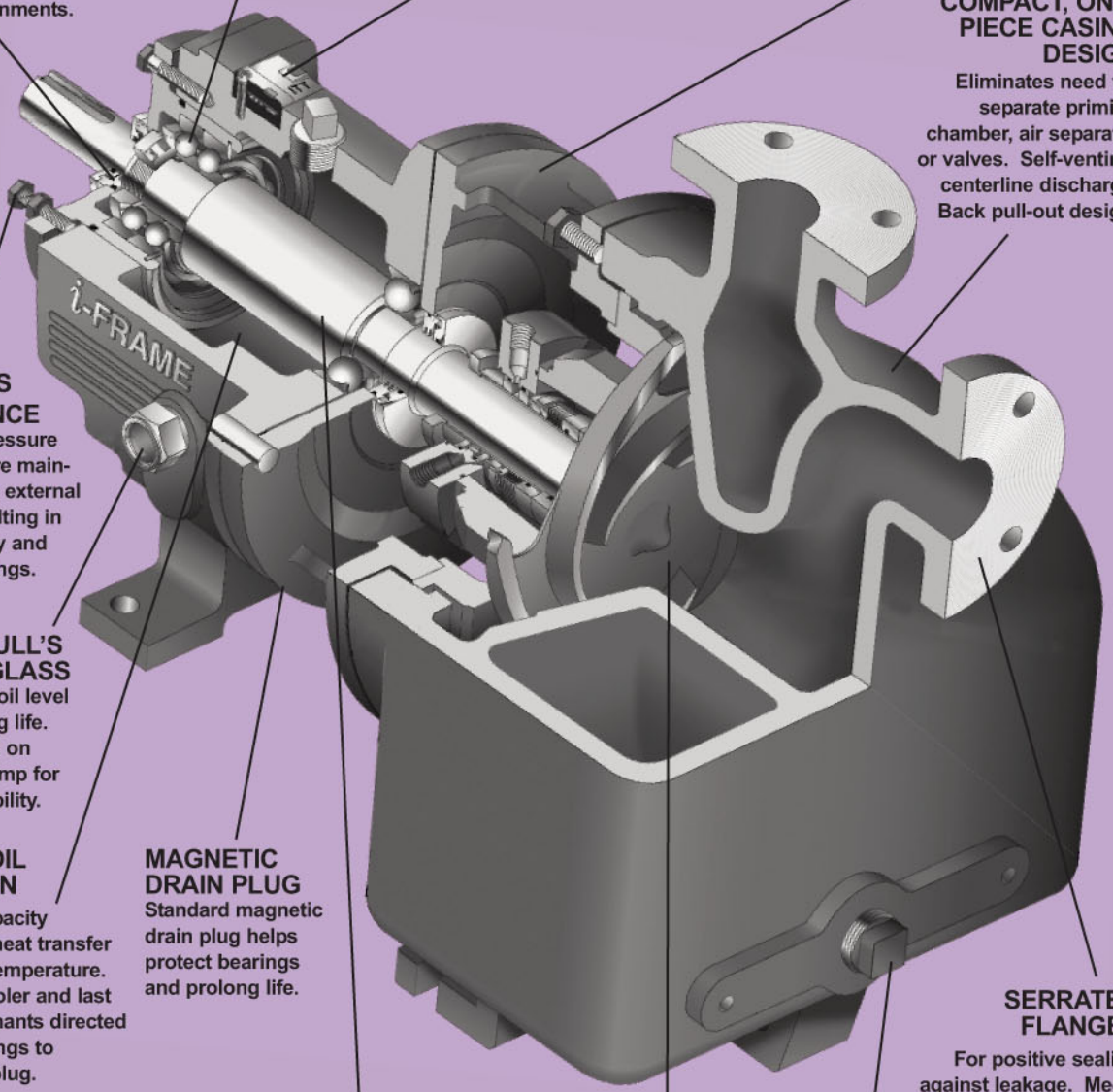
INPRO VBXX-D® HYBRID LABYRINTH SEALS
Prevents premature bearing failure caused by lubricant contamination or loss of oil. Stainless steel rotors for optimal performance in corrosive environments.

PREMIUM SEVERE-DUTY THRUST BEARINGS
Increase bearing fatigue life by 2-5X that of conventional bearing steels.

***i-ALERT™* CONDITION MONITOR**
(U.S. Patent 8,154,417)
Constantly measures vibration and temperature at the thrust bearing. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

DUCTILE IRON FRAME ADAPTER
Material strength equal to carbon steel for safety.

COMPACT, ONE-PIECE CASING DESIGN
Eliminates need for separate priming chamber, air separator or valves. Self-venting, centerline discharge. Back pull-out design.



CONTINUOUS PERFORMANCE
Original flow, pressure and efficiency are maintained by simple external adjustment resulting in long-term energy and repair parts savings.

ONE-INCH BULL'S EYE SIGHT GLASS
Assures proper oil level critical to bearing life. Can be mounted on either side of pump for installation flexibility.

OPTIMIZED OIL SUMP DESIGN
Increased oil capacity provides better heat transfer for reduced oil temperature. Bearings run cooler and last longer. Contaminants directed away from bearings to magnetic drain plug.

MAGNETIC DRAIN PLUG
Standard magnetic drain plug helps protect bearings and prolong life.

SERRATED FLANGES
For positive sealing against leakage. Meets ANSI B16.5 requirements. Class 150 FF flanges standard, optional class 150 RF.

***i-FRAME™* POWER END**
Designed for reliability and extended pump life, backed with a 5-year warranty.

HEAVY DUTY SHAFT AND BEARINGS
Rigid shaft designed for minimum deflection at seal faces–less than 0.002 in. (0.05 mm). Bearings sized for 10-year average life under tough operating conditions. Available with or without shaft sleeve.

FULLY OPEN IMPELLER
Acknowledged best design for CPI services–solids handling, stringy material, corrosives, abrasives. Back pump-out vanes minimize seal chamber pressure.

OPTIONAL CASING DRAIN

Reliable Self-Priming Operation

Before any centrifugal pump will perform, it must first be primed; that is, air or gases expelled from the suction and impeller eye area, and replaced with liquid. This is no problem when the pump is submerged (submersible or vertical sump pumps) or when liquid supply is above the pump. However, when suction pressure is negative, air must be evacuated to accomplish pump priming*.

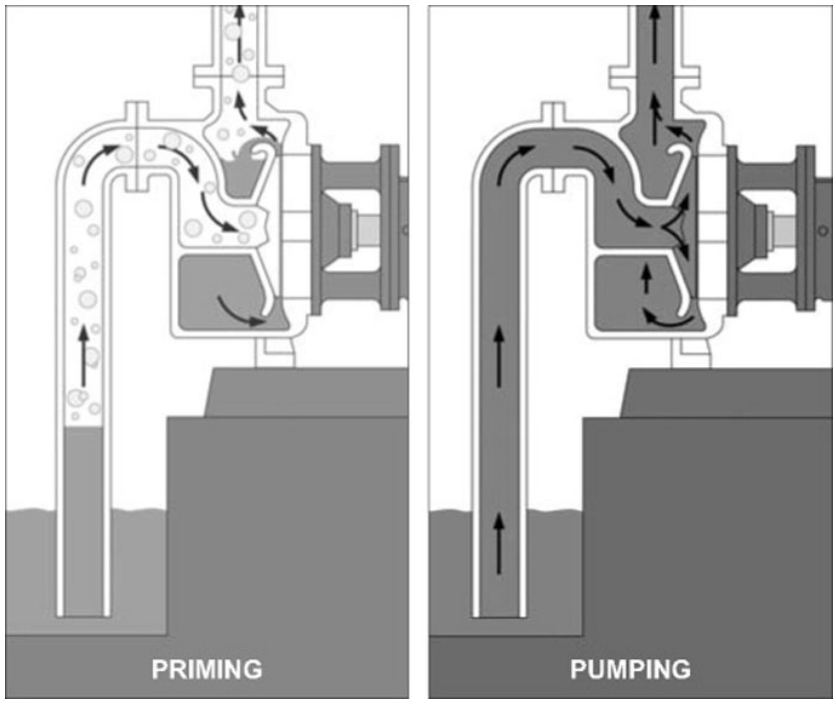
The 3796 is designed to insure that a sufficient quantity of liquid to reprime is always retained in the priming chamber...a compact, integral and completely functional self-priming pump.

** The one-piece casing is designed with integral priming and air separation chambers. Priming is accomplished within the casing, eliminating the need for auxiliary priming systems.*

Priming and Air Separation Accomplished Within Casing

Dual volute design primes suction with only an initial charge of liquid in the casing. During priming cycle, the lower volute functions as an intake while upper volute discharges liquid and entrained air into separation chamber. Air is separated and expelled through pump discharge while liquid recirculates into lower volute. Once air is completely removed from suction and liquid fills impeller eye, pump is fully primed, and functions as a conventional centrifugal pump with both volutes performing as discharges.

The casing is designed so that an adequate volume of liquid for repriming is always retained in pump even if liquid is allowed to drain back to source of supply from discharge and suction.



Parts List and Materials of Construction

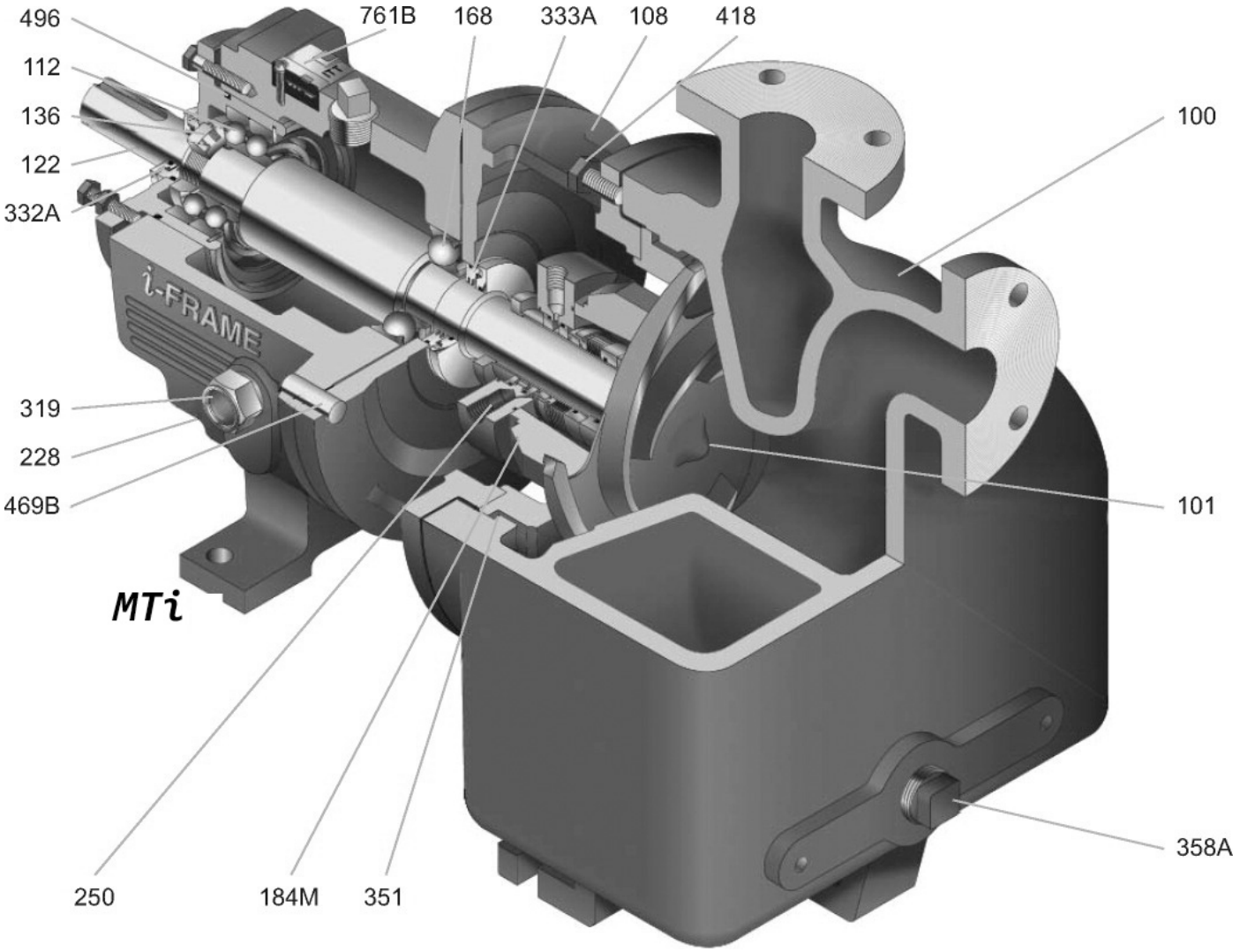
Item Number	Part Name	Material					
		Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy B & C	Titanium
100	Casing	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy	Titanium
101	Impeller	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy	Titanium
105	Lantern Ring	Glass-Filled Teflon*					
106	Stuffing Box Packing	Teflon* Impregnated Fibers					
108	Frame Adapter***	Ductile Iron					
112	Thrust Bearing	Double Row Angular Contact**					
122	Shaft—Less Sleeve (Optional)	SAE4140	316SS		Alloy 20	Hastelloy	Titanium
122	Shaft—With Sleeve	SAE4140				316SS	
126	Shaft Sleeve	316SS		Alloy 20		Hastelloy	Titanium
136	Bearing Locknut and Lockwasher	Steel					
168	Radial Bearing	Single Row Deep Groove					
184	Stuffing Box Cover (Packed Box)	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy	Titanium
184M	Seal Chamber (Mechanical Seal)	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy	Titanium
228	Bearing Frame	Cast Iron (Ductile Iron for *STi* Group)					
250	Gland	316SS		CD4MCu	Alloy 20	Hastelloy	Titanium
262	Repeller/Sleeve (Dynamic Seal Option)	CD4MCu				Hastelloy	Titanium
264	Gasket, Cover to Backplate (Dynamic Seal)	Teflon*					
265A	Stud/Nut, Cover to Adapter	304SS					
319	Oil Sight Glass	Glass/Steel					
332A	INPRO VBXX-D Labyrinth Oil Seal (Outboard)	Stainless Steel/Bronze					
333A	INPRO VBXX-D Labyrinth Oil Seal (Inboard)	Stainless Steel/Bronze					
351	Casing Gasket	Aramid Fiber with EPDM Rubber					
358A	Casing Drain Plug (Optional)	Steel	316SS	CD4MCu	Alloy 20	Hastelloy	Titanium
360	Gasket, Frame-to-Adapter	Buna					
360A	Gasket, Bearing End Cover	Vellumoid					
370	Cap Screw, Adapter-to-Casing	Steel	304SS				
418	Jacking Bolt	304SS					
444	Backplate (Dynamic Seal Option)	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy	Titanium
469B	Dowel Pin	Steel					
496	O-ring, Bearing Housing	Buna Rubber					
496A	O-ring, Impeller	Glass-Filled Teflon*					
761B	Condition Monitor	Stainless Steel/Epoxy					

*E.I. DuPont reg. trademark ** *LTi* Power End features Duplex Angular Contact ***Integral with *STi* frame

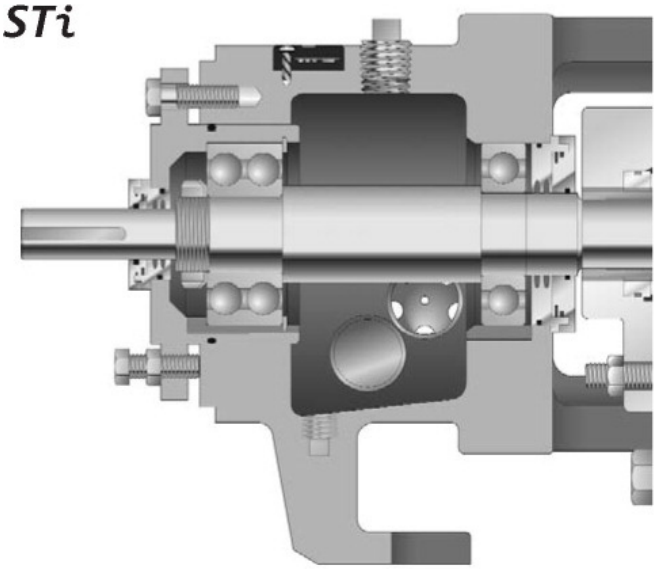
Construction Details All dimensions in inches and (mm).

		STi	*MTi*	*LTi*
Shaft	Diameter at Impeller	.75 (19)	1 (25)	1.25 (32)
	Diameter in Stuffing Box/Seal Chamber			
	(Less Sleeve)	1.375 (35)	1.75 (45)	2.125 (54)
	(With Sleeve)	1.125 (29)	1.5 (38)	1.875 (48)
	Diameter Between Bearings	1.5 (38)	2.125 (54)	2.5 (64)
	Diameter at Coupling	.875 (22)	1.125 (29)	1.875 (48)
	Overhang	6.125 (156)	8.375 (213)	8.375 (213)
	Maximum Shaft Deflection	0.002 (0.05)		
Sleeve	O.D. thru Stuffing Box/Seal Chamber	1.375 (35)	1.75 (45)	2.125 (54)
Bearings	Radial	6207	6309	6311
	Thrust	3306	3309	7310
	Bearing Span	4.125 (105)	6.75 (171)	6.875 (164)
BigBore™ Seal Chamber	Bore	2.875 (73)	3.5 (89)	3.875 (98)
Stuffing Box	Bore	2 (51)	2.5 (64)	2.875 (73)
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)	5.6 (4.2)
Maximum Liquid Temperature	Oil/Grease Lubrication without Cooling	350° F (177° C)		
	Oil Lubrication with Finned Cooler	500° F (260° C)		
Casing	Corrosion Allowance	.125 (3)		

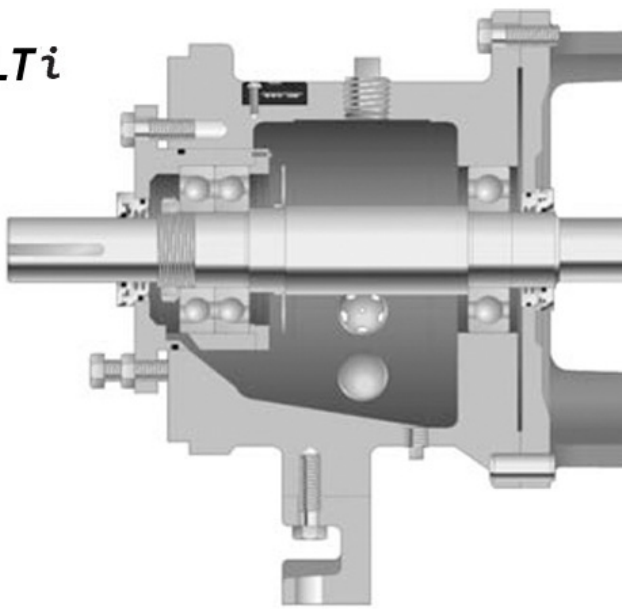
Sectional View Model 3796 *i-FRAME™*



STi

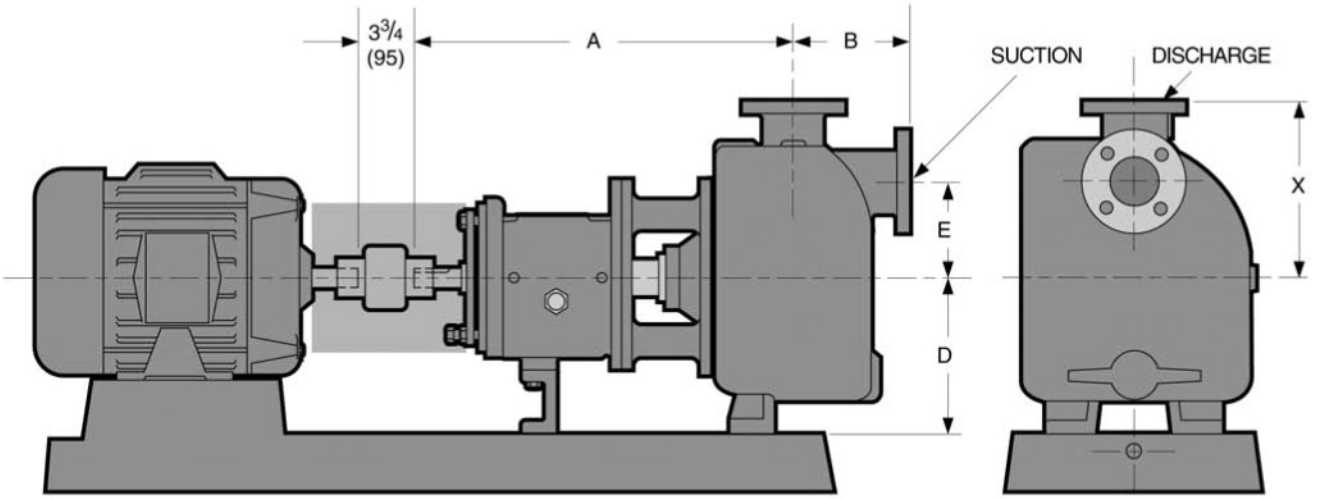


LTi



Dimensions Model 3796 *i-FRAME™*

All dimensions in inches and (mm). Not to be used for construction.



DIMENSIONS

Group	Pump Size	Discharge	Suction	A	B	D	E	X	Bare Pump Weight Lbs. (kg)
STi	1×1½-6	1	1½	15½ (394)	5 (127)	7½ (191)	4 (102)	7¼ (184)	170 (77)
	1½×1½-8	1½	1½					7⅞ (200)	
MTi/LTi	2×2-10	2	2	21⅜ (552)	6½ (165)	10 (254)	6 (152)	10 (254)	270 (123)
	3×3-10	3	3	22⅝ (575)	6¾ (171)				315 (143)
	4×4-10	4	4	23⅜ (594)	93/16 (233)				370 (168)
	3×3-13	3	3	22⅝ (575)	6¾ (171)			11½ (292)	400 (182)
	4×4-13	4	4	23⅜ (594)	93/16 (233)				470 (214)
	6×6-13	6	6	15¼ (387)	10 (254)	14 (356)	8 (203)	14 (356)	690 (314)

Baseplate Mounting Options

Goulds offers a complete range of mounting systems to meet plant reliability requirements and to make alignment and maintenance easier.

CAMBER TOP CAST IRON

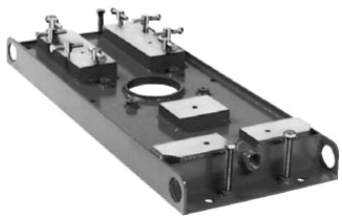
Rigid and corrosion resistant, it is preferred by many plants.

CHEMBASE PLUS™

Polymer concrete construction provides exceptional rigidity & corrosion resistance. ANSI 1991 dimensional.

FABRICATED STEEL

Economical baseplate that meets ANSI/ASME B73.1M current edition dimensional requirements.



ENHANCED FEATURE FABRICATED STEEL

Upgraded ANSI baseplate designed to maximize pump operation life and ease installation by meeting API-minded chemical pump users' toughest requirements.

Member of Hydraulic Institute

Refer to section CHEM-1A (Model 3196) for Baseplate Selection Guide.

Bonus Interchangeability

i-FRAME™ Power Ends Fit 7 Different Process Pumps

Minimize inventory, reduce downtime.

3196 *i-FRAME*
Process Pumps

CV 3196
i-FRAME
Non-Clog
Process Pumps

HT 3196
i-FRAME
High
Temperature
Process Pumps

LF 3196
i-FRAME
Low Flow ANSI
Process Pumps

3198 *i-FRAME*
PFA TEFLON®-
Lined Process
Pumps

3796 *i-FRAME*
Self-Priming
Process Pumps

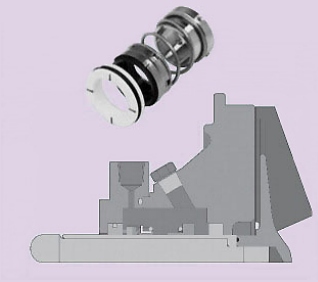
NM 3196
i-FRAME
Non-Metallic
Process Pumps

Sealing Solutions

Goulds engineered seal chambers are designed to accept a wide range of sealing arrangements to meet specific user requirements. Your Goulds representative will gladly recommend the best sealing solution for your service... some of which are illustrated here.

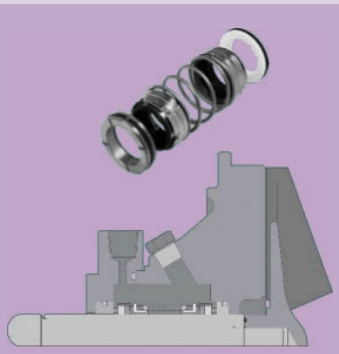
SINGLE INSIDE SEAL (with BigBore™ Seal Chamber)

- Non-corrosive to moderate corrosive liquids
- Moderate abrasives
- Liquids that have good lubrication qualities



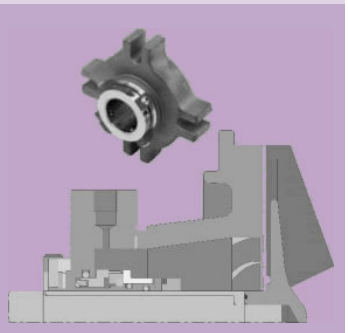
CONVENTIONAL DOUBLE SEAL (with BigBore™ Seal Chamber)

- Liquids not compatible with single seal
- Toxic, hazardous, abrasive, corrosive
- When pump is operating under cavitation or low flows
- Meet environmental regulations



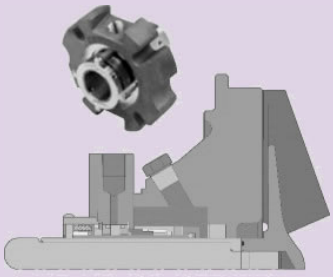
SINGLE CARTRIDGE SEAL (with TaperBore™ *PLUS* Seal Chamber)

- Same application as conventional single seal
- Ease of maintenance
- No seal setting problems



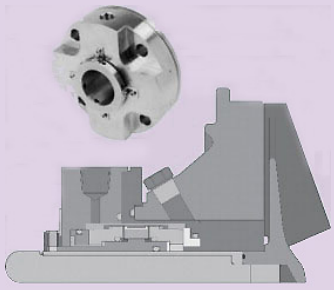
DOUBLE CARTRIDGE SEAL (with BigBore™ Seal Chamber)

- Same applications as conventional double seal
- Reduced maintenance costs
- No seal setting errors



DOUBLE GAS BARRIER SEAL (with BigBore™ Seal Chamber for Gas Seals)

- Toxic or hazardous liquids
- Meet environmental regulations
- When use of seal pot or external flush is not desirable
- When compatible seal flush liquid not available



Goulds Patented *i-FRAME™* Power Ends

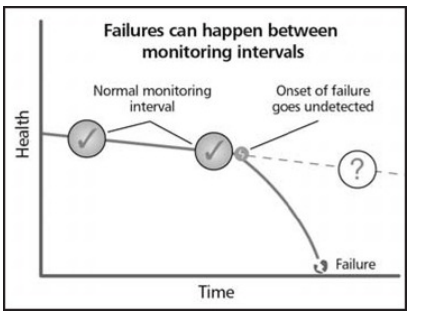
Extended Pump Life Through Intelligent Design

Goulds ***i-FRAME*** Power Ends are the result of 160 years of design experience, customer interaction, and continuous improvement. Customers get extended Mean Time Between Failure (MTBF) and lower life cycle costs (LCC)...guaranteed!

1 *i-ALERT™* CONDITION MONITOR

The heart of the *i-FRAME*, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

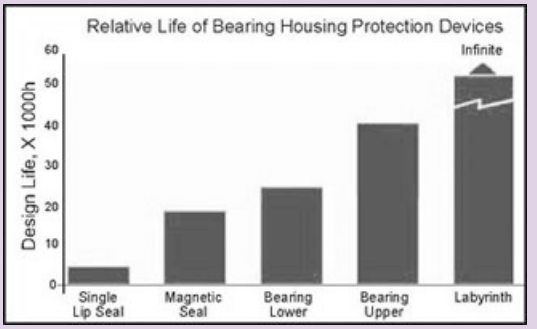
A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



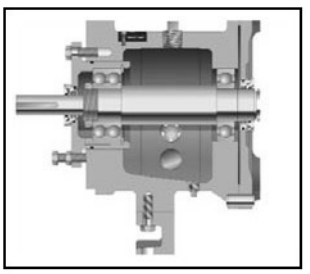
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

2 INPRO VBXX-D HYBRID BEARING ISOLATORS

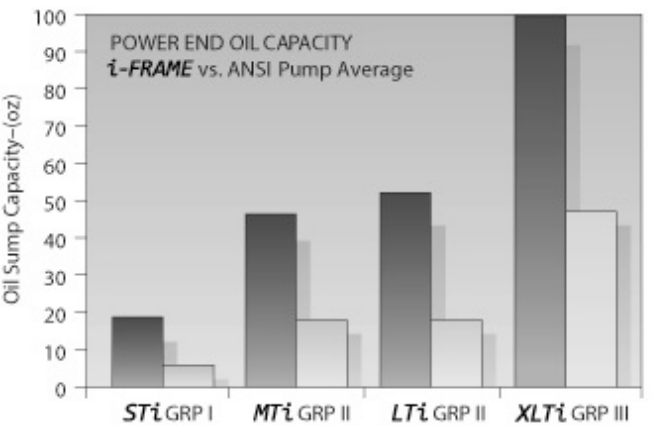
Most bearings fail before reaching their potential life. They fail for a variety of reasons, including contamination of the lubricant. INPRO VBXX-D has long been considered the industry standard in bearing lubricant protection. The ***i-FRAME*** now improves upon that design by offering stainless steel rotors, for maximum protection against contaminants and the corrosive effects of seal leakage or environmental conditions. These seals are non-contacting and do not wear.



3 OPTIMIZED OIL SUMP DESIGN



Internal sump geometry is optimized for longer bearing life. Sump size increased by 10%-20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.



Larger *Means Cooler*
GOULDS
Industry Average

4 SHAFT AND BEARINGS ENGINEERED FOR MAXIMUM RELIABILITY

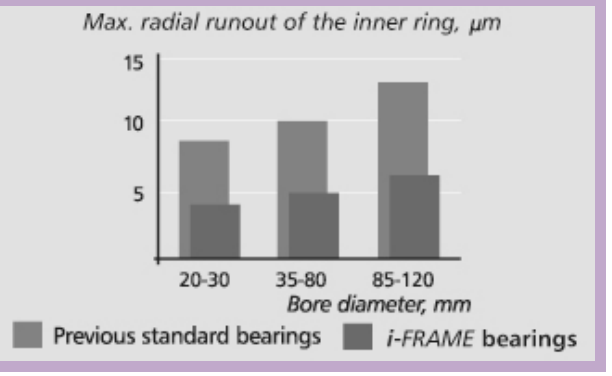
The rugged shaft and bearing combination maintains shaft deflection of less than 0.002 inches at all operating points. The result is longer seal and bearing life.

Premium severe-duty thrust bearings increase bearing fatigue life.

- High purity steels have fewer inclusions than standard steel – better grain structure and wear resistance.
- Heat treatment of bearing elements to SO stabilizaion levels provides superior thermal stability for increased service life.
- Bearing Balls are manufactured to at least one ISO grade above standard (ISO P5 for ring running accuracy and ISO P6 for dimensions). The result is reduced vibration and noise for improved shaft guidance.

Every 3196 ***i-FRAME***™ Power End is engineered and manufactured for optimal pump performance and increased MTBF.

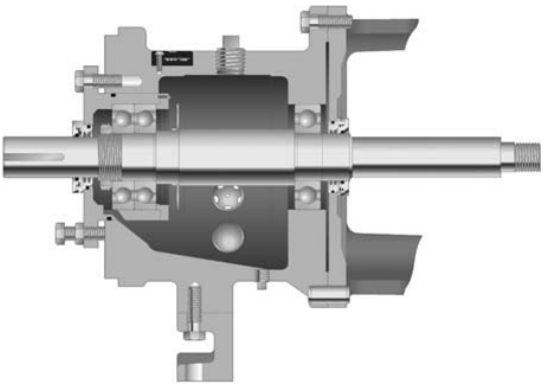
ANSI B73.1 Shaft Specification	Meets	Exceeds
Diameter Tolerance		✓
Surface Finish		✓
Runout	✓	
Deflection		✓



5 *LTi* POWER END FOR HIGH LOAD APPLICATIONS

Increased L'10 Bearing Life 150% to 200% on the Toughest Applications

Ideal for tough conditions when a power end is pushed beyond ANSI limits: operating at low flows and higher heads, pumping high specific gravity liquids, fluctuating process conditions, overhung belt drive. Oversized shaft and bearing assembly significantly expands the limits for long, trouble-free bearing and seal life. On high load applications, the *LTi* power end improves bearing life 150%-200%; oil operating temperature reduced by 45°F (25° C).



FLINGER/CHANNEL OIL LUBRICATION SYSTEM

Provides 30% increased L'10 life; 15°F (8°C) reduced oil temperature.

OVERSIZED SHAFT

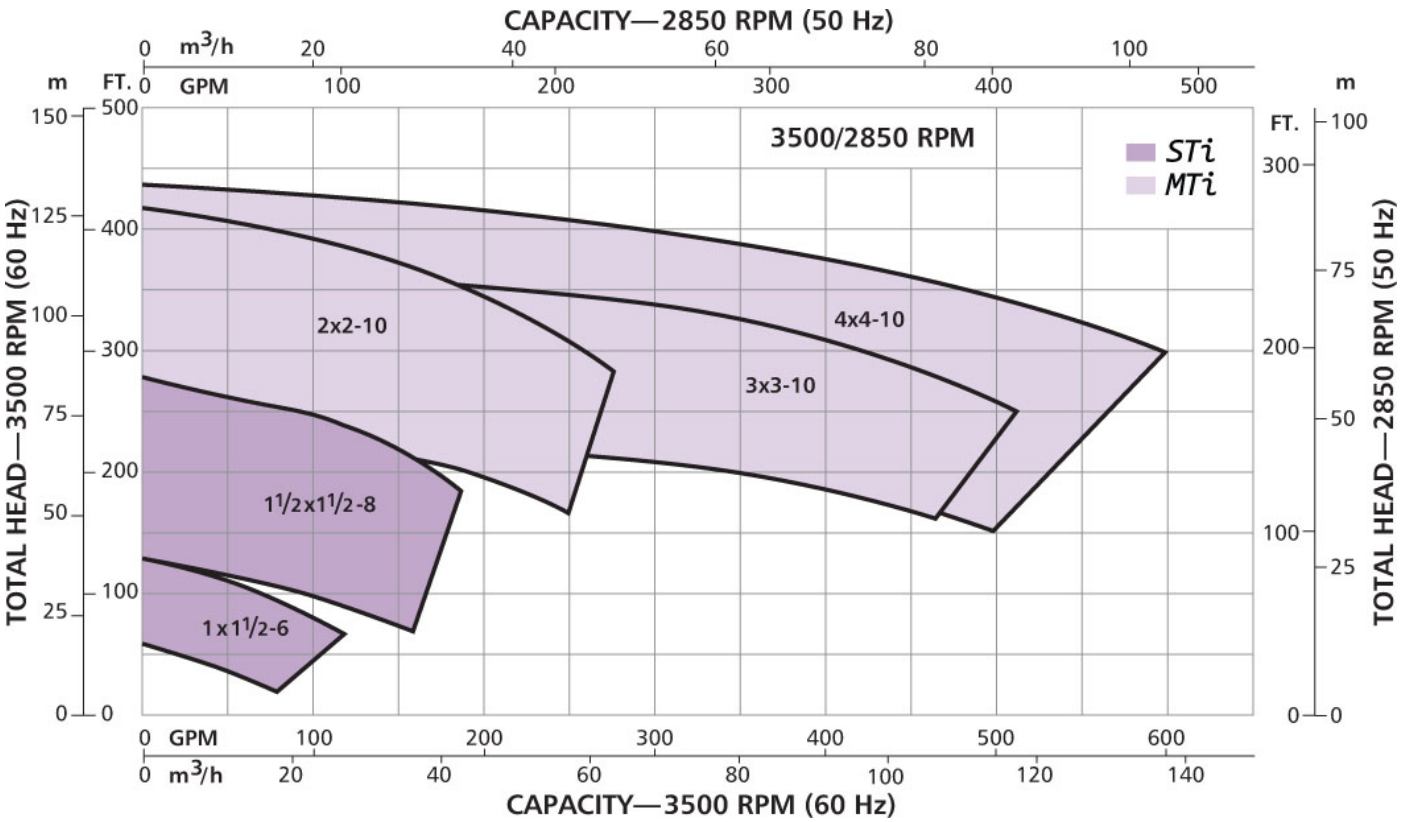
With duplex thrustbearings provide increased L'10 by 40%.

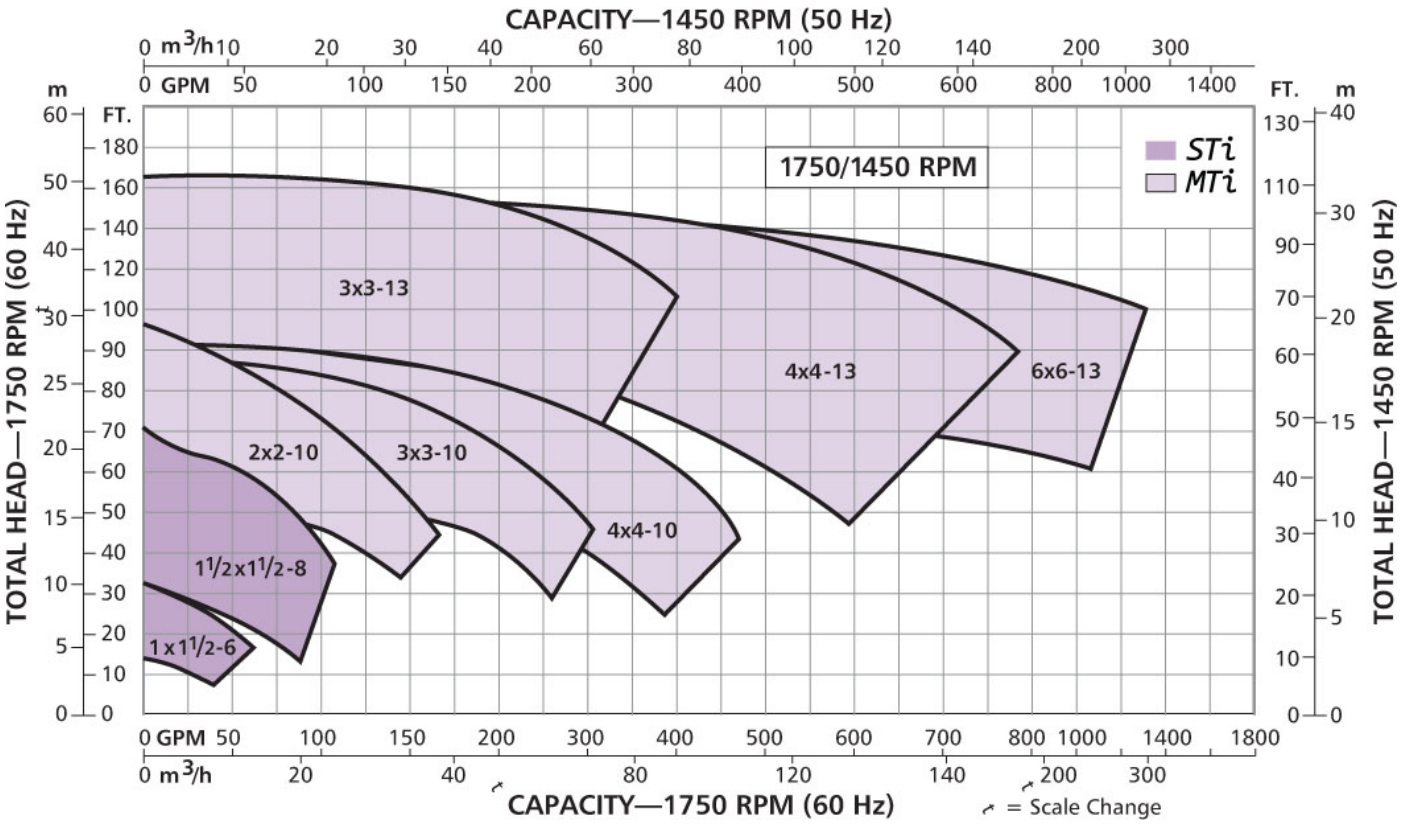
DUPLEX THRUST BEARINGS

Duplex thrust bearings (40°/40° angular contact) with machined brass cages, are ideally sized for high load applications.

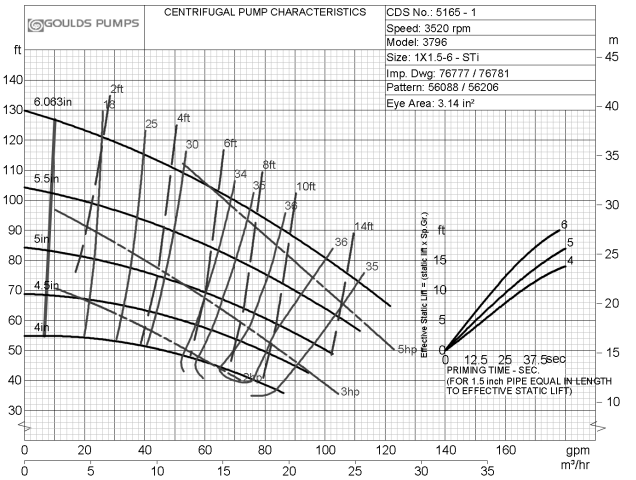
Our Guarantee We are so confident that the ***i-FRAME***™ is the most reliable Power End in the industry, that we are proud to offer a standard 5-year warranty on every ***i-FRAME*** ANSI Process Pump.

Hydraulic Coverage Model 3796 *i-FRAME™*

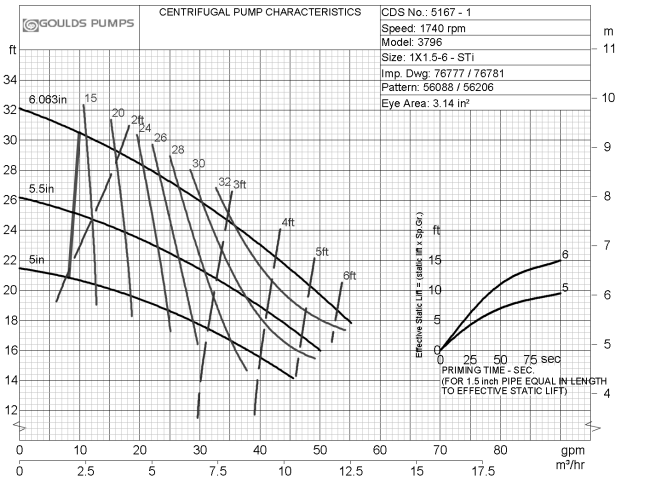




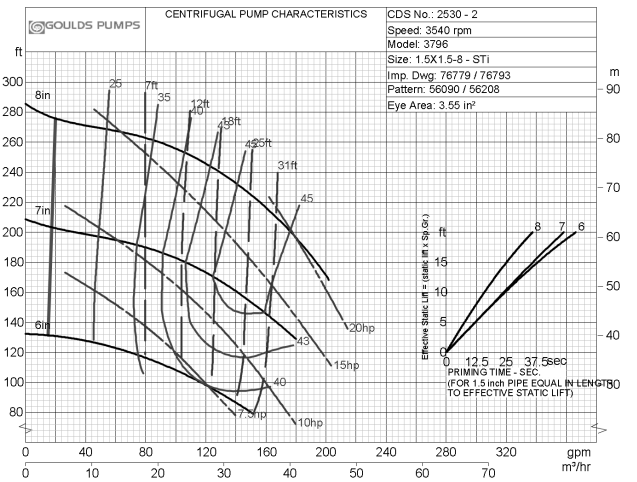
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



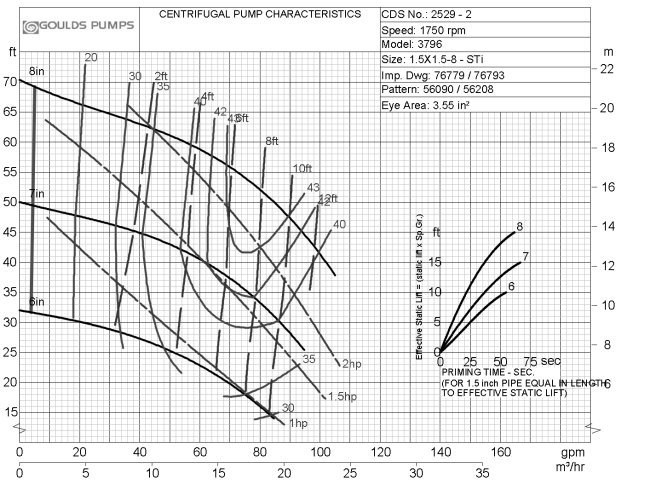
1X1.5-6 **3520rpm**



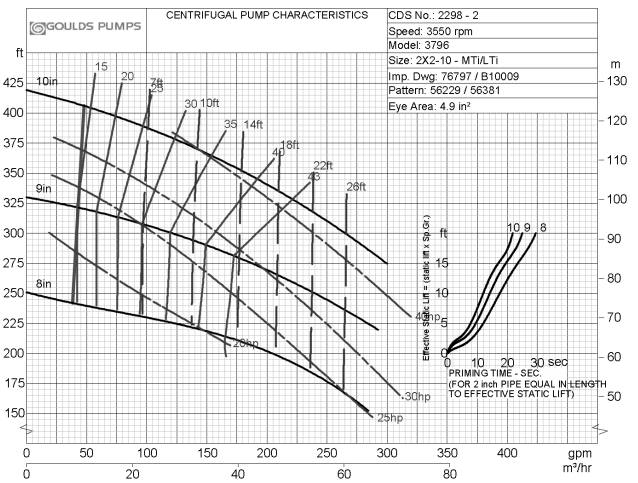
1X1.5-6 **1740rpm**



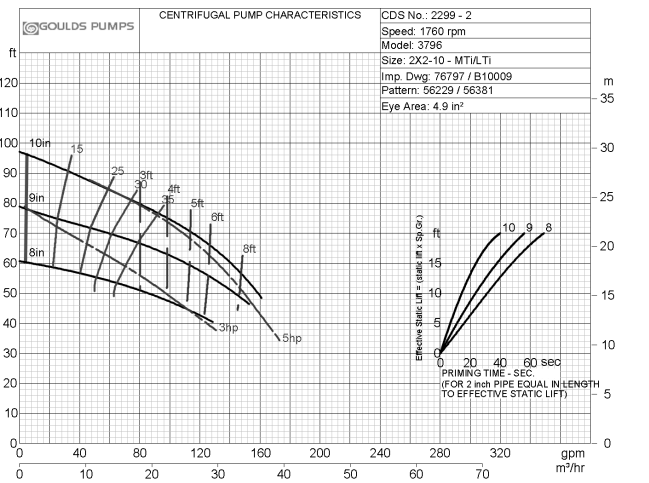
1.5X1.5-8 **3540rpm**



1.5X1.5-8 **1750rpm**



2X2-10 **3550rpm**

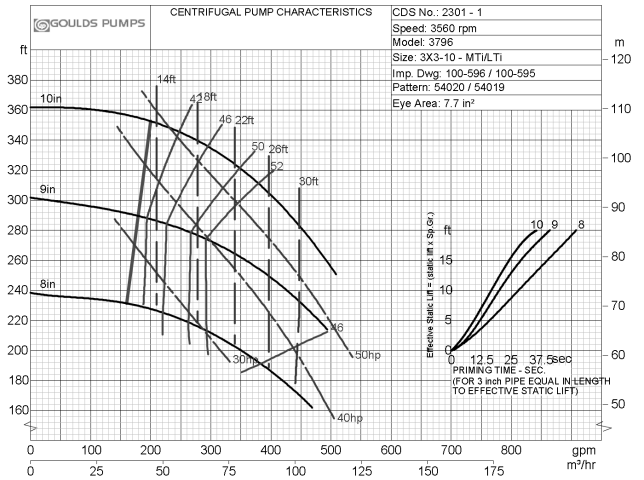


2X2-10 **1760rpm**

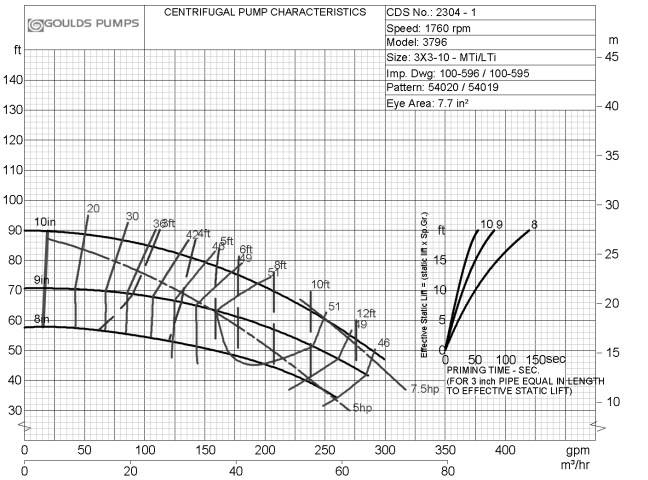
60Hz Curves

Model 3796

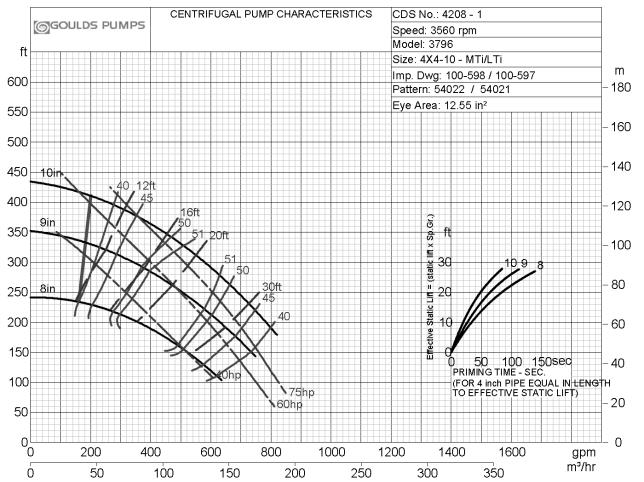
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



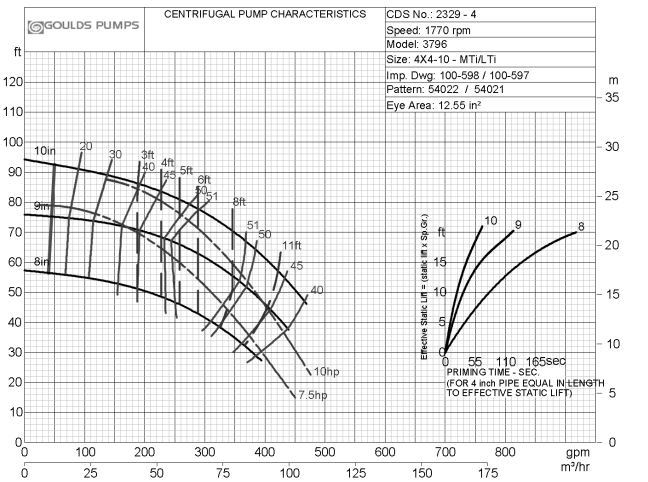
3X3-10 **3560rpm**



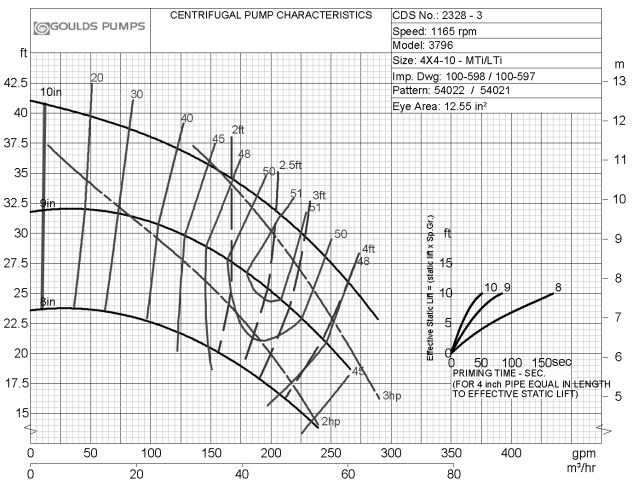
3X3-10 **1760rpm**



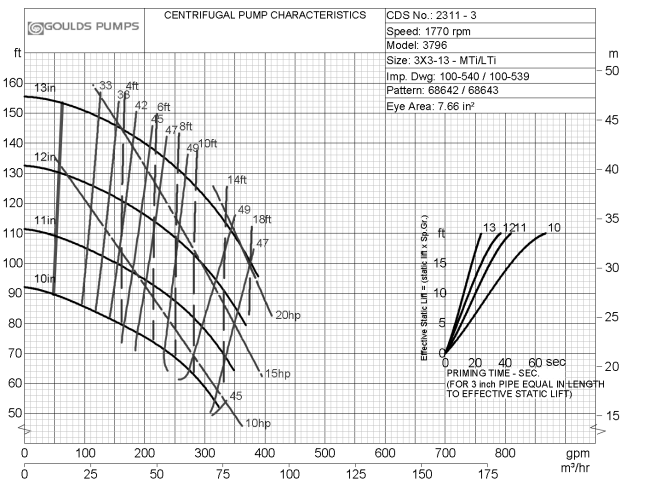
4X4-10 **3560rpm**



4X4-10 **1770rpm**

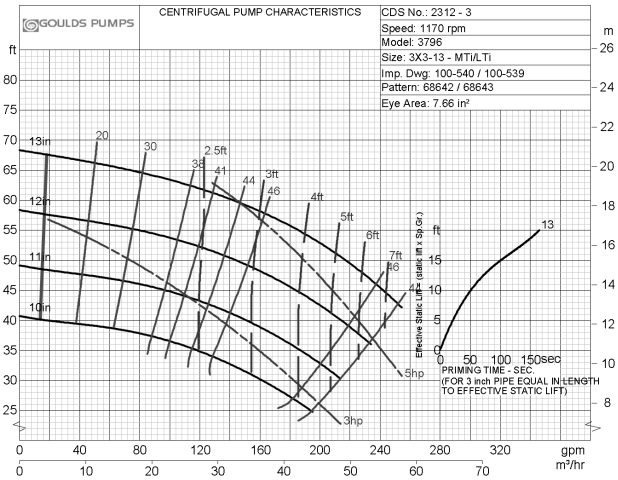


4X4-10 **1165rpm**

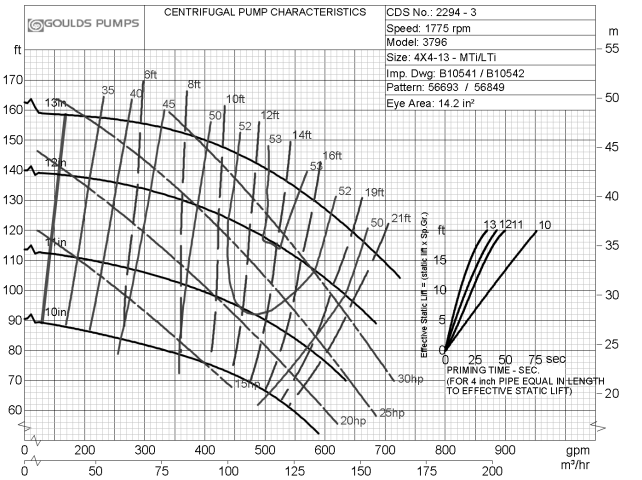


3X3-13 **1770rpm**

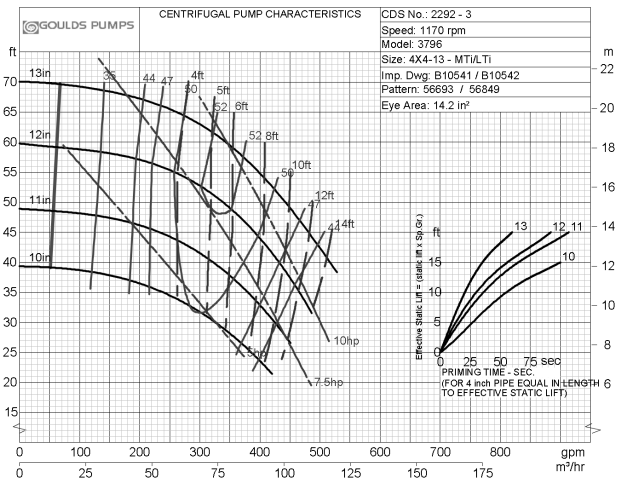
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



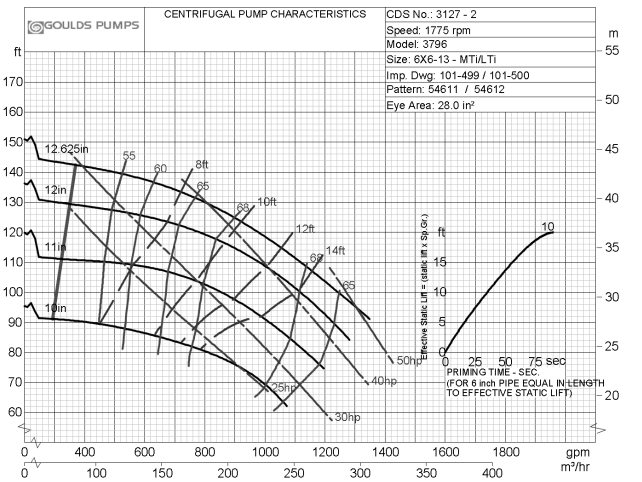
3X3-13 **1170rpm**



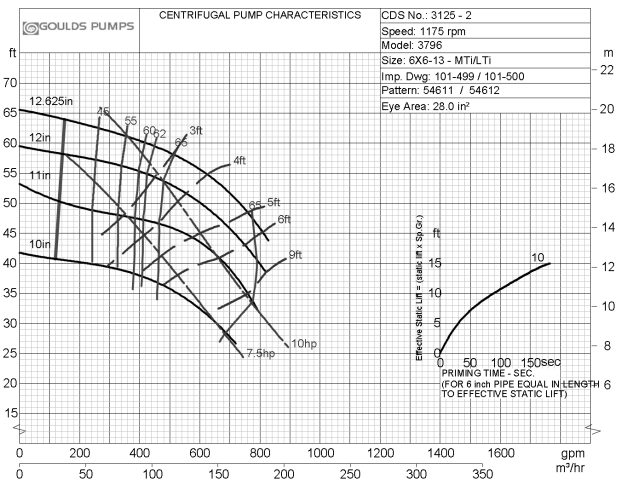
4X4-13 **1775rpm**



4X4-13 **1170rpm**



6X6-13 **1775rpm**



6X6-13 **1175rpm**

NOTES

Goulds 3996 process pump line is specifically designed to provide superior performance for in-line services of the Chemical Process Industries.

Goulds Model 3996

In-Line Process Pumps Designed for Total Range of Industry Services

- Capacities to 1,400 GPM (318 m^3/h)
- Heads to 700 feet (213 m)
- Temperatures to 500° F (260° C)
- Pressures to 375 PSIG (2,586 kPa)

Performance Features for In-Line Services

Extended Pump Life

- Integral pump bearings
- TaperBore™ *PLUS* and BigBore™ seal chambers
- Precision fits for accurate alignment
- Flexibly coupled

Ease of Maintenance

- In-line mounting
- Field alignment not required
- Back pull-out design
- External impeller adjustment

Safety

- ANSI B15.1 coupling guard
- Ductile iron frame and motor support
- Fully serrated flanges

Applications

- Caustic transfer
- Acid unloading
- Monomer/Polymer transfer
- Liquid nitrogen
- Liquid ammonia
- Reflux and light tower bottoms
- Waste acid recovery
- Pickle liquor circulation
- Chilled water
- Filter feed
- Condensate return

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3996 In-Line Process Pumps

Heavy Duty Design Features for a Wide Range of Process Services

FIELD ALIGNMENT NOT REQUIRED
Precision rabbet locks provide positive, built-in alignment between pump and motor.

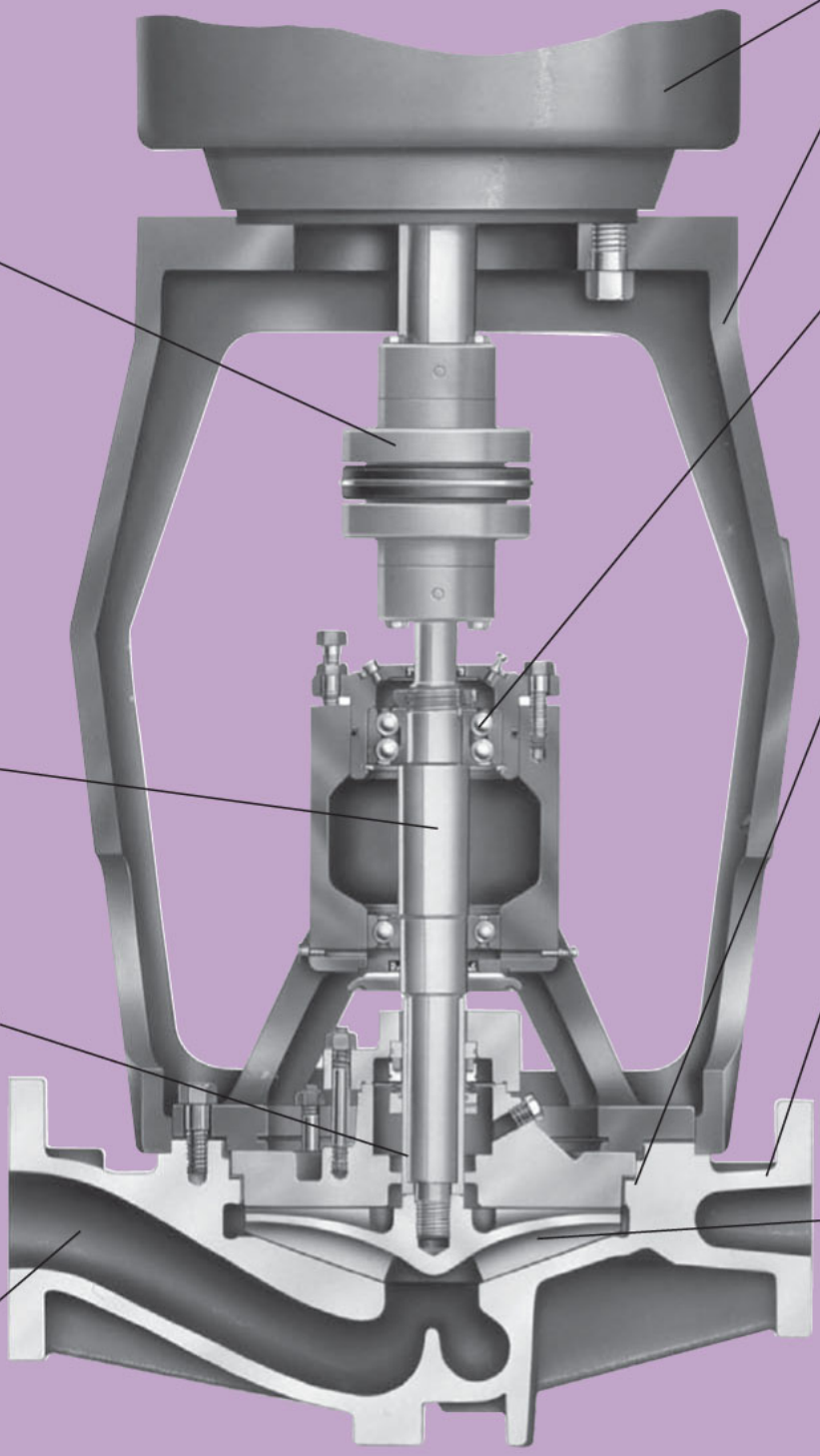
FLEXIBLY COUPLED
Conventional flexible spacer coupling.

MAXIMUM INTER-CHANGEABILITY
Most parts (shaft, sleeve, mechanical seals, etc.) except casing are fully interchangeable with Goulds Model 3196 *STi* and *MTi*.

HEAVY DUTY SHAFT
Shaft designed for minimum deflection–less than .002 in. (.05 mm)–at seal faces.

ANSI B73.1M SHAFT SEALING
Choice of large or standard bore seal chambers for maximum sealing flexibility to meet service conditions. (See section CHEM-1A for details.)

STREAMLINED SUCTION
With contoured suction baffle reduces turbulence assuring low NPSH requirements.



STANDARD NEMA C-FACE NORMAL THRUST MOTOR

HIGH STRENGTH DUCTILE IRON MOTOR SUPPORT
Open on two sides for easy access to back pull-out assembly.

INTEGRAL PUMP BEARINGS
All hydraulic loads carried by pump–not by motor. Bearings sized for 2-year minimum and 10-year average life under tough operating conditions. Regreaseable bearings standard ... available with greased-for-life or oil mist lubrication.

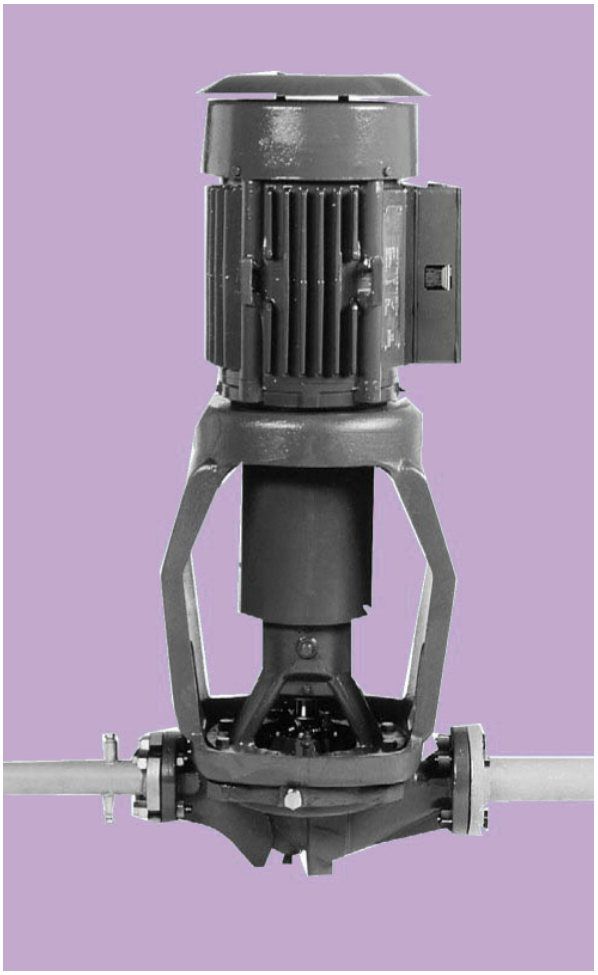
POSITIVE SEALING
Fully confined gasket at casing joint protects alignment fit from liquid.

HEAVY WALLED CASING
With ribbed suction and discharge nozzles support pump and driver and resist pipe strain without distortion. ANSI class 150 flanges standard, class 300 flanges optional.

FULLY OPEN IMPELLER
Acknowledged best design for CPI services–solids handling, stringy material, corrosives, abrasives. Back pump-out vanes minimize stuffing box/seal chamber pressure and reduce thrust for longer bearing and seal life.

Setting The Standards For Reliability

The 3996 is designed for optimum reliable service…shaft size and overhang are optimized to provide maximum seal and bearing life…precision fits provide built-in alignment between pump and motor (field alignment not required). Hydraulic and mechanical loads are carried by the pump, not by special motors (the 3996 uses standard C-face motors).



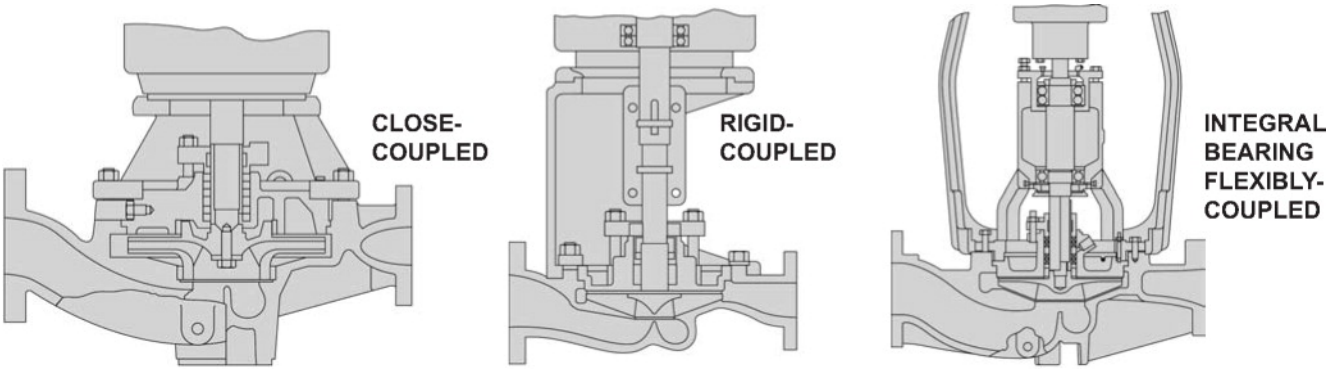
In-Line Design For Cost Savings

In-line pumps have become increasingly popular with users due to minimal floor space required and reduced installation costs. Installation is simple since the unit is mounted direct in the line like a valve. Field alignment is not required and the unit is not subject to misalignment due to pipe strain or temperature changes.

Goulds 3996…The Preferred In-Line Design

A variety of in-line pumps are available including close-coupled, rigid-coupled, and flexibly-coupled/integral bearing designs. Only the flexibly-coupled design such as the 3996 is built without compromise.

Close-coupled units are difficult to service and rigid-coupled models have long, unsupported shafts which are subject to runout, deflection and imbalance…leading to shortened bearing and seal life.



Parts List and Materials of Construction

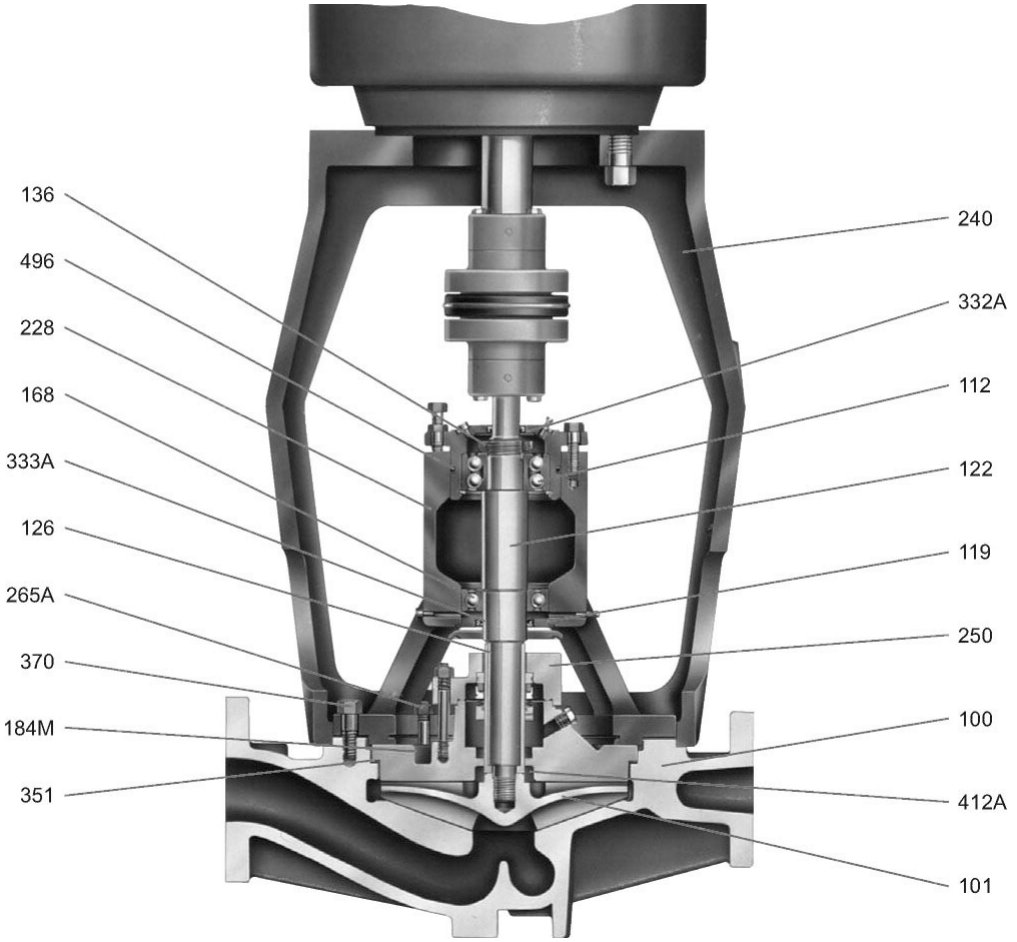
Item Number	Part Name	Material							
		Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy B & C	Titanium
100	Casing	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
101	Impeller	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
105	Lantern Ring	Glass-Filled Teflon*							
106	Stuffing Box Packing	Teflon* Impregnated Fibers							
112	Thrust Bearing	Double Row Angular Contact							
119	Bearing End Cover	Steel							
122	Shaft—Less Sleeve (Optional)	SAE4140	316SS		Alloy 20	Monel	Nickel	Hastelloy	Titanium
122	Shaft—With Sleeve	SAE4140				316SS			
126	Shaft Sleeve	316SS		Alloy 20		Monel	Nickel	Hastelloy	Titanium
136	Bearing Locknut and Lockwasher	Steel							
168	Radial Bearing	Single Row Deep Groove							
184	Stuffing Box Cover (Packed Box)	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
184M	Seal Chamber (Mechanical Seal)	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
228	Bearing Frame	Ductile Iron							
240	Motor Support	Ductile Iron							
250	Gland	316SS		CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
262	Repeller/Sleeve (Dynamic Seal Option)	CD4MCu			Alloy 20	Monel	Nickel	Hastelloy	Titanium
264	Gasket, Cover to Backplate (Dynamic Seal)	Teflon*							
265A	Stud/Nut, Cover to Frame	304SS							
332A	Grease Seal (Outboard)	Buna Rubber							
333A	Grease Seal (Inboard)	Buna Rubber							
351	Casing Gasket	Aramid Fiber with EPDM Rubber							
358A	Casing Drain Plug (Optional)	Steel	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
370	Cap Screw, Frame-to-Casing	Steel	304SS						
412A	O-ring, Impeller	Glass-Filled Teflon*							
418	Jacking Bolt	304SS							
444	Backplate (Dynamic Seal Option)	Ductile Iron	316SS	CD4MCu	Alloy 20	Monel	Nickel	Hastelloy	Titanium
469B	Dowel Pin	Steel							
496	O-ring, Bearing Housing	Buna Rubber							

*E.I. DuPont reg. trademark

Construction Details All dimensions in inches and (mm).

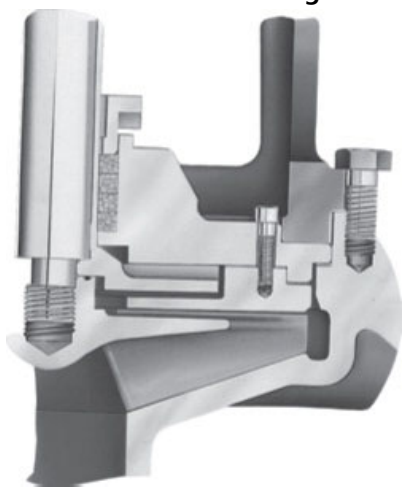
		ST	*MT*
Shaft	Diameter at Impeller	.75 (19)	1 (25)
	Diameter in Stuffing Box/Seal Chamber		
	(Less Sleeve)	1.375 (35)	1.75 (45)
	(With Sleeve)	1.125 (29)	1.5 (38)
	Diameter Between Bearings	1.5 (38)	2.125 (54)
	Diameter at Coupling	.875 (22)	1.125 (29)
	Overhang	6.125 (156)	8.375 (213)
	Maximum Shaft Deflection	0.002 (0.05)	
Sleeve	O.D. thru Stuffing Box/Seal Chamber	1.375 (35)	1.75 (45)
Bearings	Radial	6207	6309
	Thrust	3306 A/C3	3309 A/C3
	Bearing Span	4.125 (105)	6.75 (171)
	Average L'_{10} Bearing Life	87,600 hours	
BigBore™ Seal Chamber	Bore	2.875 (73)	3.5 (89)
Stuffing Box	Bore	2 (51)	2.5 (64)
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)
Maximum Liquid Temperature	Grease Lubrication without Cooling	250° F (121° C)	
	Grease Lubrication with Heat Flinger	450° F (232° C)	
	Oil Mist Lubrication with Heat Flinger and Cooling	500° F (260° C)	
Casing	Corrosion Allowance	.125 (3)	

Sectional View **Model 3996**



Dynamic Seal

For Elimination of Sealing Problems—Reduced Maintenance Costs



On tough pumping services, especially corrosives and slurries, mechanical seals require outside flush and constant, costly attention. Even then, seal failures are common, resulting in downtime.

Goulds offers the ANSI *PLUS*™ Dynamic Seal which, simply by fitting a repeller between the stuffing box and impeller, eliminates the need for a mechanical seal.

Benefits of Goulds Dynamic Seal:

- External seal water not required
- Elimination of pumpage contamination and product dilution
- Reduces utility cost
- No need to treat seal water
- Eliminates problems associated with piping from a remote source

At start-up, the repeller functions like an impeller, and pumps liquid and solids from the stuffing box. When pump is shut down, packing (illustrated) or other type of secondary seal prevents pumpage from leaking.

STUFFING BOX COVER

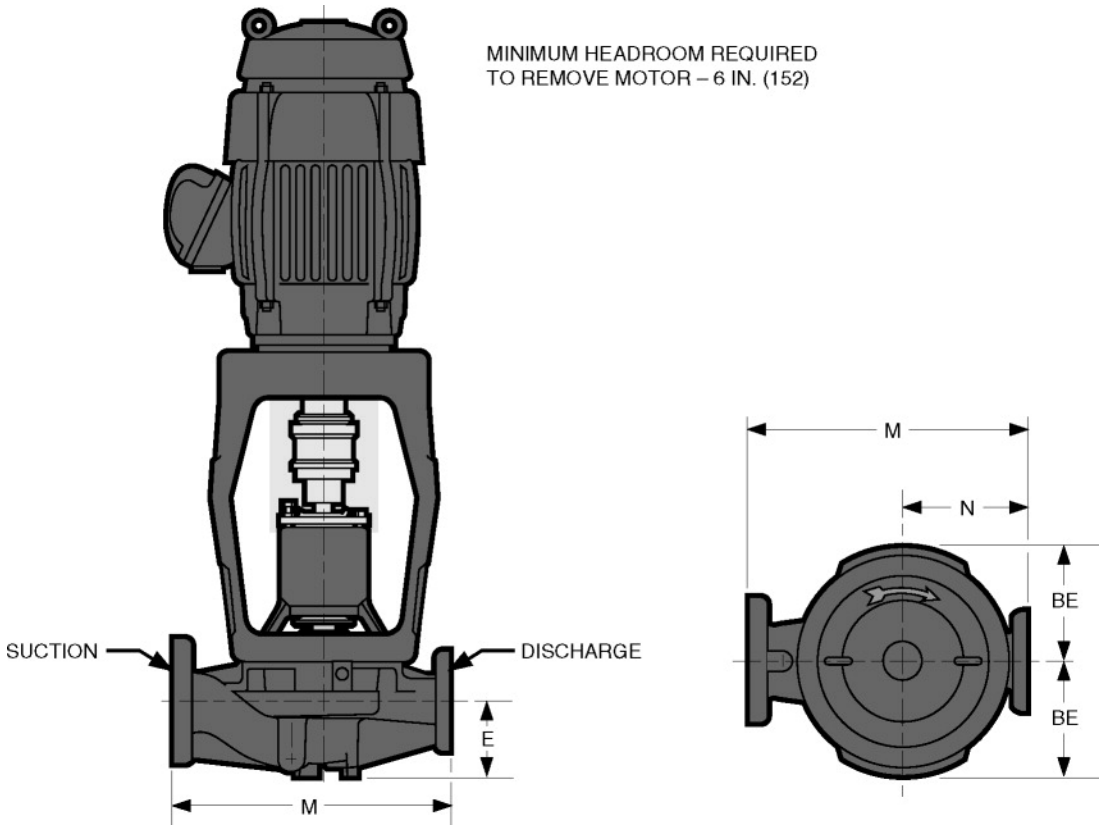
REPELLER

REPELLER PLATE

Besides being available as a complete unit, any Goulds 3996 can be easily field-converted to Dynamic Seal. Retrofit kits are readily available.

Dimensions Model 3996

All dimensions in inches and (mm). Not to be used for construction.



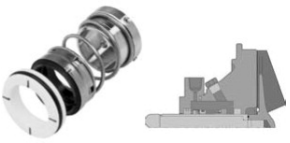
DIMENSIONS									
Group	Pump Size	ANSI Designation	Discharge	Suction	E	M	N	BE	Pump Weight (Less Motor) Lbs. (kg)
ST	1½×2-6	2015/15	1½	2	4¼ (108)	15 (381)	6¾ (171)	6⅜ (162)	190 (86)
	1½×3-6	3015/15	1½	3	4⅞ (124)	15 (381)	6¾ (171)		200 (91)
	2×3-6	3020/17	2	3	4⅝ (118)	17 (432)	7½ (191)		205 (93)
	1½×2-8	2015/17	1½	2	$4^{13}/_{16}$ (122)	17 (432)	8 (203)		200 (91)
	1½×3-8	3015/19	1½	3	5¼ (133)	19 (483)	8⅜ (213)		210 (95)
MT	1½×2-10	2015/19	1½	2	5⅛ (130)	19 (483)	9¼ (235)	10 (254)	370 (168)
	1½×3-10	3015/19	1½	3	5 (127)	19 (483)	9¼ (235)		380 (173)
	2×3-10	3020/20	2	3	5¼ (133)	20 (508)	9½ (241)		390 (177)
	3×4-10	4030/25	3	4	6 (152)	25 (635)	11½ (292)		430 (195)
	1½×3-13	3015/24	1½	3	5⅝ (143)	24 (610)	11½ (292)		460 (209)
	2×3-13	3020/24	2	3	5¾ (146)	24 (610)	11½ (292)		490 (223)
	3×4-13	4030/28	3	4	6⅞ (175)	28 (711)	13 (330)		520 (236)
	4×6-13	6040/30	4	6	8½ (216)	30 (762)	14 (356)		610 (277)

Sealing Solutions

Goulds engineered seal chambers are designed to accept a wide range of sealing arrangements to meet specific user requirements. Your Goulds representative will gladly recommend the best sealing solution for your service…some of which are illustrated here.

SINGLE INSIDE SEAL
(with BigBore™ Seal Chamber)

- Non-corrosive to moderate corrosive liquids
- Moderate abrasives
- Liquids that have good lubrication qualities

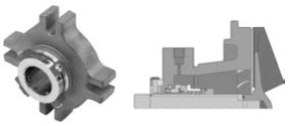


CONVENTIONAL DOUBLE SEAL
(with BigBore™ Seal Chamber)

- Liquids not compatible with single seal
- Toxic, hazardous, abrasive, corrosive
- When pump is operating under cavitation or low flows
- Meet environmental regulations

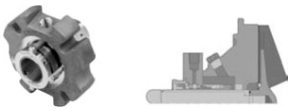
SINGLE CARTRIDGE SEAL
(with TaperBore™ *PLUS* Seal Chamber)

- Same application as conventional single seal
- Ease of maintenance
- No seal setting problems



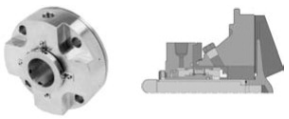
DOUBLE CARTRIDGE SEAL
(with BigBore™ Seal Chamber)

- Same applications as conventional double seal
- Reduced maintenance costs
- No seal setting errors



DOUBLE GAS BARRIER SEAL
(with BigBore™ Seal Chamber for Gas Seal)

- Toxic or hazardous liquids
- Meet environmental regulations
- When use of seal pot or external flush is not desirable
- When compatible seal flush liquid not available

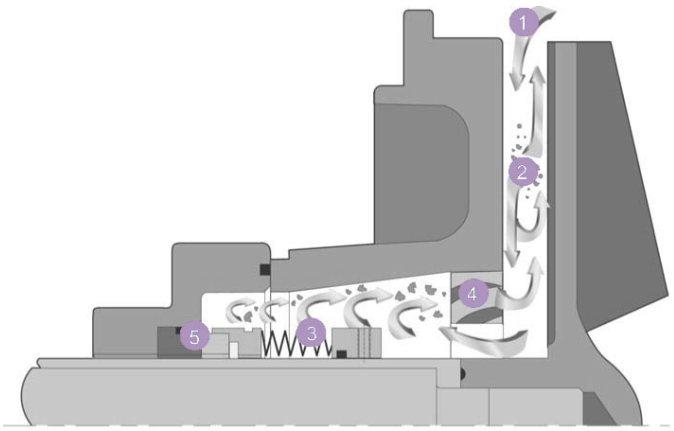


Goulds TaperBore™ *PLUS*

How It Works

The unique flow path created by the Vane Particle Ejector directs solids *away* from the mechanical seal, not *towards* the seal as with other tapered bore designs. And, the amount of solids entering the bore is minimized. Air and vapors are also efficiently removed.
On services with or without solids, air or vapors, Goulds TaperBore™ *PLUS* is the effective solution for extended seal and pump life and lower maintenance costs.

1. Solids/liquid mixture flows toward mechanical seal/seal chamber.
2. Turbulent zone. Some solids continue to flow toward shaft. Other solids are forced back out by centrifugal force (generated by back pump-out vanes).
3. Clear liquid continues to move toward mechanical seal faces. Solids, air, vapors flow away from seal.
4. Low pressure zone created by Vane Particle Ejector. Solids, air, vapor liquid mixture exit seal chamber bore.
5. Flow in TaperBore™ *PLUS* seal chamber assures efficient heat removal (cooling) and lubrication. Seal face heat is dissipated. Seal faces are continuously flushed with clean liquid.



Engineered Seal Chamber Selection Guide

A	Ideally Suited
B	Acceptable
C	Not Recommended

Service	TYPE 1 Standard Bore *Designed for packing. Also accommodates mechanical seals.*	TYPE 2 BigBore™ *Enlarged chamber for increased seal life through improved lubrication and cooling.*	TYPE 3 TaperBore™ *PLUS* *Lower seal face temperatures, self- venting and draining. Solids and vapors circulated away from seal faces.*	TYPE 4 Jacketed TaperBore™ *PLUS* *Maintains proper temperature control (heating or cooling) of seal environment.*	TYPE 5 Jacketed BigBore™ *Maintains proper temperature control (heating or cooling) of seal environment.*
Water-Based Liquids with Flush	A	A	A	A	A
Entrained Air or Vapor	C	B	A	A	B
Solids 0-10%, no Flush	C	C	A	A	C
Solids Greater than 10% with Flush	B	A	C	C	A
Paper Stock 0-5%, no Flush	C	C	A	-	-
Paper Stock 0-5%, with Flush	B	A	-	-	-
Slurries 0-5%, no Flush	C	C	A	A	C
High Boiling Point Liquids, no Flush	C	C	A	A	C
Temperature Control	C	C	C	A	A
Self-Venting and Draining	C	B	A	A	C
Seal Face Heat Removal	C	A	A	A	A
Molten or Polymerized Liquid, no Flush	C	C	C	A	A
Molten or Polymerized Liquid with Flush	C	C	C	A	A

Bonus Interchangeability

i-FRAME™ Power Ends Fit 8 Different Process Pumps

Minimize inventory, reduce downtime.

3196 *i-FRAME* Process Pumps

CV 3196 *i-FRAME*

Non-Clog Process Pumps

HT 3196 *i-FRAME*

High Temperature Process Pumps

LF 3196 *i-FRAME*

Low Flow ANSI Process Pumps

3198 *i-FRAME*

PFA TEFLON®-Lined Process Pumps

3796 *i-FRAME*

Self-Priming Process Pumps

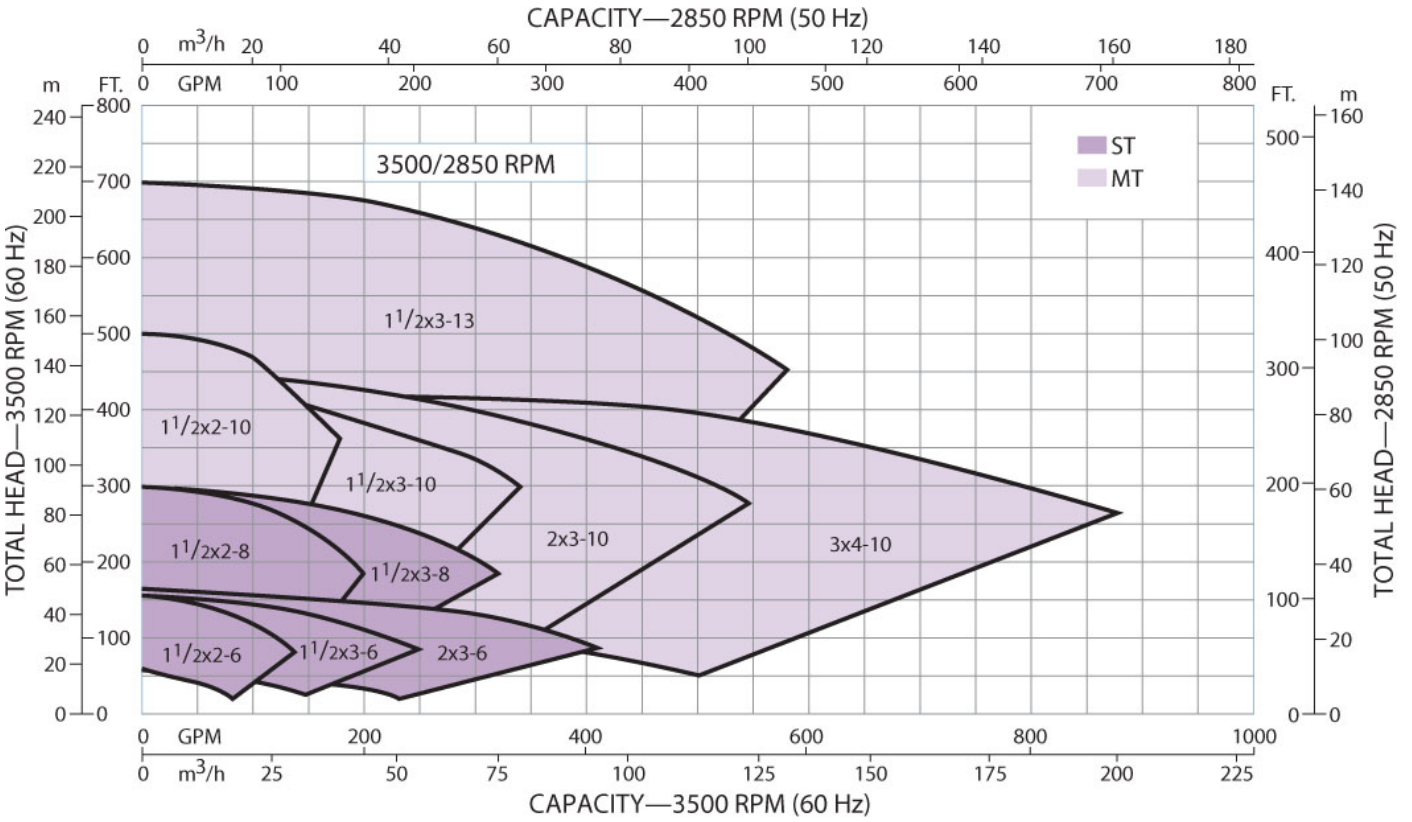
NM 3196 *i-FRAME*

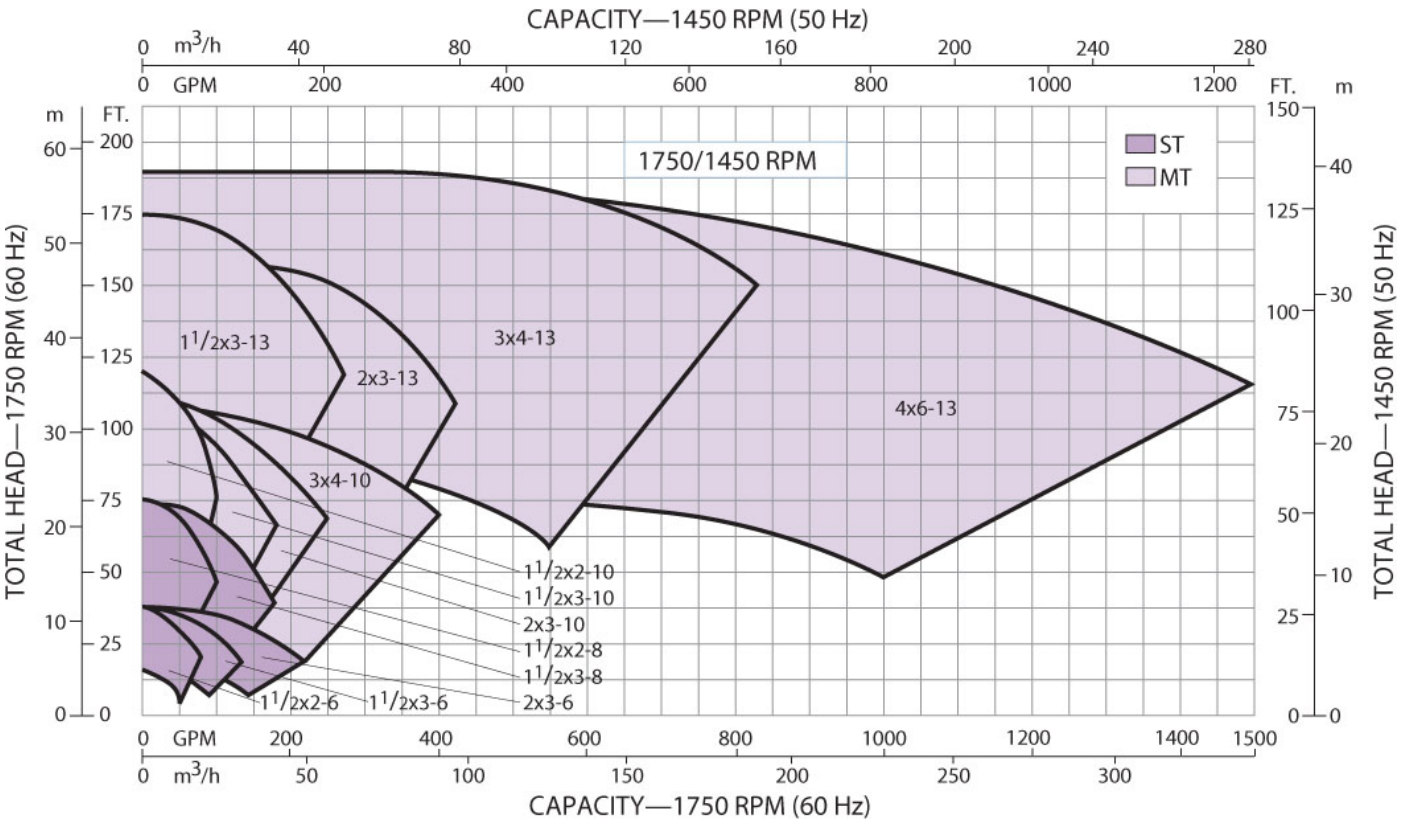
Non-Metallic Process Pumps

3996 *i-FRAME*

Inline Process Pumps

Hydraulic Coverage **Model 3996**





NOTES

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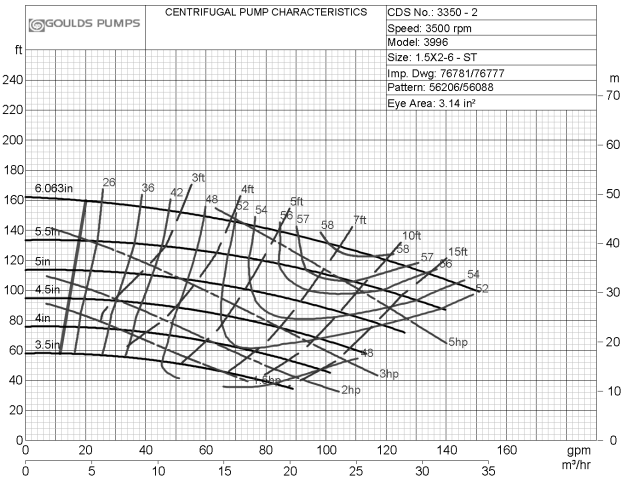
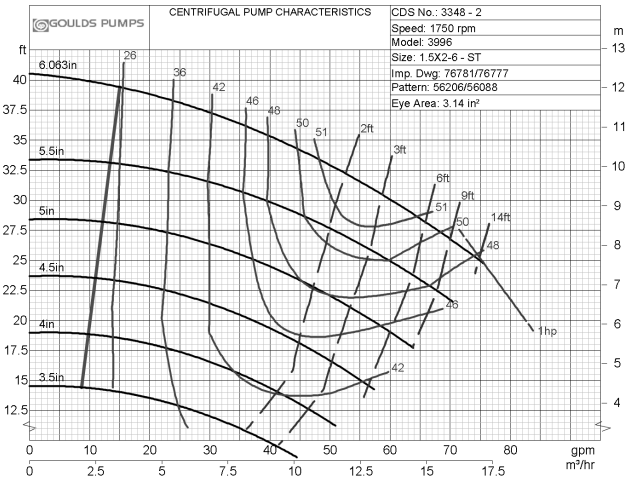
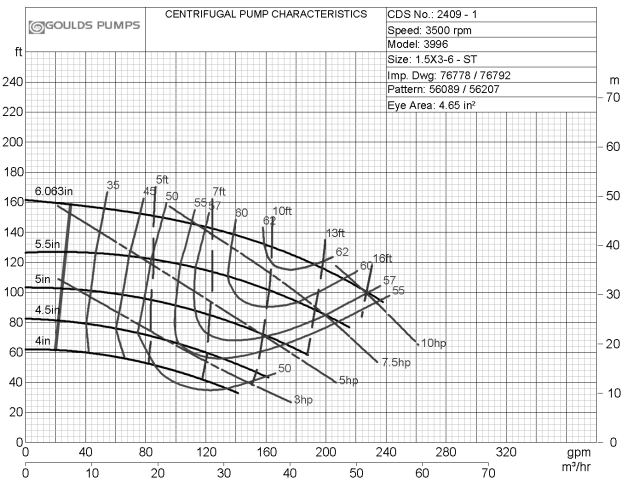


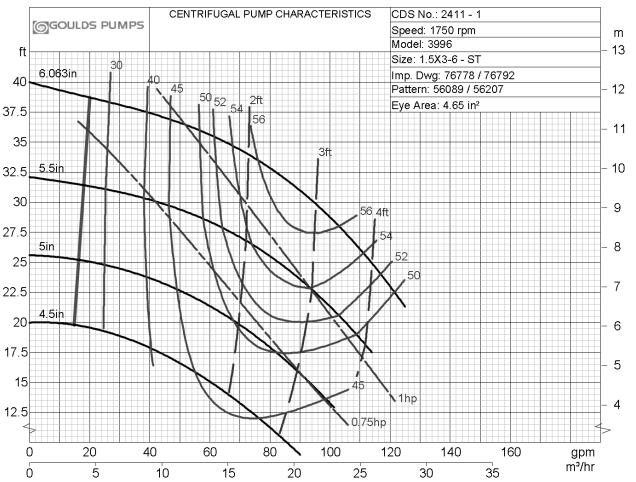
1.5X2-6 **3500rpm**



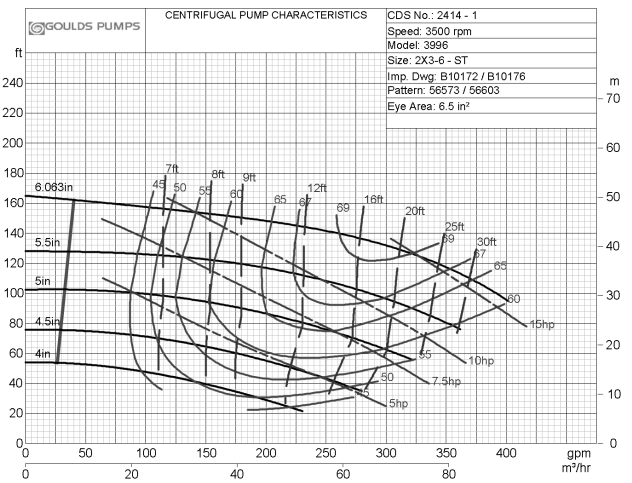
1.5X2-6 **1750rpm**



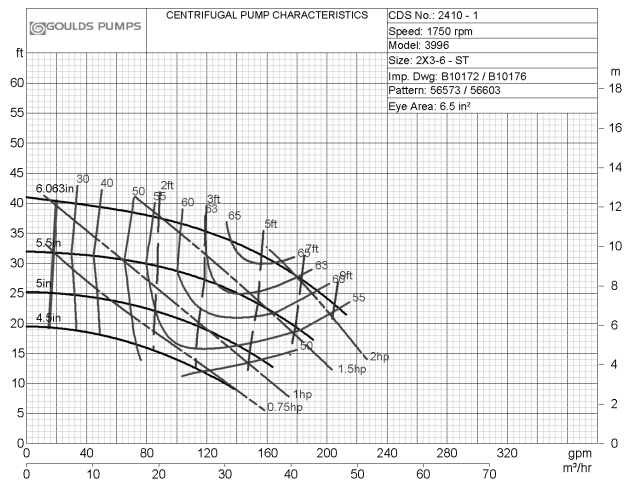
1.5X3-6 **3500rpm**



1.5X3-6 **1750rpm**



2X3-6 **3500rpm**

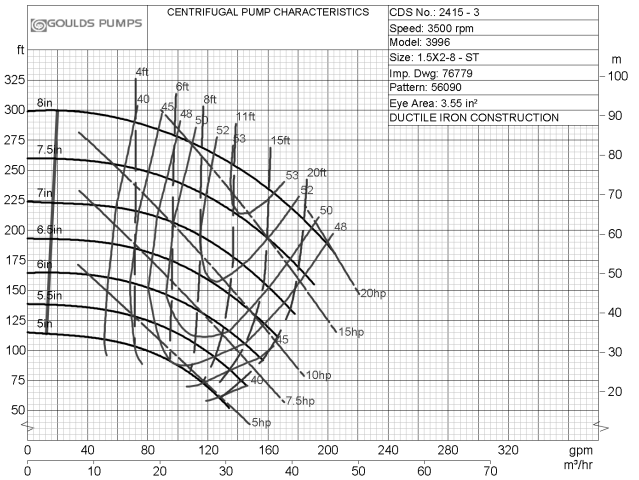


2X3-6 **1750rpm**

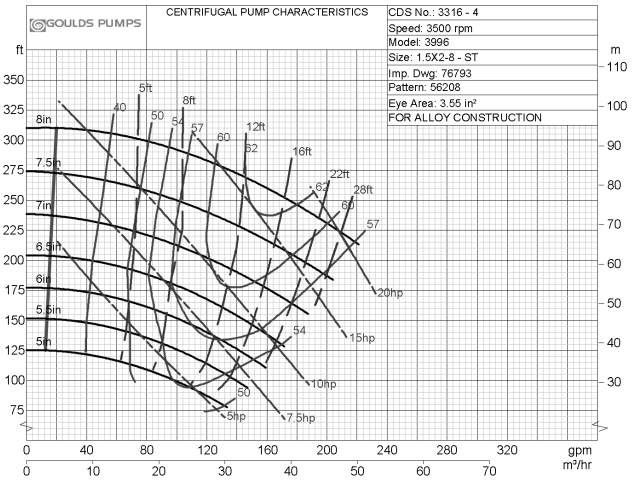
60Hz Curves

Model 3996

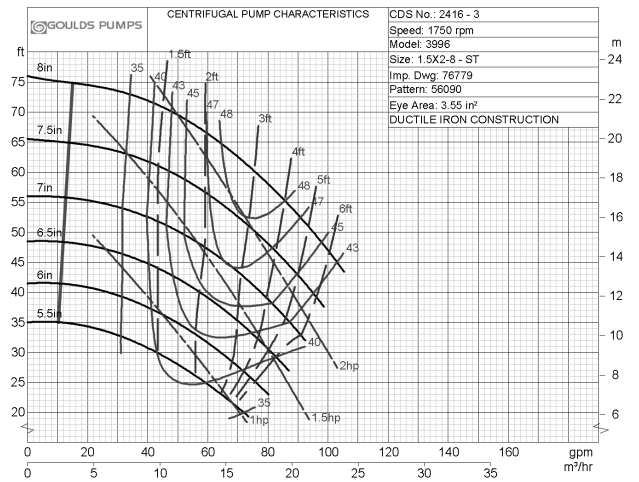
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



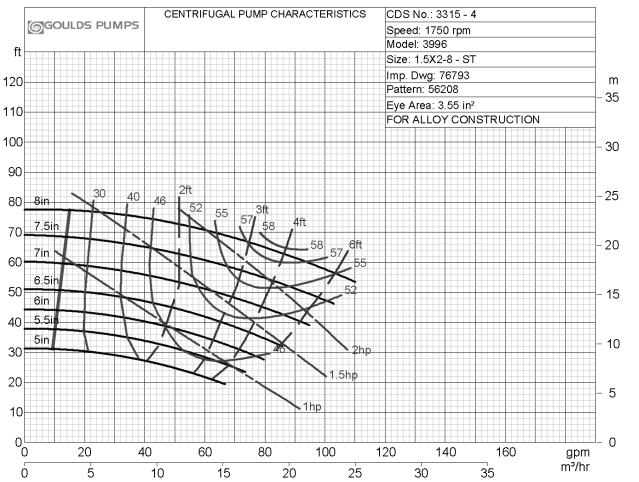
1.5X2-8 **3500rpm**



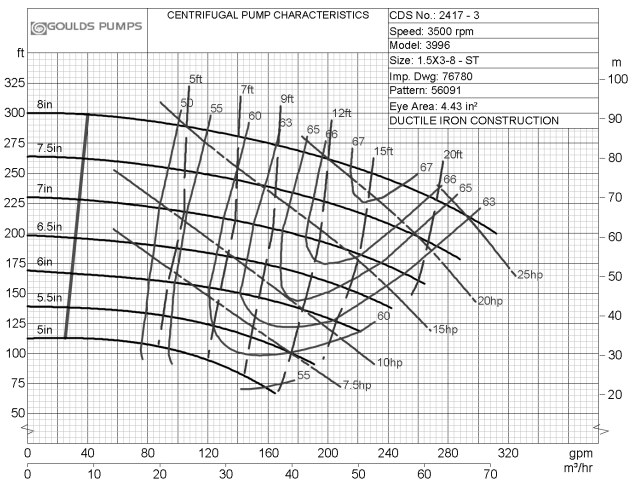
1.5X2-8 **3500rpm**



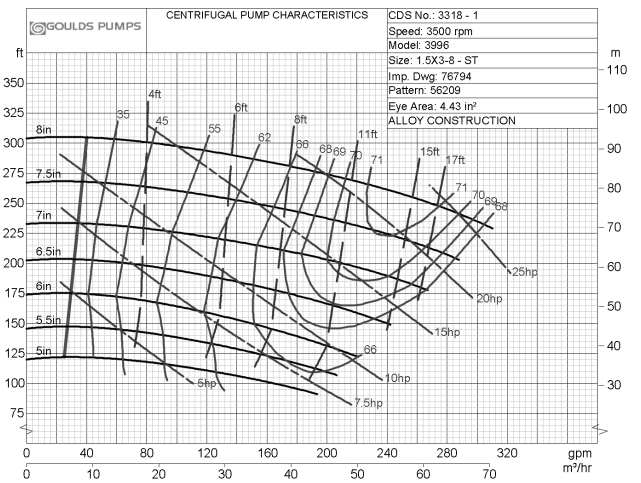
1.5X2-8 **1750rpm**



1.5X2-8 **1750rpm**



1.5X3-8 **3500rpm**



1.5X3-8 **3500rpm**

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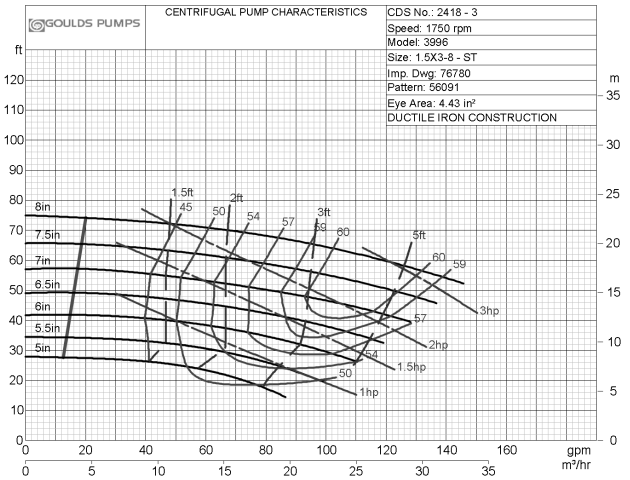
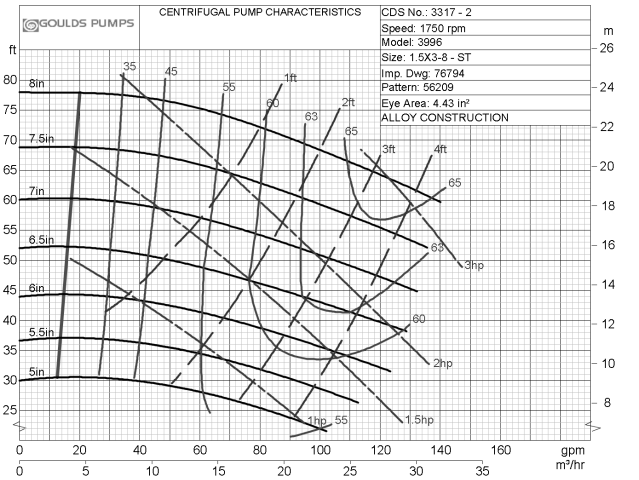
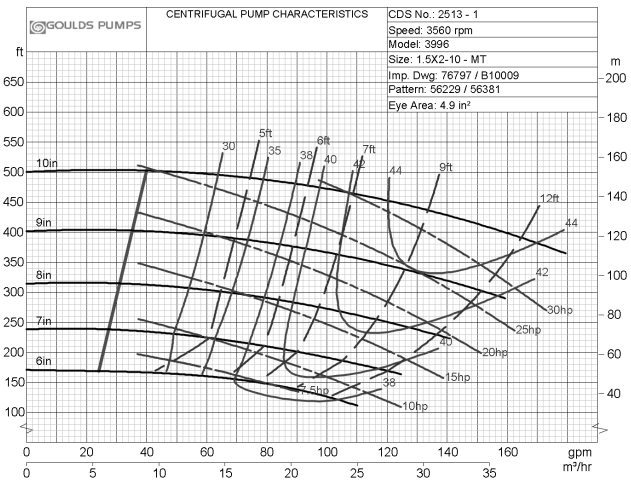


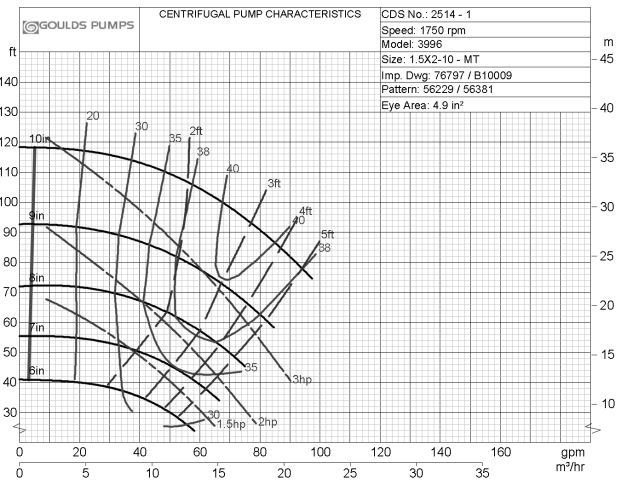
1.5X3-8 **1750rpm**



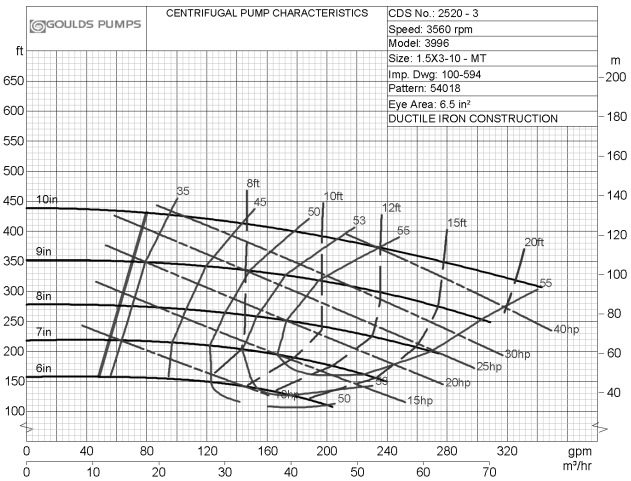
1.5X3-8 **1750rpm**



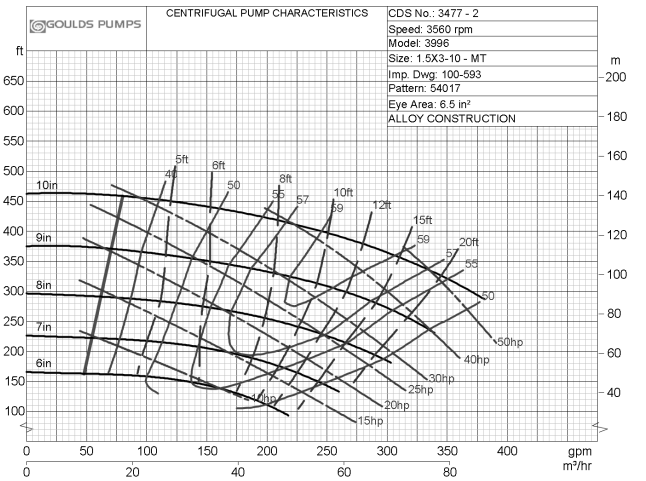
1.5X2-10 **3560rpm**



1.5X2-10 **1750rpm**



1.5X3-10 **3560rpm**

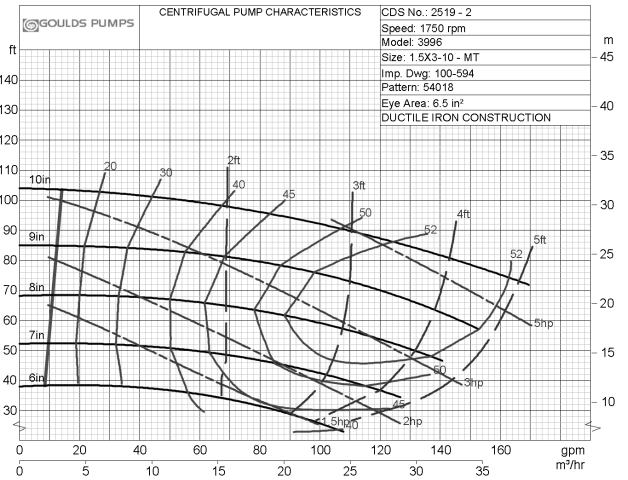


1.5X3-10 **3560rpm**

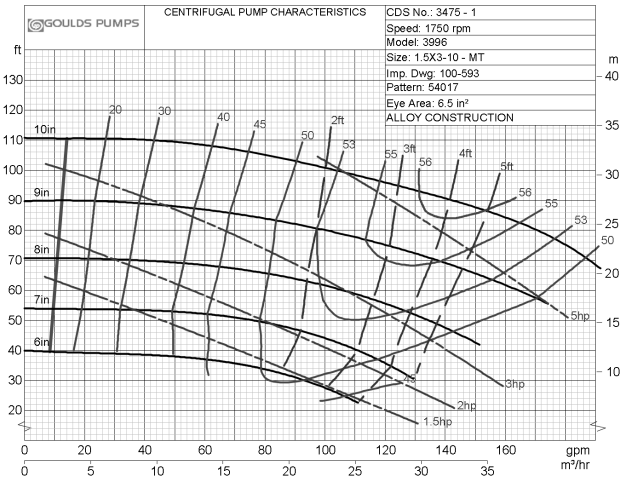
60Hz Curves

Model 3996

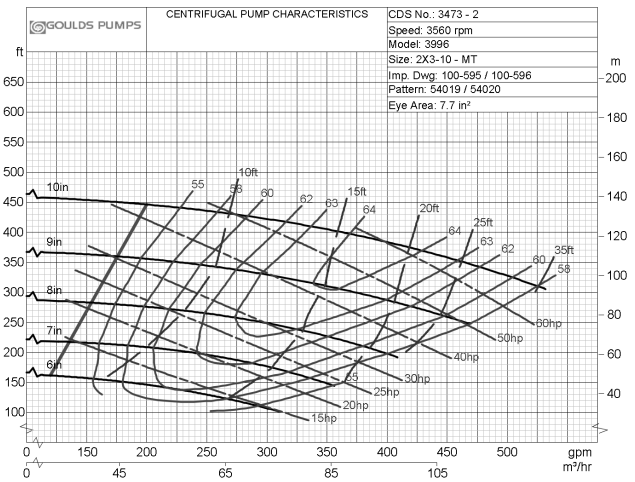
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



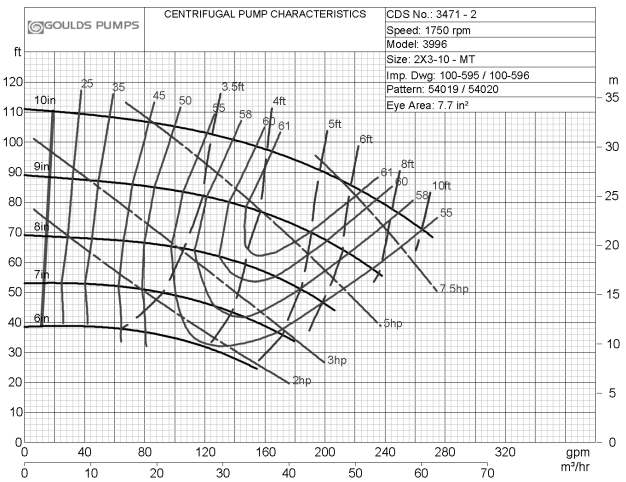
1.5X3-10 **1750rpm**



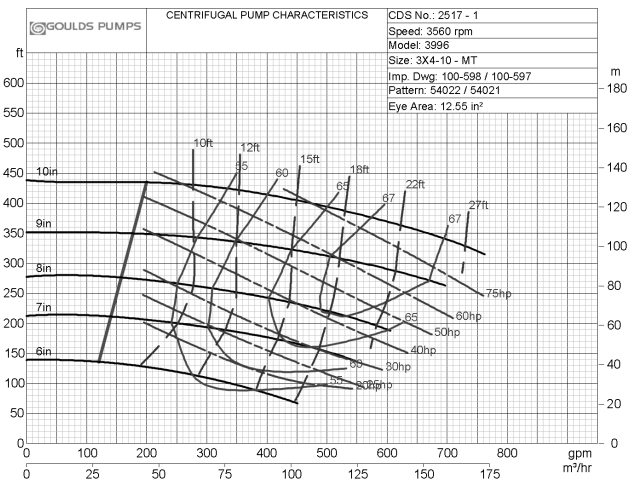
1.5X3-10 **1750rpm**



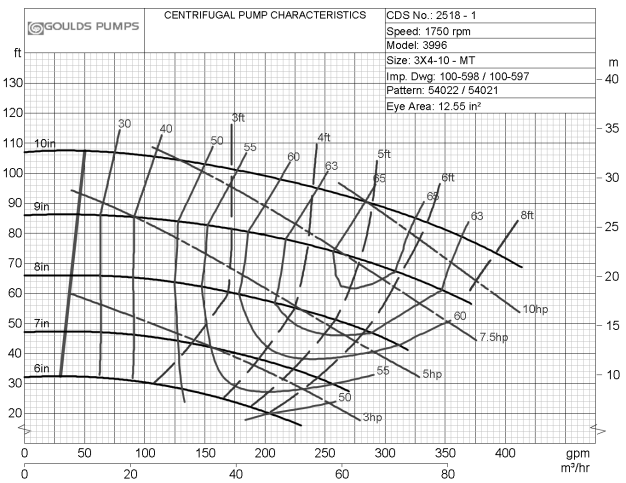
2X3-10 **3560rpm**



2X3-10 **1750rpm**



3X4-10 **3560rpm**



3X4-10 **1750rpm**

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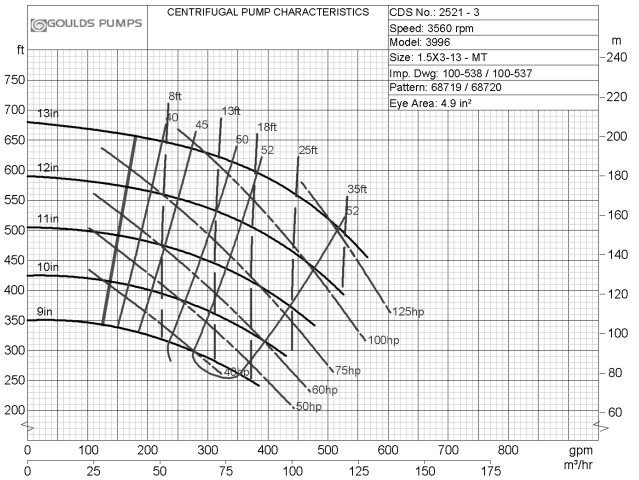
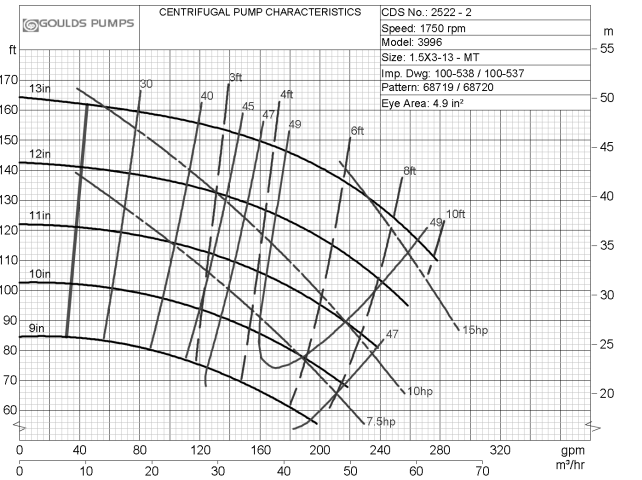
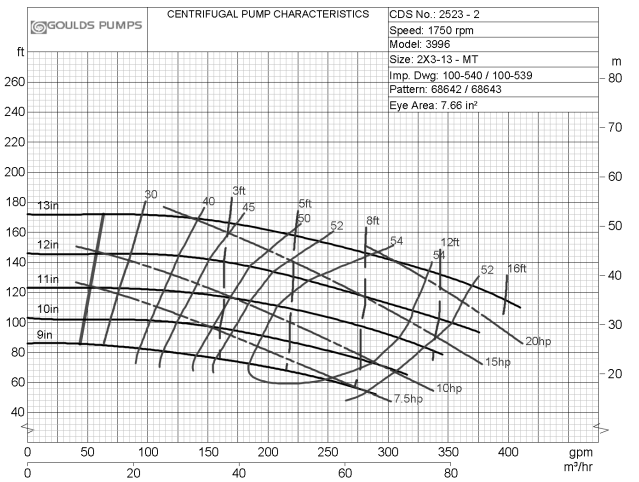


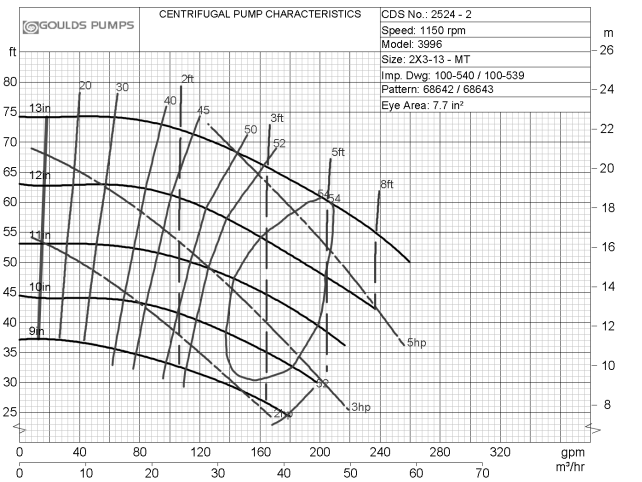
1.5X3-13 **3560rpm**



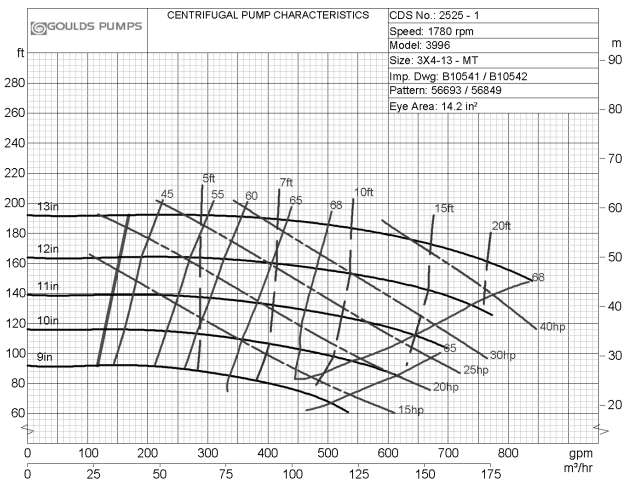
1.5X3-13 **1750rpm**



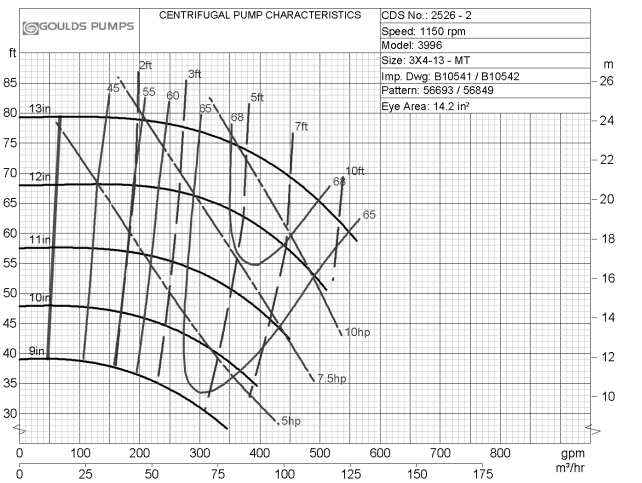
2X3-13 **1750rpm**



2X3-13 **1150rpm**



3X4-13 **1780rpm**



3X4-13 **1150rpm**

60Hz Curves

Model 3996

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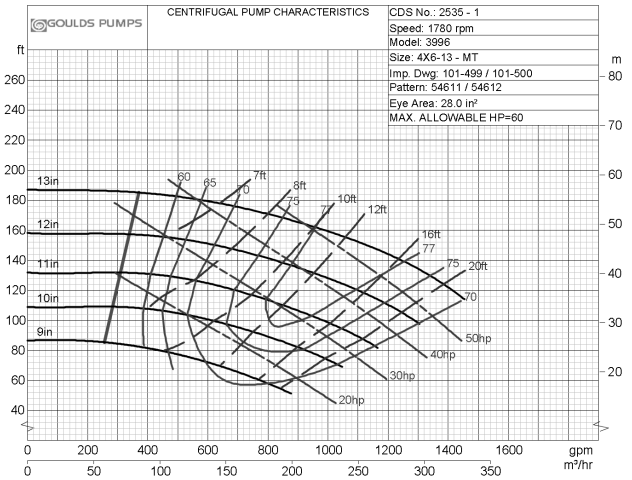
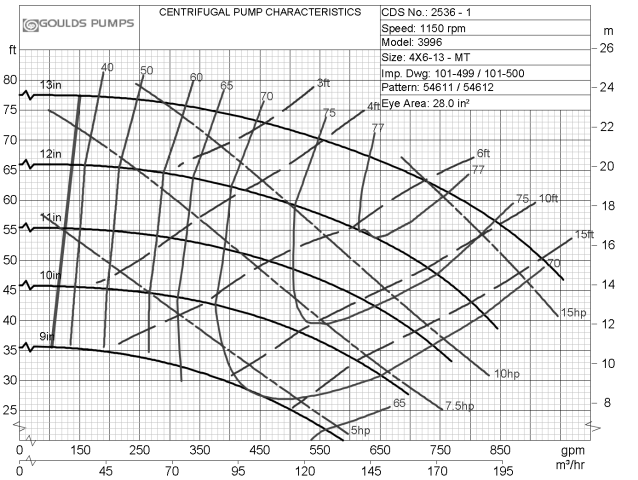


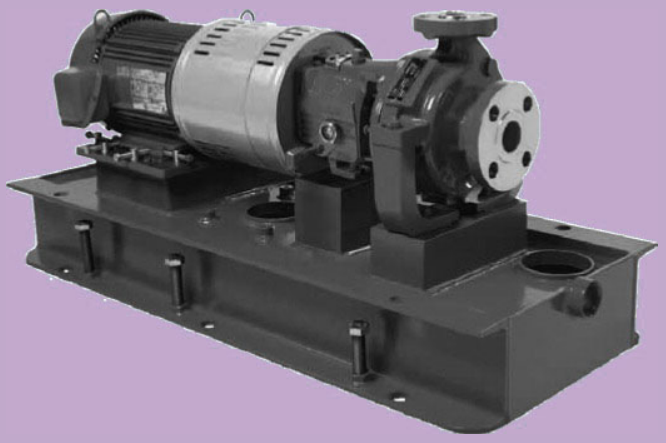
4X6-13 **1780rpm**



4X6-13 **1150rpm**

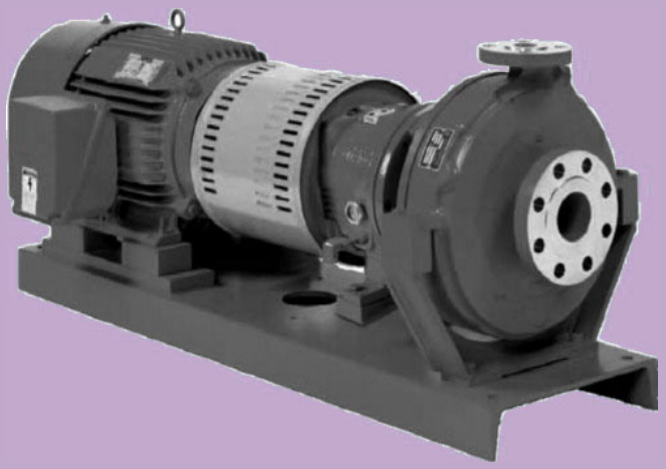
Model HT 3196 STi

5 pump sizes

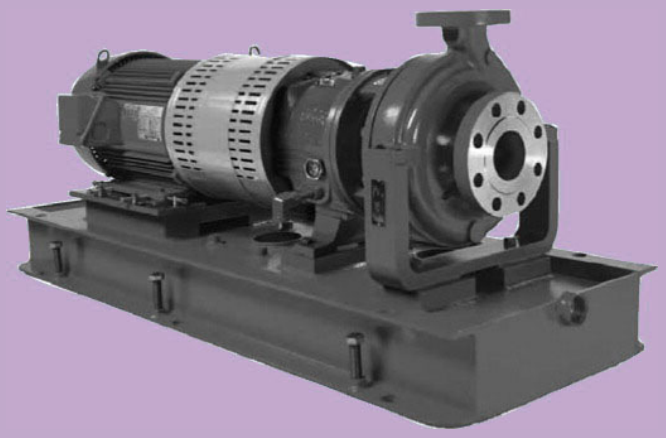


Model HT 3196 LF

3 low flow pump sizes



Model HT 3196 MTi/LTi 15 pump sizes



Model HT 3196 XLTi

5 pump sizes

Model HT 3196 *i-FRAME™*

High Temperature Process Pump

- Capacities to 4,500 GPM (1,023 m^3/h)
- Heads to 925 feet (282 m)
- Temperatures to 700°F (372°C)
- Pressures up to 450 PSIG (3,102 kPa)

Performance Features

Material of Construction

- Carbon Steel
- Ductile Iron
- 316SS Stainless Steel
- Duplex SS (CD4MCu)
- Alloy 20
- Hastelloy C

Performance Features for Extreme Temperatures, Extended Pump Life

- Centerline mounted design allows bi-directional thermal expansion which maintains shaft alignment for improved seal and bearing life
- Comprehensive range of seal chambers including TaperBore Plus™ and Big Bore™ designs maintain cool and clean seal environments critical for extended seal life
- *i-FRAME™* Power ends featuring heavy duty, large capacity oil sump with finned tube oil cooler maintains cooler oil temperatures for extended bearing life

Reduced Maintenance Cost

- Interchangeability with 3196 reduces MRO inventories (All parts except casing are the same as 3196)
- Standard ANSI dimensions simplify installation and support pump retrofits of standard foot mounted design
- Back pull-out design facilitates safe and simple maintenance activities

Markets

- Chemical/Petrochemical
- Pharmaceutical
- Pulp & Paper
- Food & Beverage
- Rubber & Plastic Manufacturing
- Power/Utility

Applications

- Hot Water
- Thermal Oils
- Heat Transfer Fluids
- Die/Mold Pre-Heating Systems
- Pilot Plants
- Electronic Heating and Cooling
- Reactor Heating
- Urea

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model HT 3196 *i-FRAME™*

Design Features For High Temperatures

HEAVY DUTY SHAFT AND BEARINGS
Rigid shaft designed for minimum deflection at seal faces - less than 0.002 in. (.05 mm). Bearings sized for 10-year average life under tough operating conditions. Available with or without shaft sleeve.

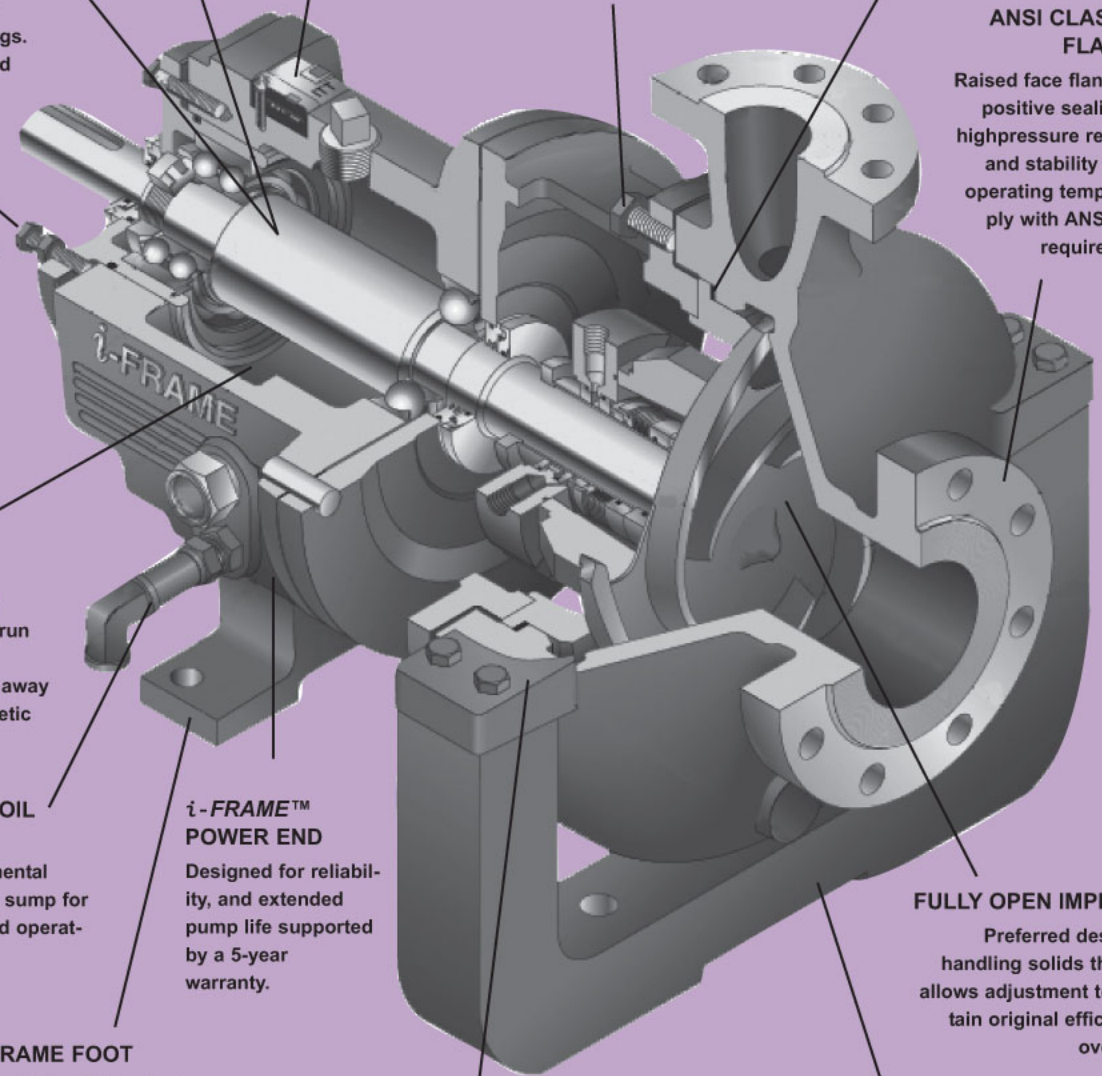
***i-ALERT* CONDITION MONITOR (U.S. Patent 8,154,417)**
Constantly measures vibration and temperature at the thrust bearing. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

LOW-THERMAL CONDUCTIVITY 316SS SHAFT
Provides optimum heat dissipation to protect bearings. Minimizes heat transfer from pumpage through shaft to bearings. Bearings run cooler and last longer.

HIGH-STRENGTH A193 B7 STEEL BOLTS AND STUDS
Extends the pressure and temperature retaining capabilities while enhancing safety.

CARBON GRAPHITE CASE GASKET AND IMPELLER O-RING
For positive sealing at elevated temps.

ANSI CLASS 300 FLANGES
Raised face flanges for positive sealing and highpressure retention and stability at high operating temps comply with ANSI B16.5 requirements.



CONTINUOUS RENEWABLE PERFORMANCE
Original flow, pressure and efficiencey are maintained by simple external adjustment resulting in long-term energy and repair parts savings.

OPTIMIZED OIL SUMP DESIGN
Increased oil capacity provides better heat transfer for reduced oil temperature. Bearings run cooler and last longer. Contaminants directed away from bearings to magnetic drain plug.

FINNED TUBE OIL COOLER
Delivers supplemental cooling to the oil sump for high process fluid operating temps.

***i-FRAME™* POWER END**
Designed for reliability, and extended pump life supported by a 5-year warranty.

RIGID FRAME FOOT
Reduces effects of pipe loads on shaft alignment; pump vibration reduced. Especially significant for high process fluid operating temperatures.

CENTERLINE MOUNTING
Allows for bi-directional thermal growth which minimizes shaft deflection and flange loading for improved seal and bearing life.

FULLY OPEN IMPELLER
Preferred design for handling solids that also allows adjustment to maintain original efficiencies over time.

HEAVY -DUTY STEEL CASING SUPPORT
Rigid design prevents against distortion caused by pipe strain to maintain shaft alignment. Mounting dimensions are identical to foot-mounted pumps, which makes retrofits simple and extends interchangebility.

Optimized Performance At High Operating Temps Up To 700° F (372° C)

The HT 3196 *i-FRAME™* is furnished with the following standard features:

- Centerline-mounted casing
- ANSI Class 300 RF flanges
- Graphite casing gasket
- Graphite impeller O-ring
- High temperature bolting
- Stainless steel shaft
- Finned tube oil cooler
- ***i-FRAME*** Power Ends

Thermal expansion due to high temperature process fluids handling is optimally controlled with centerline mounted casings. Centerline mounting minimizes shaft misalignment since the casing can expand bi-directionally. This same feature minimizes pipe strain as the casing is permitted to grow in two directions theoretically negating strain on suction piping.

ANSI Class 300 raised face flanges provide a positive sealing surface to prevent tough-to-seal liquids like hot hydrocarbons and heat transfer liquids from escaping into your regulated environment.

The HT 3196 *i-FRAME™* delivers...

ANSI and PIP Compliance

ANSI B73.1M and PIP RESP 73H-97 dimensional compliance and rugged construction for proven performance. Heavy duty centerline mounted casing stabilizes shaft alignment and minimizes piping strain while compensating for thermal expansion when pumping fluids up to process temperatures of 700° F (372° C).

Sealing Flexibility

The HT 3196 ***i-FRAME*** offers the industry's greatest cartridge sealing flexibility with optimum seal environments including Standard Bore, Big Bore and Goulds Taper Bore Plus™ with VPE rings. Jacketed seal chambers are available for controlling the temperature of the mechanical seal's environment and maximizing seal life. High performance, high temperature cartridge mechanical seals are available from nearly all manufacturers for optimum sealing reliability.

High Alloy Availability

Liquid ends are available in Carbon Steel, Ductile Iron, 316SS, CD4MCu, Alloy 20 and Hastelloy C constructions to provide materials flexibility for pumping heat transfer fluids, hot oils and moderate to highly aggressive hot chemicals.

Interchangeability

Completely interchangeable with the Goulds model 3196 ***i-FRAME*** , the world's most installed ANSI process pump. All internal components are common between models except for the casing. The ***i-FRAME*** power end provides common inventory for models 3196, CV 3196, HT 3196, LF 3196, NM 3196, 3198 and 3796.

Lead-times

Maximized parts interchangeability with the Goulds 3196 ***i-FRAME*** results in optimized lead-times with our ANSI product line for fast response to customer needs.

Five-Year Standard Warranty

i-FRAME pumps feature a 5-year warranty that acknowledges superior performance, optimum run time, and extended pump life.

High Temperature Pumping Applications

High Temperature Oils and Heat Transfer Fluids

The use of synthetic heat transfer liquids continues to expand as these liquids offer chemical stability and efficient heat transfer properties. In addition, the use of these liquids allows system pressures to be reduced for added safety and lower design costs. Hot natural oils and synthetic oils are used in heat transfer, food processing, oil refining and petrochemical mining applications. Some applications for hot oils and heat transfer fluids include computer and power supply, energy storage, transformer cooling, recirculating chillers, train traction rectifiers, re-flow soldering, industrial processing, pharmaceutical processing and semiconductor processing.

High Temperature Chemical Processing

The Goulds HT 3196 ***i-FRAME*** features superior chemical corrosion resistance through optimal manufacturability of high alloy wetted pump components. Offered in Carbon Steel, Ductile Iron, 316ss, CD4MCu, Alloy 20 and Hastelloy C, the HT 3196 ***i-FRAME*** provides a well-rounded selection of materials to maximize pump life when pumping hot, aggressive solvents, acids and chlorides.

High temperature fluid applications include asphalt, tars, Naphtha, Naphthalene, aromatics, hydrocarbons, urethanes, epoxies, paints, zinc compounds, magnesium compounds, adhesives, plastisizers, polyols, polymers, monomers, resins, oxide slurries, pigments, dyes, inks and many more.

Bonus Interchangeability

i-FRAME™ Power Ends Fit 7 Different Process Pumps

Minimize inventory, reduce downtime.

3196 *i-FRAME* Process Pumps

CV 3196 *i-FRAME* *Non-Clog* Process Pumps

HT 3196 *i-FRAME* *High Temperature* Process Pumps

LF 3196 *i-FRAME* *Low Flow ANSI* Process Pumps

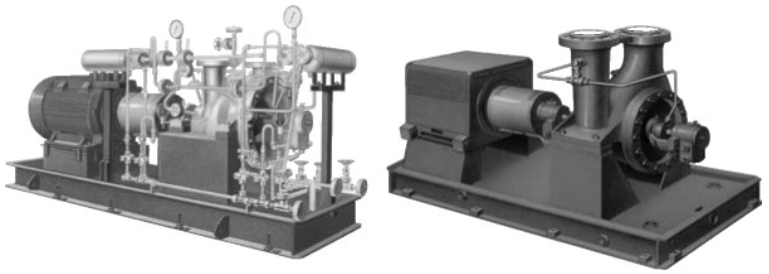
3198 *i-FRAME* *PFA TEFLON®-Lined* Process Pumps

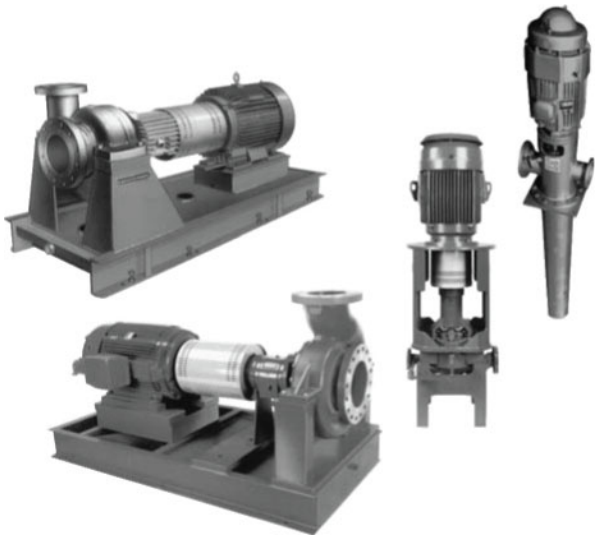
3796 *i-FRAME* *Self-Priming* Process Pumps

NM 3196 *i-FRAME* *Non-Metallic* Process Pumps

High Temperature Pumping Expertise

In addition to ANSI Process Pump Expertise, ITT Goulds Pumps delivers decades of premier experience in centerline mounted, high temperature pump applications with thousands of pump models installed, including the Models 3700, 3910, 3900, 3600, 3620, 3640, 3181, and high temperature vertical turbine pumps.

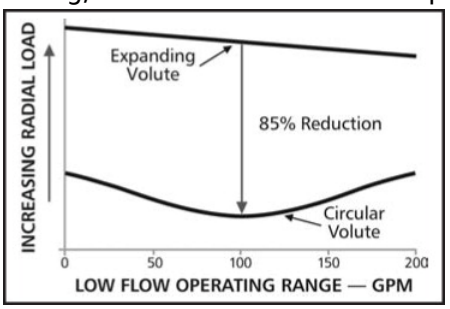




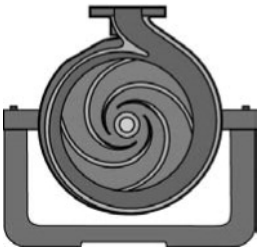
Goulds HT 3196 *i-FRAME™*

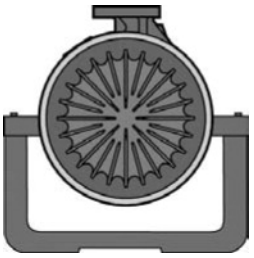
Designed for High Temperature, Low Flow Services

Reduced Radial Loads For Optimum Reliability
Radial loads are reduced by as much as 85% compared to end suction expanding volute pumps at low flows. Bearing, mechanical seal and overall pump life are optimized.



HT 3196 LF *i-FRAME* PUMP CURVE


EXPANDING VOLUTE PUMP


HT 3196 LF *i-FRAME*
CIRCULAR VOLUTE PUMP

Options High and Low Temperature Capability

Goulds offers users a variety of options to meet specific plant and process requirements.

HEAT JACKET

Economical clamp-on jacket provides practical method of heating or cooling the casing. Excellent heat transfer characteristics. Easy to install or remove for pump servicing.

JACKETED SEAL CHAMBER

Maintains proper temperature control of sealing environment. Ideal for maintaining temperature for services such as molten sulphur and polymerizing liquids. Available in BigBore™ and TaperBore™ designs.

CUSTOM FITTED INSULATED FABRIC THERMAL JACKET

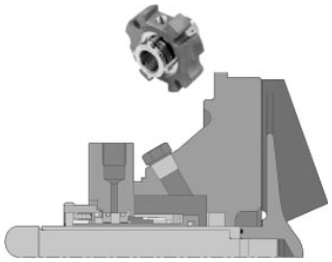
Insulates and provides thermal retention of the process fluid within the pump. Insulation jackets are custom fitted and easily removable for installing and servicing the pump.

High Temperature Seal Selection Shaft Sealing Systems

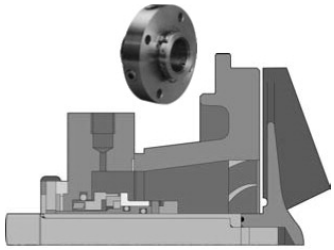
The most difficult challenge for pumping hot fluids is to effectively seal the rotating shaft from emitting excessive or undesirable fluids into the atmosphere for the purposes of safety and equipment reliability. The selection of optimum sealing device for specific pumping systems is simplified by combining the world's premier sealing suppliers with the perfect high temperature pumping system.

Multiple high temperature sealing devices and mechanical seal flushing systems are designed and available for a multitude of challenging high temperature sealing applications. The standard HT 3196 ***i-FRAME*** configuration includes graphite packing rings in a standard bore box for basic high temperature fluid applications.

Single and dual cartridge mechanical seals for moderate temperature applications.


Big Bore™

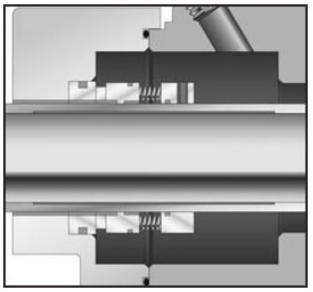
Single and dual cartridge mechanical seals for high temperature applications.


Taper Bore™ Plus

Engineered Seal Chambers

Extended Seal Life and Lower Maintenance Costs

SEAL ENVIRONMENT IS CRITICAL FOR EXTENDED SEAL LIFE



The number one cause of pump downtime is failure of the shaft seal. These failures are normally the result of an unfavorable seal environment such as improper heat dissipation (cooling), poor lubrication of the seal faces, or seals operating in liquids containing solids, air or vapors.

Goulds engineered seal chambers are designed to provide the best seal environment for any sealing arrangement.

Enlarged bore seal chambers (BigBore™ and TaperBore™ PLUS) with increased radial clearance between the mechanical seal and seal chamber provide better circulation of liquid to and from seal faces. Improved lubrication and heat removal extend seal life and pump uptime.

The bottom line is lower maintenance costs.

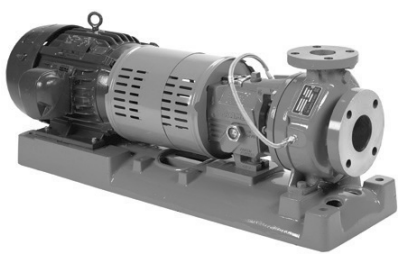
Engineered Seal Chamber Selection Guide

A	Ideally Suited
B	Acceptable
C	Not Recommended

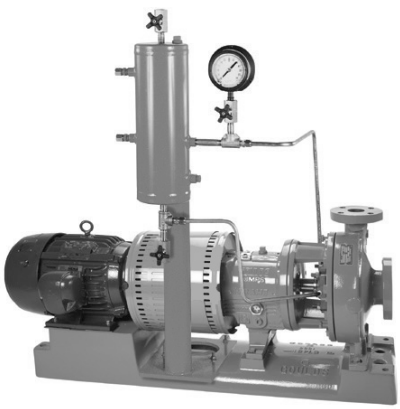
Service	TYPE 1 **Standard Bore** *Designed for packing. Also accommodates mechanical seals.*	TYPE 2 **BigBore™** *Enlarged chamber for increased seal life through improved lubrication and cooling.*	TYPE 3 **TaperBore™ PLUS** *Lower seal face temperatures, self-venting and draining. Solids and vapors circulated away from seal faces.*	TYPE 4 **Jacketed TaperBore™ PLUS** *Maintains proper temperature control (heating or cooling) of seal environment.*	TYPE 5 **Jacketed BigBore™** *Maintains proper temperature control (heating or cooling) of seal environment.*
Water-Based Liquids with Flush	A	A	A	A	A
Entrained Air or Vapor	C	B	A	A	B
Solids 0-10%, no Flush	C	C	A	A	C
Solids Greater than 10% with Flush	B	A	C	C	A
Paper Stock 0-5%, no Flush	C	C	A	-	-
Paper Stock 0-5%, with Flush	B	A	-	-	-
Slurries 0-5%, no Flush	C	C	A	A	C
High Boiling Point Liquids, no Flush	C	C	A	A	C
Temperature Control	C	C	C	A	A
Self-Venting and Draining	C	B	A	A	C
Seal Face Heat Removal	C	A	A	A	A
Molten or Polymerized Liquid, no Flush	C	C	C	A	A
Molten or Polymerized Liquid with Flush	C	C	C	A	A

Seal Flush Plans

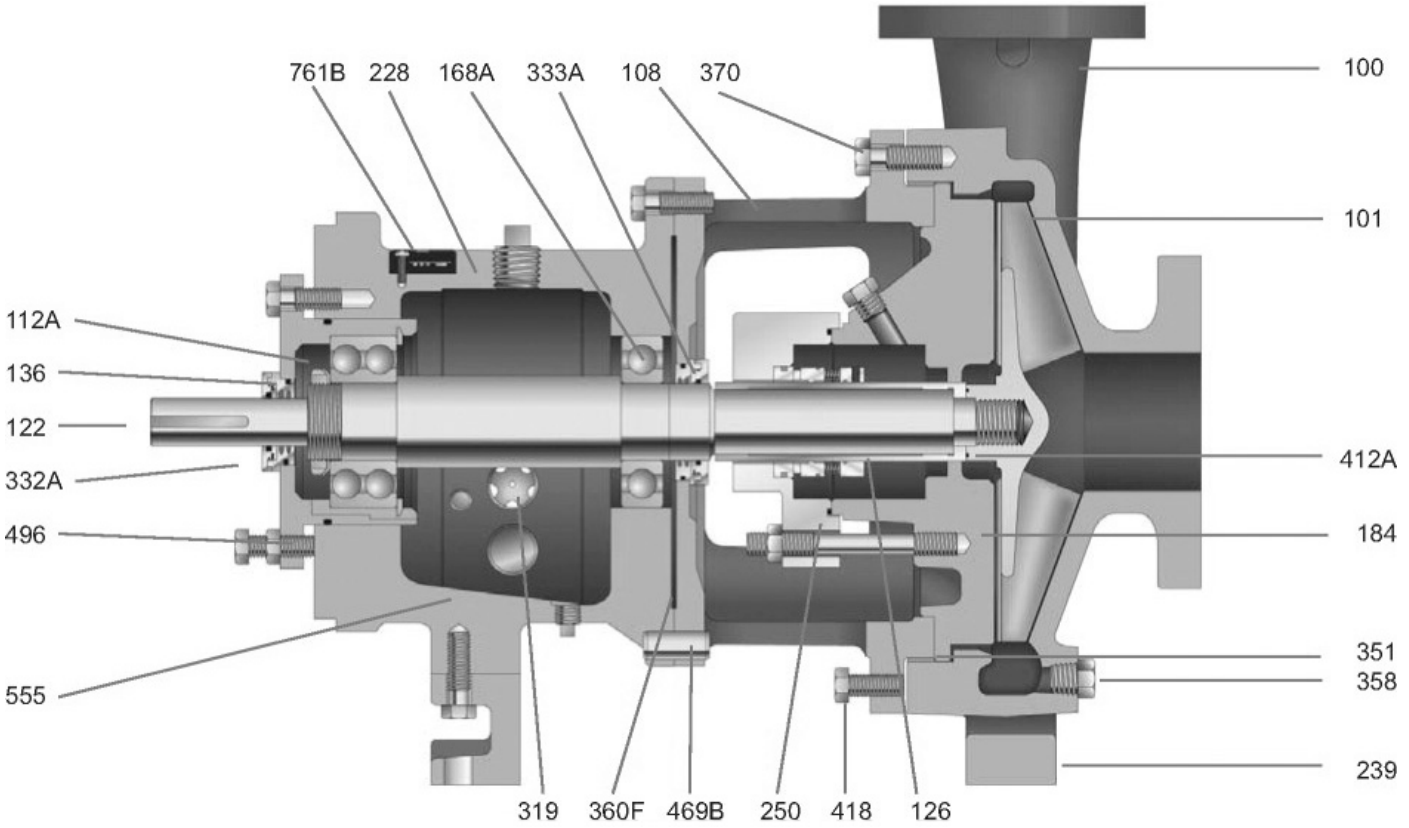
All ANSI B73.1 seal flush and cooling plans are available to control emission levels and meet seal installation requirements. Goulds can also provide other special arrangements of user preference.



CPI PLAN 7311
By-pass flush lubricates single seal faces.



CPI PLAN 7353
Pressurized circulation lubricates double seal faces.



Parts List and Materials of Construction

Item Number	Part Name	Material					
		Carbon Steel	Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy C
100	Casing	CS	316SS	316SS	CD4MCu	Alloy 20	Hastelloy C
101	Impeller		Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy C
106	Stuffing Box Packing	Graphite					
108	Frame Adapter	Ductile Iron					
112A	Thrust Bearing	Double Row Angular Contact*					
122	Shaft—Less Sleeve (Optional)	316SS			316SS	Alloy 20	Hastelloy C
122	Shaft—With Sleeve	316SS					
126	Shaft Sleeve	316SS				Alloy 20	Hastelloy C
136	Bearing Locknut and Lockwasher	Steel					
168A	Radial Bearing	Single Row Deep Groove					
184	Stuffing Box Cover (Packed Box)	316SS			CD4MCu	Alloy 20	Hastelloy C
184	Seal Chamber (Mechanical Seal)		Ductile Iron	316SS	CD4MCu	Alloy 20	Hastelloy C
228	Bearing Frame	Cast Iron (Ductile Iron for *STi* Group)					
239	Casing Support	Fabricated Steel					
250	Gland	316SS			CD4MCu	Alloy 20	Hastelloy C
370H	Stud/Nut, Cover-to-Adapter	304SS					
319	Oil Sight Glass	Glass/Steel					
332A	INPRO® Labyrinth Oil Seal (Outboard)	Stainless Steel/Bronze					
333A	INPRO® Labyrinth Oil Seal (Inboard)	Stainless Steel/Bronze					
351	Casing Gasket	Graphite					
358	Casing Drain Plug (Optional)	316SS			CD4MCu	Alloy 20	Hastelloy C
360F	Gasket, Frame-to-Adapter	Buna					
360C	Gasket, Bearing End Cover	Cellulose Fiber with Binder					
370	Cap Screw, Adapter-to-Casing	304SS					
412A	O-ring, Impeller	Graphite					
418	Jacking Bolt	304SS					
444	Backplate (Dynamic Seal Option)	316SS			CD4MCu	Alloy 20	Hastelloy C
469B	Dowel Pin, Frame-to-Adapter	Steel					
496	O-ring, Bearing Housing	Buna Rubber					
555	Bearing Frame Finned Cooler	Steel/Copper					
761B	Condition Monitor	Stainless Steel/Epoxy					

**LTi* Power End features Duplex Angular Contact
® Teflon is a registered trademark for Fluoropolymer Resins, Films, Fibers manufactured by DuPont.

Goulds Patented *i-FRAME™* Power Ends

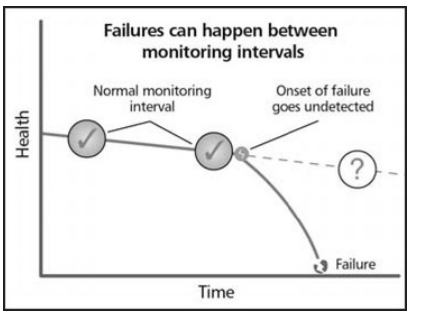
Extended Pump Life Through Intelligent Design

Goulds ***i-FRAME*** Power Ends are the result of 160 years of design experience, customer interaction, and continuous improvement. Customers get extended Mean Time Between Failure (MTBF) and lower life cycle costs (LCC)...guaranteed!

1 *i-ALERT™* CONDITION MONITOR

The heart of the *i-FRAME*, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

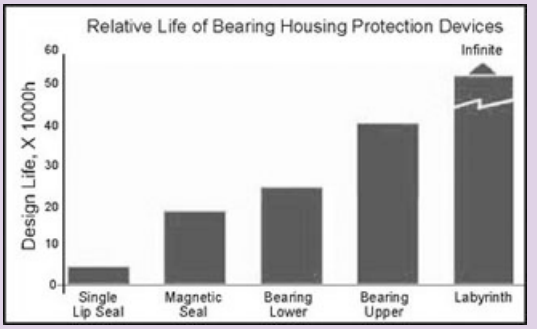
A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



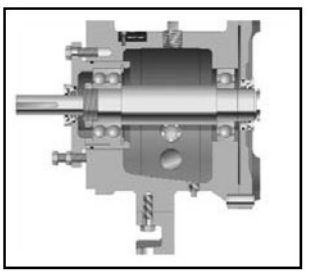
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

2 INPRO VBXX-D HYBRID BEARING ISOLATORS

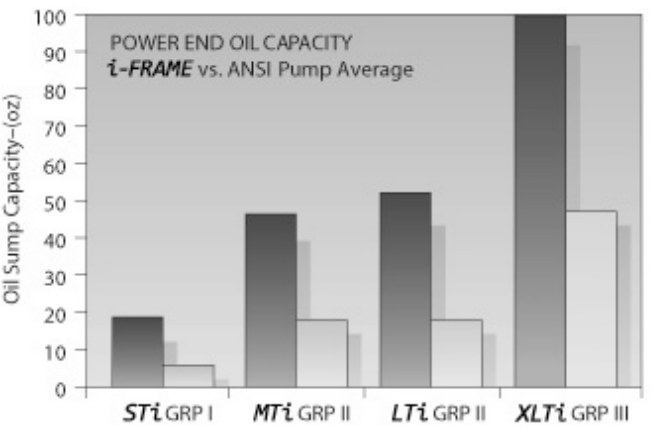
Most bearings fail before reaching their potential life. They fail for a variety of reasons, including contamination of the lubricant. INPRO VBXX-D has long been considered the industry standard in bearing lubricant protection. The ***i-FRAME*** now improves upon that design by offering stainless steel rotors, for maximum protection against contaminants and the corrosive effects of seal leakage or environmental conditions. These seals are non-contacting and do not wear.



3 OPTIMIZED OIL SUMP DESIGN



Internal sump geometry is optimized for longer bearing life. Sump size increased by 10%-20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.



Larger *Means Cooler*
GOULDS
Industry Average

4 SHAFT AND BEARINGS ENGINEERED FOR MAXIMUM RELIABILITY

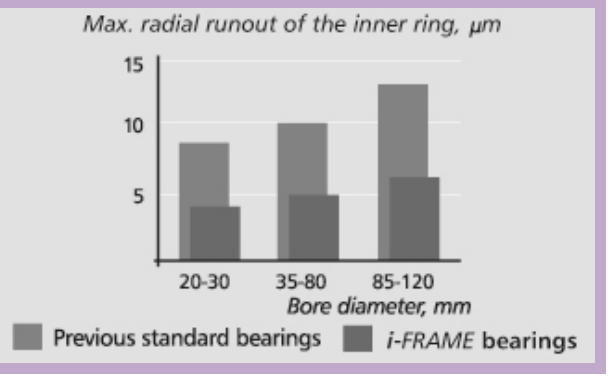
The rugged shaft and bearing combination maintains shaft deflection of less than 0.002 inches at all operating points. The result is longer seal and bearing life.

Premium severe-duty thrust bearings increase bearing fatigue life.

- High purity steels have fewer inclusions than standard steel – better grain structure and wear resistance.
- Heat treatment of bearing elements to SO stabilizaion levels provides superior thermal stability for increased service life.
- Bearing Balls are manufactured to at least one ISO grade above standard (ISO P5 for ring running accuracy and ISO P6 for dimensions). The result is reduced vibration and noise for improved shaft guidance.

Every 3196 ***i-FRAME***™ Power End is engineered and manufactured for optimal pump performance and increased MTBF.

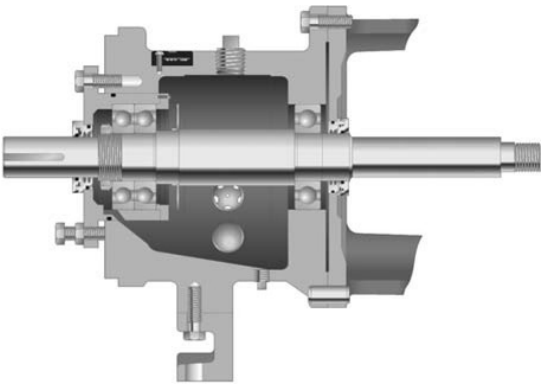
ANSI B73.1 Shaft Specification	Meets	Exceeds
Diameter Tolerance		✓
Surface Finish		✓
Runout	✓	
Deflection		✓



5 *LTi* POWER END FOR HIGH LOAD APPLICATIONS

Increased L'10 Bearing Life 150% to 200% on the Toughest Applications

Ideal for tough conditions when a power end is pushed beyond ANSI limits: operating at low flows and higher heads, pumping high specific gravity liquids, fluctuating process conditions, overhung belt drive. Oversized shaft and bearing assembly significantly expands the limits for long, trouble-free bearing and seal life. On high load applications, the *LTi* power end improves bearing life 150%-200%; oil operating temperature reduced by 45°F (25° C).



FLINGER/CHANNEL OIL LUBRICATION SYSTEM

Provides 30% increased L'10 life; 15°F (8°C) reduced oil temperature.

OVERSIZED SHAFT

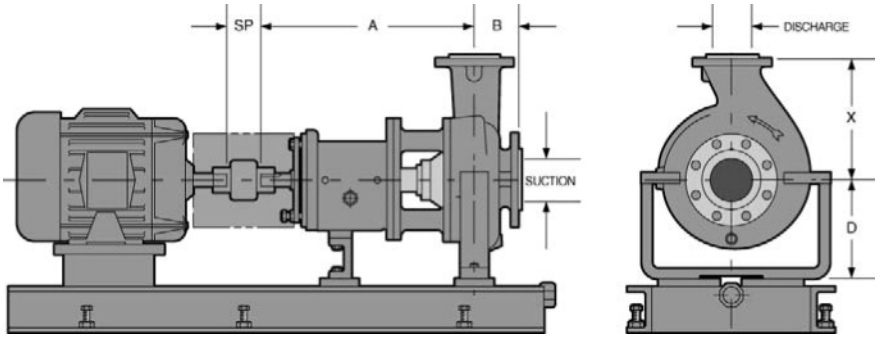
With duplex thrustbearings provide increased L'10 by 40%.

DUPLEX THRUST BEARINGS

Duplex thrust bearings (40°/40° angular contact) with machined brass cages, are ideally sized for high load applications.

Our Guarantee We are so confident that the ***i-FRAME***™ is the most reliable Power End in the industry, that we are proud to offer a standard 5-year warranty on every ***i-FRAME*** ANSI Process Pump.

Dimensions Model HT 3196 *i-FRAME™*



DIMENSIONS										
Group	Pump Size	ANSI Designation	Discharge Size	Suction Size	×	A	B	D	SP	Bare Pump Weight Lbs. (kg)
STi	1×1½-6	AA	1	1½	6.5 (165)	13.5 (343)	4 (102)	5.25 (133)	3.75 (95)	84 (38)
	1½×3-6	AB	1½	3						92 (42)
	2×3-6	-	2	3						95 (43)
	1×1½-8	AA	1	1½						100 (45)
	1½×3-8	AB	1½	3						108 (49)
MTi/LTi	3×4-7	A70	3	4	11 (280)	19.5 (495)	4 (12)	8.25 (210)	3.75 (95)	220 (100)
	2×3-8	A60	2	3	9.5 (242)					220 (91)
	3×4-8	A70	3	4	11 (280)					220 (100)
	3×4-8G	A70	3	4						
	1×2-10	A05	1	2	8.5 (216)					200 (91)
	1½×3-10	A50	1½	3						220 (100)
	2×3-10	A60	2	3	9.5 (242)					230 (104)
	3×4-10	A70	3	4	11 (280)					265 (120)
	3×4-10H	A40	3	4	12.5 (318)	19.5 (495)	4 (102)	10 (254)		275 (125)
	4×6-10G	A80	4	6	13.5 (343)					305 (138)
	4×6-10H	A80	4	6						
	1½×3-13	A20	1½	3	10.5 (267)					245 (111)
	2×3-13	A30	2	3	11.5 (292)					275 (125)
	3×4-13	A40	3	4	12.5 (318					330 (150)
	4×6-13	A80	4	6	13.5 (343)					405 (184)
XLTi	6×8-13	A90	6	8	16 (406)	27.875 (708)	6 (152)	14.5 (368)	5.25 (133)	560 (254)
	8×10-13	A100	8	10	18 (457)					670 (304)
	6×8-15	A110	6	8						610 (277)
	8×10-15	A120	8	10	19 (483)					740 (336)
	8×10-15G	A120	8	10						710 (322)
	8×10-16H	-	8	10						850 (385)
	4×6-17	-	4	6	16 (406					650 (295)
	6×8-17	-	6	8	18 (457)					730 (331)
	8×10-17	-	8	10	19 (483)					830 (376)

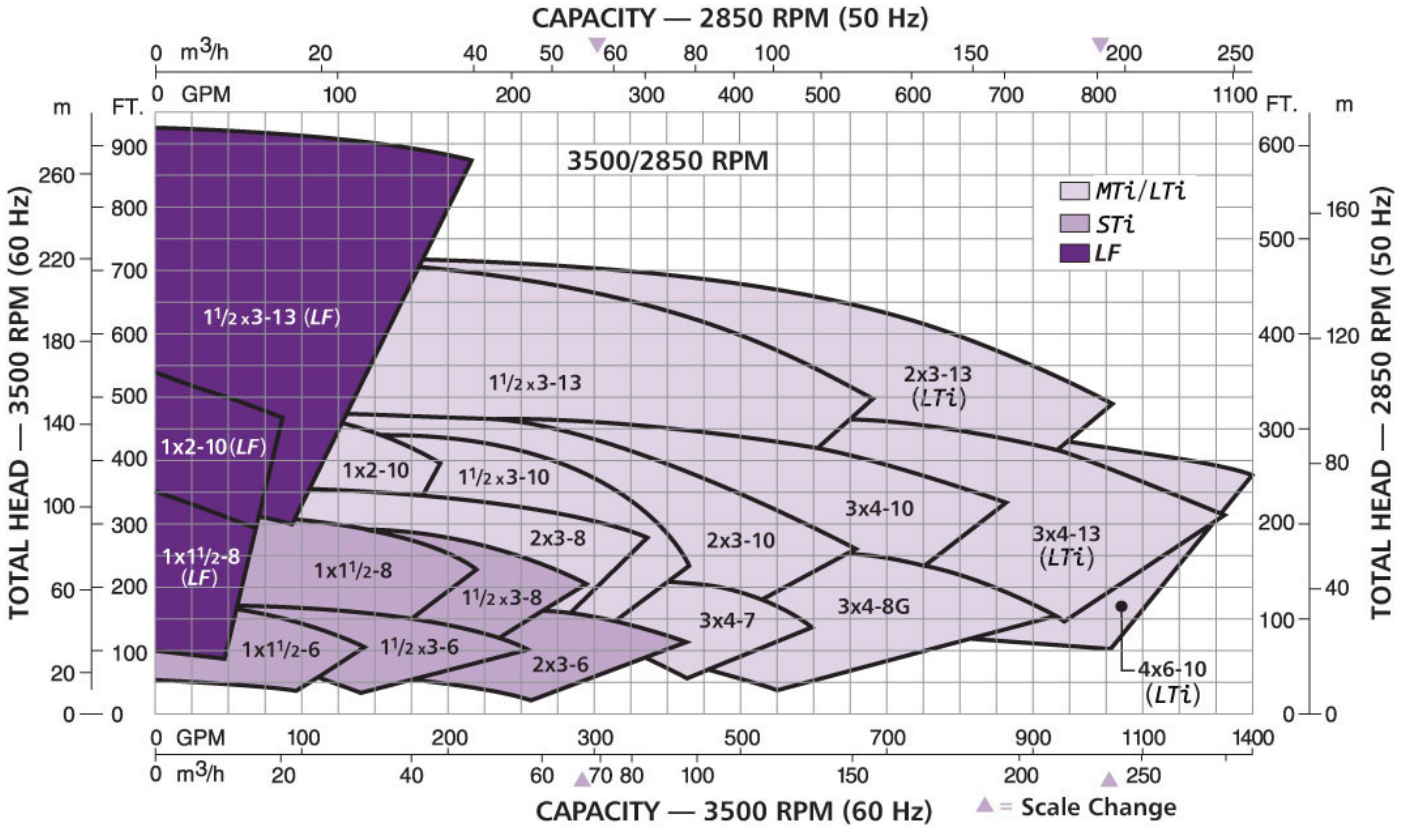
All dimensions in inches and (mm). Not to be used for construction.

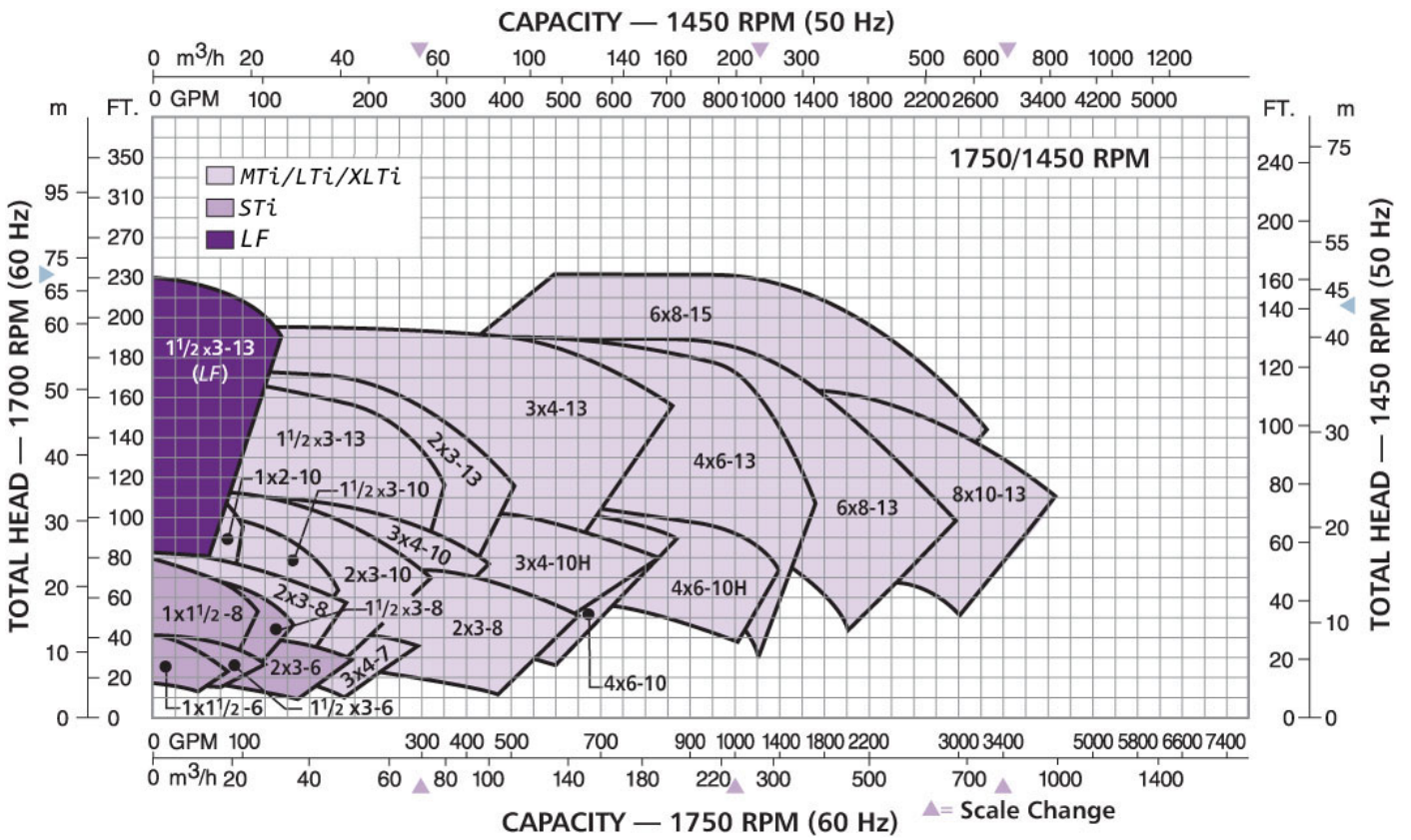
Construction Details All dimensions in inches and (mm).

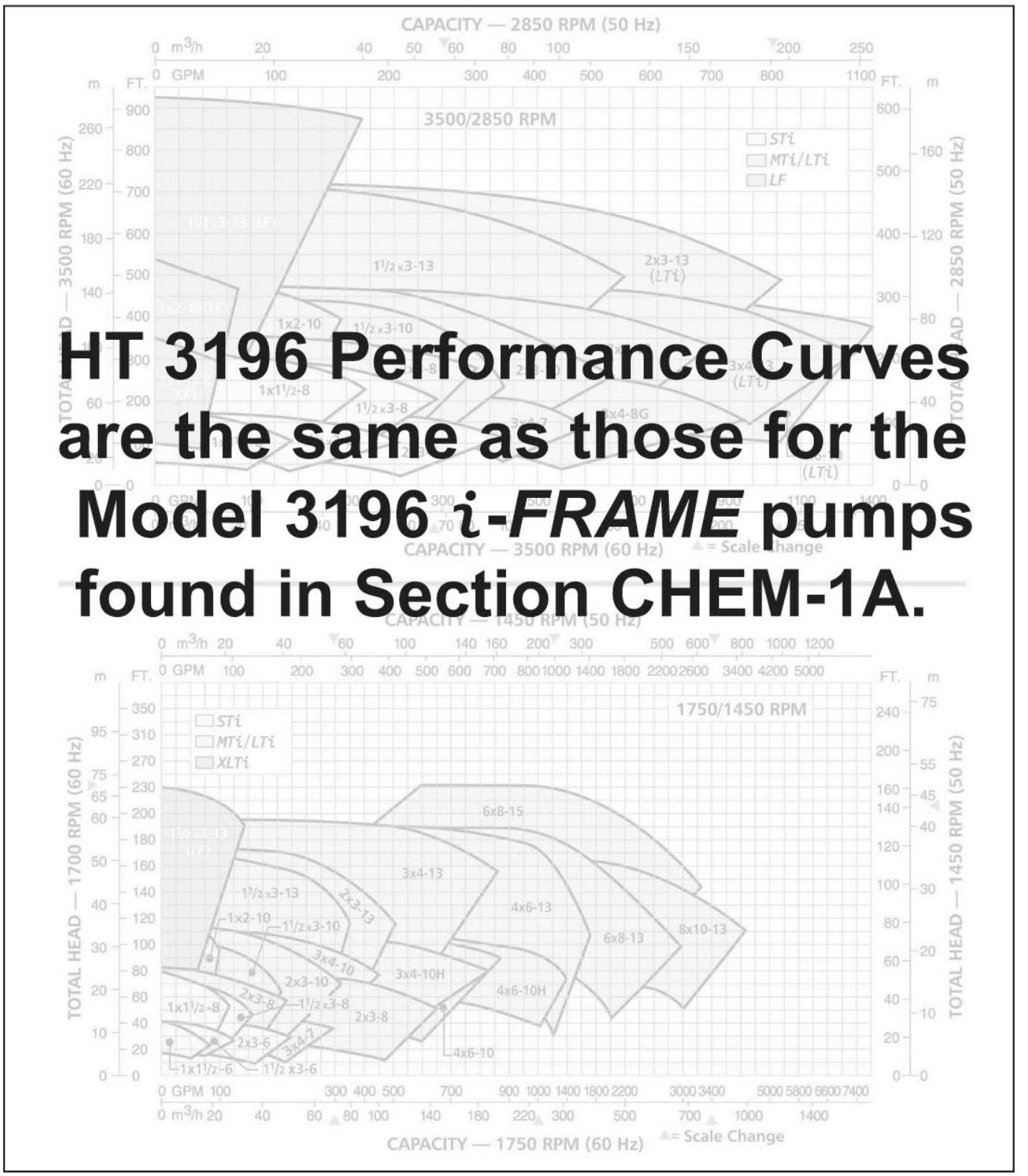
		STi	*MTi*	*LTi*	*XLTi*
Shaft	Diameter at Impeller	.75 (19)	1 (25)	1.25 (32)	1.5 (38)
	Diameter in Stuffing Box/Seal Chamber				
	(Less Sleeve)	1.375 (35)	1.75 (45)	2.125 (54)	2.5 (64)
	(With Sleeve)	1.125 (29)	1.5 (38)	1.875 (48)	2 (51)*
	Diameter Between Bearings	1.5 (38)	2.125 (54)	2.5 (64)	3.125 (79)
	Diameter at Coupling	.875 (22)	1.125 (29)	1.875 (48)	2.375 (60)
	Overhang	6.125 (156)	8.375 (213)	8.375 (213)	9.969 (253)
	Maximum Shaft Deflection		0.002	(0.05)	
	Shaft Deflection Index (L^3/D^4)				
	(With Sleeve)	143	116	48	62
	(Less Sleeve)	64	63	29	25
Sleeve	O.D. thru Stuffing Box/Seal Chamber	1.375 (35)	1.75 (45)	2.125 (54)	2.5 (64)*
Bearings	Radial	6207	6309	6311	6313
	Thrust	3306	3309	7310	3313
	Bearing Span	4.125 (105)	6.75 (171)	6.875 (164)	9.25 (235)
BigBore™ Seal Chamber	Bore	2.875 (73)	3.5 (89)	3.875 (98)	4.75 (120)*
Stuffing Box	Bore	2 (51)	2.5 (64)	2.875 (73)	3.375 (86)*
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)	5.6 (4.2)	14 (10.5)**
Temperature	Maximum Liquid Temperature—Oil/Grease Lubrication without Cooling	350° F (177° C)			
	Maximum Liquid Temperature—Oil Lubrication with High Temp. Option	700°F (370°C)			
Casing	Corrosion Allowance	.125 (3)			

* 17 inch sizes have 2¼ inch (57) shaft diameters in stuffing box/seal chamber with sleeve. Shaft sleeve O.D. is 2¾ inches (70) for packing and 2½ inches (64) for mechanical seals. Seal chamber bore is 4¾ inches (121). Stuffing box bore is 3⅝ inches (92).
** 17 inch sizes power limit per 100 RPM is 20HP (15kW).

Hydraulic Coverage Model HT 3196 *i-FRAME™*



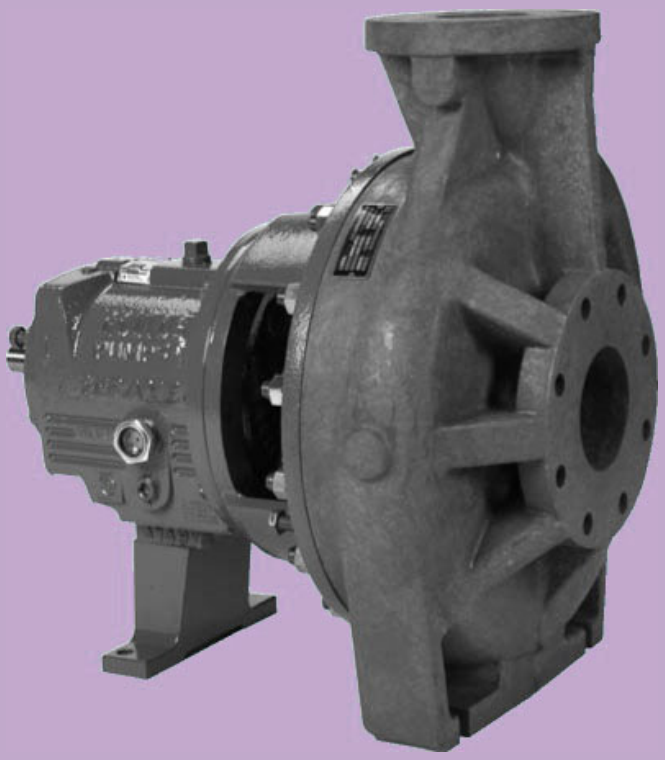




HT 3196 Performance Curves are the same as those for the Model 3196 *i-FRAME* pumps found in Section CHEM-1A.

Model NM 3196 *STi*

Goulds NM 3196 pump line is designed specifically to provide superior performance for the corrosive services of the Chemical Process Industries.



Model NM 3196 *MTi*

Goulds Model NM 3196 *i-FRAME™*

FRP Process Pumps Designed for Severe Corrosive Services

- Capacities to 800 GPM (182 m^3/h)
- Heads to 500 feet (152 m)
- Temperatures to 200° F (93° C)
- Pressures to 220 PSIG (1,517 kPa)

Performance Features for Severe Corrosive Services

Extended Pump Life

- Fiberglass Reinforced Vinylester Construction
  - Random fiber orientation provides strength equal to metal
  - Same flange loading capability as metallic Model 3196
  - Superior corrosion resistance
- *i-FRAME™* power ends

Ease of Maintenance

- Back pull-out design
- ANSI standard dimensions
- External impeller adjustment
- Parts interchangeable with Model 3196
- Easy retrofit

Optimum Hydraulic Performance

- True volute casing
- Fully open impeller

Safety

- ANSI B15.1 coupling guard
- No through-bolt fastening

Applications

- Hydrochloric Acid Unloading
- Ferric Chloride
- Sulfuric Acid Transfer
- Sodium Sulphite
- Sulphate Liquors
- Plating Solution
- Filter Feed
- Aquarium Water
- Sea Water

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model NM 3196 *i-FRAME™* FRP Process Pumps

Design Features for Wide Range of Corrosive Services

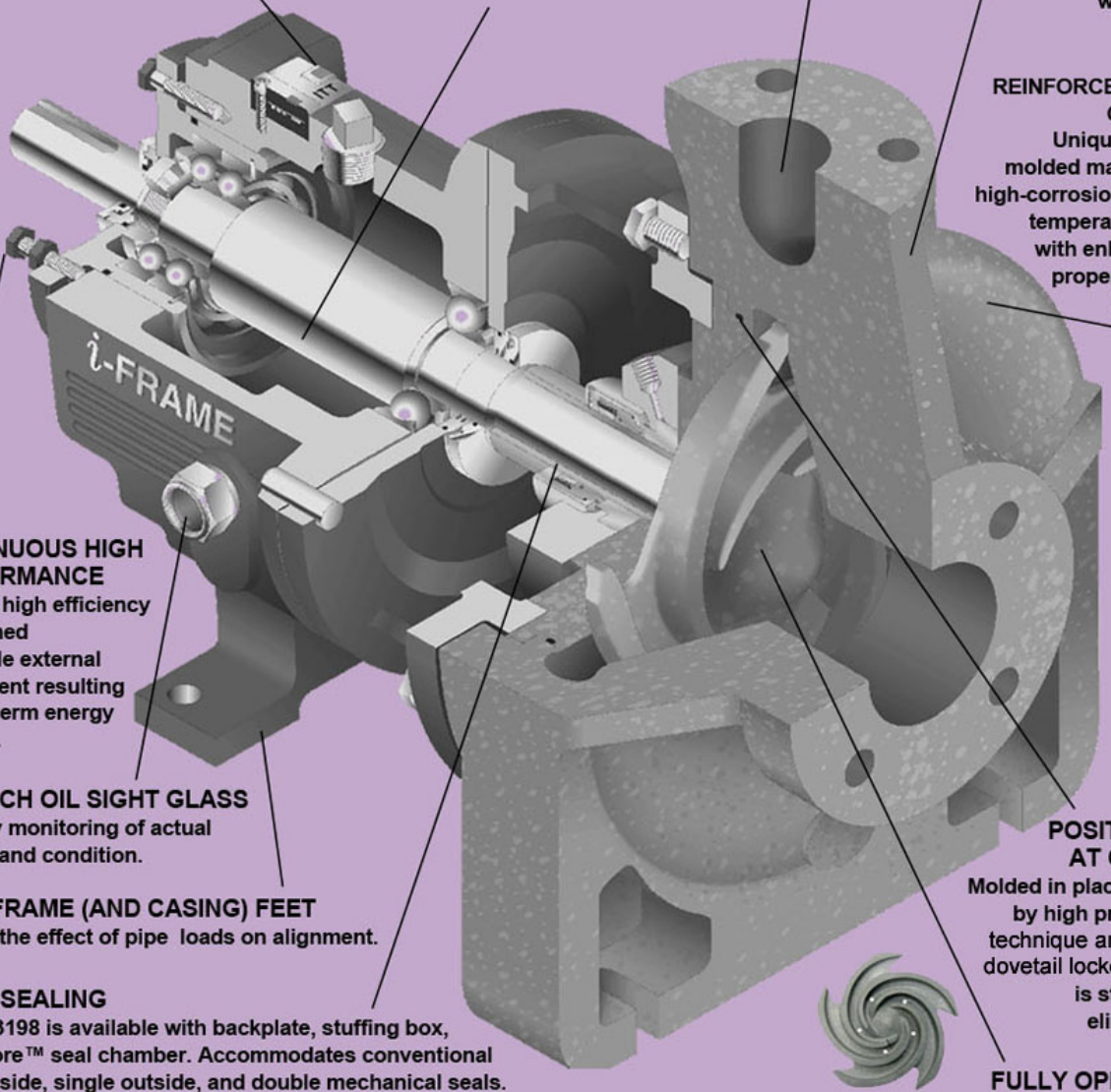
INPRO VBXX-D HYBRID LABYRINTH SEALS
Prevents premature bearing failure caused by lubricant contamination or loss of oil. Stainless steel rotors for optimal performance in corrosive environments.

HIGH PERFORMANCE VOLUTE DESIGN
High-efficiency, true volute design achieved by exclusive Goulds Molding Process. Unlike other designs, efficiencies comparable to cast alloy ANSI pumps.

CONDITION MONITOR
Constantly measures vibration and temperature at the thrust bearing. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

HEAVY DUTY SHAFT AND BEARINGS
Rigid shaft designed for minimum deflection at seal faces – less than 0.002 in. (.05 mm). Bearings sized for 2-year minimum and 10-year average life under tough operating conditions.

ONE PIECE RIBBED CASING
Ribs provide maximum support to resist casing distortion and withstand flange loading. No need for expansion joints to reduce pipe loads as NM 3196 loading same as Model 3196. Casing stud design eliminates need for through bolt fastening – allows complete interchangeability with 3196 casings.



REINFORCED VINYLESTER CONSTRUCTION
Unique high-strength molded material combines high-corrosion resistance and temperature capabilities with enhanced strength properties attained by Goulds Molding Process.

CONTINUOUS HIGH PERFORMANCE
Original high efficiency maintained by simple external adjustment resulting in long-term energy savings.

ONE-INCH OIL SIGHT GLASS
For easy monitoring of actual oil level and condition.

RIGID FRAME (AND CASING) FEET
Reduce the effect of pipe loads on alignment.

SHAFT SEALING
Goulds 3198 is available with backplate, stuffing box, or BigBore™ seal chamber. Accommodates conventional single inside, single outside, and double mechanical seals. BigBore™ seal chamber accommodates cartridge single and double seals.

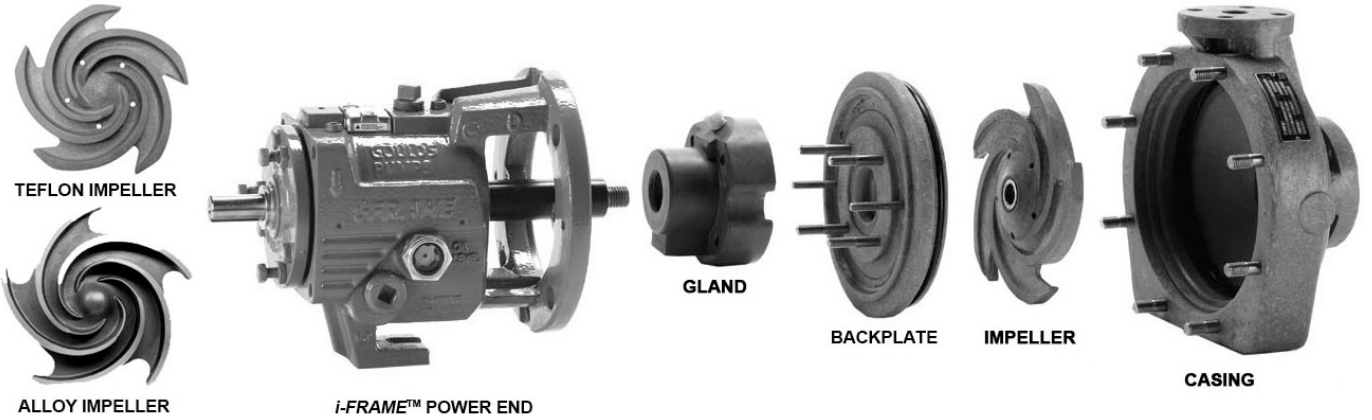
POSITIVE SEALING AT CASING JOINT
Molded in place to ductile iron by high pressure molding technique and mechanically dovetail locked. PFATeflon® is stress relieved to eliminate cracking.

FULLY OPEN IMPELLER
Acknowledged best design for chemical services – solids handling, stringy material, corrosives, abrasives. Back pump-out vanes minimize seal chamber pressure. Impeller insert assures maximum mechanical integrity, provides uniform low-stress torque transfer and maximum FRP material support. Assures close tolerance impeller-to-shaft alignment and fit. Metal to metal impeller drive.

***i-FRAME™* POWER END**
Designed for reliability and extended pump life, backed with a 5-year warranty.

Designed for Corrosive Services

Goulds NM 3196 *i-FRAME™* ...An Economical Solution



The traditional choice of pump construction for handling moderate corrosive liquids has been high alloys such as Alloy 20 and Hastelloy. Today, minimizing plant costs and maximizing equipment reliability are priorities. High alloys can be expensive and difficult to select...pump users want an alternative.

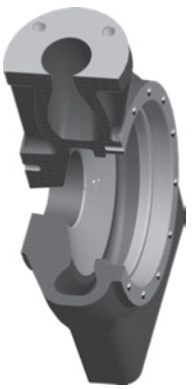
The NM 3196 is an economical solution. For little more than the price of a stainless steel ANSI pump, the NM 3196 is ideally suited for corrosive services from hydrochloric acid to sulfuric acid to sodium hydroxide.

Maintenance and downtime costs require a pump to be tough and provide service and reliability under adverse conditions for extended periods of time. The NM 3196 proves itself every day in demanding installations...standing up to tough services and lasting!

Corrosion Resistant Construction

The NM 3196 casing and impeller are constructed of vinylester thermoset resin–industry's choice for moderate corrosives. Maximum strength is achieved by fiber reinforcement. No fillers are used which reduce corrosion resistance.

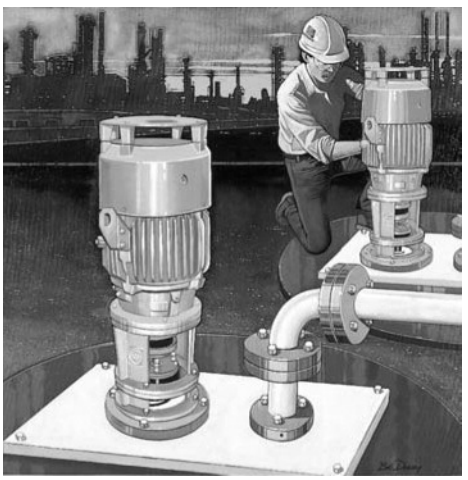
Goulds utilizes our proprietary Process which permits a true volute to be molded in the casing, just like a metal ANSI pump. Other materials available upon request.



Application Flexibility

Goulds Model NM 3171 is a vertical version of the NM 3196. Liquid end parts are made of the same material–high strength, corrosion resistant fiber reinforced vinylester.

Refer to section CHEM-4C for details.



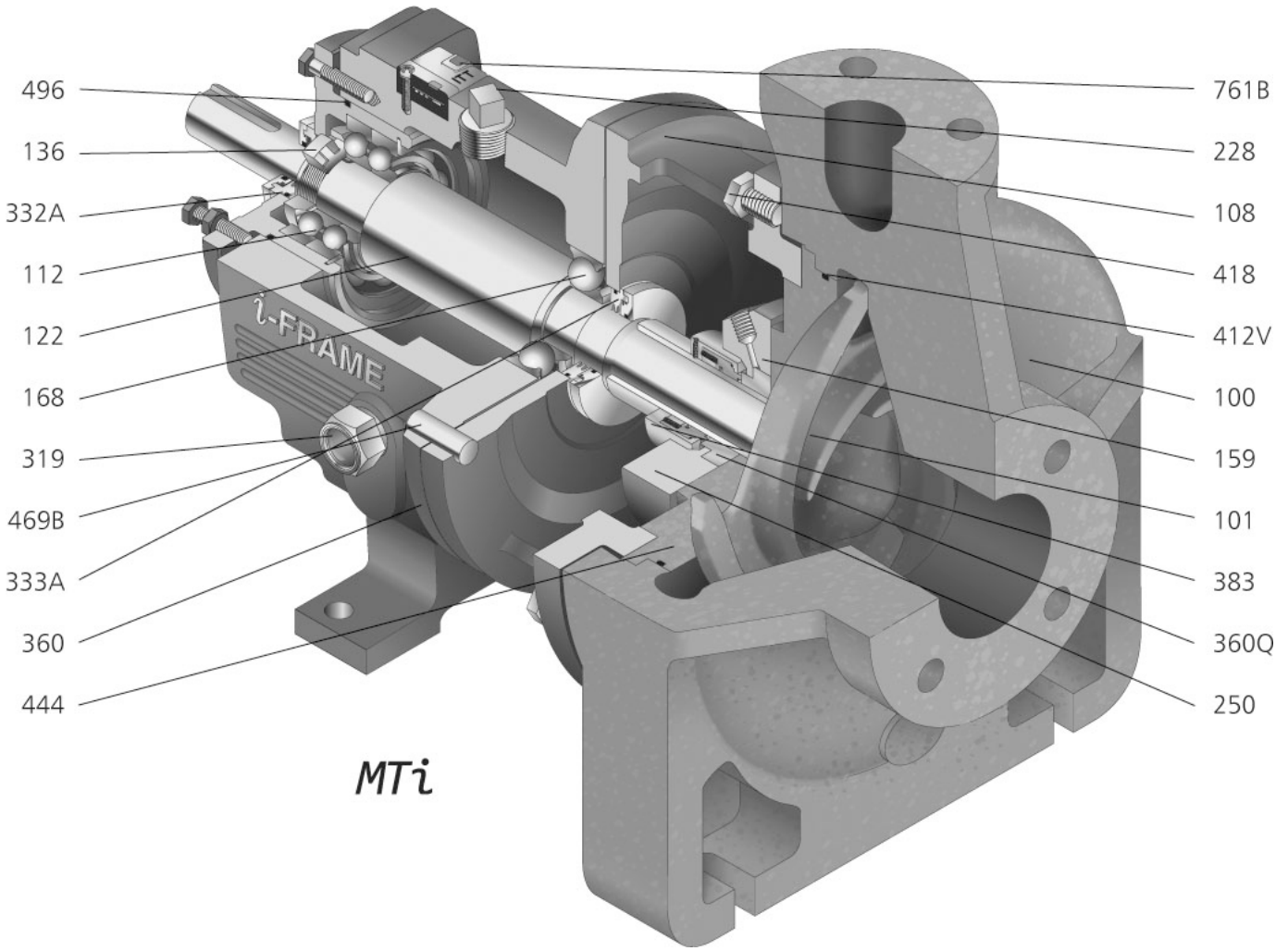
Parts List and Materials of Construction

Item Number	Part Name	Material
100	Casing	Fiberglass Reinforced Vinylester
101	Impeller (with insert)	Fiberglass Reinforced Vinylester (Hastelloy)
108	Frame Adapter	Ductile Iron
112	Thrust Bearing	Double Row Angular Contact Conrad
122	Shaft	SAE 4140 (Standard) Optional: 316SS, Alloy 20, Hastelloy B & C
126	Shaft Sleeve	Choice: FRP, 316SS, Alloy 20, Hastelloy B & C, Titanium, Zirconium
136	Bearing Locknut and Washer	Steel
159	Seal Chamber	Fiberglass Reinforced Vinylester
168	Radial Bearing	Single Row Deep Groove
228	Bearing Frame	Cast Iron (Ductile Iron for STX Group)
250	Gland	Fiberglass Reinforced Vinylester
319	Oil Sight Glass	Glass/Steel
332A	Labyrinth Seal (Outboard)	Bronze (ASTM)
333A	Labyrinth Seal (Inboard)	Bronze (ASTM)
356A	Stud-Casing to Frame or Frame Adapter	316SS
360	Gasket, Frame to Adapter	Vellumoid
360Q	Gland Gasket	Viton A (Teflon Optional)
370H	Stud and Nut—Backplate/Frame or Frame Adapter	304SS
383	Mechanical Seal	(As Specified)
412A	O-ring—Impeller	Viton A (Teflon Optional)
412V	O-ring—Casing/Backplate	Viton A (Teflon Optional)
418	Jacking Bolt	304SS
444	Backplate	Fiberglass Reinforced Vinylester
469B	Dowel Pin	Steel
496	O-ring—Bearing Housing	Buna Rubber
496A	O-ring—Impeller	PFA Teflon®
761B	Condition Monitor	Stainless-Steel/Epoxy

Construction Details All dimensions in inches and (mm).

		STi	*MTi*
Shaft	Diameter at Impeller	.75 (19)	1 (25)
	Diameter in Seal Chamber		
	(Less Sleeve)	1.375 (35)	1.75 (45)
	(With Sleeve)	1.125 (29)	1.5 (38)
	Diameter Between Bearings	1.5 (38)	2.125 (54)
	Diameter at Coupling	.875 (22)	1.125 (29)
	Overhang	6.125 (156)	8.375 (213)
	Maximum Shaft Deflection	0.002 (0.05)	
Sleeve	O.D. thru Seal Chamber	1.375 (35)	1.75 (45)
Bearings	Radial	6207	6309
	Thrust	3306 A/C3	3309 A/C3
	Bearing Span	4.125 (105)	6.75 (171)
	Average L'_{10} Bearing Life	87,600 hours	
Seal Chamber	Bore	2.07 (53)	2.57 (65)
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)
Maximum Liquid Temperature	Oil/Grease Lubrication	200° F (93° C)	
Casing	Corrosion Allowance	.125 (3)	

Sectional View Model NM 3196 *i-FRAME™*

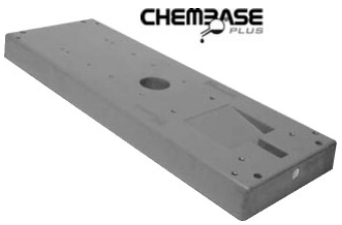


Baseplate Mounting Options

Goulds offers a complete range of mounting systems to meet plant reliability requirements and to make alignment and maintenance easier.

CAMBER TOP CAST IRON

Rigid and corrosion resistant, it is preferred by many plants.

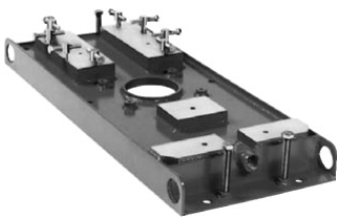


CHEMBASE PLUS™

Polymer concrete construction provides exceptional rigidity & corrosion resistance. ANSI 1991 dimensional.

FABRICATED STEEL

Economical baseplate that meets ANSI/ASME B73.1M current edition dimensional requirements.



ENHANCED FEATURE FABRICATED STEEL

Upgraded ANSI baseplate designed to maximize pump operation life and ease installation by meeting API-minded chemical pump users' toughest requirements.

Member of Hydraulic Institute

Refer to section CHEM-1A (Model 3196) for Baseplate Selection Guide.

Sealing Flexibility

A wide range is readily available

A wide range of sealing arrangements is readily available to meet specific service requirements. Your Goulds representative can recommend the best solution for any application. Some are illustrated here.

1 SINGLE CARTRIDGE SEAL WITH BACKPLATE EXTENSION PIECE

- Accommodates a single or double cartridge seal
- Taper Bore or Big Bore seal chamber available
- Optional Big Bore with a restrictor bushing for external flush

2 SINGLE OUTSIDE SEAL WITH CLAMPED SEAT

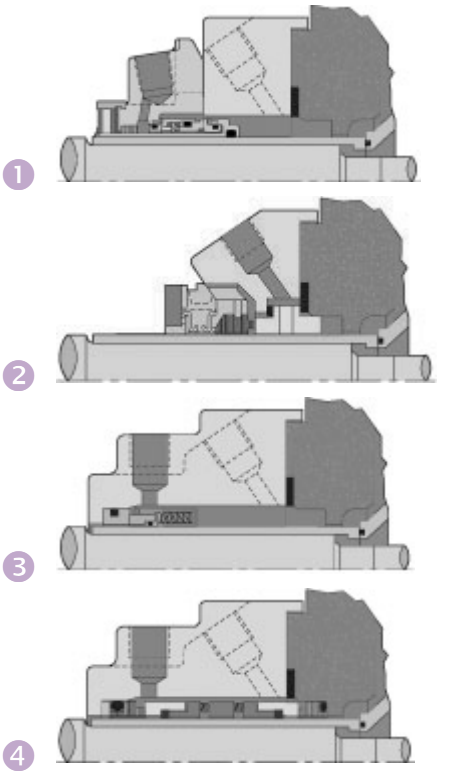
- Most used configuration
- Lamped stationary seat with flush connection
- Non-wetted FRP gland for added corrosion resistance

3 SINGLE CONVENTIONAL SEAL WITH SEAL CHAMBER EXTENSION

- Accommodates a conventional single seal
- FRP seal chamber extension for optimum corrosion resistance
- Optional restrictor bushing for use with external flush

4 DOUBLE CONVENTIONAL SEAL WITH SEAL CHAMBER EXTENSION

- Accommodates a conventional double seal
- FRP seal chamber extension for optimum corrosion resistance



Goulds Patented *i-FRAME™* Power Ends

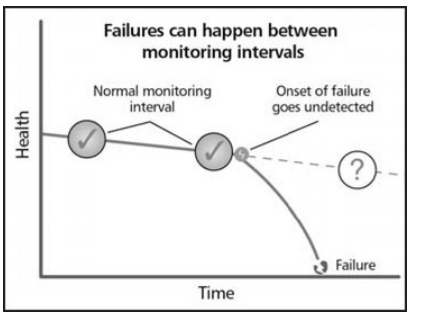
Extended Pump Life Through Intelligent Design

Goulds ***i-FRAME™*** Power Ends are the result of 160 years of design experience, customer interaction, and continuous improvement. Customers get extended Mean Time Between Failure (MTBF) and lower life cycle costs (LCC)...guaranteed!

1 *i-ALERT™* CONDITION MONITOR

The heart of the *i-FRAME*, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

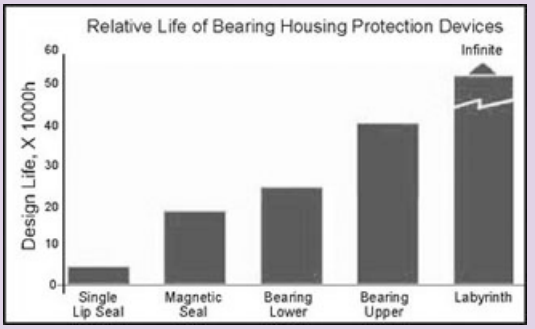
A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



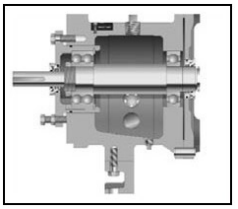
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

2 INPRO VBXX-D HYBRID BEARING ISOLATORS

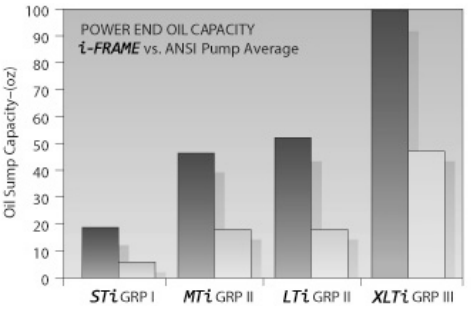
Most bearings fail before reaching their potential life. They fail for a variety of reasons, including contamination of the lubricant. INPRO VBXX-D has long been considered the industry standard in bearing lubricant protection. The ***i-FRAME*** now improves upon that design by offering stainless steel rotors, for maximum protection against contaminants and the corrosive effects of seal leakage or environmental conditions. These seals are non-contacting and do not wear.



3 OPTIMIZED OIL SUMP DESIGN



Internal sump geometry is optimized for longer bearing life. Sump size increased by 10%-20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.



4 SHAFT AND BEARINGS ENGINEERED FOR MAXIMUM RELIABILITY

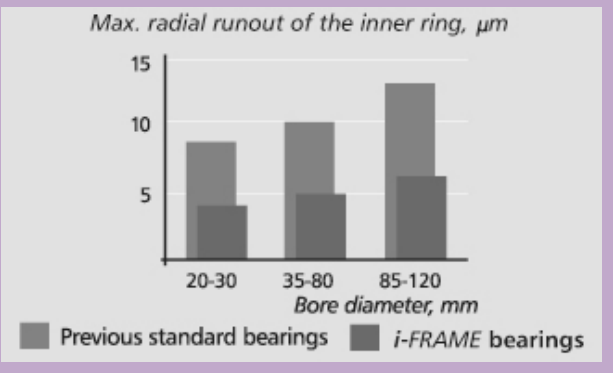
The rugged shaft and bearing combination maintains shaft deflection of less than 0.002 inches at all operating points. The result is longer seal and bearing life.

Premium severe-duty thrust bearings increase bearing fatigue life.

- High purity steels have fewer inclusions than standard steel – better grain structure and wear resistance.
- Heat treatment of bearing elements to SO stabilizaion levels provides superior thermal stability for increased service life.
- Bearing Balls are manufactured to at least one ISO grade above standard (ISO P5 for ring running accuracy and ISO P6 for dimensions). The result is reduced vibration and noise for improved shaft guidance.

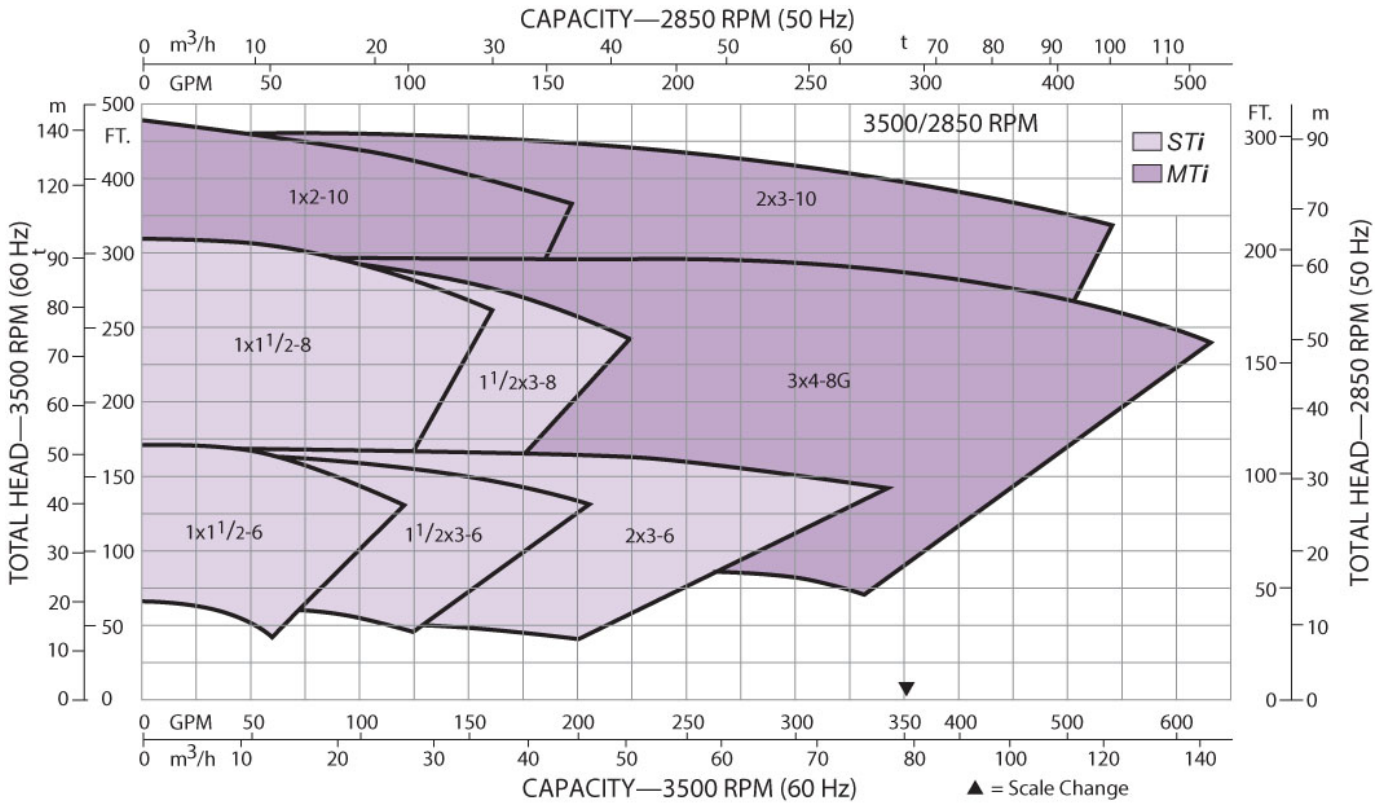
Every 3196 ***i-FRAME***™ Power End is engineered and manufactured for optimal pump performance and increased MTBF.

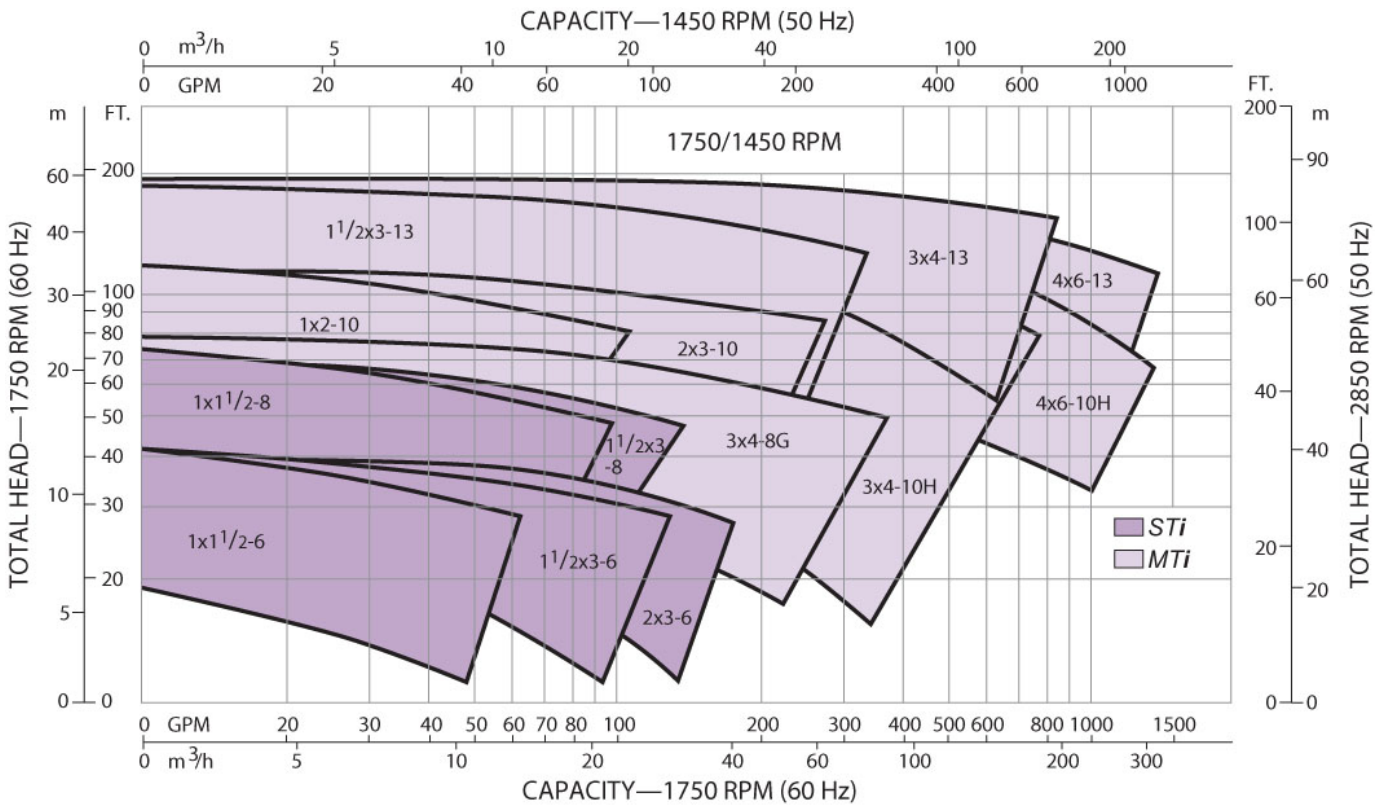
ANSI B73.1 Shaft Specification	Meets	Exceeds
Diameter Tolerance		✓
Surface Finish		✓
Runout	✓	
Deflection		✓



Our Guarantee We are so confident that the ***i-FRAME***™ is the most reliable Power End in the industry, that we are proud to offer a standard 5-year warranty on every ***i-FRAME*** ANSI Process Pump.

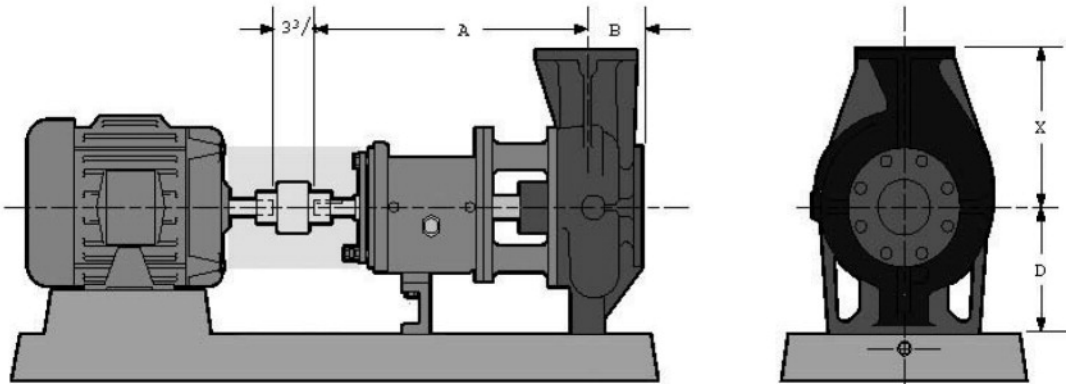
Hydraulic Coverage **Model NM 3196 *i-FRAME™***





Dimensions Model NM 3196 *i-FRAME™*

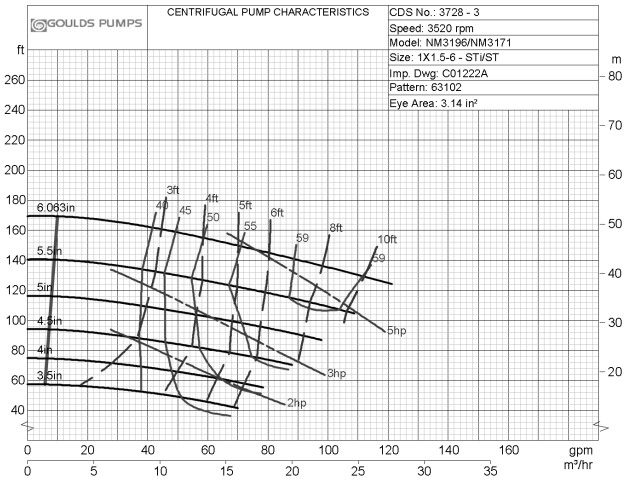
All dimensions in inches and (mm). Not to be used for construction.



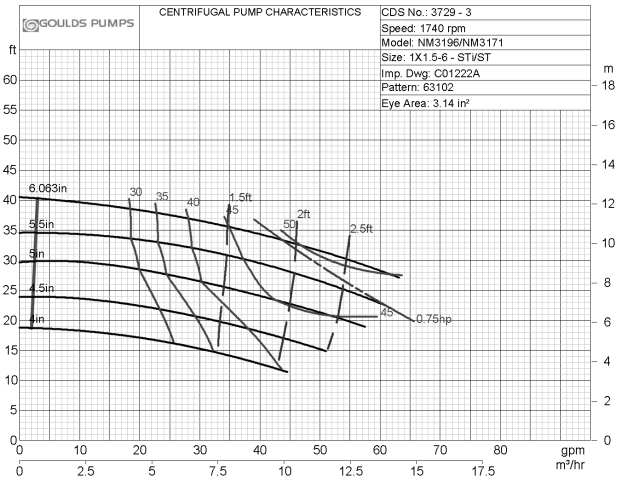
DIMENSIONS									
Group	Pump Size	ANSI Designation	Discharge	Suction	A	B	D	X	Bare Pump Weight Lbs. (kg)
STi	1×1½-6	AA	1	1½	13 ½ (343)	4 (102)	5 1/4 (133)	6½ (165)	55 (25)
	1½×3-6	AB	1½	3					57 (26)
	2×3-6	AC	2	3					57 (26)
	1×1½-8	AA	1	1½					67 (30)
	1½×3-8	AB	1½	3					69 (31)
MTi	3×4-8G	A70	3	4	19 ½ (495)	4 (102)	8 1/4 (210)	11 (279)	140 (64)
	1×2-10	A05	1	2				8½ (216)	155 (70)
	2×3-10	A60	2	3				9½ (241)	160 (73)
	3×4-10H	A40	3	4			10 (254)	12½ (318)	165 (75)
	4×6-10H	A80	4	6				13½ (343)	175 (80)
	1½×3-13	A20	1½	3				10½ (267)	175 (80)
	3×4-13	A40	3	4				12½ (318)	180 (82)
	4×6-13	A80	4	6				13½ (343)	185 (84)

NOTES

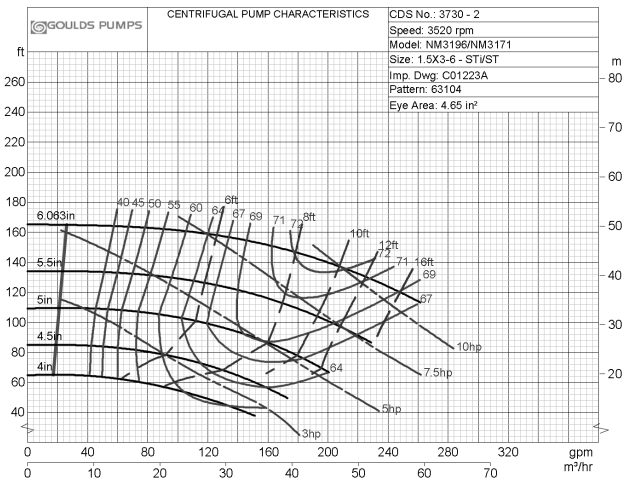
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



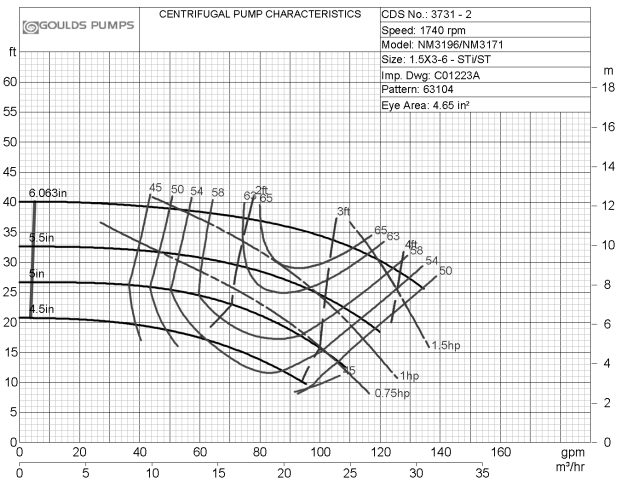
1X1.5-6 **3520rpm**



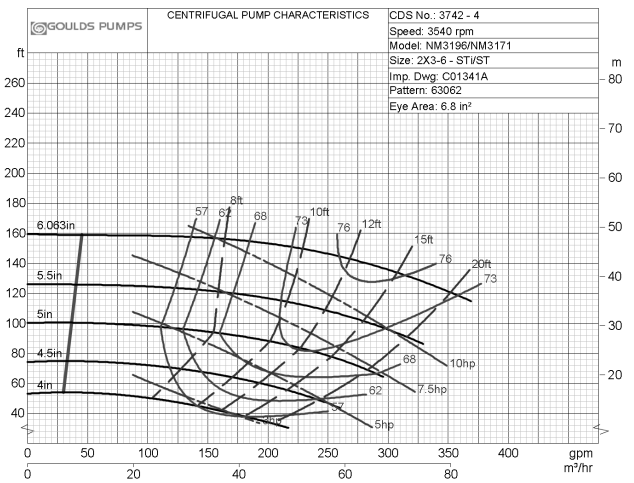
1X1.5-6 **1740rpm**



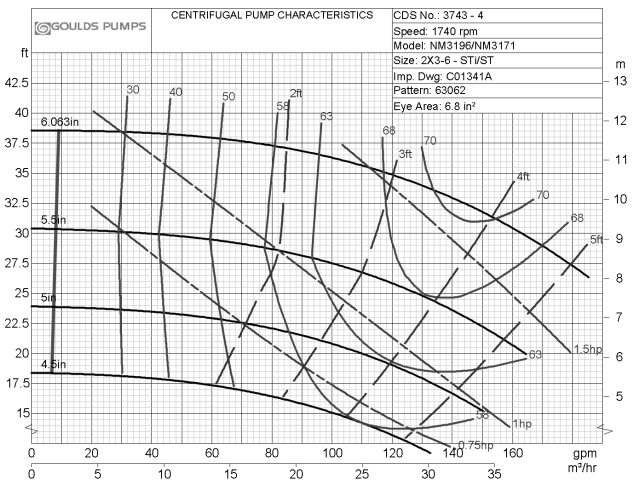
1.5X3-6 **3520rpm**



1.5X3-6 **1740rpm**

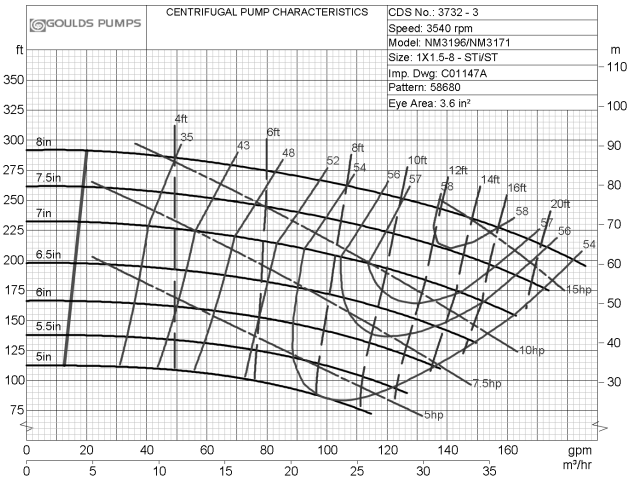


2X3-6 **3540rpm**

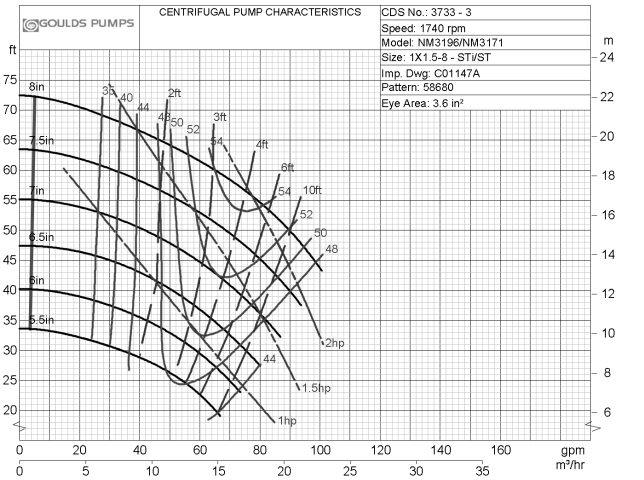


2X3-6 **1740rpm**

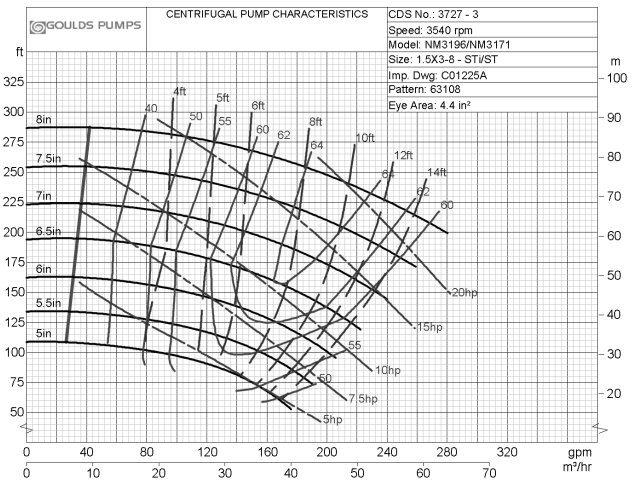
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



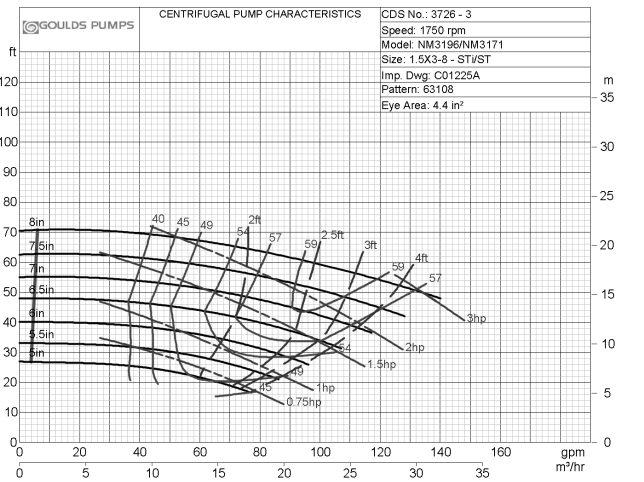
1X1.5-8 **3540rpm**



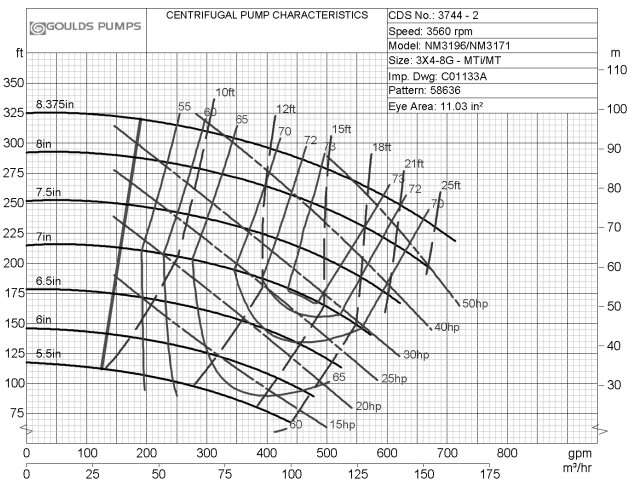
1X1.5-8 **1740rpm**



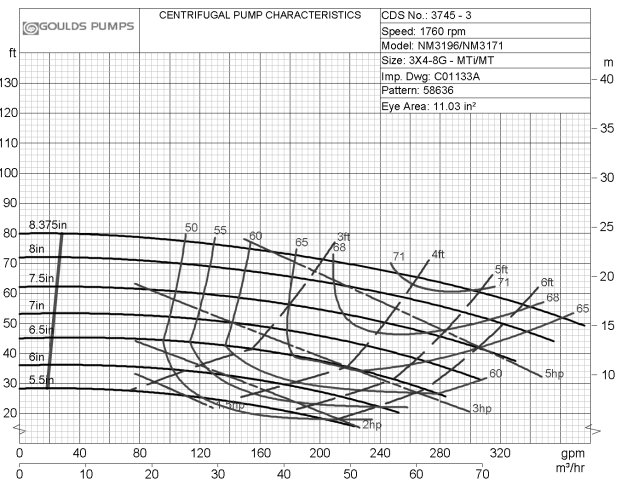
1.5X3-8 **3540rpm**



1.5X3-8 **1750rpm**



3X4-8G **3560rpm**



3X4-8G **1760rpm**

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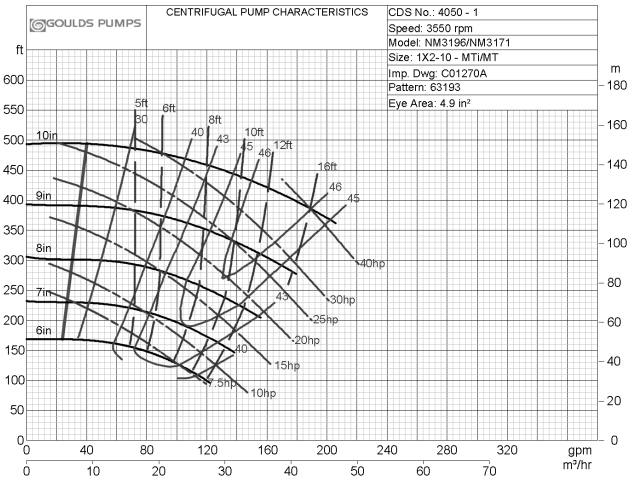
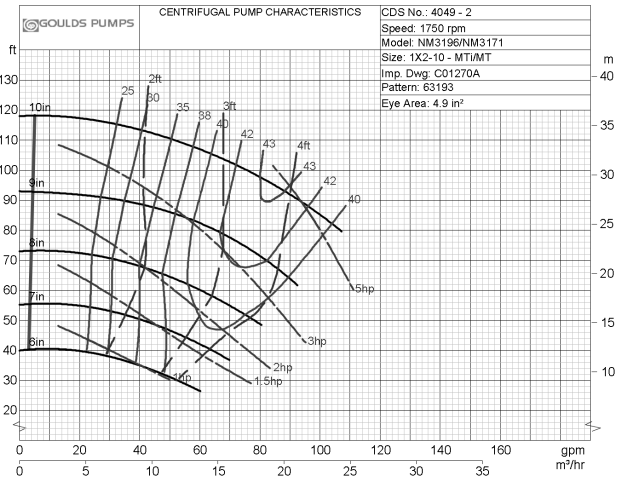
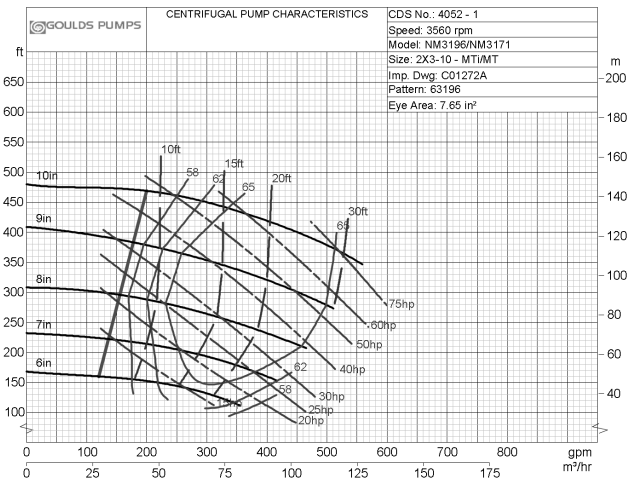


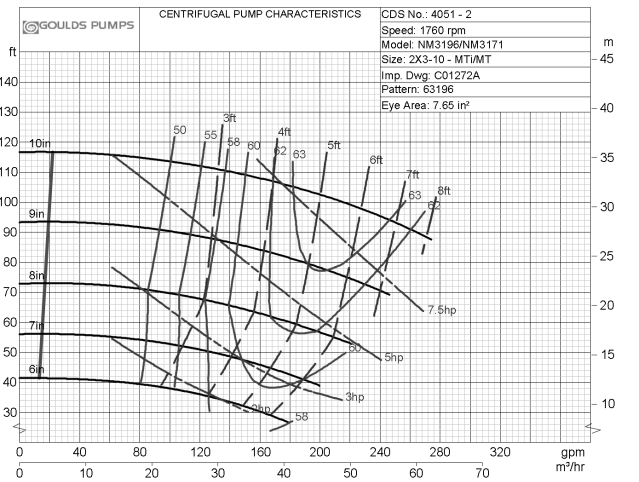
1X2-10 **3550rpm**



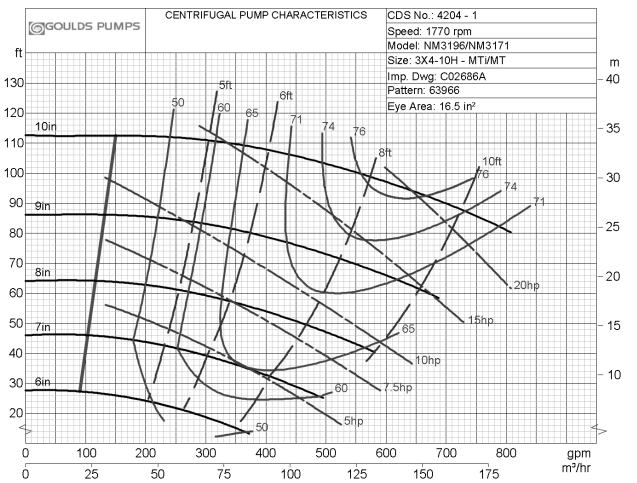
1X2-10 **1750rpm**



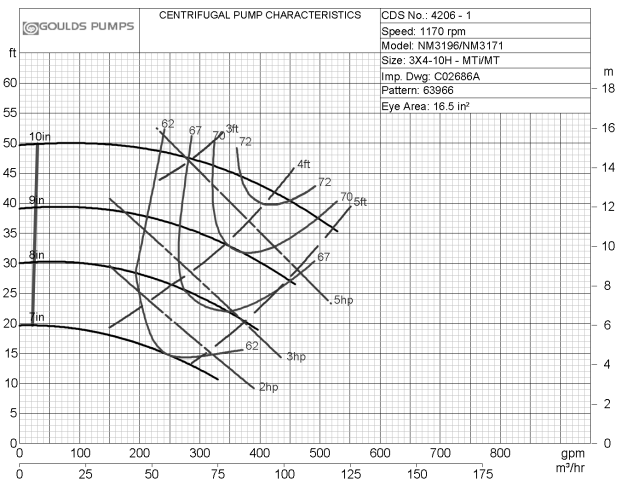
2X3-10 **3560rpm**



2X3-10 **1760rpm**

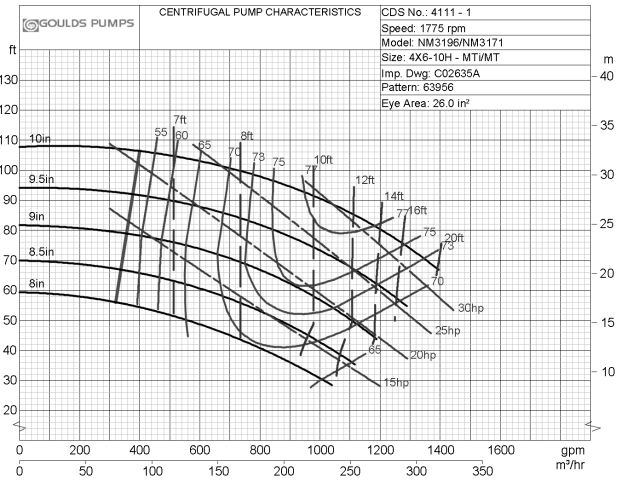


3X4-10H **1770rpm**

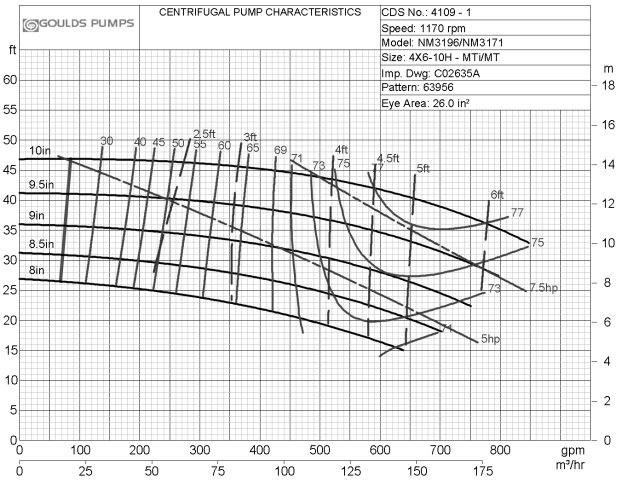


3X4-10H **1170rpm**

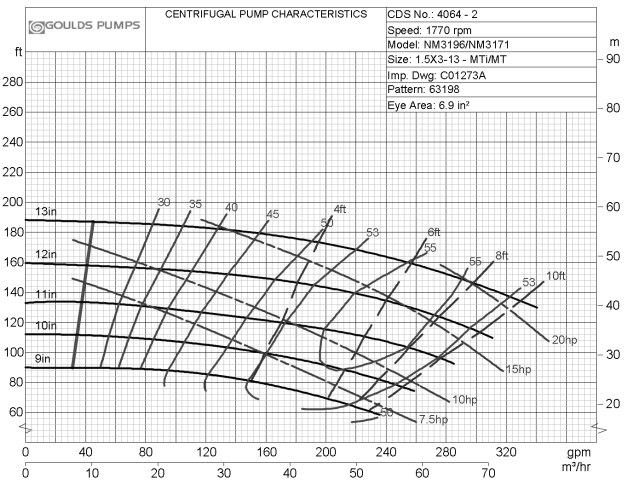
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



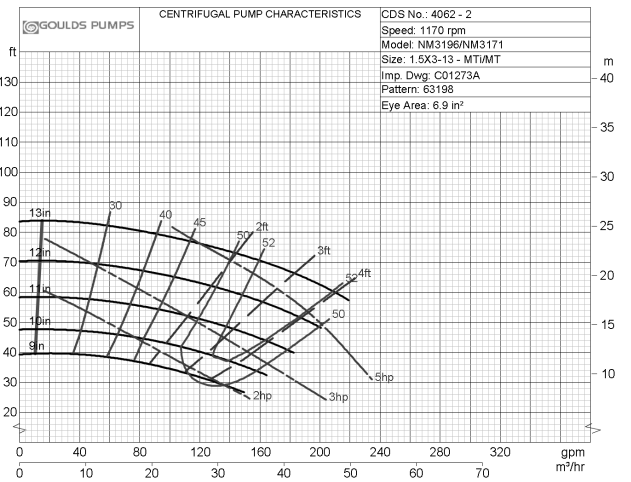
4X6-10H **1775rpm**



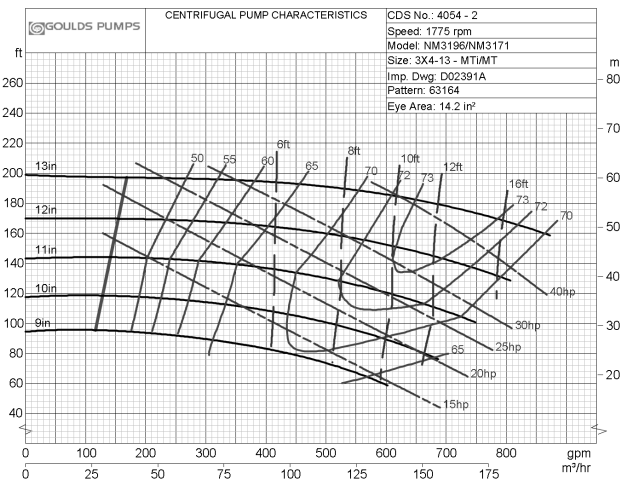
4X6-10H **1170rpm**



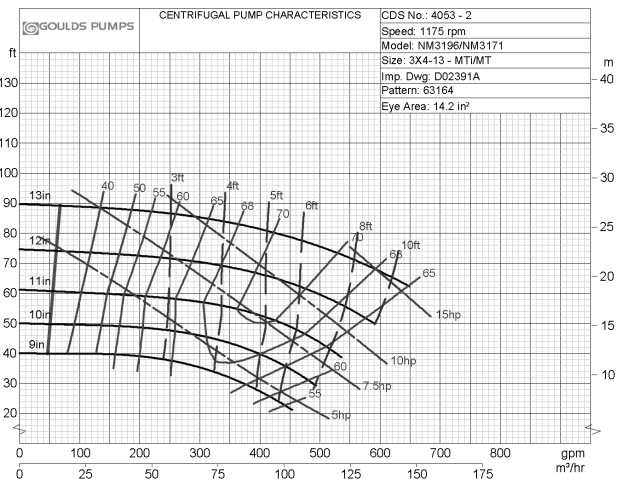
1.5X3-13 **1770rpm**



1.5X3-13 **1170rpm**



3X4-13 **1775rpm**



3X4-13 **1175rpm**

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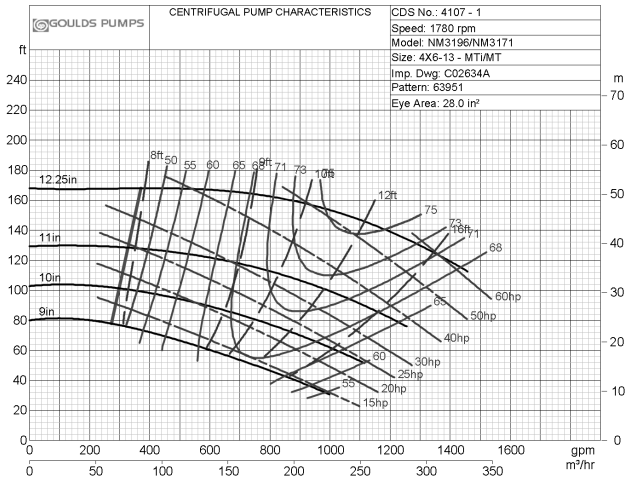
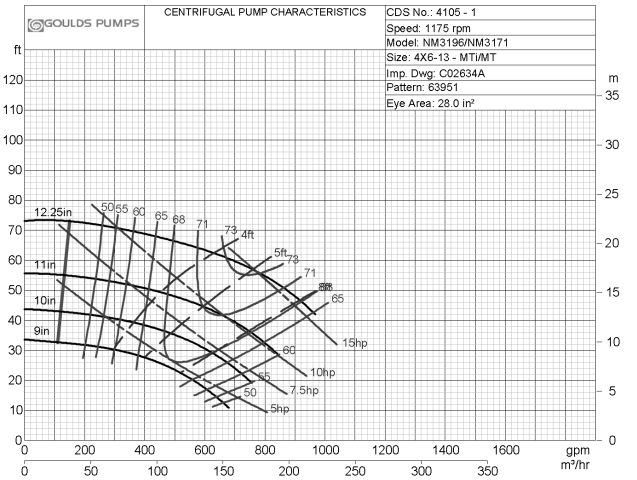
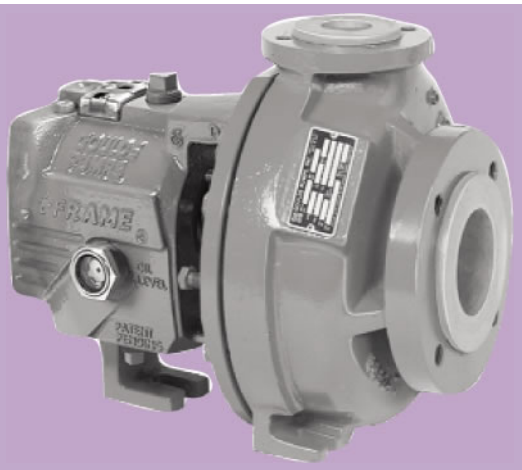


4X6-13 **1780rpm**



4X6-13 **1175rpm**

NOTES



Model 3198 *i-FRAME STi*

The 3198 *i-FRAME*™ PFA TEFLON® -lined process pump line is specifically designed to provide superior performance for the severe corrosive services of the Chemical Process Industries.

Model 3198 *i-FRAME*

® TEFLON is a registered trademark of E.I. DuPont

Goulds Model 3198 *i-FRAME*™

PFA *TEFLON* ®-Lined Process Pumps Designed for Total Range of Severe Corrosive Services

- Capacities to 800 GPM (182 m³/h)
- Heads to 450 feet (137 m)
- Temperatures to 300° F (149° C)
- Pressures to 225 PSIG (1,552 kPa)

Performance Features for Severe Corrosive Services

Extended Pump Life

- Virgin PFA *TEFLON* * Lining
  - Optimum lining thickness
  - Superior corrosion resistance
- ***i-FRAME***™ Power Ends
- Fully open impeller

Ease of Maintenance

- Back pull-out design
- External impeller adjustment
- Parts interchangeable with Goulds 3196 ***i-FRAME***™
- Easy retrofit
- ANSI standard dimensions

Safety

- ANSI B15.1 coupling guard
- Ductile iron frame adapter

Applications

- Hydrochloric Acid
- Hydrofluoric Acid
- Ferric Chloride
- Pickling Acid
- Plating Acid
- Plating Solutions
- Chlorinated Brine
- Chlorinated Hydrocarbons
- Sodium Hypochlorite
- Chlorine Dioxide

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3198 *i-FRAME™ TEFLON®* Process Pumps

Design Features for Wide Range of Severe Corrosive Services

INTRO VBXX-D HYBRID LABYRINTH SEALS
Prevents premature bearing failure caused by lubricant contamination and loss of oil. Stainless steel rotors for optimal performance in corrosive environments.

i-ALERT™ CONDITION MONITOR (U.S. Patent 8,154,417)
Constantly measures vibration and temperature at the thrust bearing. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

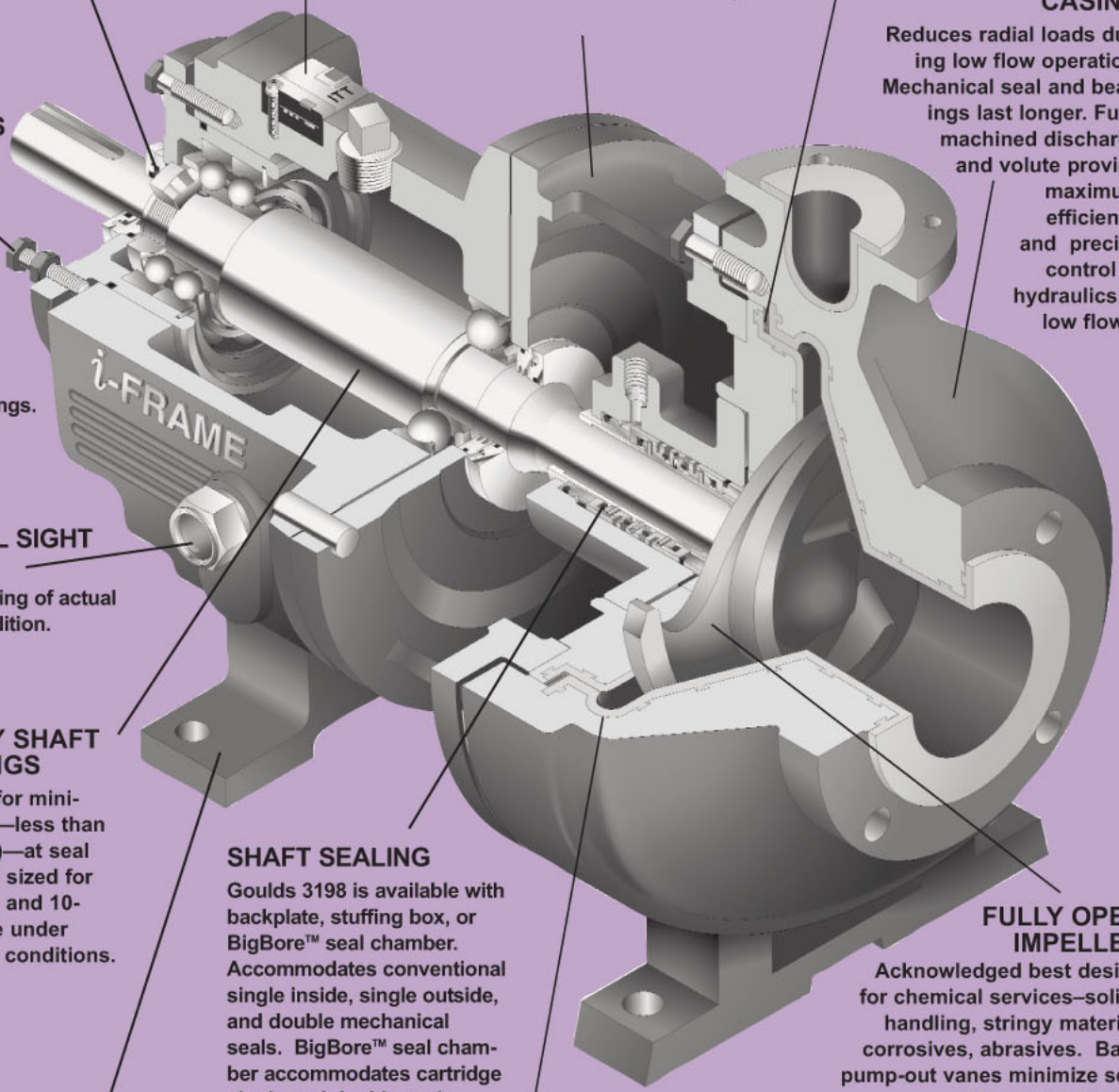
i-FRAME POWER END
Designed for reliability and extended pump life, backed with a 5-year warranty.

DUCTILE IRON FRAME ADAPTER
Material strength equal to carbon steel for safety.

POSITIVE SEALING
Assured by renewable, confined TEFLON® envelope casing gasket. Compressible filler ensures positive seal with low bolt load and without need for retightening.

CIRCULAR VOLUTE CASING
Reduces radial loads during low flow operation. Mechanical seal and bearings last longer. Fully machined discharge and volute provide maximum efficiency and precise control of hydraulics at low flows.

CONTINUOUS HIGH PERFORMANCE
Original high efficiency maintained by simple external adjustments resulting in long-term energy savings.



ONE-INCH OIL SIGHT GLASS
For easy monitoring of actual oil level and condition.

HEAVY DUTY SHAFT AND BEARINGS
Shaft designed for minimum deflection—less than .002 in. (.05 mm)—at seal faces. Bearings sized for 2-year minimum and 10-year average life under tough operating conditions.

SHAFT SEALING
Goulds 3198 is available with backplate, stuffing box, or BigBore™ seal chamber. Accommodates conventional single inside, single outside, and double mechanical seals. BigBore™ seal chamber accommodates cartridge single and double seals.

FULLY OPEN IMPELLER
Acknowledged best design for chemical services–solids handling, stringy material, corrosives, abrasives. Back pump-out vanes minimize seal chamber pressure.

Impeller inserts provide uniform low-stress torque transfer and maximum PFA *TEFLON* material support. Assures close tolerance impeller-to-shaft alignment and fit. Metal-to-metal impeller drive.

TEFLON impeller O-ring in controlled compression protects threaded area against corrosion.

RIGID FRAME (AND CASING) FEET
Reduce the effect of pipe loads on alignment.

THICK PFA *TEFLON®*
Molded in place to ductile iron by high pressure molding technique and mechanically dovetail locked. PFA *TEFLON* is stress relieved to eliminate cracking.

Designed for Severe Corrosive Services

Goulds 3198 *i-FRAME™* ...An Economical Solution

TEFLON® IMPELLER

ALLOY IMPELLER

i-FRAME POWER END

GLAND

BACKPLATE

IMPELLER

CASING

Goulds 3198 *i-FRAME* ...An Economical Solution

For severe corrosive services, users have traditionally specified pumps constructed of exotic alloys such as titanium, zirconium, and monel. The high cost of these alloys, plus the difficulty in making the proper selection, have prompted pump users to seek alternatives.

The 3198 ***i-FRAME*** is an economical solution. For less than the price of an exotic alloy ANSI process pump, the 3198 ***i-FRAME*** can be reliably used for handling a wide range of severe corrosives. The 3198 ***i-FRAME*** is constructed for optimum reliability. Every day it proves itself in demanding installations, standing up to tough services—and lasting!

Virgin PFA Teflon®-Lined Construction

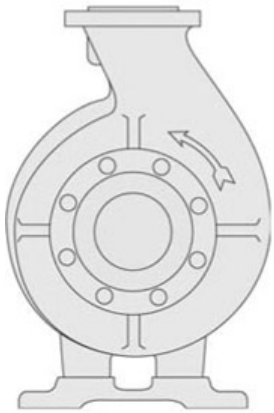
Corrosion Resistance

The PFA Teflon® lining is resistant to most industrial chemicals and solvents with the exception of molten alkali metals and related compounds. It's the acknowledged material of choice for handling severe corrosives.

Outstanding Strength

Ductile iron and carbon steel backing provide strength equal to all-metal pump components. Outstanding strength reduces the effect of pipe loads on shaft alignment (flange loading capability is the same as all-metal Model 3196).

True volute casing provides performance and efficiencies similar to the standard of the industry—Goulds Model 3196.



Baseplate Mounting Systems

i-FRAME™ Power Ends Fit 7 Different Process Pumps

Minimize inventory, reduce downtime.

3196
Process Pumps

CV 3196
Non-Clog
Process Pumps

HT 3196
High Temperature
Process Pumps

LF 3196
Low Flow ANSI
Process Pumps

3198
PFA TEFLON®-Lined
Process Pumps

3796
Self-Priming
Process Pumps

NM 3196
i-FRAME
Non-Metallic
Process Pumps

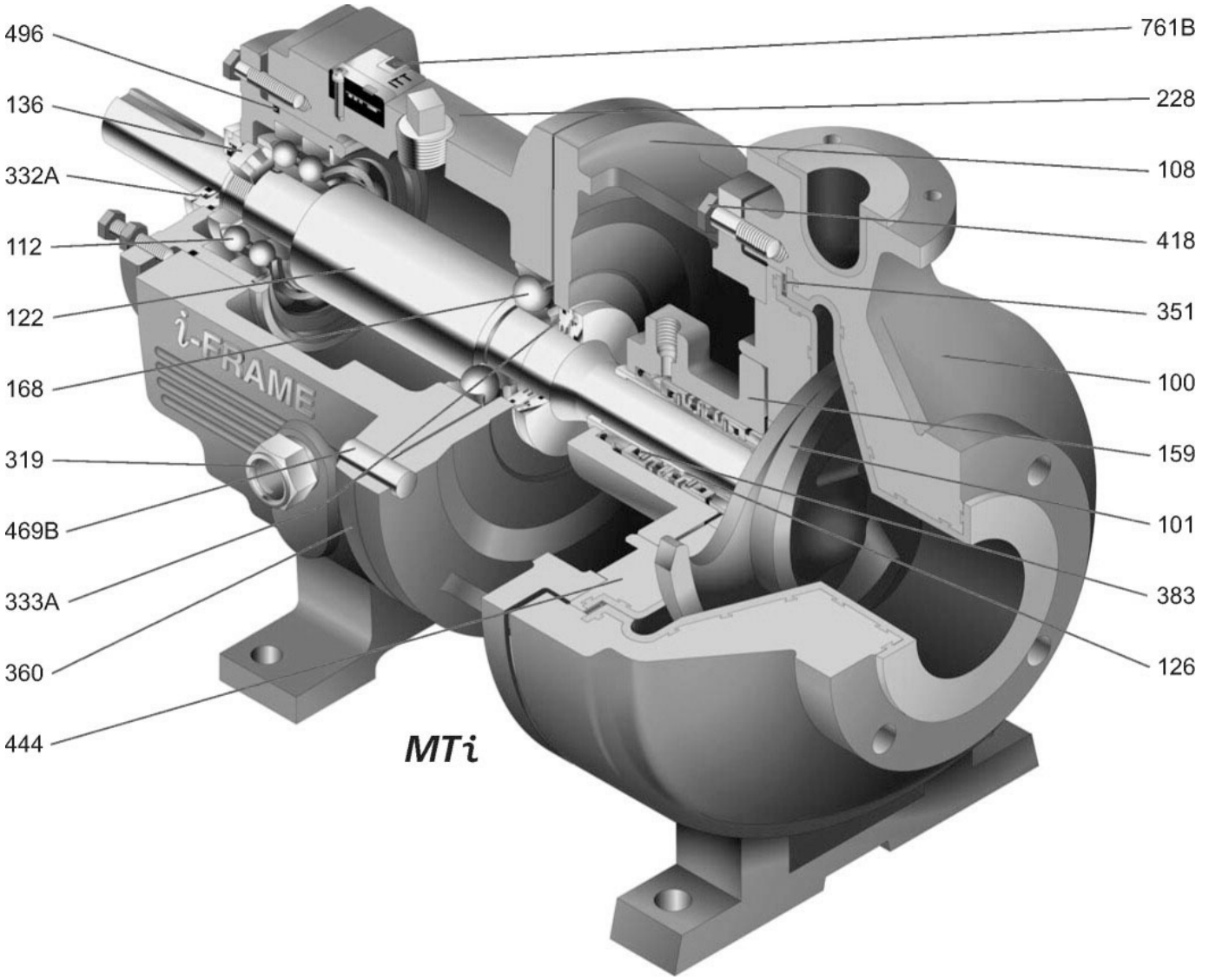
Parts List and Materials of Construction

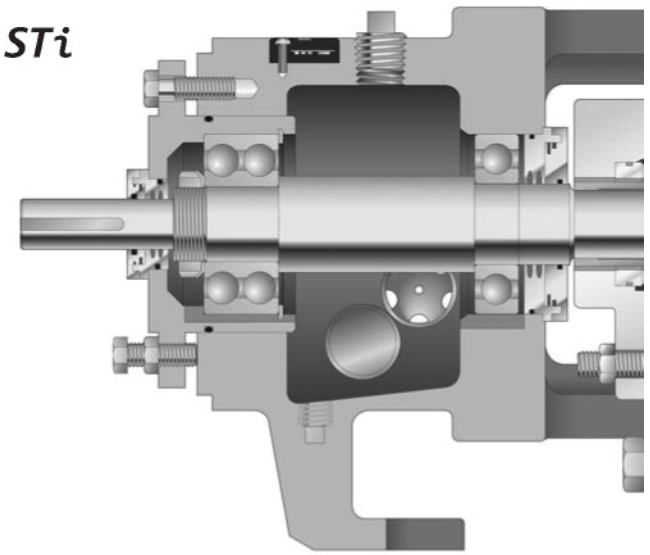
Item Number	Part Name	Material
100	Casing	PFA Teflon® Lined Ductile Iron
101	Impeller (with insert)	PFA Teflon® Lined Steel
108	Frame Adapter	Ductile Iron
112	Thrust Bearing	Double Row Angular Contact
122	Shaft	316SS (Standard) Optional: Alloy 20, Hastelloy B & C
126	Shaft Sleeve	Choice: PFA Teflon®, 316SS, Alloy 20, Hastelloy B & C, Titanium, Zirconium
136	Bearing Locknut and Washer	Steel
159	Seal Chamber (Backplate Design)	316SS
168	Radial Bearing	Single Row Deep Groove
228	Bearing Frame	Cast Iron (Ductile Iron for STX)
319	Oil Sight Glass	Glass/Steel
332A	Labyrinth Seal (Outboard)	Stainless Steel/Bronze
333A	Labyrinth Seal (Inboard)	Stainless Steel/Bronze
351	Casing Gasket	Teflon® Envelope
356A	Stud–Casing to Frame or Frame Adapter	316SS
360	Gasket–Frame to Adapter	Vellumoid
370H	Stud and Nut–Backplate/Frame or Frame Adapter	304SS
383	Mechanical Seal	(As Specified)
418	Jacking Bolt	304SS
444	Backplate	PFA Teflon® Lined Ductile Iron
469B	Dowel Pin	Steel
496	O-ring—Bearing Housing	Buna Rubber
496A	O-ring—Impeller	PFA Teflon®
761B	Condition Monitor	Stainless Steel/Epoxy

Construction Details All dimensions in inches and (mm).

		3198 *STi*	3198 *MTi*
Lining Thickness	Casing	3/16 (4.8)	
	Impeller	⅛ (3.2)	
	Stuffing Box Cover	3/16 (4.8)	
	Backplate	3/16 (4.8)	
	Shaft Sleeve	⅛ (3.2)	
Shaft	Diameter at Impeller	.75 (19)	1 (25)
	Diameter in Seal Chamber (Less Sleeve)	1.375 (35)	1.75 (45)
	(With Sleeve)	1.125 (29)	1.5 (38)
	Diameter Between Bearings	1½ (38.1)	2⅛ (54)
	Diameter at Coupling	⅞ (22.2)	1⅛ (28.6)
	Overhang	6.125 (156)	8.375 (213)
	Maximum Shaft Deflection	0.002 (0.05)	
Sleeve	Outer Diameter thru Seal Chamber	1⅜ (34.9)	1¾ (44.5)
Bearings	Radial	6207	6309
	Thrust	3306 A/C3	3309 A/C3
	Bearing Span	4.125 (105)	6.75 (171)
Seal Chamber	Bore	2.1 (53)	2.6 (66)
Power Limits	HP (kW) per 100 RPM	1.1 (.82)	3.4 (2.6)
Maximum Liquid Temperature	Oil/Grease Lubrication	300˚F (150˚C)	

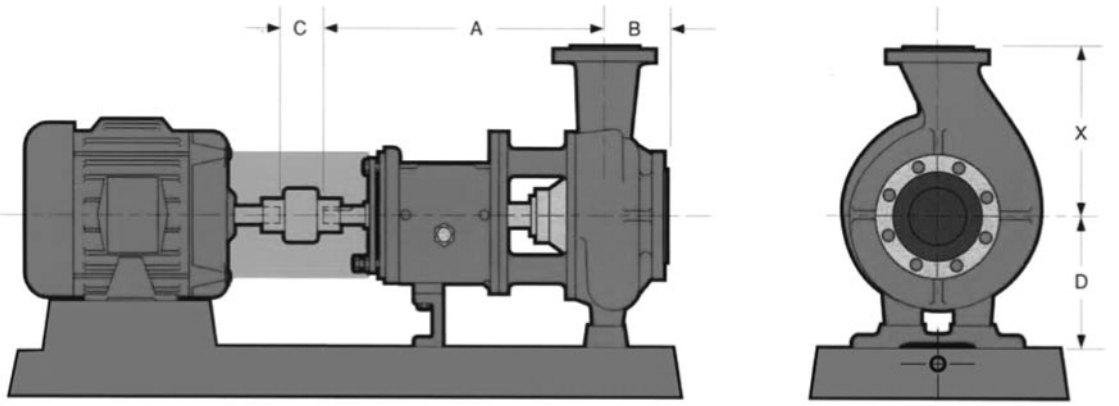
Sectional View Model 3198 *i-FRAME™*





Dimensions Model 3198 *i-FRAME™*

All dimensions in inches and (mm). Not to be used for construction.



DIMENSIONS

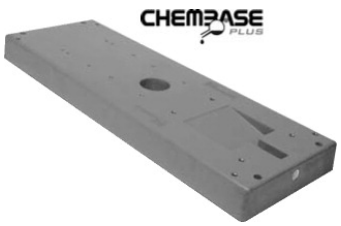
Group	Pump Size	ANSI Designation	Discharge Size	Suction Size	A	B	C	D	X	Bare Pump Weight Lbs. (kg)
3198 *STi*	1½ ×3-7	AB	1½	3	13½ (343)	4 (102)	3¾(95)	5¼ (133)	6½ (165)	108 (49)
3198 *MTi*	1½×3-10	A50	1½	3	19½ (495)	4 (102)	3¾ (95)	8¼ (210)	8½ (216)	230 (104)
	3×4-10	A70	3	4					11 (279)	280 (127)
	3×4-13	A40	3	4				10 (254)	12½ (318)	343 (156)

Baseplate Mounting Options

Goulds offers a complete range of mounting systems to meet plant reliability requirements and to make alignment and maintenance easier.

CAMBER TOP CAST IRON

Rigid and corrosion resistant, it is preferred by many plants.

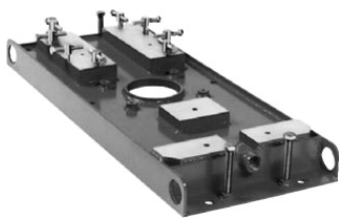


CHEMBASE PLUS™

Polymer concrete construction provides exceptional rigidity & corrosion resistance. ANSI 1991 dimensional.

FABRICATED STEEL

Economical baseplate that meets ANSI/ASME B73.1M current edition dimensional requirements.



ENHANCED FEATURE FABRICATED STEEL

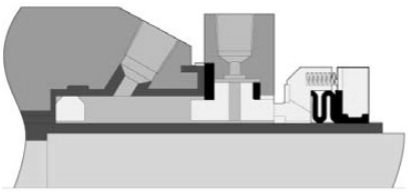
Upgraded ANSI baseplate designed to maximize pump operation life and ease installation by meeting API-minded chemical pump users' toughest requirements.

Member of Hydraulic Institute

Refer to section CHEM-1A (Model 3196) for Baseplate Selection Guide.

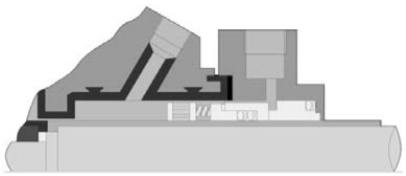
Maximum Sealing Flexibility

A wide range of sealing arrangements are readily available to meet specific user requirements. Your Goulds representative can recommend the best solution for any service. Some are illustrated here.



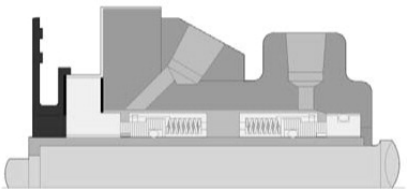
SINGLE OUTSIDE SEAL

- Stuffing box design
- Flush gland
- By-pass flush



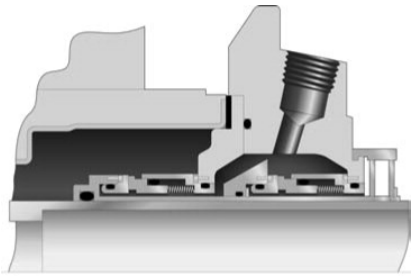
CONVENTIONAL SINGLE SEAL

- Stuffing box design
- Flush gland
- By-pass flush



CONVENTIONAL DOUBLE SEAL

- Backplate design
- Seal chamber
- External flush or CPI Plan 7353



DOUBLE CARTRIDGE SEAL

- BigBore™ seal chamber
- Flush gland
- Tefzel® Lined

Goulds Patented *i-FRAME™* Power Ends

Extended Pump Life Through Intelligent Design

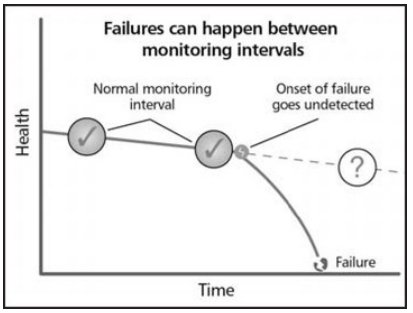
Goulds ***i-FRAME***™ Power Ends are the result of 160 years of design experience, customer interaction, and continuous improvement. Customers get extended Mean Time Between Failure (MTBF) and lower life cycle costs (LCC)...guaranteed!

1

i-ALERT™ CONDITION MONITOR

The heart of the *i-FRAME*, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

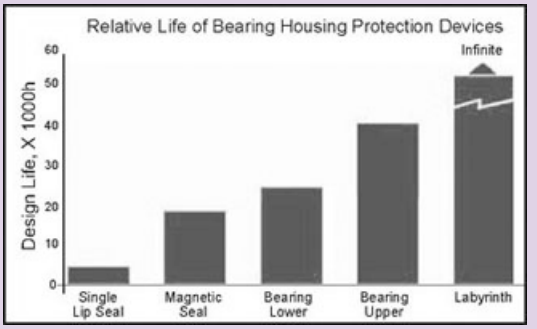
A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



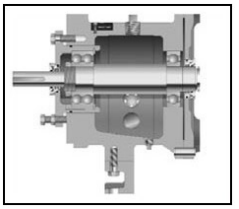
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

2 INPRO VBXX-D HYBRID BEARING ISOLATORS

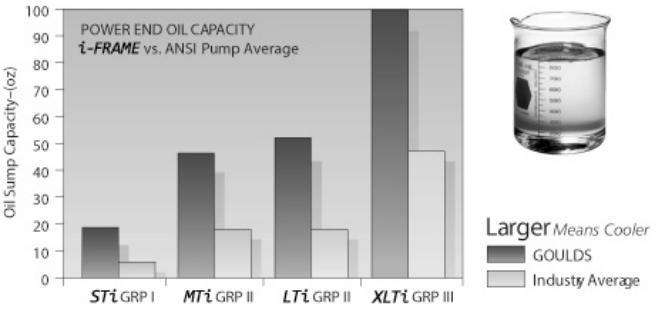
Most bearings fail before reaching their potential life. They fail for a variety of reasons, including contamination of the lubricant. INPRO VBXX-D has long been considered the industry standard in bearing lubricant protection. The ***i-FRAME*** now improves upon that design by offering stainless steel rotors, for maximum protection against contaminants and the corrosive effects of seal leakage or environmental conditions. These seals are non-contacting and do not wear.



3 OPTIMIZED OIL SUMP DESIGN



Internal sump geometry is optimized for longer bearing life. Sump size increased by 10%-20% results in better heat transfer and cooler bearings. Contoured design directs contaminants away from bearings, to the magnetic drain plug for safe removal.



4 SHAFT AND BEARINGS ENGINEERED FOR MAXIMUM RELIABILITY

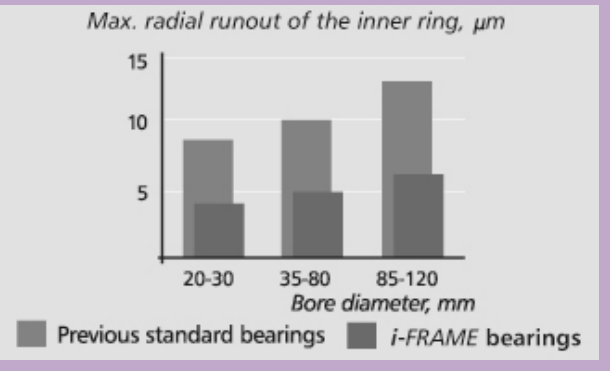
The rugged shaft and bearing combination maintains shaft deflection of less than 0.002 inches at all operating points. The result is longer seal and bearing life.

Premium severe-duty thrust bearings increase bearing fatigue life.

- High purity steels have fewer inclusions than standard steel – better grain structure and wear resistance.
- Heat treatment of bearing elements to SO stabilizaion levels provides superior thermal stability for increased service life.
- Bearing Balls are manufactured to at least one ISO grade above standard (ISO P5 for ring running accuracy and ISO P6 for dimensions). The result is reduced vibration and noise for improved shaft guidance.

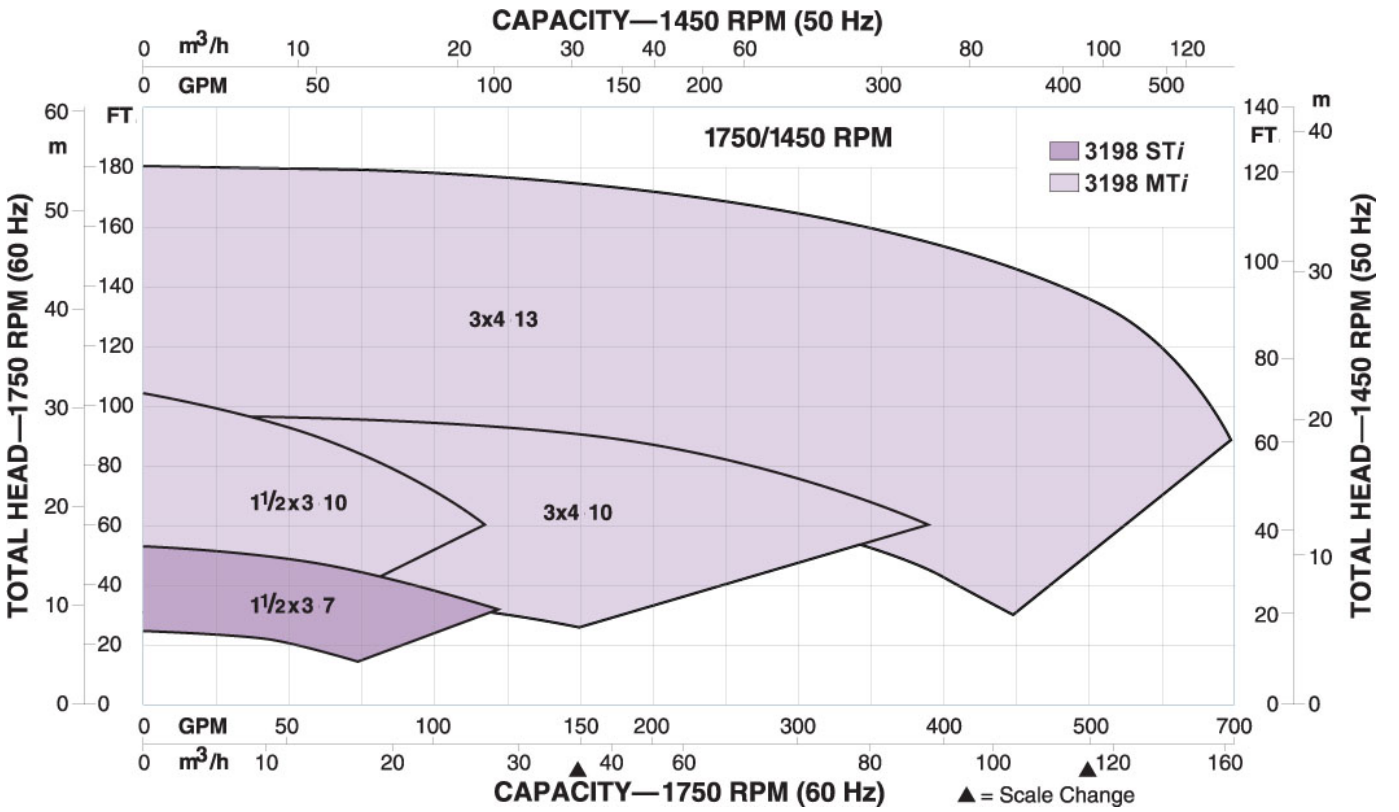
Every 3196 ***i-FRAME***™ Power End is engineered and manufactured for optimal pump performance and increased MTBF.

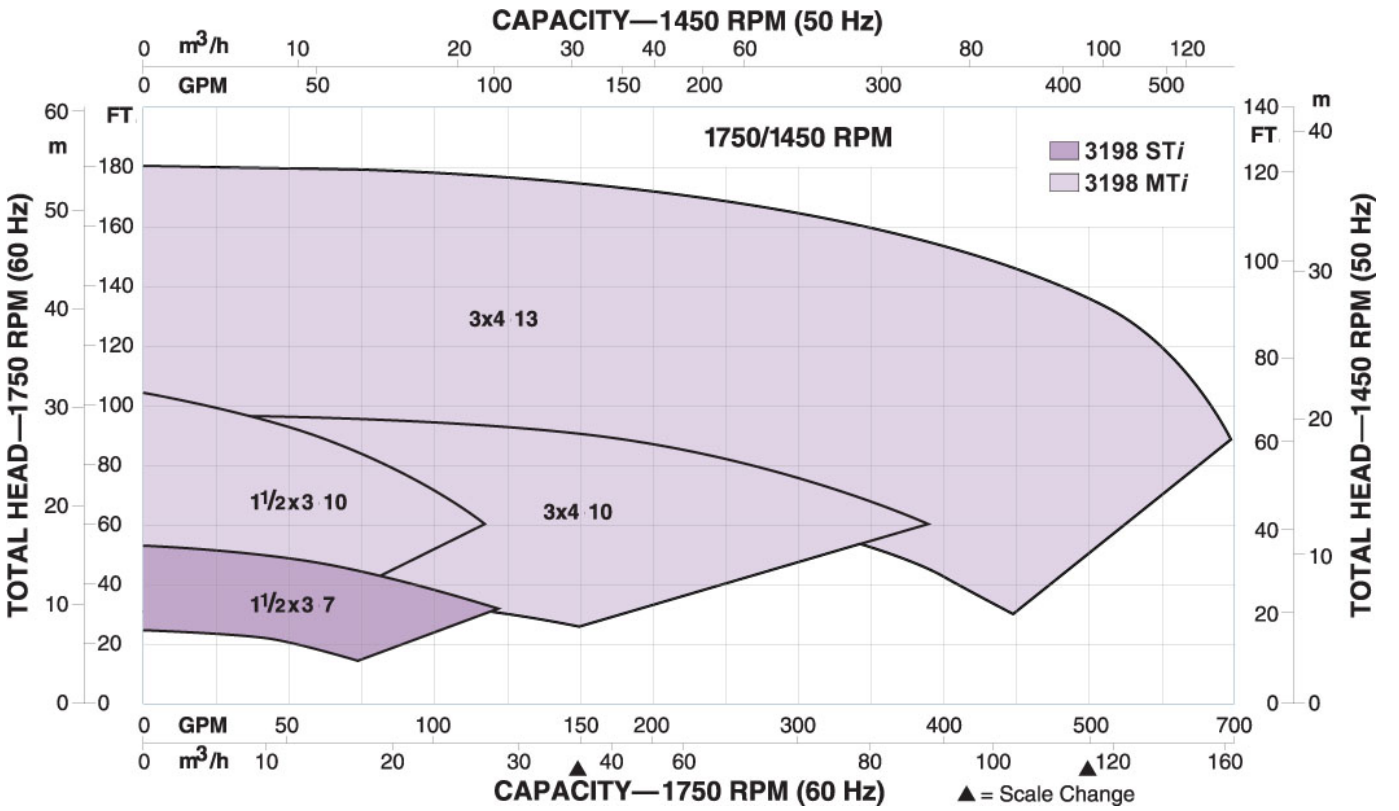
ANSI B73.1 Shaft Specification	Meets	Exceeds
Diameter Tolerance		✓
Surface Finish		✓
Runout	✓	
Deflection		✓



Our Guarantee We are so confident that the ***i-FRAME***™ is the most reliable Power End in the industry, that we are proud to offer a standard 5-year warranty on every ***i-FRAME*** ANSI Process Pump.

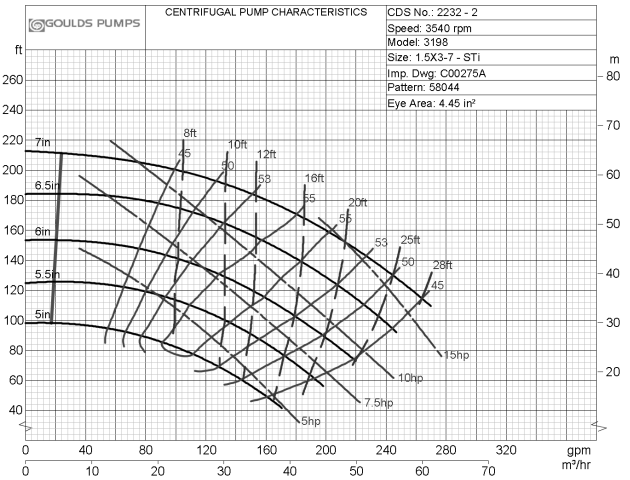
Hydraulic Coverage Models 3198 *i-FRAME™*



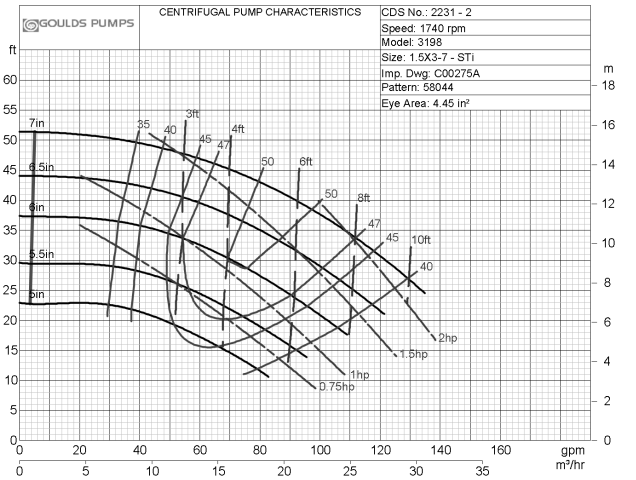


NOTES

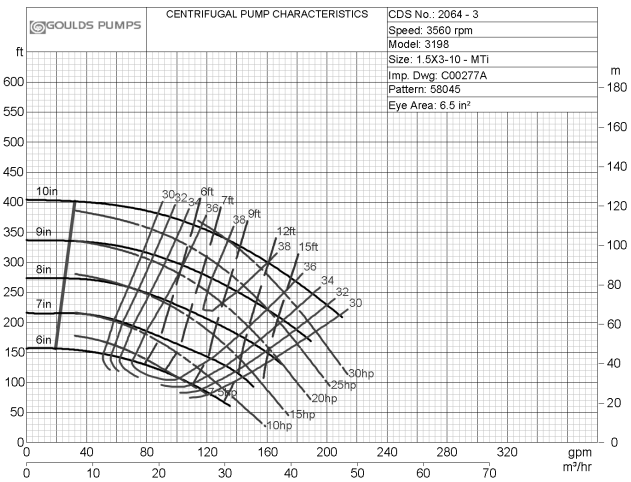
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



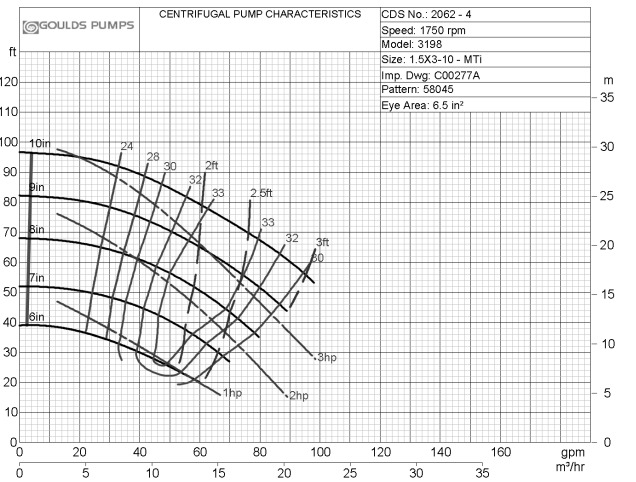
1.5X3-7 **3540rpm**



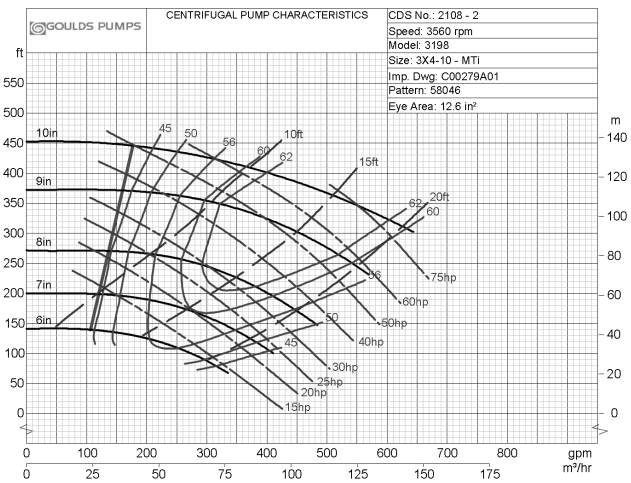
1.5X3-7 **1740rpm**



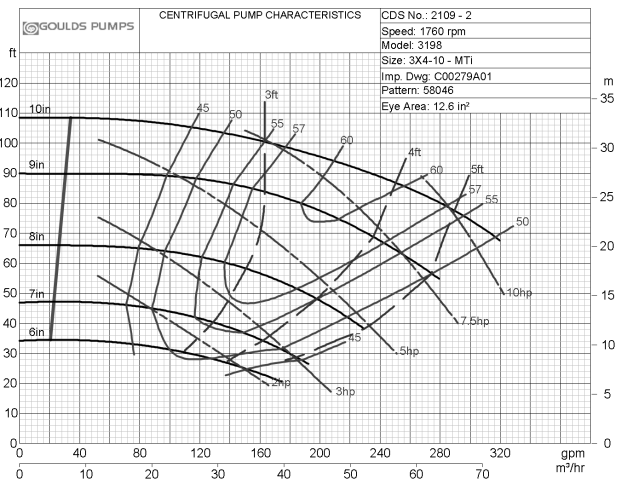
1.5X3-10 **3560rpm**



1.5X3-10 **1750rpm**



3X4-10 **3560rpm**



3X4-10 **1760rpm**

60Hz Curves

Model 3198

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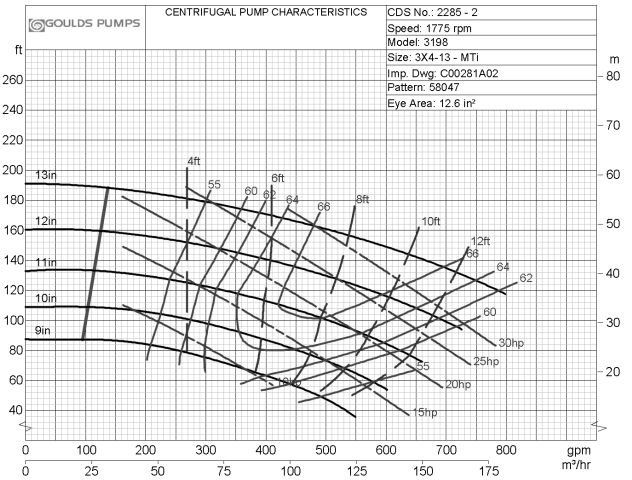
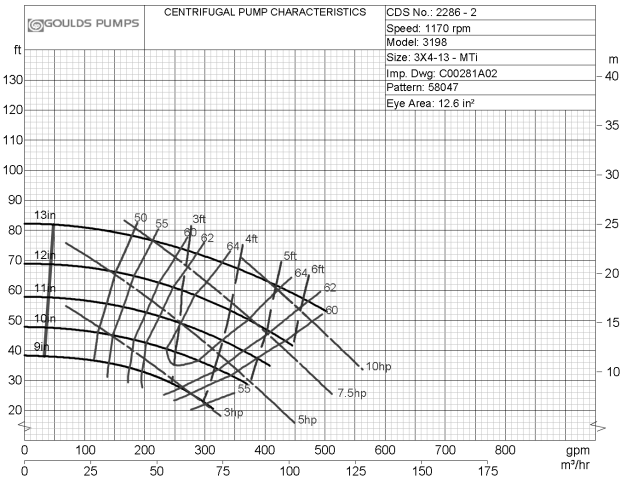
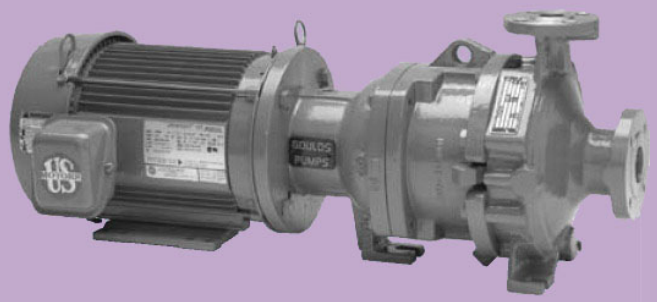


3X4-13 **1775rpm**



3X4-13 **1170rpm**

3296 EZMAG Frame Mounted Design



3296 EZMAG Close Coupled Design (S Group Only)

Model 3296 EZMAG

Sealless Chemical Process Pump Designed for Difficult Liquids such as Corrosives, Pollutants, Ultra-Pure Liquids and Toxics

- Capacities to 700 GPM (160 m^3/h)
- Heads to 550 ft (168 m)
- Temperatures to 535°F (280°C)
- Pressures to 275 PSIG

Performance Features

Extended Pump Life

- Sealless design
- Enclosed Impeller
- Silicon carbide radial and thrust bearings
- Optional Dryguard™ bearings for dry run protection
- Reliable flush circuit

Ease of Maintenance

- Bearing Cartridge design
- Double-back pull-out
- Close coupled option on S Group
- ANSI B73.1 dimensional standards
- No mechanical seal
- Minimum number of parts

Safety

- Zero emissions
- One-piece Hastelloy C containment shell
- Drive and driven magnet clearances protect containment shell
- Bearing Cartridge design contains bearings in case of failure
- Adapter drain connection
- Optional casing drain

Services

- Nitric Acid
- Caustic
- Heat Transfer Fluids
- Butodiene
- Methylene Chloride

Applications

- Batch Chemical Process
- Rail Car or Tank Unloading
- Specialty Chemicals

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

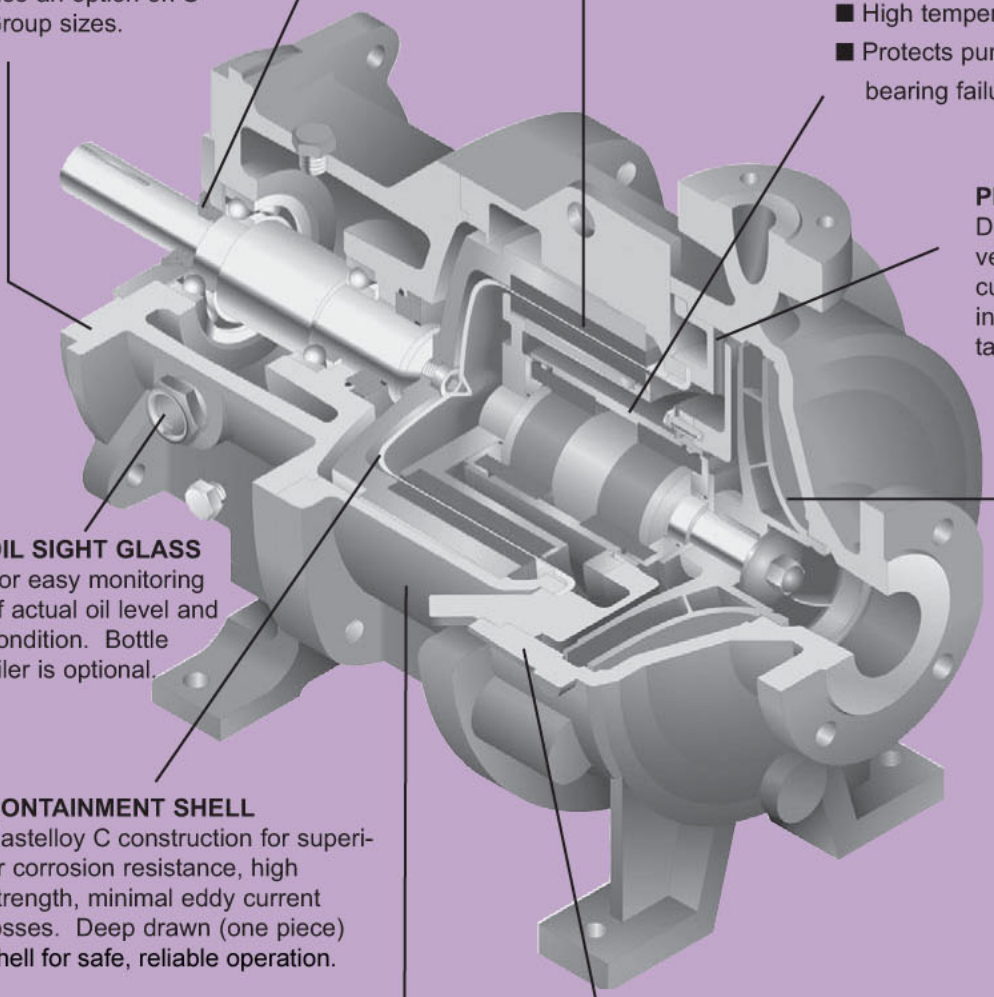
Model 3296 EZMAG

LABYRINTH OIL SEAL
Prevents premature bearing failure caused by lubricant contamination and loss of oil.

CAST IRON BEARING FRAME
Ideal constructions for safety and strength. Flood oil lubrication standard, regreasable bearings optional. Close coupled design is also an option on S Group sizes.

RARE EARTH MAGNETS
Neodymium iron standard. Optional Samarium Cobalt for higher temperatures. Rare earth material provides high torque capability.

BEARING CARTRIDGE
- Standard pure Silicon Carbide, highly abrasion-resistant with universal chemical resistance.
- Cartridge design eliminates measurements and fitting for simplified maintenance.
- Optional Dryguard™ bearing enables safe operation in temporary dry run conditions.
- High temperature cartridge is also available.
- Protects pump internals in the event of a bearing failure.



PRESSURIZED RECIRCULATION
Dual path internal recirculation prevents vaporization of product in circuit. Ensures lubrication of bearings and continuous cooling of containment shell.

ENCLOSED IMPELLER
Positively keyed and locked to shaft prevents catastrophic failure due to reverse rotation. Designed for minimum axial thrust, extended thrust bearing life.

OIL SIGHT GLASS
For easy monitoring of actual oil level and condition. Bottle oiler is optional.

CONTAINMENT SHELL
Hastelloy C construction for superior corrosion resistance, high strength, minimal eddy current losses. Deep drawn (one piece) shell for safe, reliable operation.

SIMPLIFIED ASSEMBLY AND DISASSEMBLY
- The number of "loose" components has been minimized due to its modular design concept.
- High component interchangeability within the frame size groups.
- No special tools required.
- No fitting measurements.
- Back pull-out design allows for maintenance of the drive side while keeping the liquid end assembled and pressurized.

Heavy Duty Casing
- ANSI dimensional
- 1/8" corrosion allowance
- Optional tapped connections

Reliable, Simple and EZ to Maintain

Bearing Cartridge

Individual bearings are contained in a single cartridge assembly.

- Bearings are made of highly abrasion and corrosion resistant silicon carbide. Dryguard™ bearings are available for protection against occasional dry run conditions.
- In the event of bearing failure, the cartridge design contains the bearings and prevents further damage to pump internals.
- Installation and replacement of bearings is simple. Only one component to install.

Containment Shell

The containment shell is the most important component isolating pumpage from the atmosphere.

- The containment shell is a deep-drawn single piece design made from Hastelloy C for reliable corrosion resistance.
- The vortex-breaking bead at the bottom of the can prevents erosion.
- Burst pressure is greater than 2,175 psi.

Maintenance Made Simple

The 3296 EZMAG was designed with the end user in mind. Fewer parts make planned maintenance faster and easier than other sealless and sealed process pumps. The S Group is also available in a close coupled configuration, futher eliminating the need for time-consuming pump and motor alignment.

3296 EZMAG Options

Dryguard™ Bearings

The heat generation from dry run conditions is the number one mode of failure for sealless pumps. Dryguard™ is a diamond-like carbon that reduces the coefficient of friction by over 70%, enabling short periods of safe operation under dry run conditions. Dryguard™ is up to 2X harder than silicon carbide, ensuring its benefits cannot be compromised in even the harshest conditions.

High Temperature Applications

The 3296 EZMAG is perfect for applications up to 535°F. For fluids between 350° and 535°F, special design considerations are incorporated. A “High Temperature” bearing cartridge is used to handle the additional rate of thermal expansion. Secondly, Samarium Cobalt magnets are used to ensure performance at elevated temperatures.

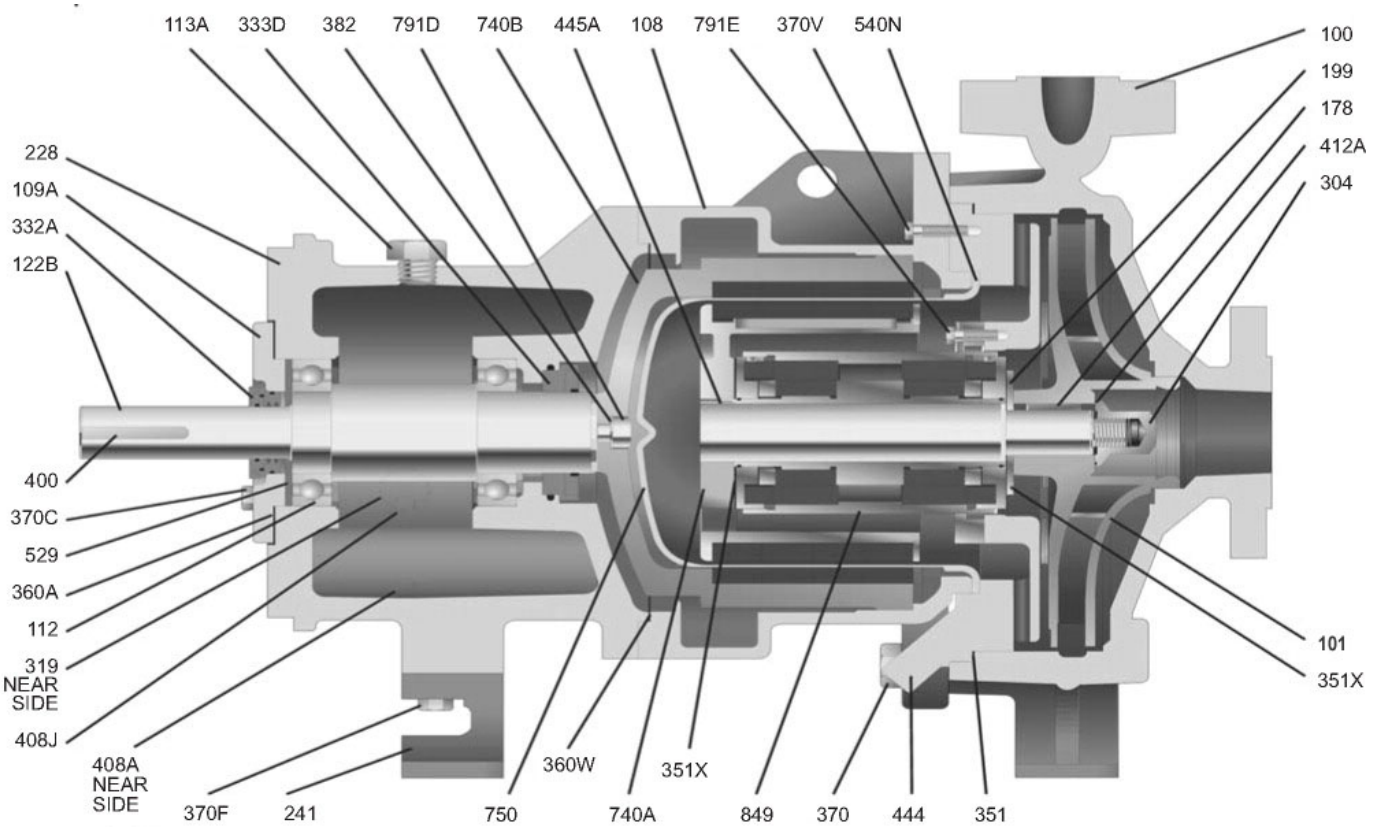
Parts List and Materials of Construction

Item Number	Description	Material of Construction	
		Stainless	Hastelloy C
100	Casing	Stainless Steel	Hastelloy C
101	Impeller	Stainless Steel	Hastelloy C
108	Frame Adapter	Ductile Iron	Ductile Iron
109A [2]	End Cover	Ductile Iron	Ductile Iron
112 [2]	Ball Bearing	Steel	Steel
113A [2]	Plug, Pipe Fill	Steel	Steel
122A [1]	StubShaft	Steel	Steel
122B [2]	Drive Shaft	Steel 4140	Steel 4140
178	Impeller Key	303SS	Hastelloy C
199	Washer, Distance	Stainless Steel	Hastelloy C
222E [3]	Set Screw (backplate to adaptor)	Stainless Steel	Stainless Steel
222L [1]	Set Screw (stub shaft to motor)	Steel	Steel
228 [2]	Bearing Frame	Cast Iron	Cast Iron
241 [4]	Foot, Frame	Cast Iron	Cast Iron
304	Impeller Nut	Stainless Steel	Hastelloy C
319 [2]	Sight Window	Steel/Glass	Steel/Glass
332A [2]	Labyrinth Oil Seal - outboard	Bronze	Bronze
333D [2,5]	Labyrinth Oil Seal - inboard	Bronze	Bronze
351X	Gasket, Intermediate Ring	Teflon (Glass Filled)	Teflon (Glass Filled)
351 [6]	Gasket (backplate to casing)	Aramid Fiber EPDM	Aramid Fiber EPDM
360A	Gasket (endcover)	Vellumoid	Vellumoid
360W	Gasket (frame to adapter)	Aramid Fiber EPDM	Aramid Fiber EPDM
370	Hex Cap Screw (adapter to casing)	Stainless Steel	Stainless Steel
370B	Hex Cap Screw (frame to adapter)	Steel	Steel
370C [2]	Hex Cap Screw (end cover)	Steel	Steel
370F [4]	Hex Cap Screw (foot to frame)	Steel	Steel
370V	Hex Cap Screw (backplate to adapter)	Stainless Steel	Stainless Steel
371 [1]	Hex Cap Screw (motor to adapter)	Steel	Steel
382	Lockwasher	Steel	Steel
400 [2]	Key, Square	Steel	Steel
408A [2]	Plug, Drain	Steel	Steel
408J [2]	Plug, Oiler	Steel	Steel
412A	Impeller Nut O-ring	Teflon®	Teflon®
444	Backplate	Stainless Steel	Hastelloy C
445A	Pin (backplate to cartridge)	303SS	Hastelloy C
503 [1]	Adapter, Close Coupled	Cast Iron	Cast Iron
504 [1]	Adapter, Ring (280 NEMA C-face motors)	Steel	Steel
529 [2]	Washer, Wave	Steel	Steel
540N [6]	Gasket, Containment Shell	Aramid Fiber EPDM	Aramid Fiber EPDM
740A	Driven Carrier / Shaft Assembly	Duplex SS / NdFeB	Hastelloy C / NdFeB
740B	Drive Carrier Assembly	Ductile Iron / NdFeB	Ductile Iron / NdFeB
750	Containment Shell	Hastelloy C	Hastelloy C
791D	Socket Head Screw (carrier)	Steel	Steel
791E	Hex Cap Screw (cartridge to backplate)	Stainless Steel	Hastelloy C
849	Bearing Cartridge	Duplex SS / Silicon Carbide	Hastelloy C / Silicon Carbide

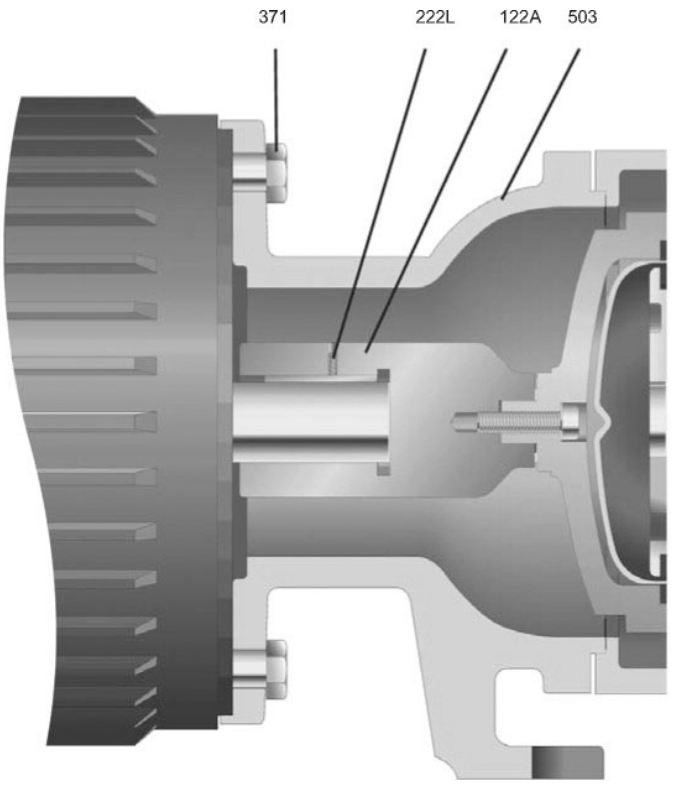
1 Close Coupled Configuration Only
2 Frame Configuration Only
3 6" S Group Only
4 M Group Frame Configuration Only
5 Carbon-filled Teflon® for S Group Only
6 Optional Gasket Material: White Gylon and Fawn Gylon
*® EI Dupont reg. trademark
Alloy 20 and other materials available upon request.

Sectional View Model 3296 EZMAG

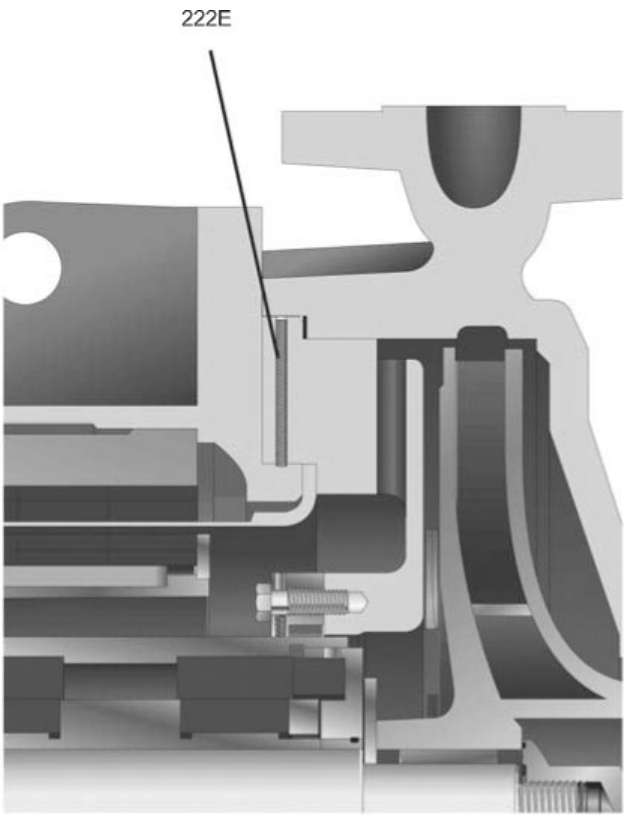
M Group Frame Mounted



S Group Close Coupled

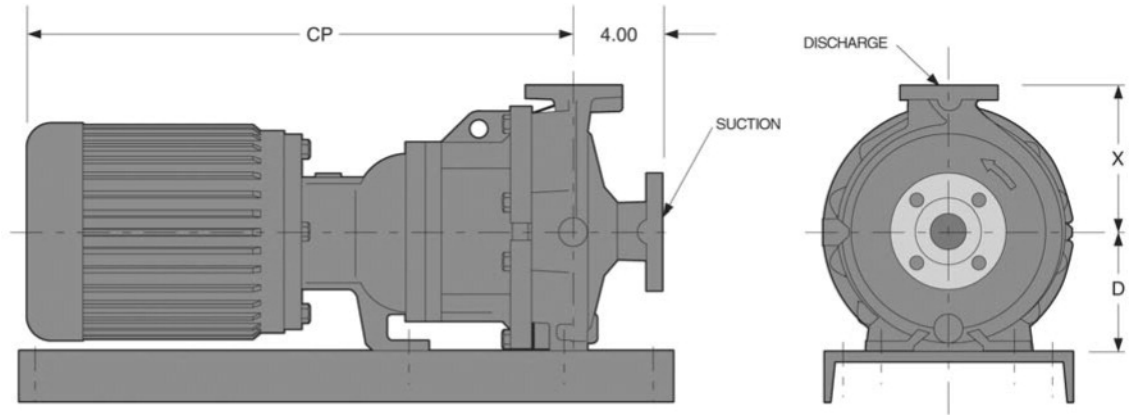


S Group 6" Only

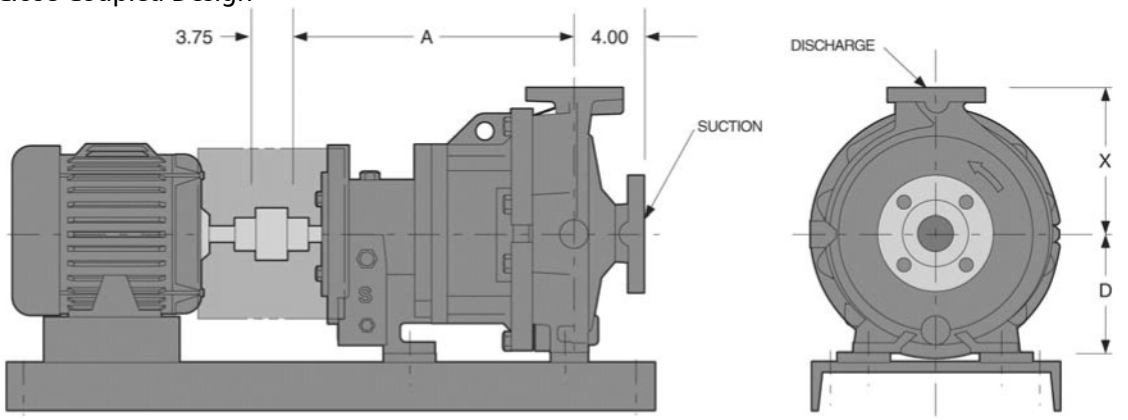


Dimensions Model 3296 EZMAG

Not to be used for construction



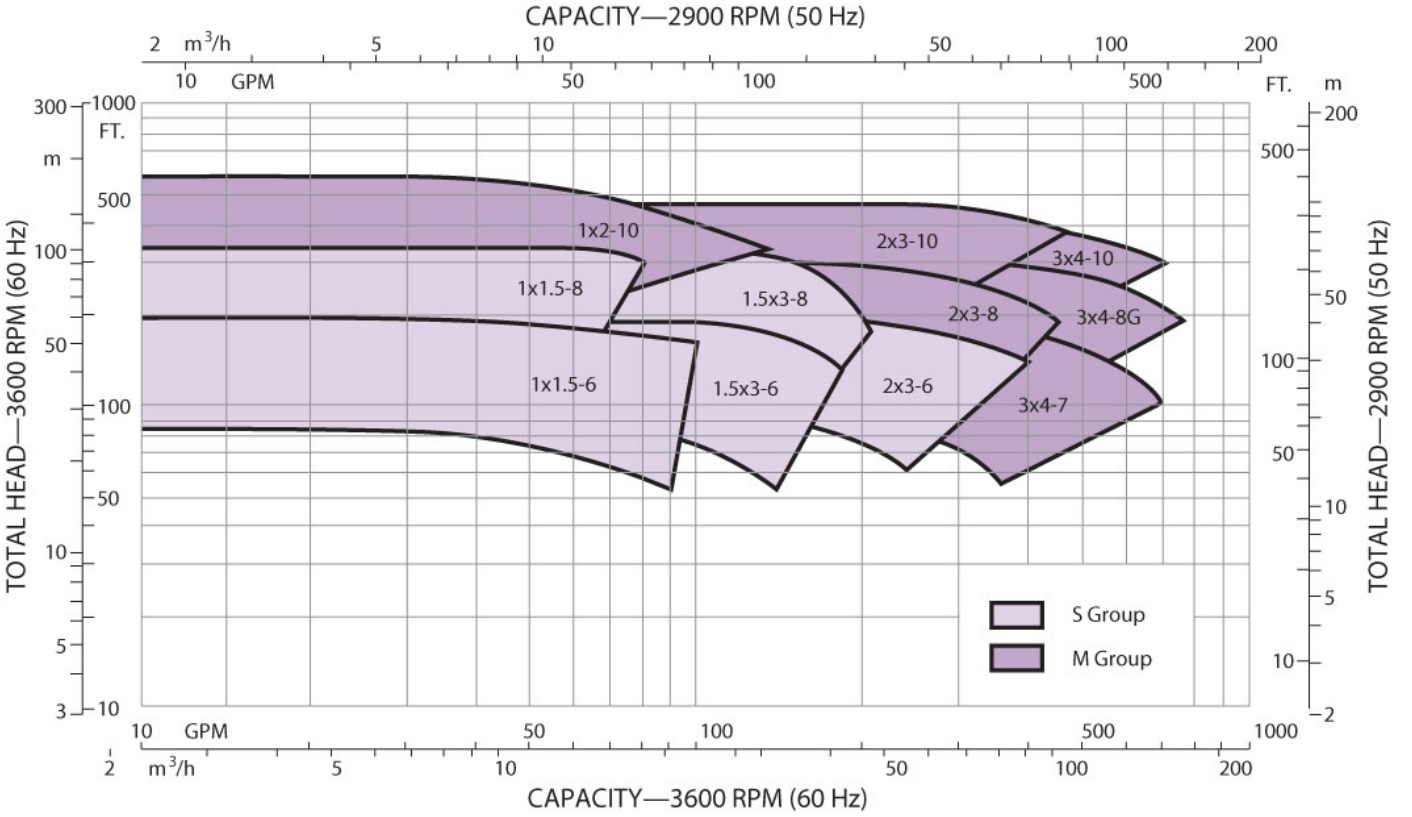
Close Coupled Design



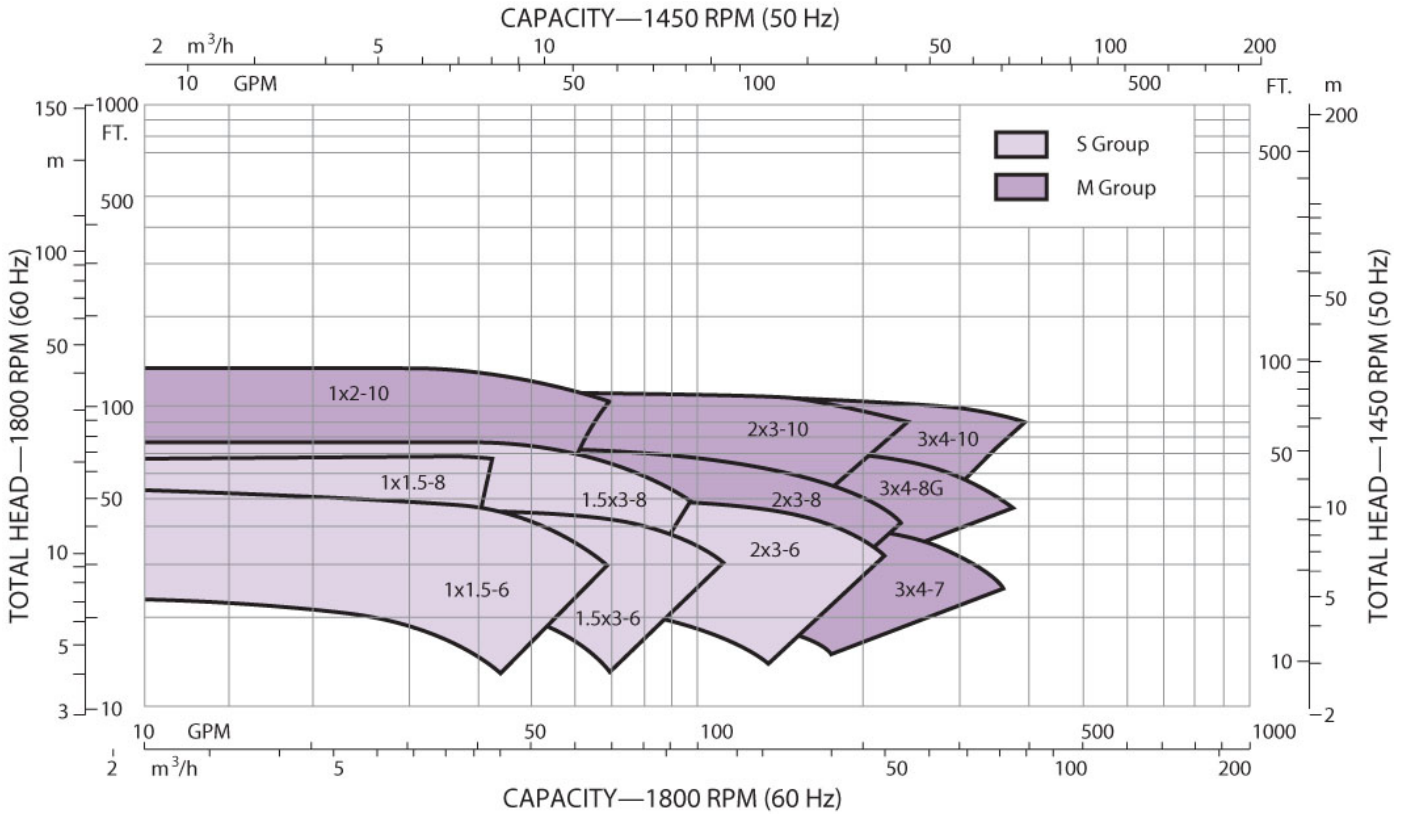
Frame-Mounted Design

Bare Pump Dimensions							S Group Close Coupled	
Group	Pump Size	A in (mm)	D in (mm)	X in (mm)	Close-Coupled Pump Weight lb (kg)	Frame-Mounted Pump Weight lb (kg)	Motor Frame	CP Approx in (cm)
S	1×1½-6	13.5 (343)	5.25 (133)	6.5 (165)	112 (51)	133 (60.5)	143TC	25 (635)
	1½×3-6	13.5 (343)	5.25 (133)	6.5 (165)	119 (54)	136 (61.5)	145TC	24 (610)
	2×3-6	13.5 (343)	5.25 (133)	6.5 (165)	140 (63.5)	142 (64.5)	182TC/184TC	26 (660)
	1×1½-8	13.5 (343)	5.25 (133)	6.5 (165)	133 (60.5)	144 (65.5)	213TC/215TC	29.5 (749)
	1½×3-8	13.5 (343)	5.25 (133)	6.5 (165)	148 (67)	154 (70)	254TC/256TC	34 (864)
S/M	2×3-8	19.5 (495)	8.25 (210)	9.5 (242)	153 (69.5)	158 (71.5)	284TC	36 (914)
8″ M	3×4-7	19.5 (495)	8.25 (210)	11 (280)	NA	244 (110.5)	284TSC	34 (864)
	3×4-8G	19.5 (495)	8.25 (210)	11 (280)	NA	255 (115.5)	286TC	37.5 (953)
10″ M	1×2-10	19.5 (495)	8.25 (210)	8.5 (216)	NA	271 (123)	286TSC	34 (864)
	2×3-10	19.5 (495)	8.25 (210)	9.5 (242)	NA	276 (125)		
	3×4-10	19.5 (495)	8.25 (210)	11 (280)	NA	300 (136)		

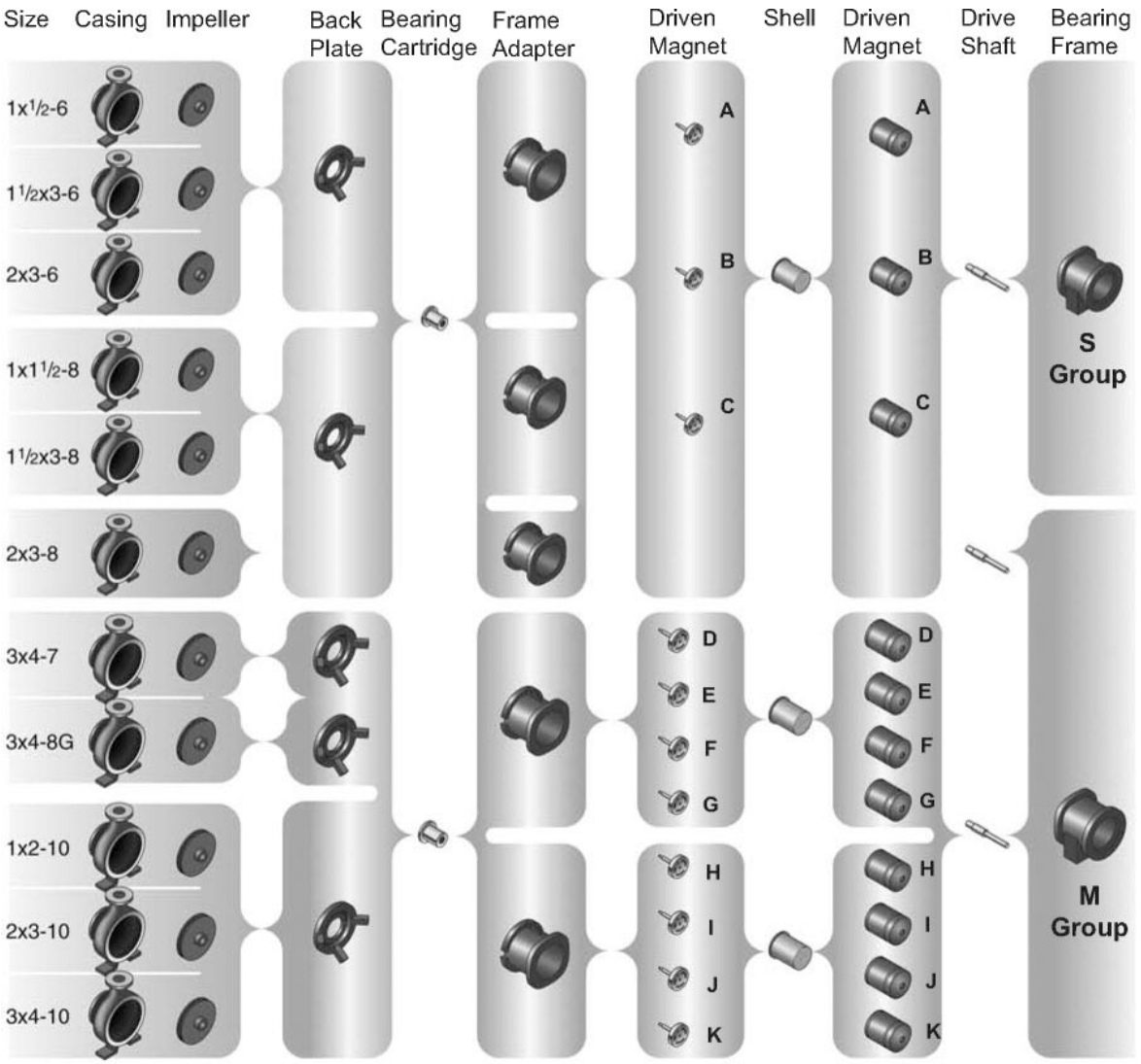
Hydraulic Coverage **3600/2900 RPM**

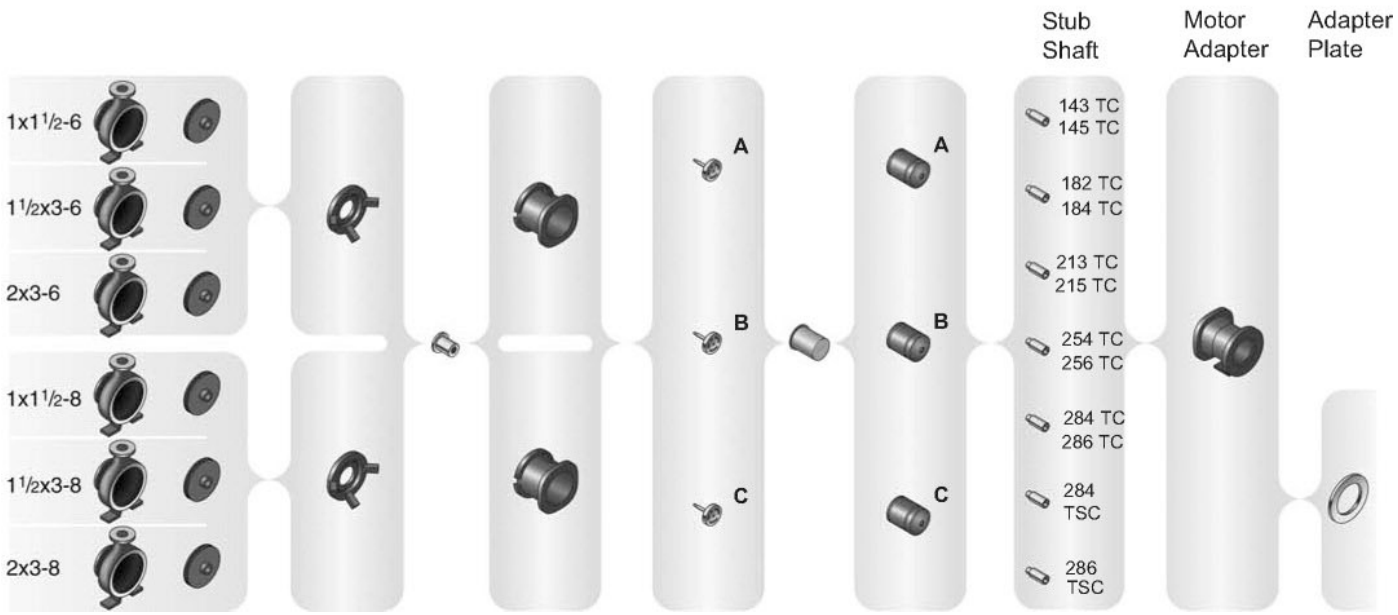


Hydraulic Coverage **1800/1450 RPM**



Interchangeability Chart

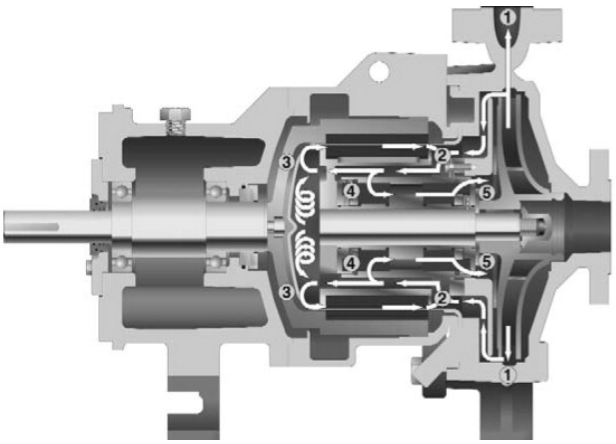




Reliable Recirculation

Simple, Reliable Recirculation Circuit

The 3296 EZMAG's reliable flush circuit features patented geometry to ensure the bearings receive proper lubrication. Axial vanes on the driven magnet move fluid around the back of the containment shell. Spiral grooves in the bearing cartridge transport fluid through the cartridge and back into the casing. Bearings stay lubricated and heat resulting from eddy current losses is carried away.



Optional Features

Condition Monitoring

RTD or Thermocouple

Monitors containment shell temperature, provides basic pump protection by indicating system malfunctions such as dry-run conditions, plugged recirculation, flashing of pumpage or decoupling of magnets.

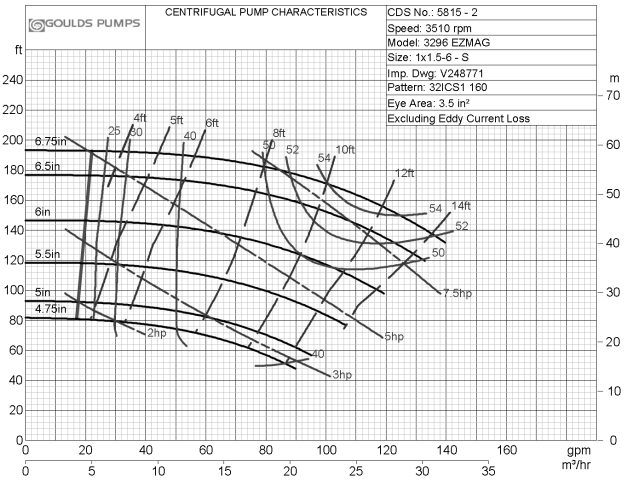
Temperature Controller

Used to measure signal from containment shell temperature sensor. Has adjustable trip point to sound alarm and/or stop the pump.

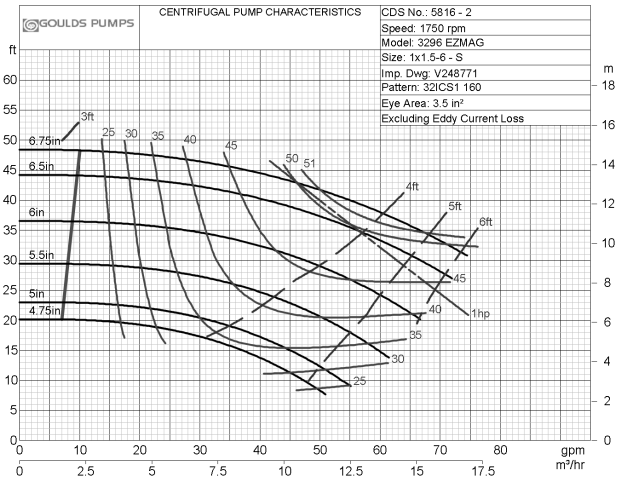
Power Monitoring

The PS20 Pump Load Monitors measure the motor input power in combination with a proprietary algorithm to accurately determine the pump's power draw. The devices can be set to automatically shutdown the pump or warn the operator when upset conditions occur, protecting the pump from damage.

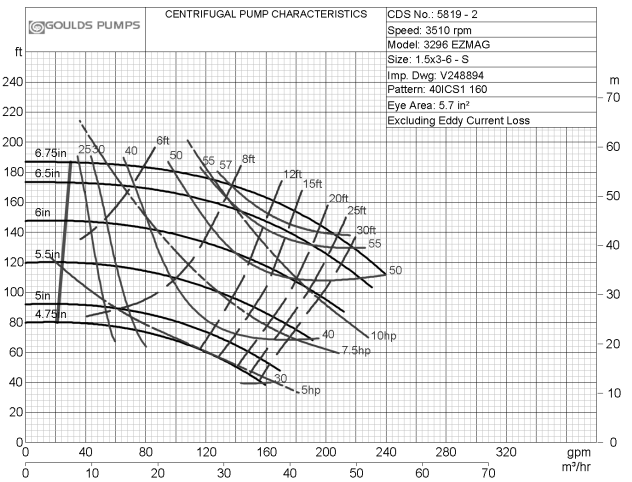
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



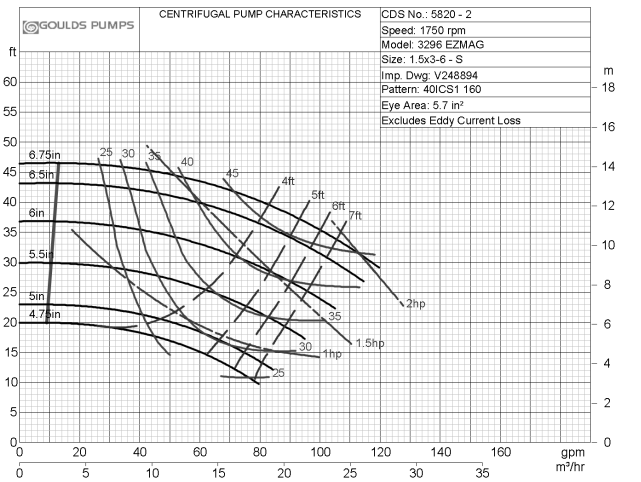
1x1.5-6 **3510rpm**



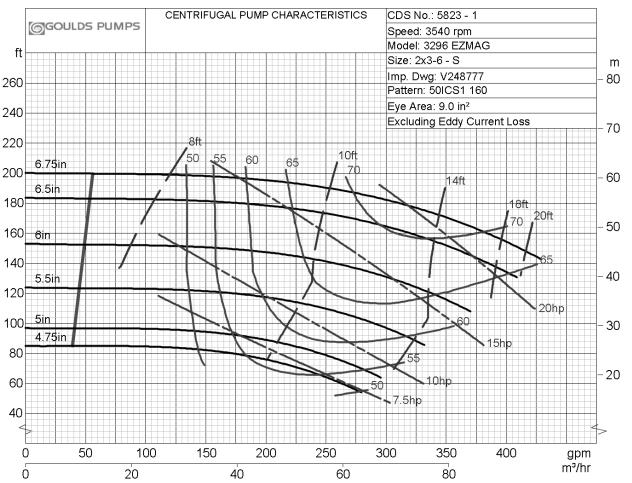
1x1.5-6 **1750rpm**



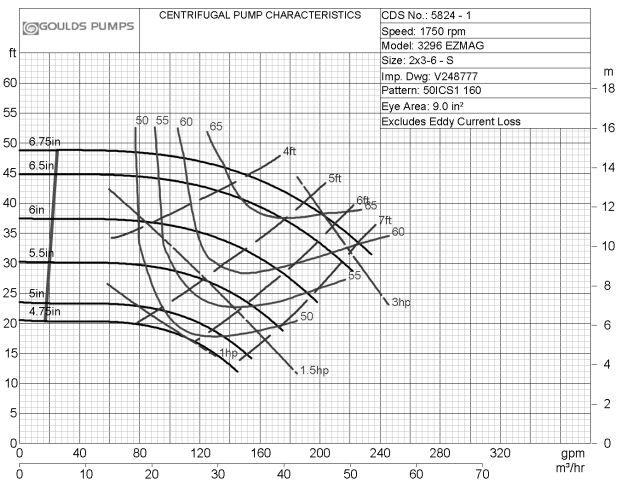
1.5x3-6 **3510rpm**



1.5x3-6 **1750rpm**

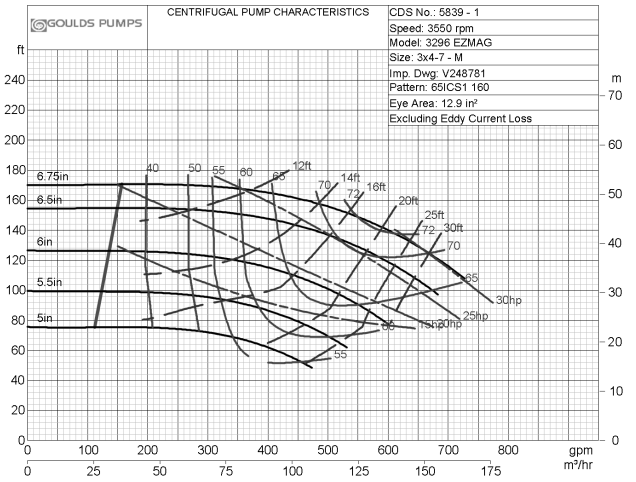


2x3-6 **3540rpm**

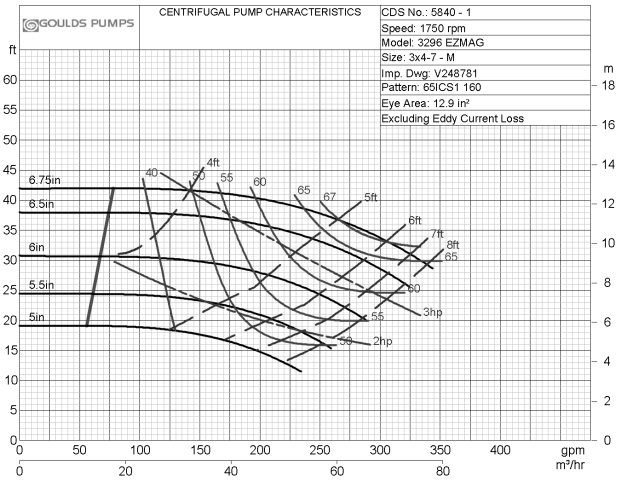


2x3-6 **1750rpm**

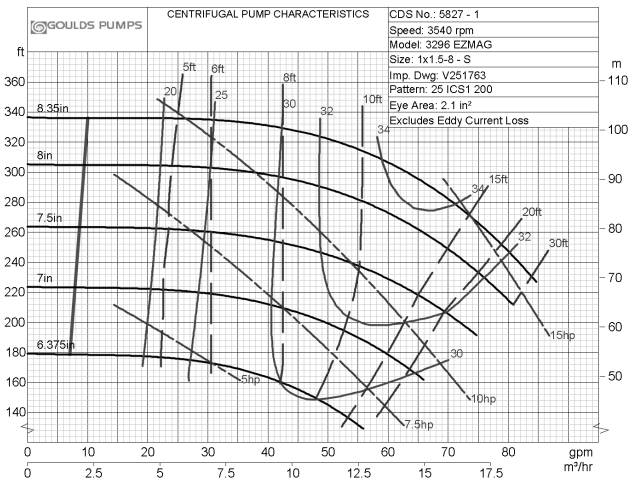
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



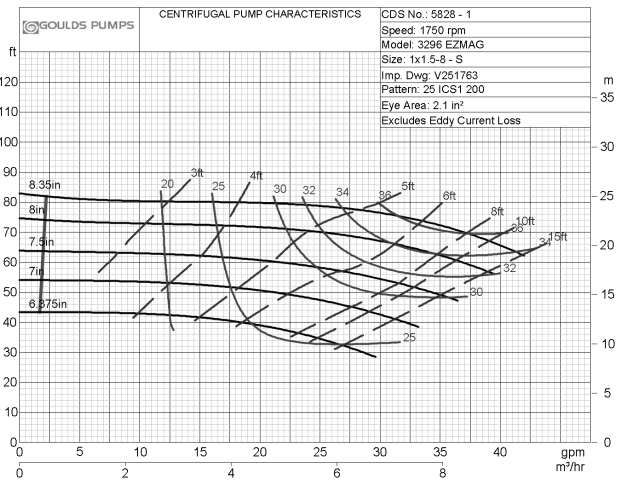
3x4-7 **3550rpm**



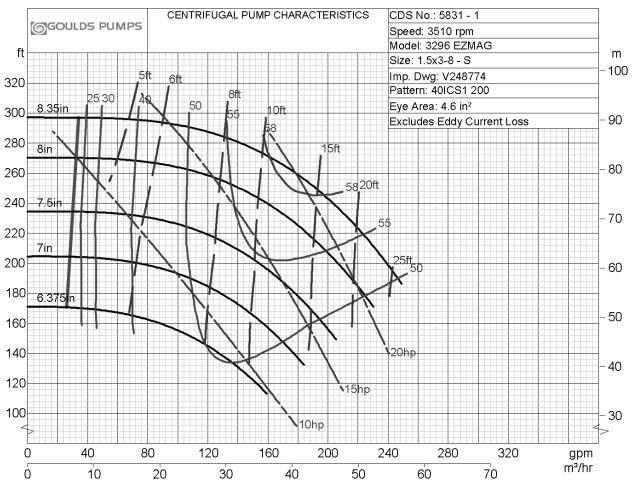
3x4-7 **1750rpm**



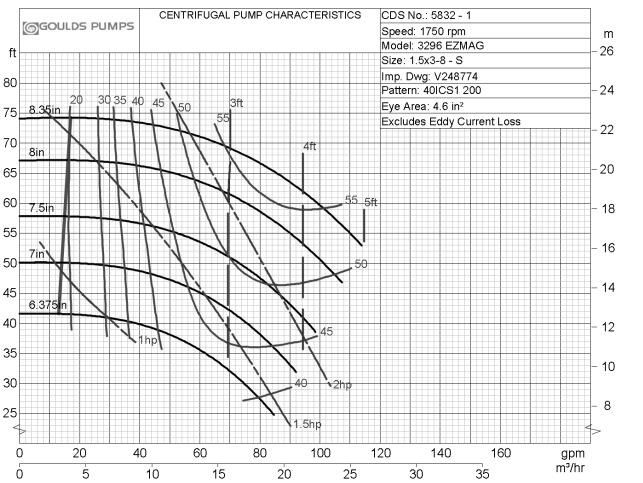
1x1.5-8 **3540rpm**



1x1.5-8 **1750rpm**

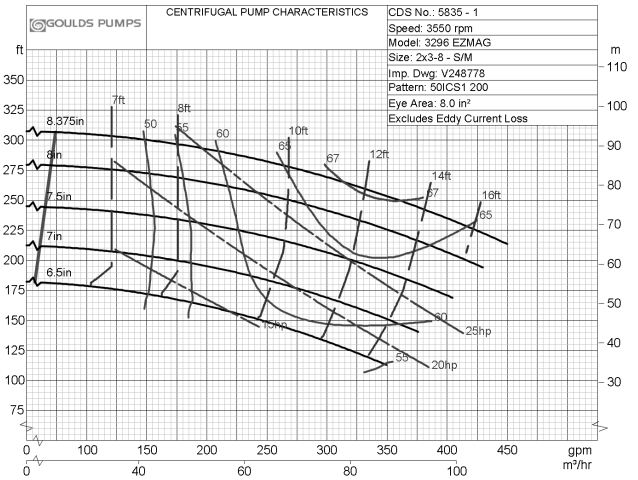


1.5x3-8 **3510rpm**

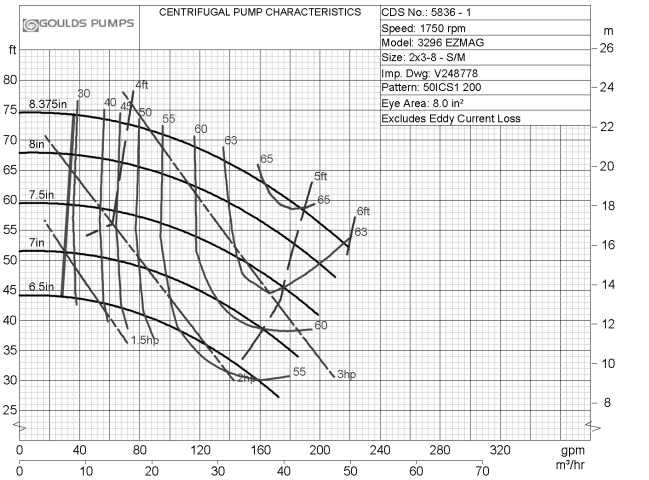


1.5x3-8 **1750rpm**

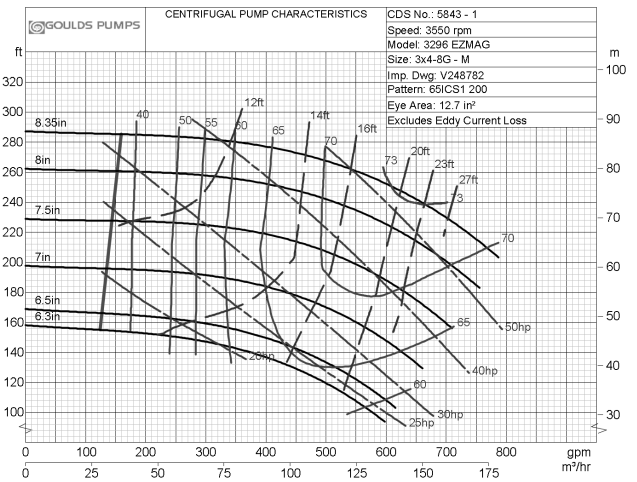
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



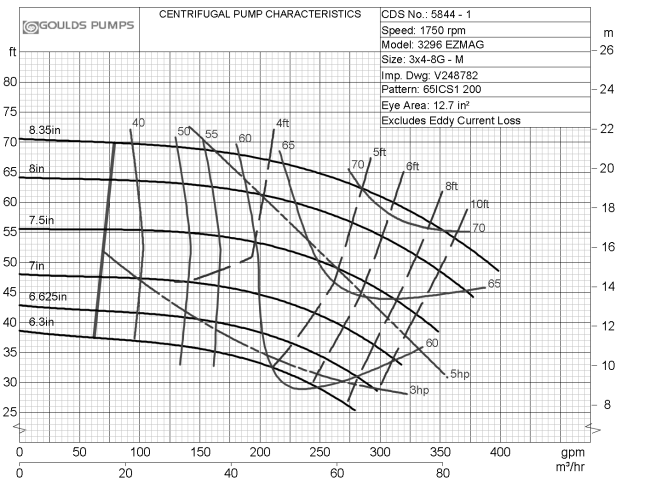
2x3-8 **3550rpm**



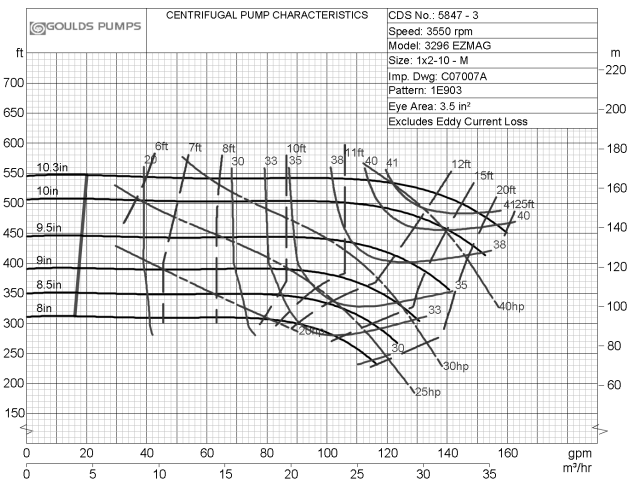
2x3-8 **1750rpm**



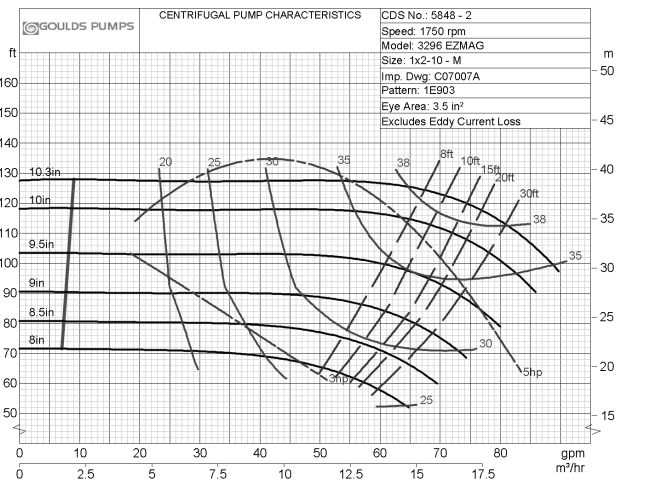
3x4-8G **3550rpm**



3x4-8G **1750rpm**



1x2-10 **3550rpm**

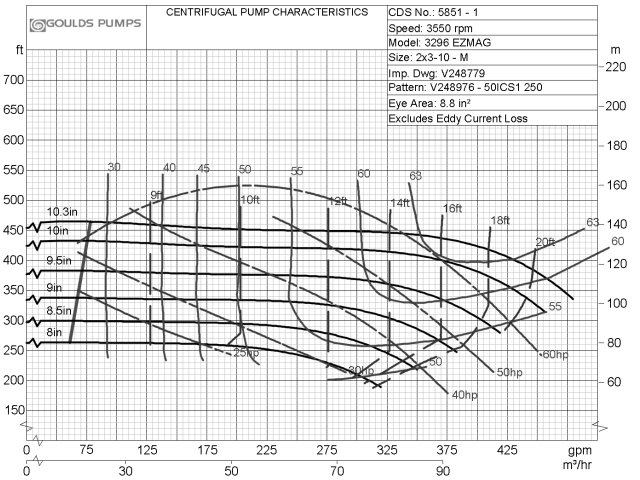


1x2-10 **1750rpm**

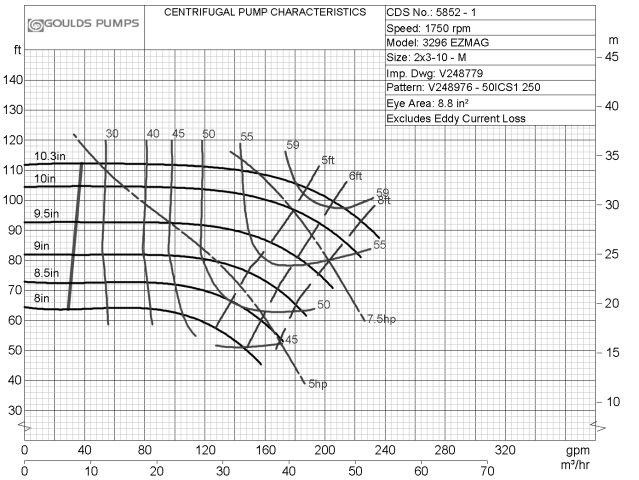
60Hz Curves

Model 3296 EZMAG

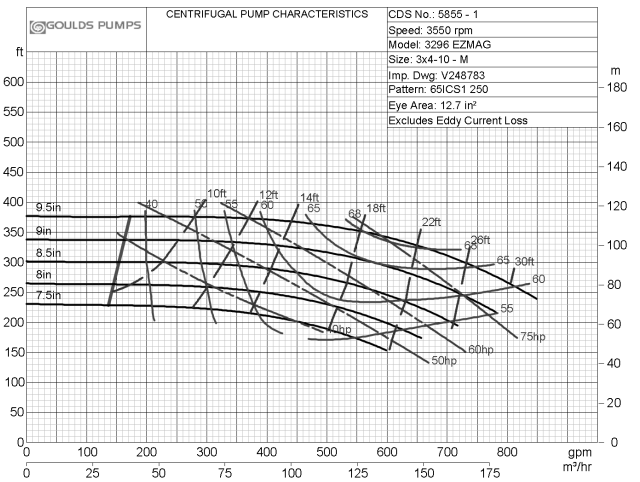
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



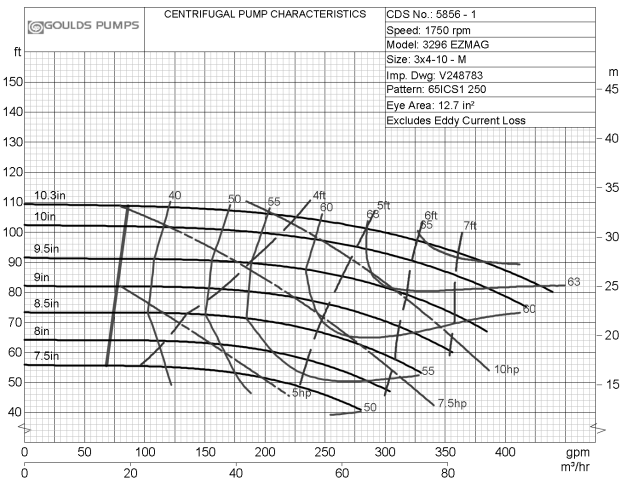
2x3-10 **3550rpm**



2x3-10 **1750rpm**



3x4-10 **3550rpm**



3x4-10 **1750rpm**

3298 Close-Coupled Standard Design

SP 3298 Self-Priming

V 3298 Space Saving Vertical In-Line

Ideal for Moderate to Severe Corrosives!

The 3298 can handle the tough chemical services. As a sealless design, it's an effective alternative to pumps with mechanical seal problems. Meets strictest EPA regulations.

Goulds Model 3298

Medium Duty Sealless Pumps Designed for Chemical Services

- Capacities to 1200 GPM (270 m^3/h)
- Heads to 350 feet (162 m)
- Temperatures to 250°F (121°C)
- Pressures to 225 PSIG (1551 kPa)

Performance Features for Chemical Services

Extended Pump Life

- Tefzel® (ETFE) Construction
- Sealless Design
- Stationary Silicon Carbide Shaft
- Optional Silicon Carbide Dryguard™ Bearings

Optimum Performance

- Non-slip Synchronous Drive
- Efficiency Equivalent to Sealed ANSI Pumps, 30% Higher than Metal Sealless Pumps

Ease of Maintenance

- Minimum Parts
- No Pump/Motor Alignment Required with Close-Coupled Design
- ANSI Dimensional
- Optional Frame-Mounted Design
- No Mechanical Seal

Safety

- Drive and Driven Magnet Assembly Safety Clearances (Frame-Mounted Design)
- Adapter and Casing Drain Connections
- Zero Emissions

Services

- Hydrochloric Acid
- Sodium Sulfate
- Sodium Hypochlorite
- Methane
- Sodium Hydroxide
- Sulfuric Acid

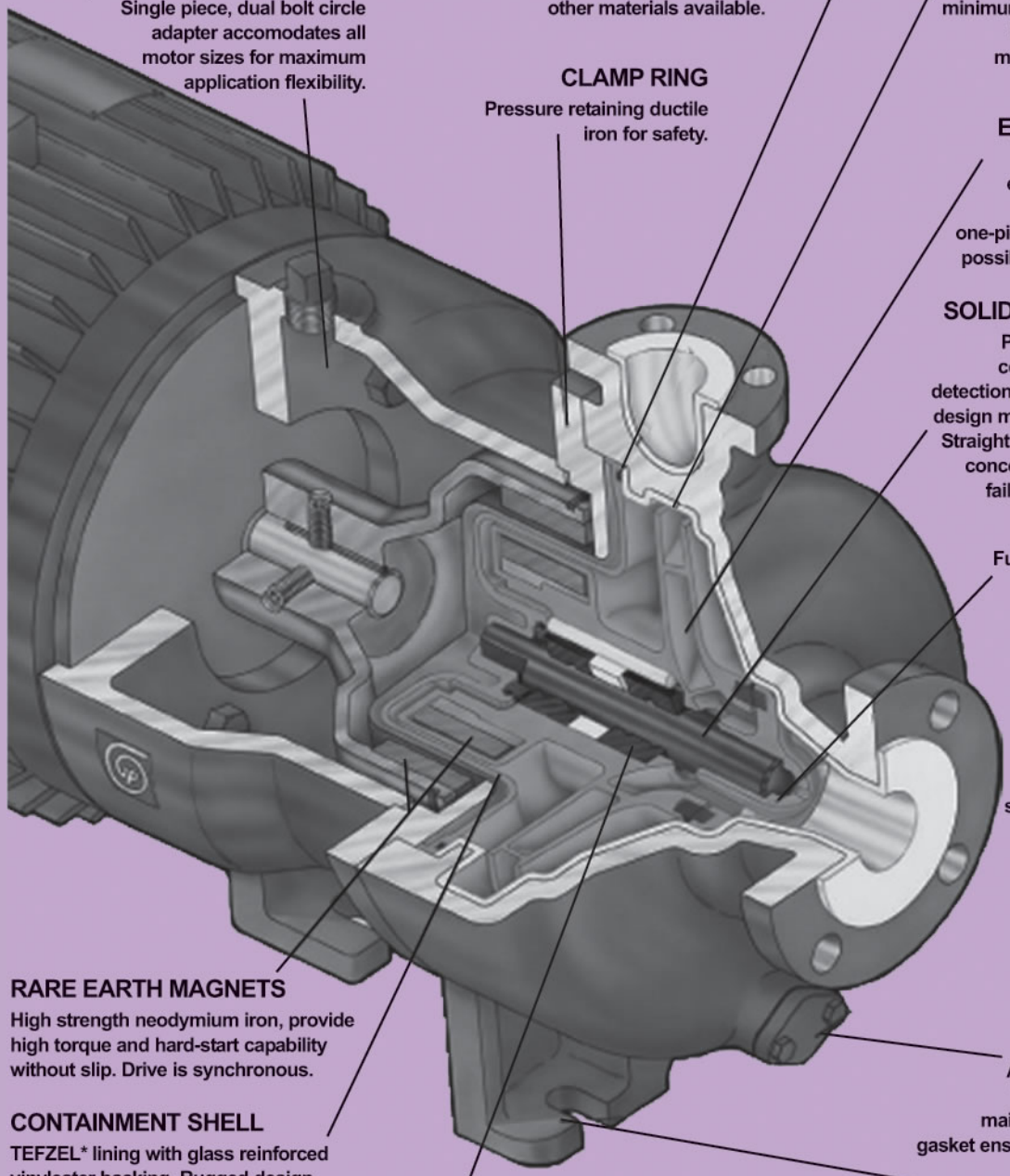
Applications

- Rail Car or Tank Unloading
- Batch Chemical Process
- Specialty Chemicals
- Column Reflux or Bottoms
- Reactor Feed

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3298 Chemical Process Pumps

Design Features for Wide Range of Process Services



CLOSE-COUPLED DESIGN
Arrangement eliminates need to perform pump/motor alignment. Single piece, dual bolt circle adapter accomodates all motor sizes for maximum application flexibility.

FULLY CONFINED O-RING
Sealed to casing for zero leakage. Acid-resistant Viton standard; other materials available.

CLAMP RING
Pressure retaining ductile iron for safety.

TEFZEL* LINING WITH -DUCTILE IRON CASING
One-piece solid casing lined with minimum 1/8 inch (3 mm) TEFZEL*. Rotolining process assures mechanical integrity of lining.

ONE-PIECE ENCLOSED IMPELLER
Minimizes axial thrust for extended thrust bearing life. Unlike two-piece designs, one-piece construction eliminates possibility of front shroud failure.

SOLID STATIONARY SHAFT
Pure sintered silicon carbide construction eliminates shaft detection. Fully supported stationary design maximizes radial bearing life. Straight geometry eliminates stress concentrations and possibility of failure during pump operation.

BEARING SPIDER
Fully supports silicon carbide shaft for maximum shaft rigidity. Protects the end of the silicon carbide shaft from damage. Smooth hydraulic flow path into the eye of the impeller, equal to that of a standard ANSI pump. Rounded spider hub and spider supports (flowstraighteners) reduce turbulence and pre-rotation for better hydraulic stability.

ANSI DIMENSIONS
Allows easy retrofit of problem ANSI pumps.

CASING DRAIN
Allows complete draining of fluid from pump for system maintenance. Blind flange and gasket ensure leak-free seal for safety.

RIGID CASING FEET
Reduce effect of pipe loads on pump and motor shaft alignment.

RARE EARTH MAGNETS
High strength neodymium iron, provide high torque and hard-start capability without slip. Drive is synchronous.

CONTAINMENT SHELL
TEFZEL* lining with glass reinforced vinylester backing. Rugged design with burst pressure greater than 500 psi. Non-metallic construction provides efficiencies same as sealed ANSI pumps. (30% higher efficiencies than metal sealless pumps.)

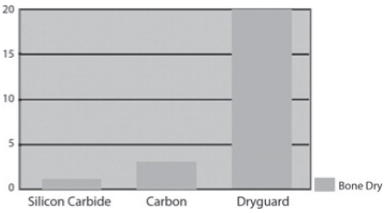
RADIAL BEARING WITH TEFLON* SPACER
Two-piece design with Teflon* spacer allows bearings to self-align under load. Independent movement maximizes bearing life. Carbon bearing constructions standard; silicon carbide and Dryguard silicon carbide optional.

TEFZEL* (ETFE) CONSTRUCTION
Provides superior corrosion resistance; inert to most chemicals. Tough material for superior solids handling/abrasion resistance (same or better than 316 SS).

*E.I. DuPont Reg. Trademark

Exceptional Performance for Chemical Services

10X More Dry Run Protection



10X MORE DRY RUN PROTECTION WITH DRYGUARD™ BEARINGS

Goulds unique Dryguard™ diamond-like carbon coating significantly reduces the coefficient of friction enabling periods of safe operation under dry run conditions. Dryguard™ is up to 1.5X harder than silicon carbide, ensuring its protection lasts throughout the life of the pump.

POWER MONITORS

No pump is designed to run dry for an extended period of time. Goulds recommends that pumps be protected with a power monitor. Easy to install and easy to operate, power monitors will ensure extended time between planned maintenance for the 3298 or any other pump in the facility.

Ultimate Protection

Magnetic drive pump failures are often due to dry running and closed discharge valve conditions. With Dryguard™ silicon carbide bearings and a power monitor, you have the best protection technology can offer. Goulds always recommends the use of a power monitor because… **FAILURE IS NOT AN OPTION!**

TEFZEL® Construction for Extreme Corrosion Resistance

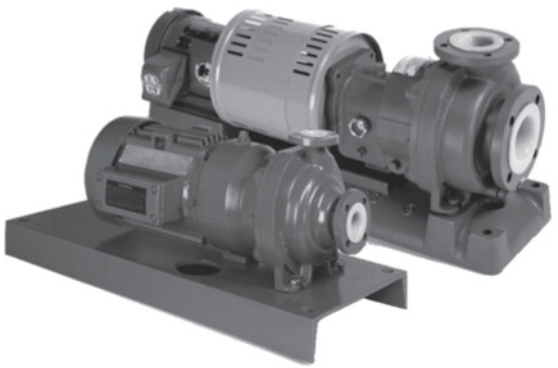
TEFZEL ® (ETFE) is inert to most chemicals, and has good abrasion resistance. TEFZEL ® lined casing and containment shell with solid TEFZEL ® impeller provide superior corrosion resistance and long life unequalled by alloy pumps.

Installation/Pump Replacement Flexibility

The 3298 is available in close-coupled or frame-mounted designs for true installation or pump replacement flexibility.

Since the 3298 meets ANSI dimensional standards, retrofitting mechanically sealed ANSI pumps is easy: simply replace the old pump with the equivalent close-coupled or frame-mounted ANSI size 3298.

Frame Mounted



Close-Coupled

Reliable, Simple – Easy To Maintain

Design Features for Extended Pump Life

CASING WITH TEFZEL ® LINING

One-piece solid ductile iron casing with Tefzel ® lining. Generous lining thickness of 1/8 inch (3 mm). Rotolining process assures integrity of lining. Rugged foot mounted design provides maximum resistance to and distortion from pipe loads. Flange loads are the same as metal ANSI pumps. Casing drain allows complete evacuation of pump fluid.

CONTAINMENT SHELL

TEFZEL ® lining with glass reinforced vinylester backing. Burst pressure greater than 500 psig. Fully confined O-ring seals containment shell to casing. Non-metallic construction provides efficiencies same or better than sealed ANSI pumps; 30% higher efficiencies than metal sealless pumps. Non-metallic construction eliminates magnet losses and heat generation. Heat sensitive liquids are easily pumped.

ENCLOSED ONE-PIECE IMPELLER/MAGNET ASSEMBLY

Enclosed design minimizes axial thrust, extends thrust bearing life. One-piece construction eliminates front shroud failure possible with two-piece impellers. Neodymium iron magnets are molded in place, reducing the chance of permeation.

RADIAL AND THRUST BEARINGS

Carbon radial bearings, carbon-filled Teflon ®, and silicon carbide thrust bearings are standard. Pure sintered silicon carbide thrust and radial bearings are optional for superior corrosion and abrasion resistance. Dryguard™ bearings also optional for dry run system upset conditions.

STATIONARY SHAFT

Silicon carbide construction eliminates shaft deflection. Fully supported stationary design maximizes radial bearing life.

Extreme Ease of Maintenance

DESIGN CONCEPT

The 3298 design concept is simple – few parts and only one bolt size. One-craft maintenance is all that's required – with one wrench! Planned maintenance is fast and easier than other process pumps – sealed or sealless. Standard close-coupled model eliminates need to perform time consuming pump and motor alignment.

SIMPLE OPERATION

Unlike most magnetic drive pumps, the 3298 is as easy to operate as any standard ANSI pump. Non-metallic construction with no heat build-up makes the 3298 ideally suited for tank transfer, tank unloading, or any batch type service.

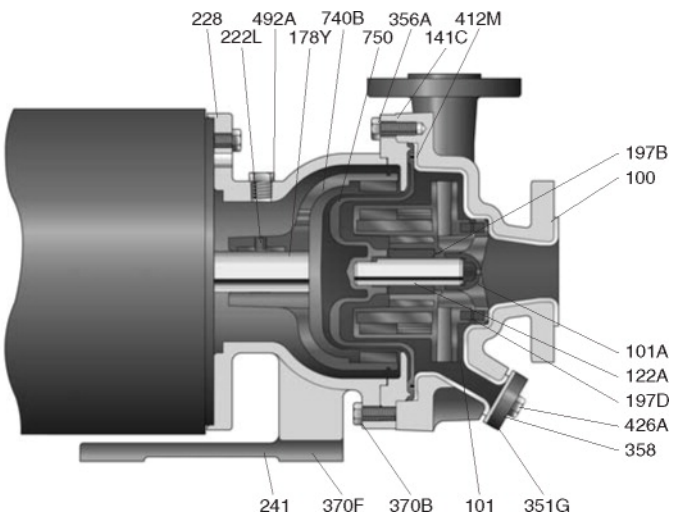
ZERO LEAKAGE

The 3298 is sealless and environmentally safe. No mechanical seal assures zero leakage on moderate to severe corrosives, hazardous liquids. A great solution to pumps with mechanical seal problems.

Parts List and Materials of Construction

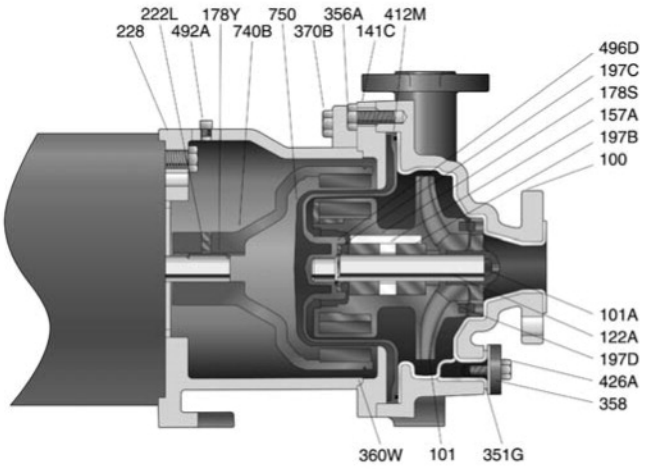
Item Number	Part Name	Material
100	Casing	Ductile Iron/TEFZEL*
101	Impeller Assembly	TEFZEL
101A	Bearing Spider	TEFZEL/Silicon Carbide, Optional - TEFZEL/Dryguard™
109A	Bearing End Cover (Frame-Mounted)	Ductile Iron
112	Ball Bearing (Frame-Mounted)	Steel
113A	Plug–Oil Fill (Frame-Mounted)	Steel
122A	Stationary Shaft	Silicon Carbide, Optional - Dryguard™
122B	Drive Shaft (Frame-Mounted)	Steel
141C	Clamp Ring	Ductile Iron
144A	Rub Ring (M&L Frame-Mounted)	Cast Iron
157A	Bearing Spacer–Radial	TEFLON*
178S	Key, Impeller to Bearings	TEFLON
178Y	Key, Drive Carrier	Steel
197B	Radial Bearing	Standard-Carbon Graphite, Optional–Silicon Carbide or Dryguard™
197C	Bearing, Reverse Thrust	Carbon-Filled TEFLON
197D	Bearing, Impeller Thrust	Standard-Carbon-Filled TEFLON, Optional–Silicon Carbide or Dryguard™
203	Rear Impeller Wear Ring (M and L Group only)	Carbon-Filled TEFLON
222L	Set Screw (Close-Coupled)	Steel
228	Frame	Cast Iron
241	Frame Foot	Cast Iron
314H	Retaining Ring, Impeller/Driven Magnet Assembly	TEFZEL
332A	Labyrinth Seal (Frame-Mounted)	Carbon-Filled TEFLON
333D	Lip Seal (Frame-Mounted)	Buna Rubber
351G	Gasket, Case Drain	Gylon
355A	Hex Nut (Frame-Mounted)	Steel
356A	Hex Cap Screw–Clamp Ring to Case	304 Stainless Steel
358	Flange, Case Drain	Steel
360A	Gasket–Bearing End Cover to Frame (Frame-Mounted)	Varnished Kraft
360W	Gasket–Frame to Clamp Ring	Aramid Fibers with EPDM Rubber
361H	Retaining Ring (L Group Only)	TEFLON Encapsulated Silicon
370B	Hex Cap Screw–Frame to Clamp Ring	304 Stainless Steel
370C	Hex Cap Screw–End Cover to Frame (Frame-Mounted)	304 Stainless Steel
370F	Hex Cap Screw–Frame Foot	304 Stainless Steel
372Y	Hex Cap Screw–Frame To Rub Ring (M & L Group Only)	304 Stainless Steel
412M	O-ring–Containment Shell	Standard-Viton, Optional-EPDM, Optional-Viton Encapsulated in TEFLON
418	Hex Tap Bolt–Jacking (M & L Group Only)	304 Stainless Steel
426A	Hex Cap Screw–Case Drain	304 Stainless Steel
496D	O-ring–Reverse Thrust Bearing	Viton Encapsulated in TEFLON
529	Washer, Wave Spring (L Group Only)	Steel
740A	Driven Magnet Assembly (L Group Only)	TEFZEL Neodymium Iron
740B	Drive Carrier Assembly	Cast Iron/Neodymium Iron
750	Containment Shell	TEFZEL/Fiber Reinforced Vinyl Ester

*Registered trademarks for fluoropolymer resins, films and fibers made by DuPont.

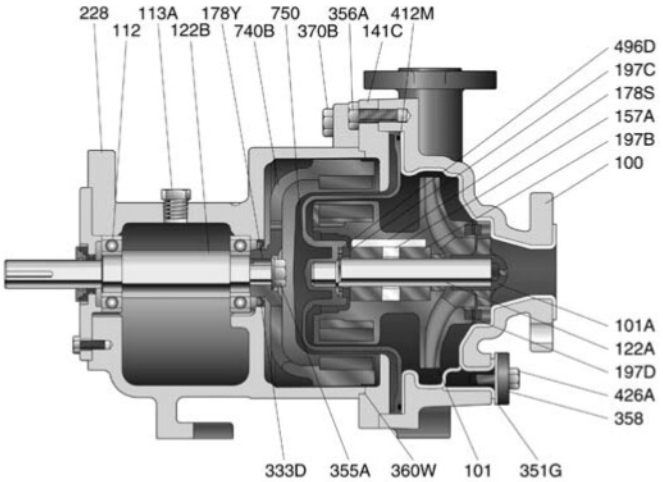


The 3298 S provides additional low flow coverage below the hydraulics of the smallest traditional ANSI pump size. XS pumps meet user requirements for low flow capabilities. Applying an oversized ANSI pump is not required.

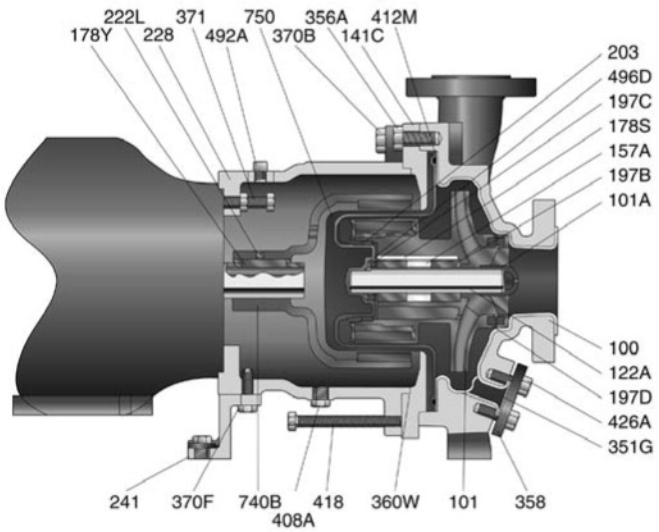
- Capacities to 120 GPM (27 m^3/h)
- Heads to 160 feet (49 m)
- Temperatures to 250° F (121° C)
- Pressures to 150 PSIG (1,034 kPa)



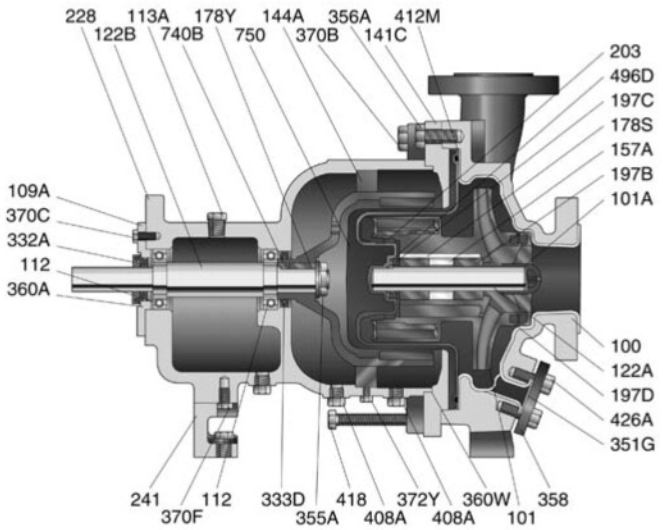
3298 S Close-Coupled



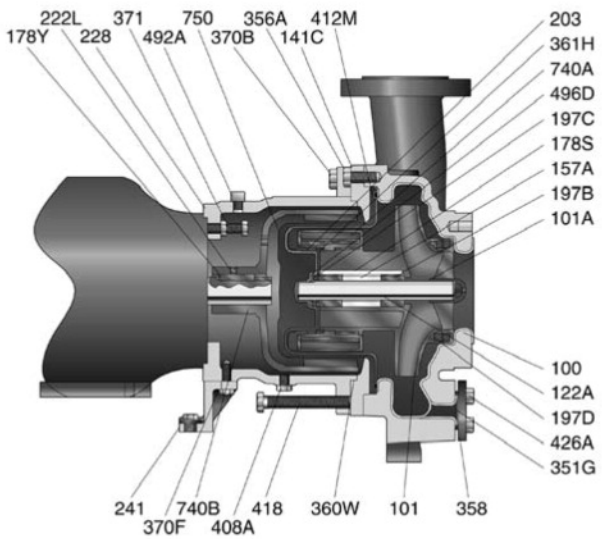
3298 S Frame-Mounted



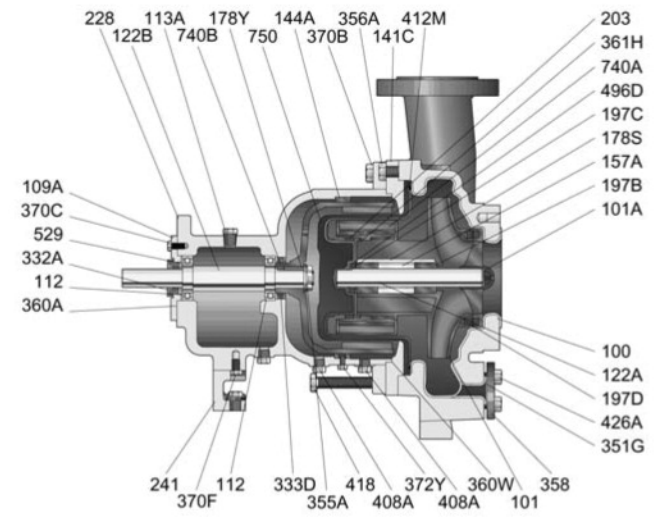
3298 M Close-Coupled



3298 M Frame-Mounted

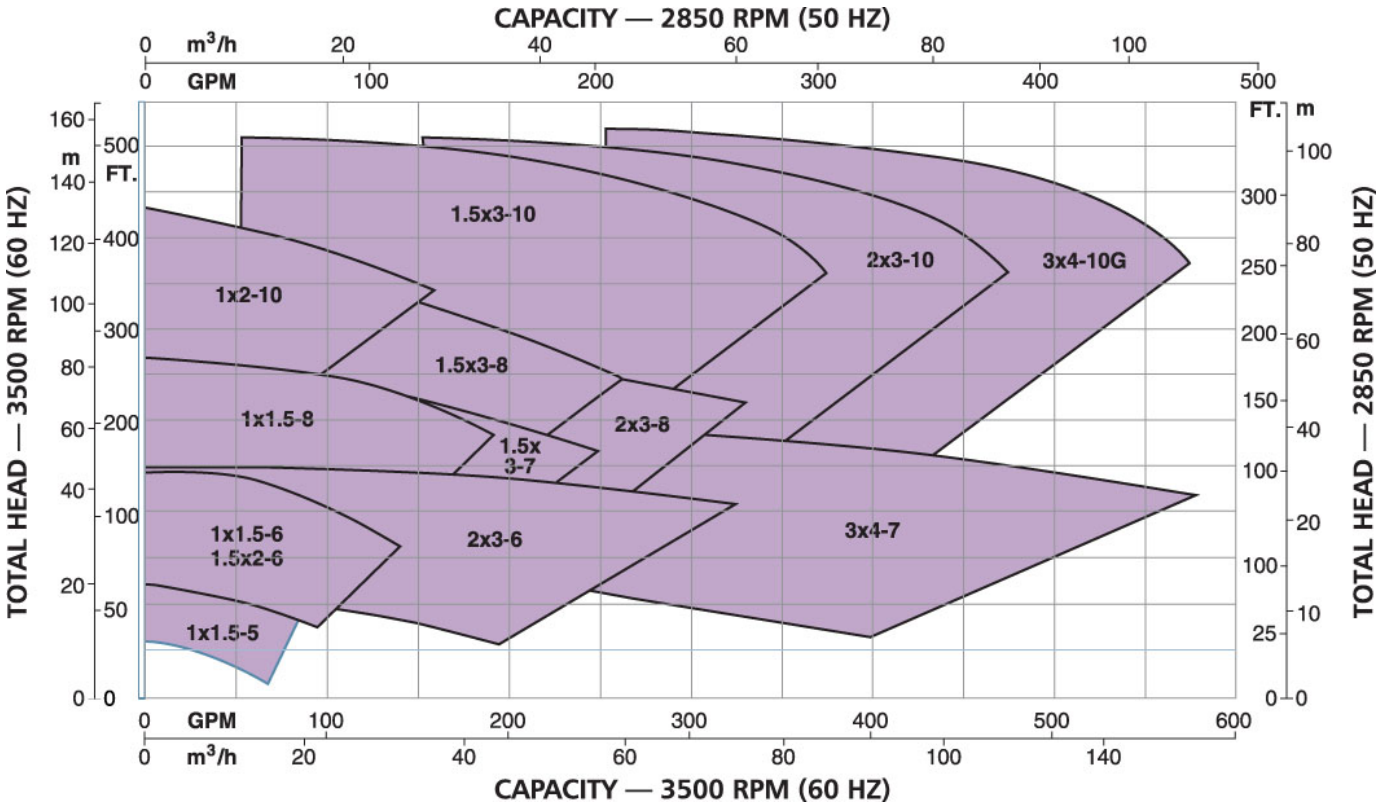


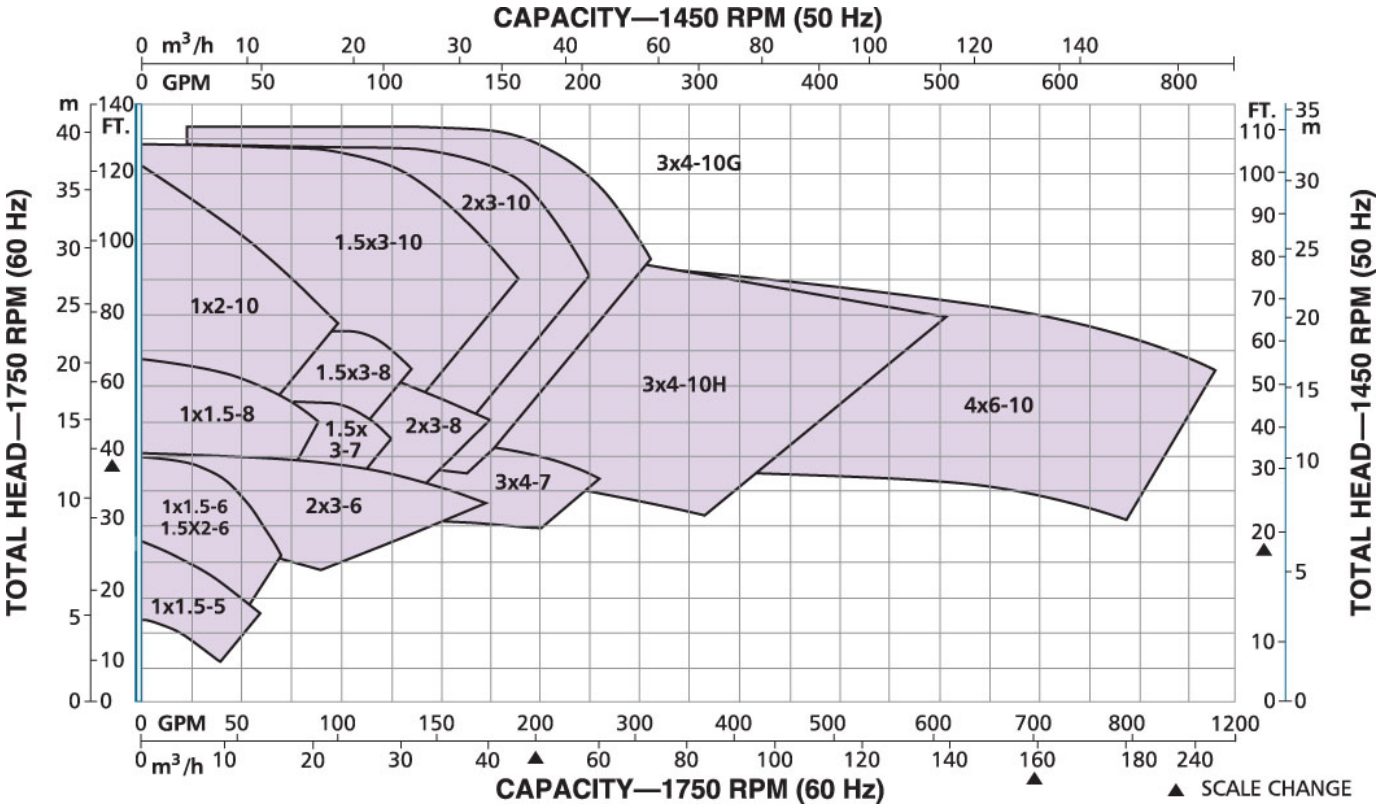
3298 L Close-Coupled



3298 L Frame-Mounted

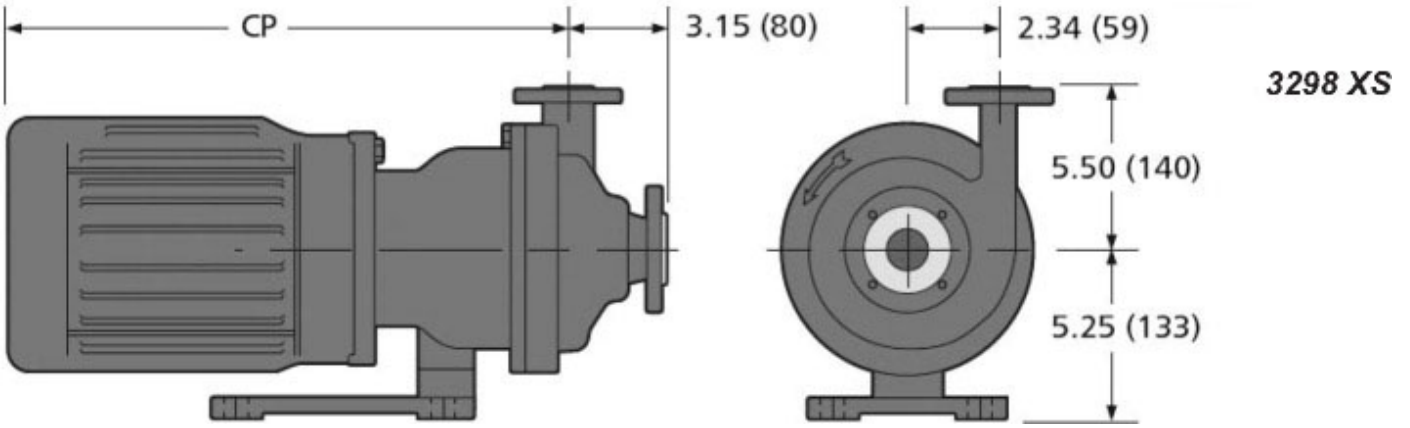
Hydraulic Coverage Model 3298





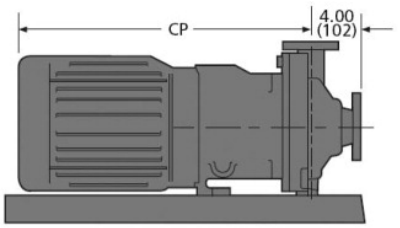
Dimensions Model 3298

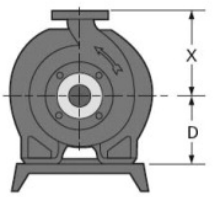
All dimensions in inches and (mm). Not to be used for construction.



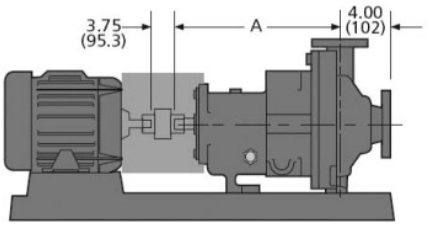
DIMENSIONS (1 X 1½ - 5)

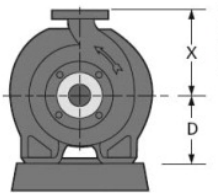
Group	Size	Motor Frame	CP Approx.	Motor Weight lb (kg)	Pump Weight lb (kg)	Y	Z
XS	1 × 1.5 -5	56C	16.9 (429)	45 (21)	46 (21)	3.15 (80)	2.34 (59)
		143-145TC	18.9 (480)	65 (30)			
		182-184TC	19.9 (505)	105 (48)			
	1.5 × 2 - 6	56C	16.6 (422)	45 (21)	60 (27)	3.41 (87)	2.56 (65)
		143-145TC	18.6 (472)	65 (30)			
		182-184TC	19.6 (498)	105 (48)			
		213-215TC	25.0 (635)	150 (68)			





3298 Close-Coupled Design





3298 Frame-Mounted Design

CLOSE-COUPLED

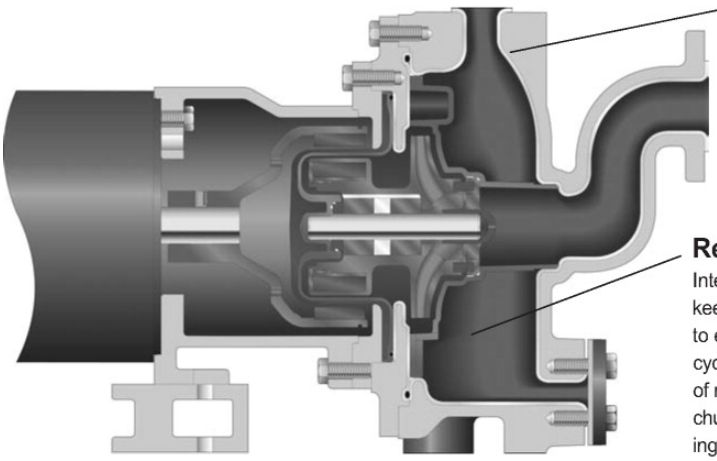
Motor Frame	Group	CP (Approx.)
143TC	S	19 (483)
	M	NA
	L	
145TC	S	18 (457)
	M	NA
	L	
182TC/184TC	S	22.1 (562)
	M	25 (635)
	L	NA
213TC/215TC	S	25.6 (651)
	M	28.5 (724)
	L	
254TC/256TC	S	30.1 (765)
	M	33 (838)
	L	
284TSC/256TSC	S	NA
	M	37 (940)
	L	
324TSC/326TSC	S	NA
	M	40 (1016)
	L	
364TSC	S	NA
	M	42.5 (1080)
	L	

BARE PUMP DIMENSIONS

Group	Size	A	D	X	Close-Coupled	Frame Mounted
S	1 × 1.5 - 6	13.50 (34.3)	5.25 (133)	6.50 (165)	68 (31 kg)	97 (44 kg)
	2 × 3 - 6				79 (36 kg)	108 (49 kg)
	1 × 1.5 - 8				84 (38 kg)	113 (52 kg)
	1.5 × 3 - 7				89 (41 kg)	118 (54 kg)
M	1 × 2 - 10	19.50 (495)	8.25 (210)	8.47 (215)	170 (78 kg)	190 (87 kg)
	1.5 × 3 - 8			8.47 (215)	176 (80 kg)	194 (88 kg)
	2 × 3 - 8			9.47 (241)	178 (81 kg)	196 (90 kg)
	3 × 4 - 7			10.97 (279)	193 (89 kg)	214 (98 kg)
L	1.5 × 3 - 10	19.50 (495)	8.25 (210)	8.47 (215)	180 (82 kg)	203 (92 kg)
	2 × 3 - 10			9.47 (241)	184 (84 kg)	207 (94 kg)
	3 × 4 - 10G			10.97 (279)	198 (91 kg)	221 (102 kg)
	3 × 4 - 10H		10.00 (254)	12.47 (317)	198 (91 kg)	221 (102 kg)
	4 × 6 - 10			13.47 (342)	223 (103 kg)	249 (115 kg)

Model SP 3298 for Self-Priming Applications

When suction lift conditions exist, air must be evacuated to effectively prime the pump.This air or vapor must be expelled each time the pump is started. The Goulds design incorporates a highly reliable one-piece casing without the use of an internal check valve or external gooseneck.



Optimally-sized Casing
Retains enough liquid to prime but not too much to increase fluid temperature during priming. Temperature rise is half of the competition.

Retained Liquid
Integrated suction gooseneck keeps all bearings fully submerged to ensure lubrication during priming cycles. By minimizing the amount of retained liquid, there is less churning of the liquid during priming, thus, minimizing temperature rise during priming.

Design Features for Superior Self-Priming Performance

One-Piece Casing without Check Valve
Provides reliable priming in all conditions. Eliminates the additional gooseneck component found on other brands. Retains proper amount of liquid in casing to prime without the use of a troublesome check valve. Check valves are commonly used to retain liquid in the casing to assist in priming on successive uses. However, these check valves wear quickly and contribute additional losses on the suction side due to induced drag. Goulds has eliminated the check valve and the SP 3298 out performs our competition in priming times.

The Volute Insert
Completes the self-priming design. The volute separates the air from the liquid, expels the air through the discharge, and returns the liquid to the suction until all the air is removed and the pump is operating like a standard centrifugal pump.

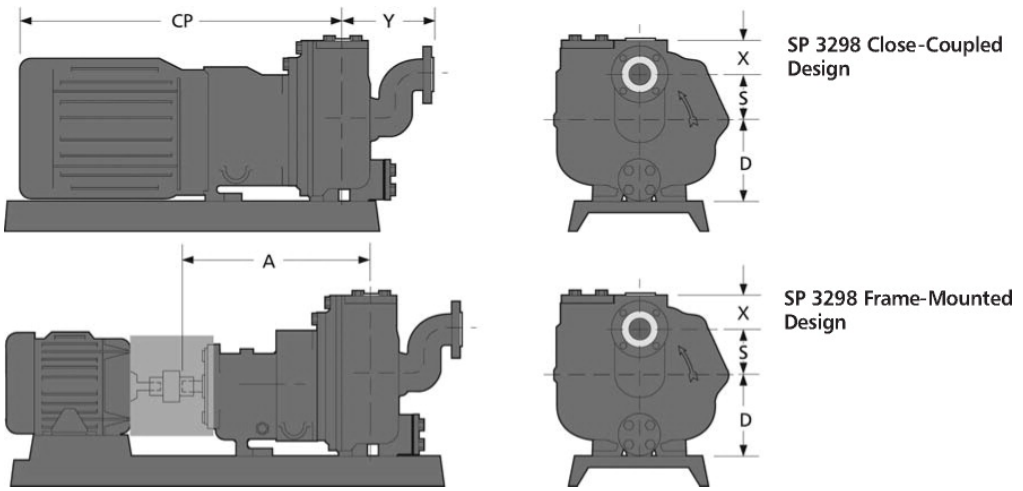
For Ease of Maintenance

Parts Interchangeability

All components fully interchangeable with 3298 and V 3298, except the casing, volute insert, and backplate. Reduces spare parts inventory requirements.

Dimensions Model SP 3298

All dimensions in inches and (mm). Not to be used for construction.



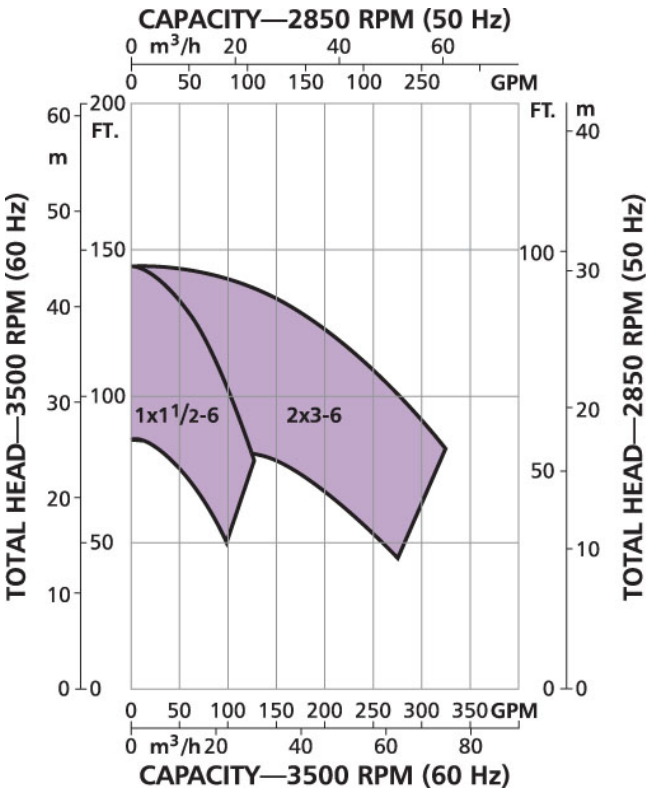
Bare Pump Dimensions

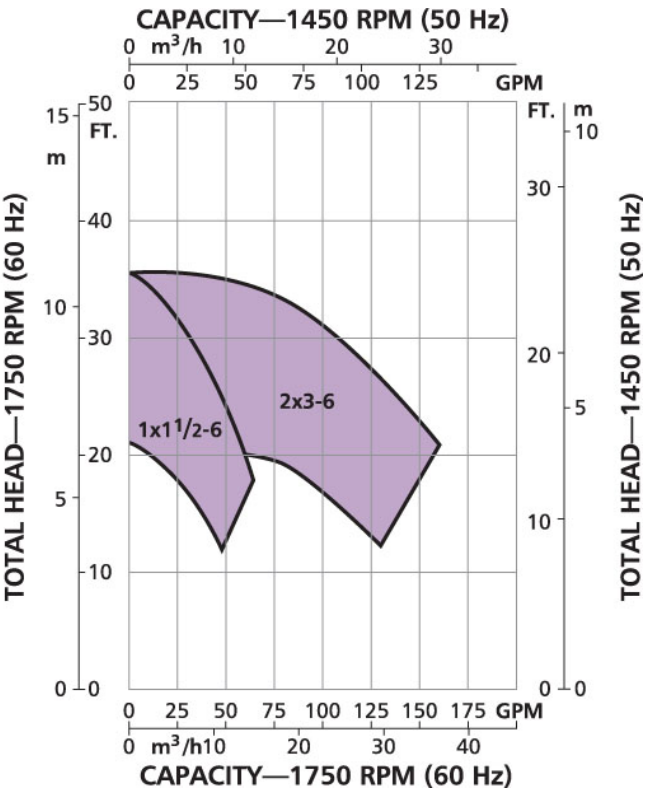
Size	A	D	S	X	Y	Close-Coupled	Frame-Mounted
1 × 11/2-6	15.5 (393.7)	11.5 (292.1)	4.0 (101.6)	7.25 (184.2)	7.5 (190.5)	160 lbs. (72.7 kg.)	175 lbs. (79.5 kg.)
2 × 3-6	15.5 (393.7)	13.5 (342.9)	6.0 (152.4)	10.75 (273.1)	12.12 (307.8)	198 lbs. (90 kg.)	213 lbs. (96.8 kg.)

Close-Coupled

Motor Frame	CP (Approx.)
143TC	21 (533)
145TC	20 (508)
182TC/184TC	24 (610)
213TC/215TC	27.63 (702)
254TC/256TC	32.12 (816)
284TSC/286TSC	32.12 (816)

Hydraulic Coverage Model SP 3298





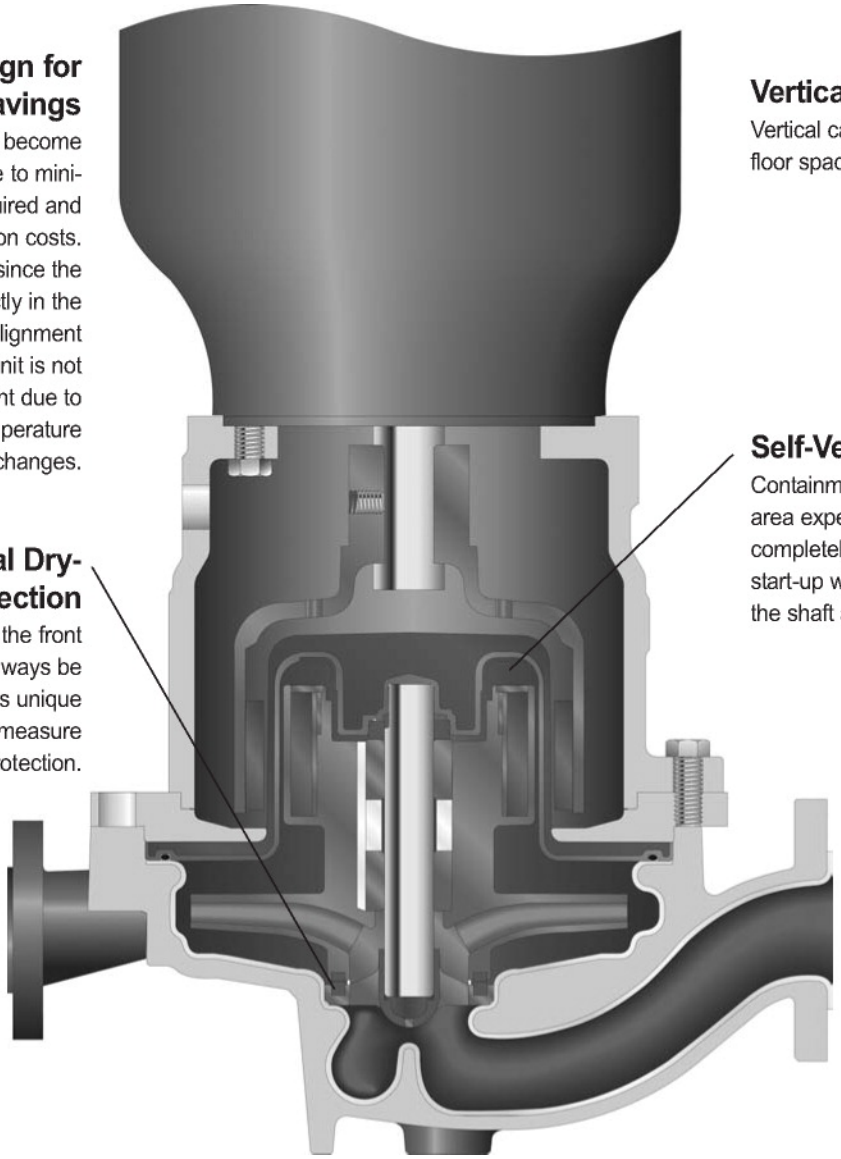
Model V 3298 In-Line Design for Cost Savings

In-Line Design for Cost Savings

In-line pumps have become increasingly popular due to minimal floor space required and reduced installation costs. Installation is simple since the unit is mounted directly in the line, like a valve. Field alignment is not required and the unit is not subject to misalignment due to pipe strain or temperature changes.

Additional Dry-Run Protection

With the vertical design, the front thrust bearing will always be submerged in liquid. This unique feature adds an extra measure of dry run protection.



Vertical Configuration

Vertical casing frees up additional floor space required for pump.

Self-Venting Design

Containment shell and magnet area expel all trapped air/gases completely and efficiently during start-up without adversely affecting the shaft and bearings.

Drain Connection

Allows complete draining of fluid from pump for system maintenance. Blind flange and gasket ensure leak-free seal for safety.

Casing Support

Optional casing supports provide rigid pump support when a pipe hung pump is not an option.

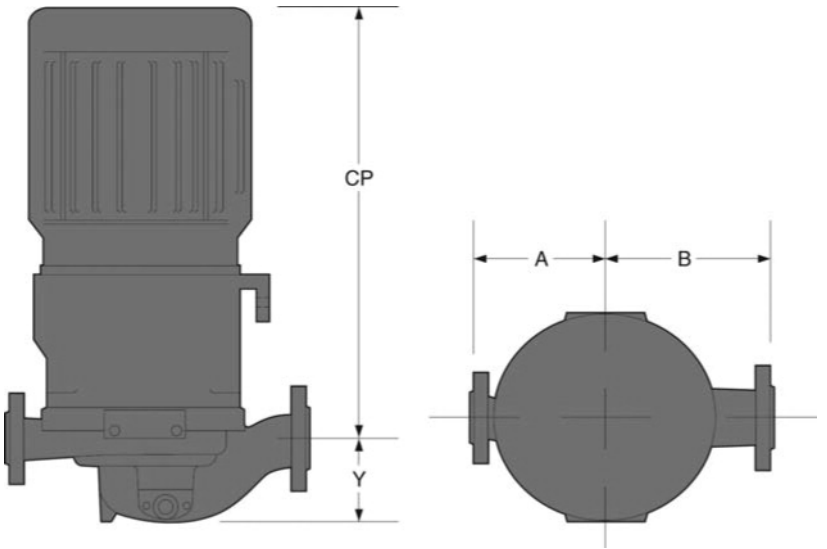
Parts Interchangeability

All components fully interchangeable with 3298 and SP3298, except the casing.

Reduces spare parts inventory requirements.

Dimensions Model V 3298

All dimensions in inches and (mm). Not to be used for construction.

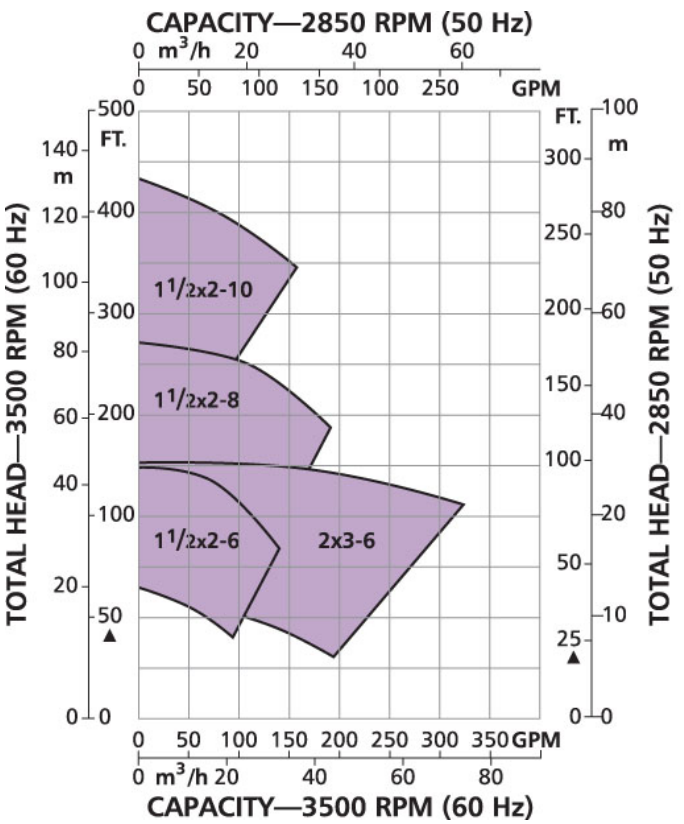


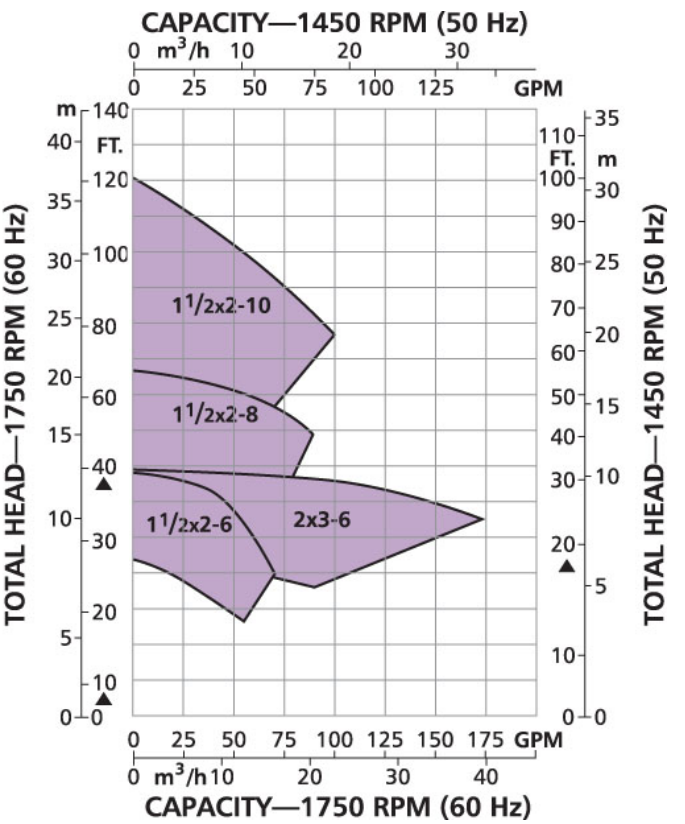
Group	Size	Y	A	B	Weight
	1½ × 2-6	4.50 (114.3)	8.12 (206.2	6.62 (168.1)	79 lbs (35.9 kg)
S	1½ × 2-8	5.06 (128.5)	8.88 (225.6)	7.88 (200.2)	91 lbs (41.4 kg)
	2 × 3-6	4.88 (124)	9.39 (238.5)	7.39 (187.7)	100 lbs (45.5 kg)
M	1½ × 2-10	5.12 (130)	9.69 (246.1)	9.19 (233.4)	188 lbs (85.5 kg)

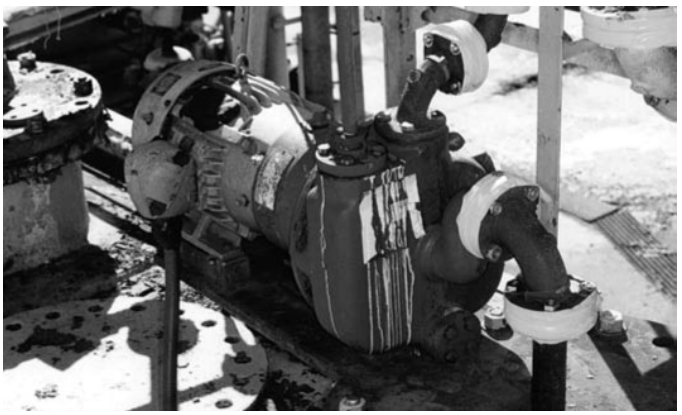
Close-Coupled

Motor Frame	Group	CP (Approx.)
143TC	S	19.00 (463)
145TC	S	18.00 (457)
182TC/184TC	S	22.12 (562)
	M	25.03 (636)
213TC/215TC	S	25.62 (651)
	M	28.53 (725)
254TC/256TC	S	30.12 (765)
	M	33.03 (839)
284TSC-286TSC	M	36.78 (934)
324TSC-326TSC	M	40.00 (1016)

Hydraulic Coverage Model SP 3298

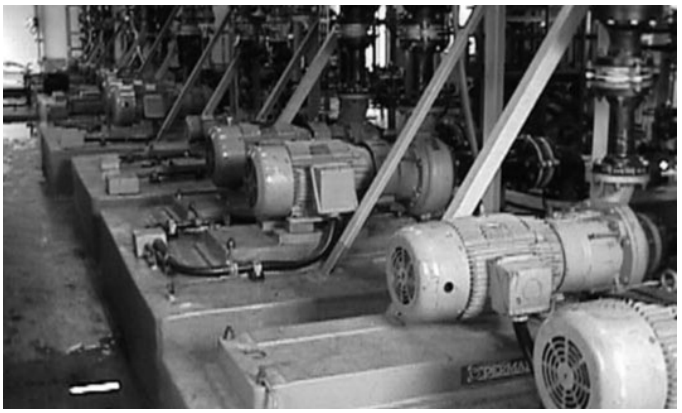




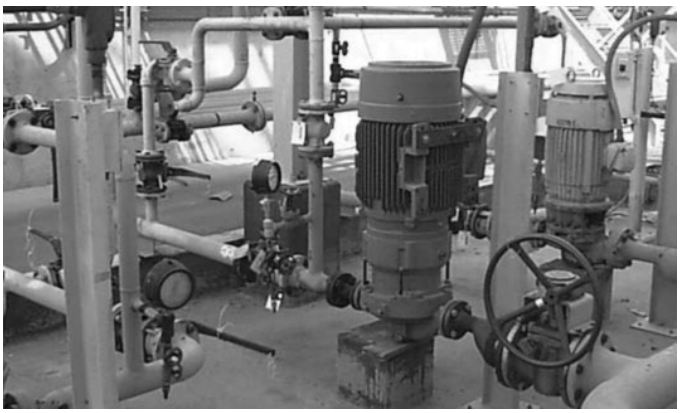


Close-coupled SP 3298 in Sulfuric Acid (H_2SO_4) service at a southeastern US papermill. SP 3298 replaced a conventional self-priming pump that had corroded to the point of requiring a casing replacement. The yellow tape is leak detecting tape for safety.

Close-coupled 3298 replaced a standard horizontal ANSI pump at an upstate New York chemical plant that was consistently leaking through the mechanical seal due to corrosion. The pump has been operating for several years, since its initial installation, without failure.



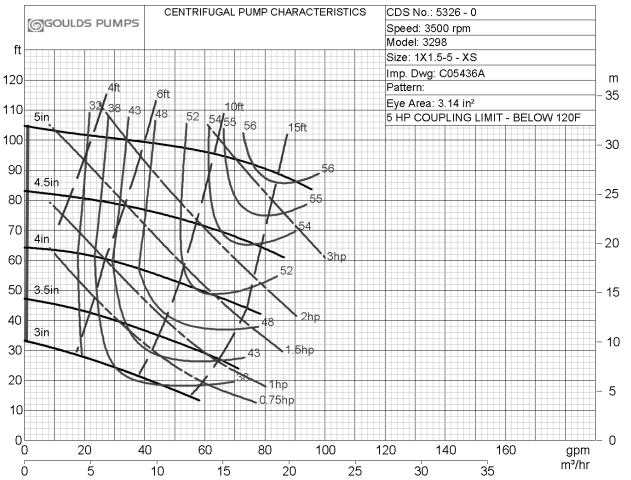
A bank of 3298's installed in a Korean steel mill in pickling services. The 3298 is ideally suited for pickling services using various acids. Goulds has installations in pickling services worldwide including Korea, France and various US locations.



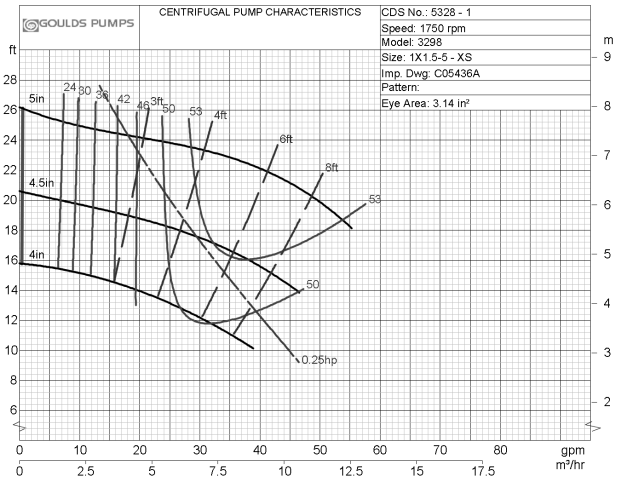
This V 3298 replaced a standard ANSI in-line sealed pump. The V 3298 was installed to eliminate the mechanical seal. It is used to transfer and load chloroform at a large Midwest chemical plant. Chloroform is a regulated liquid and all mechanical seals in chloroform service must be leak checked. The pump has been operating without a failure since its installation.

NOTES

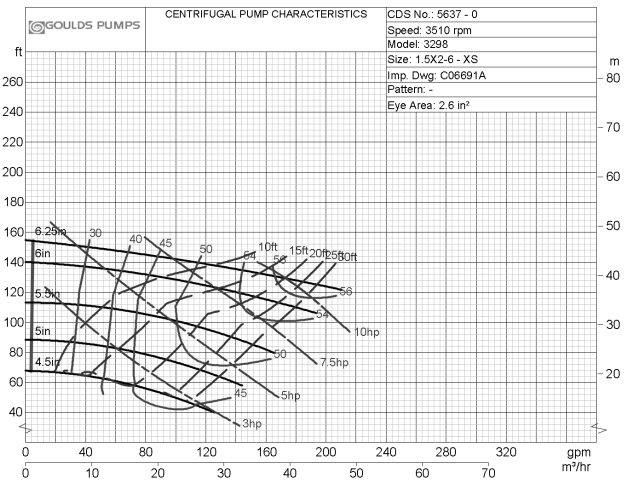
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



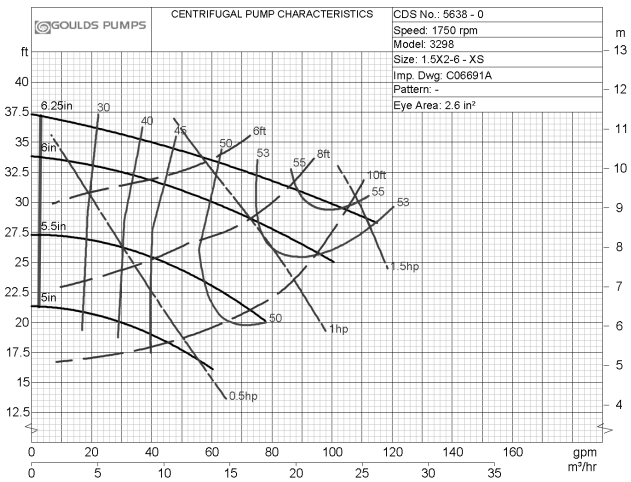
1X1.5-5 **3500rpm**



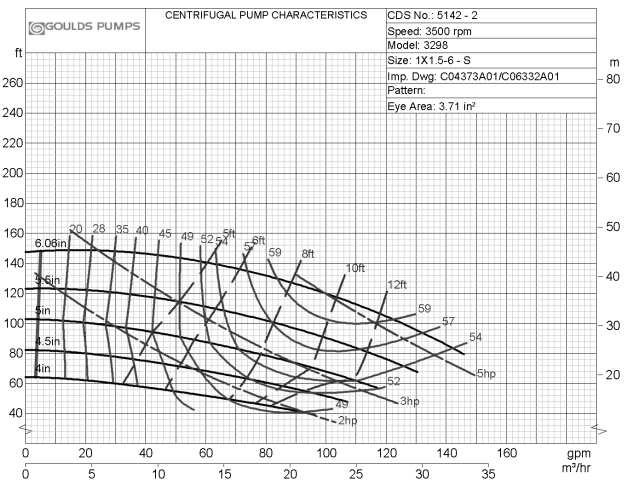
1X1.5-5 **1750rpm**



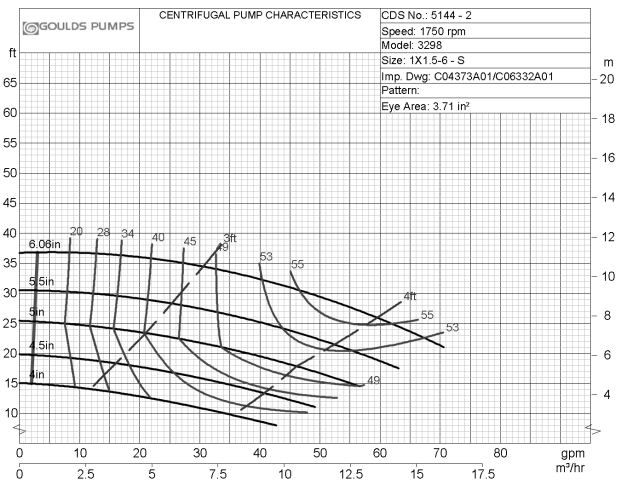
1.5X2-6 **3510rpm**



1.5X2-6 **1750rpm**



1X1.5-6 **3500rpm**



1X1.5-6 **1750rpm**

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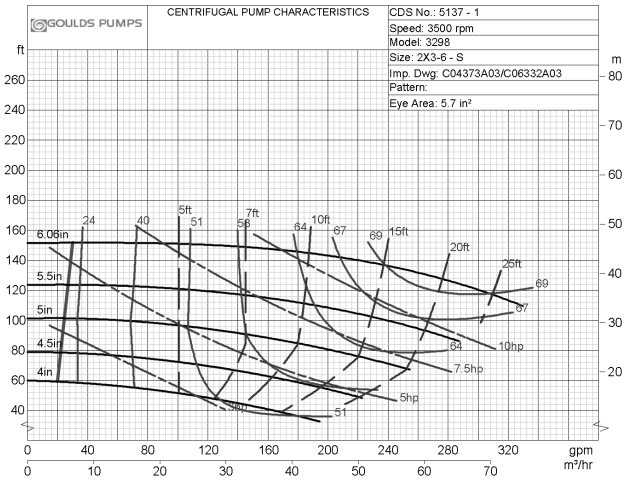
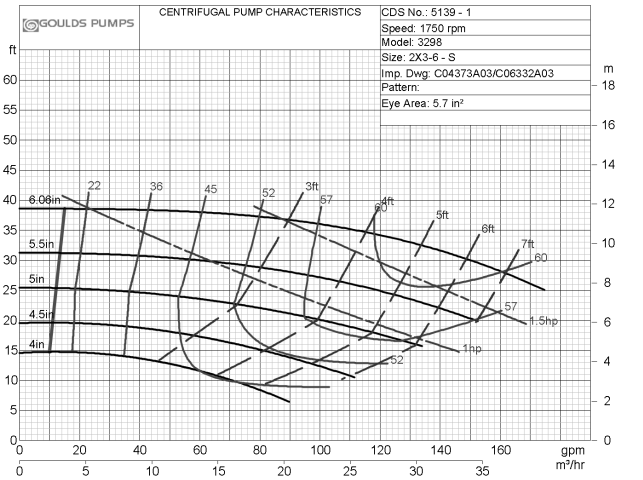
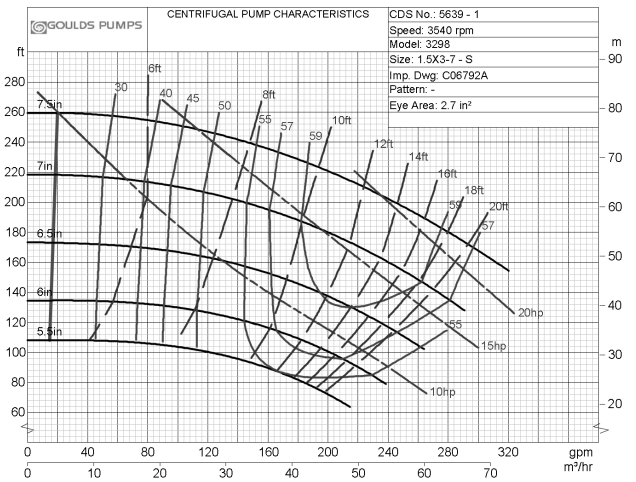


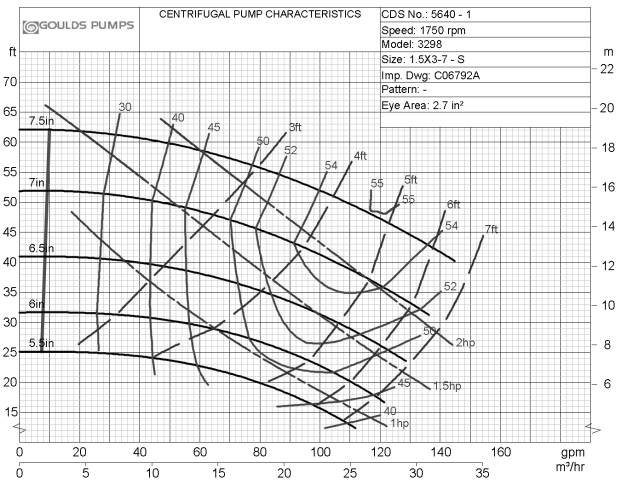
2X3-6 **3500rpm**



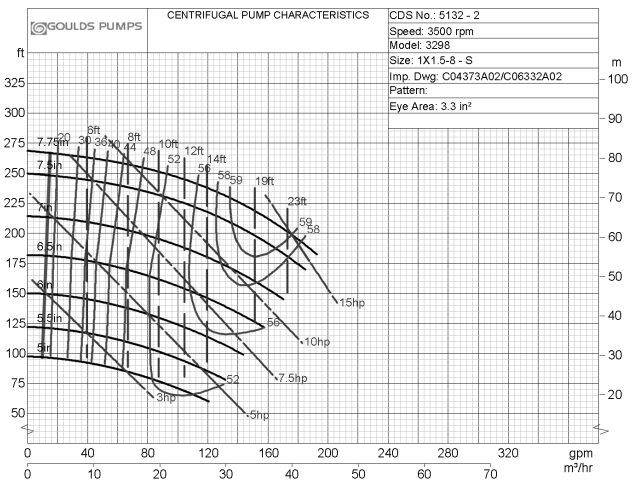
2X3-6 **1750rpm**



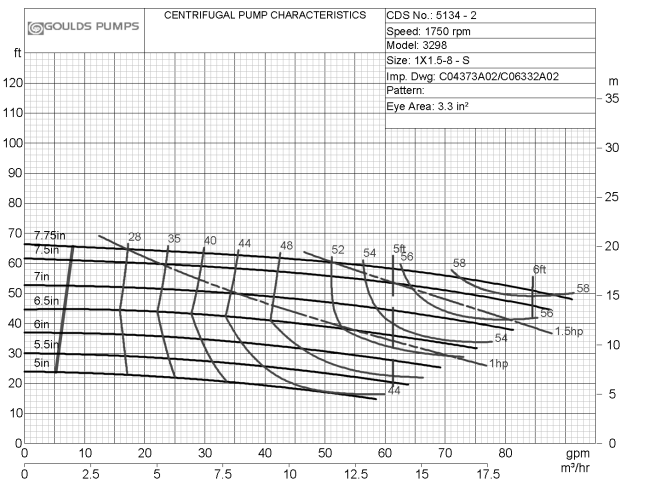
1.5X3-7 **3540rpm**



1.5X3-7 **1750rpm**

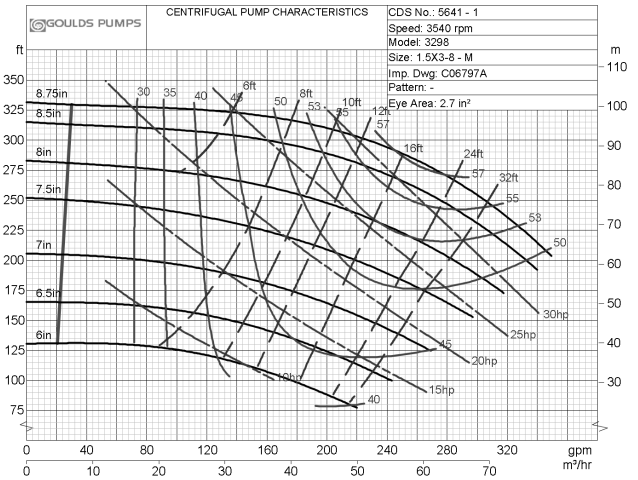


1X1.5-8 **3500rpm**

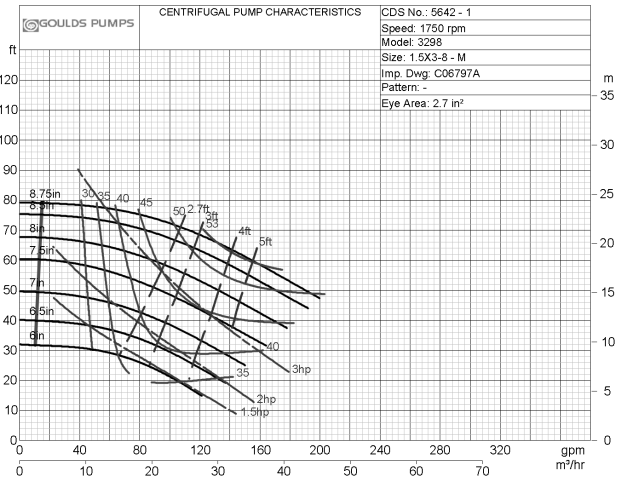


1X1.5-8 **1750rpm**

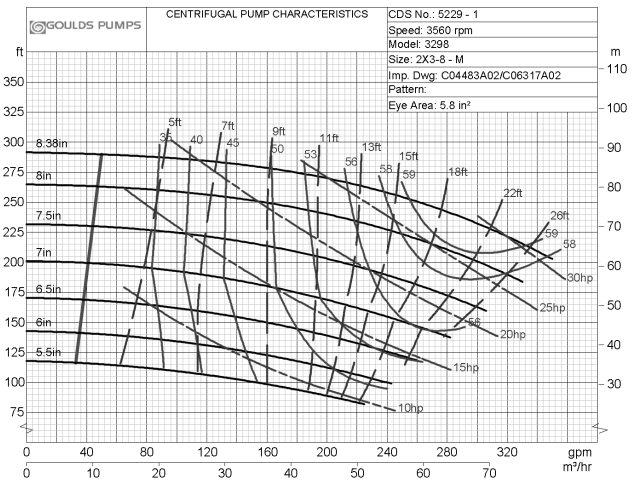
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



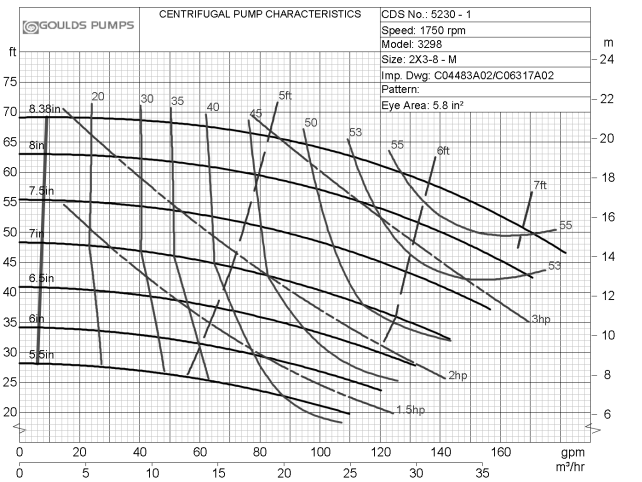
1.5X3-8 **3540rpm**



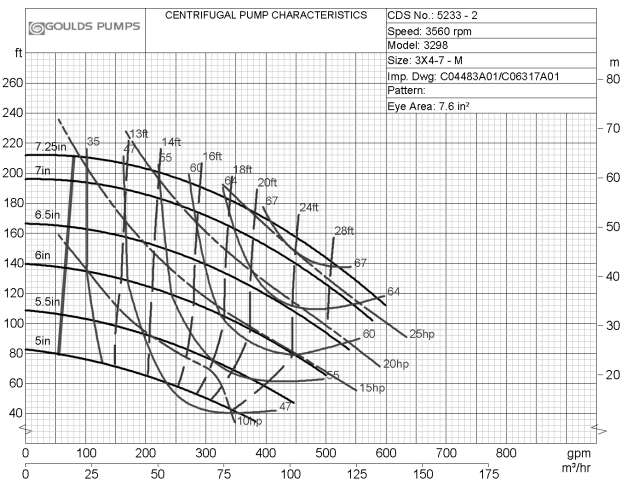
1.5X3-8 **1750rpm**



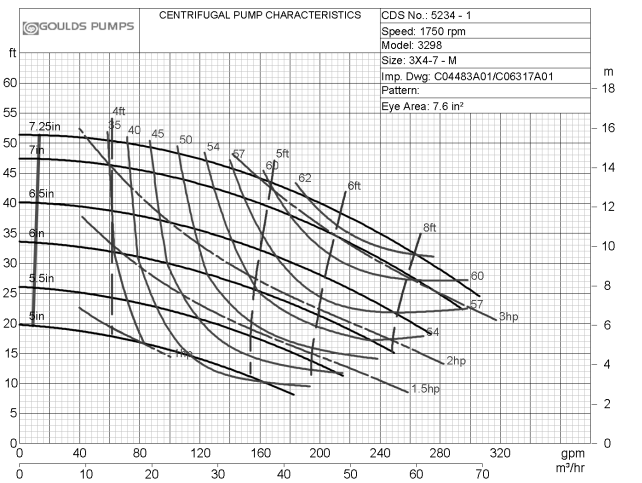
2X3-8 **3560rpm**



2X3-8 **1750rpm**

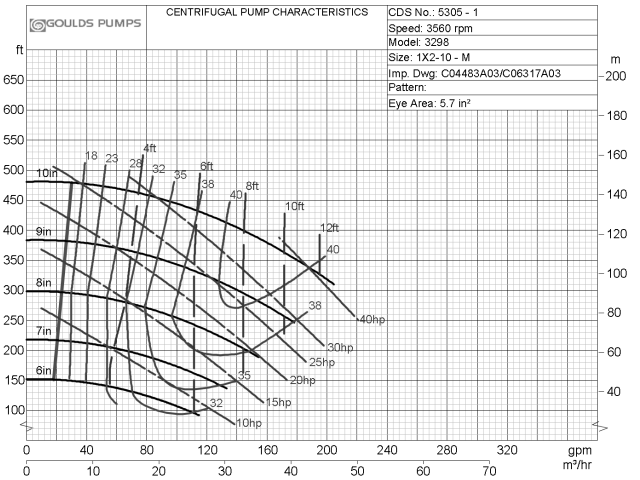


3X4-7 **3560rpm**

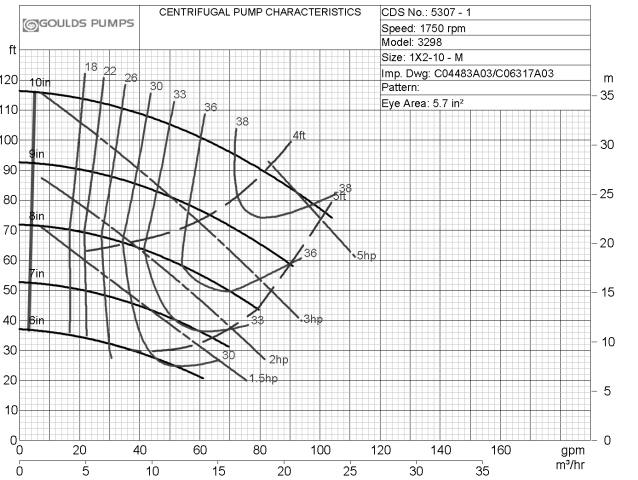


3X4-7 **1750rpm**

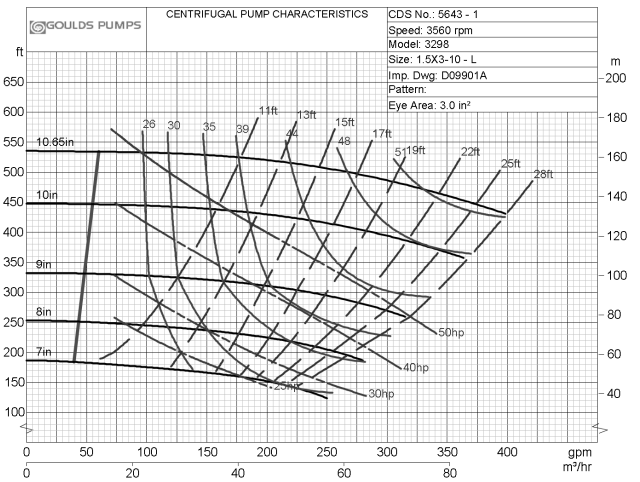
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



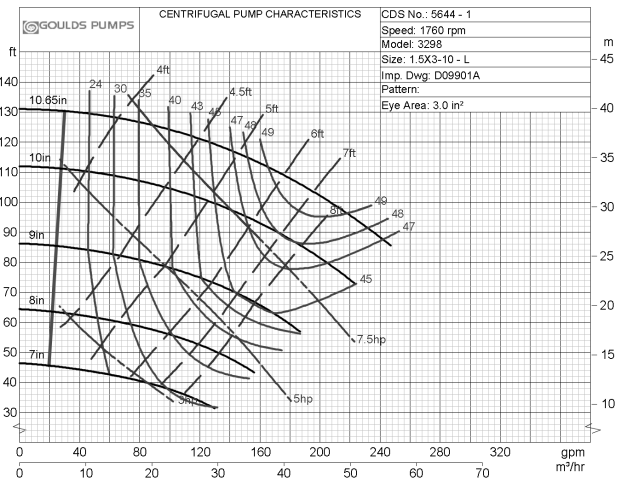
1X2-10 **3560rpm**



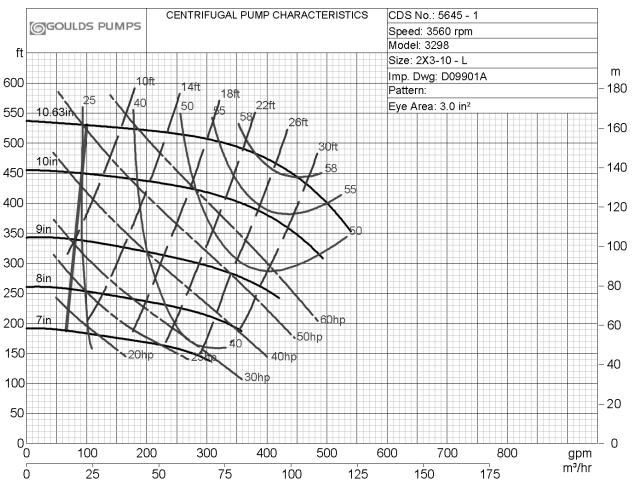
1X2-10 **1750rpm**



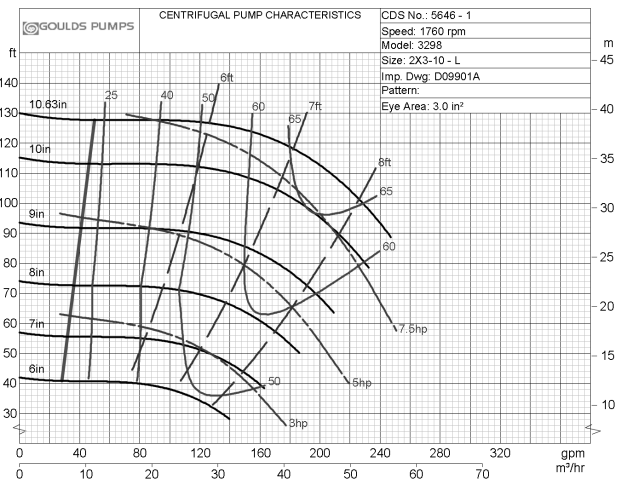
1.5X3-10 **3560rpm**



1.5X3-10 **1760rpm**

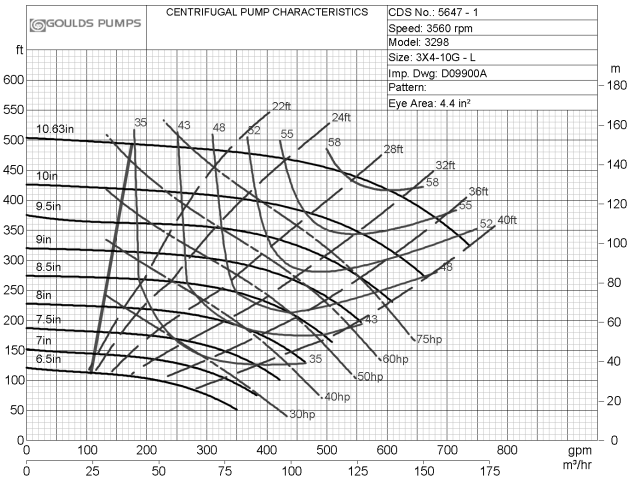


2X3-10 **3560rpm**

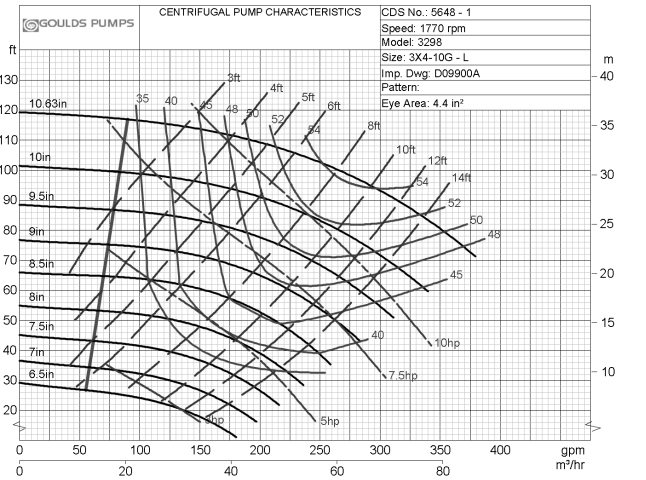


2X3-10 **1760rpm**

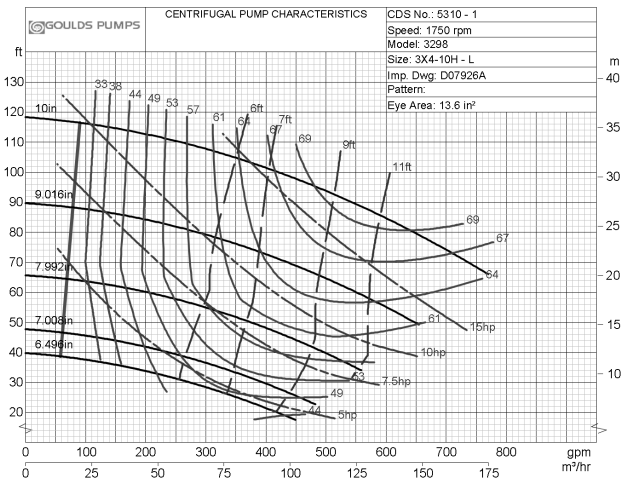
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



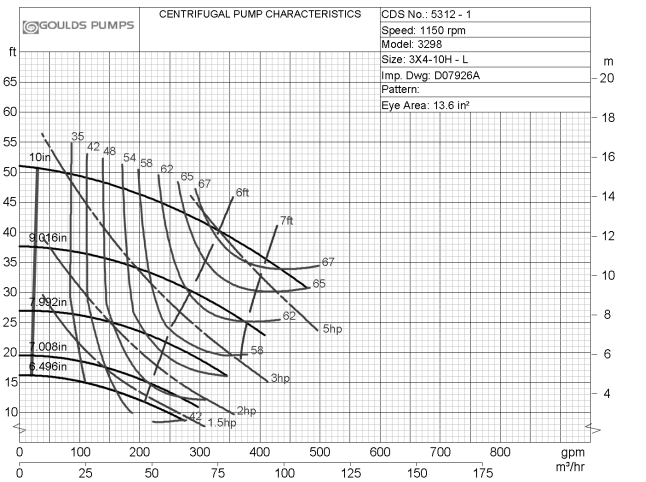
3X4-10G **3560rpm**



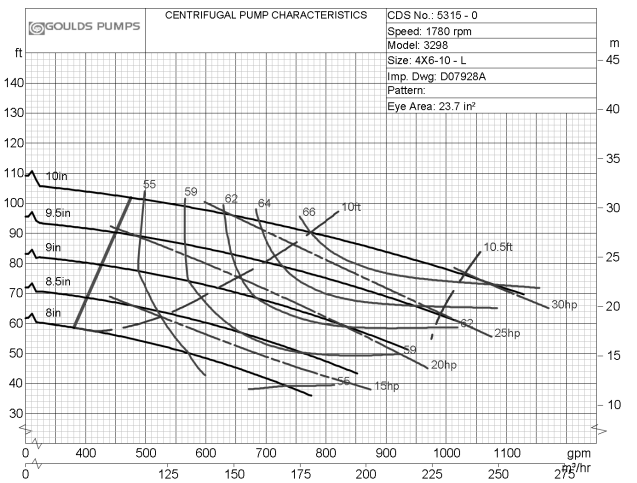
3X4-10G **1770rpm**



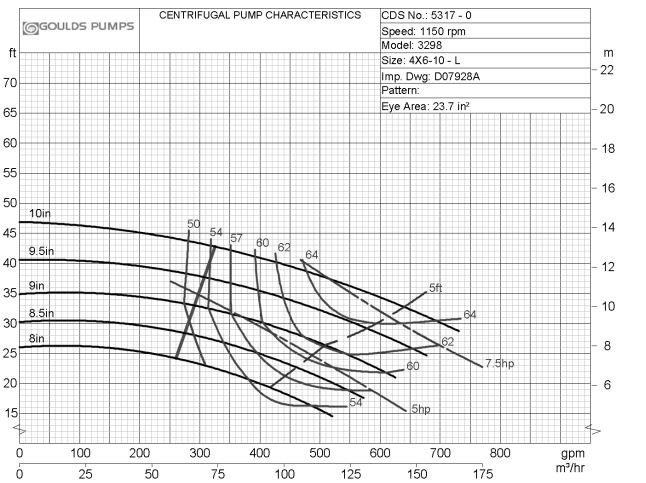
3X4-10H **1750rpm**



3X4-10H **1150rpm**



4X6-10 **1780rpm**



4X6-10 **1150rpm**

NOTES

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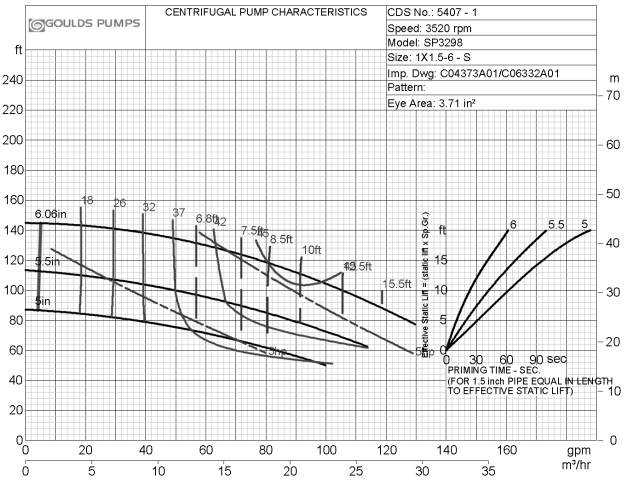
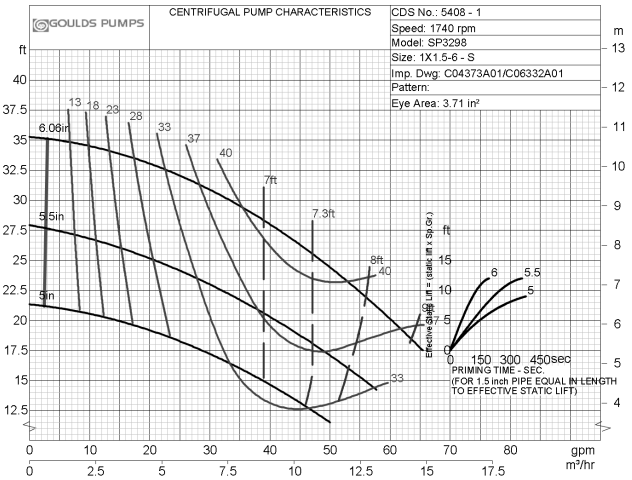
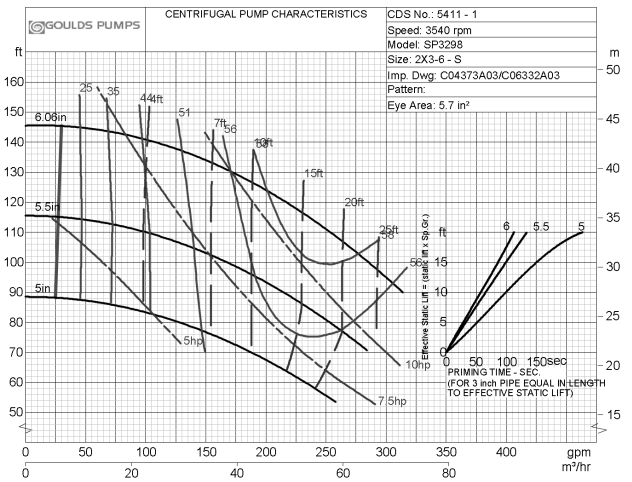


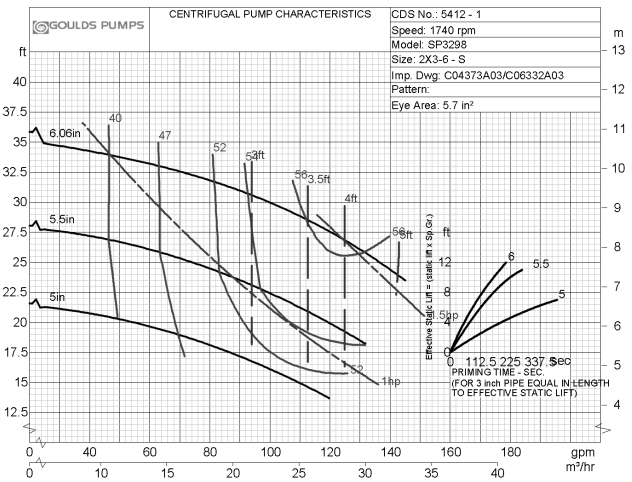
1X1.5-6 **3520rpm**



1X1.5-6 **1740rpm**



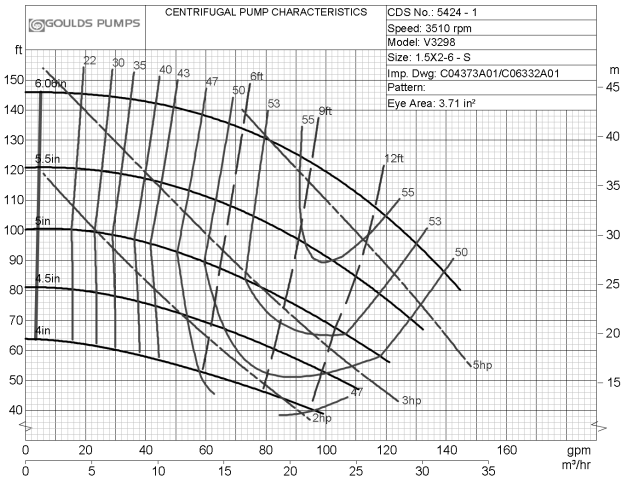
2X3-6 **3540rpm**



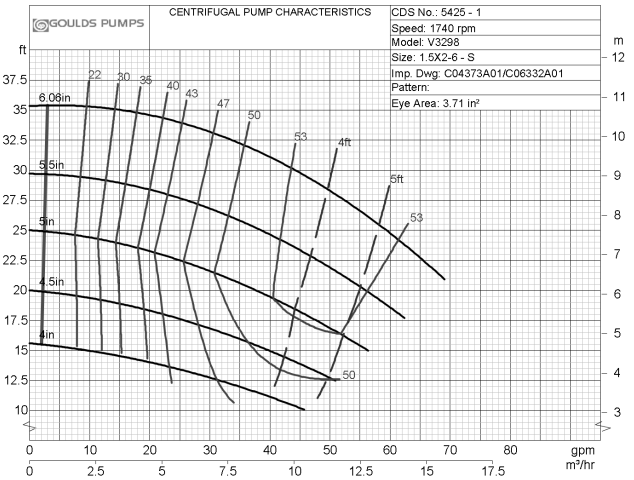
2X3-6 **1740rpm**

NOTES

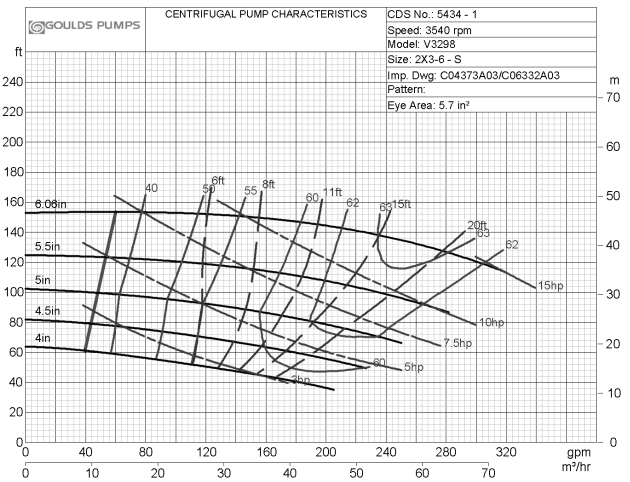
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



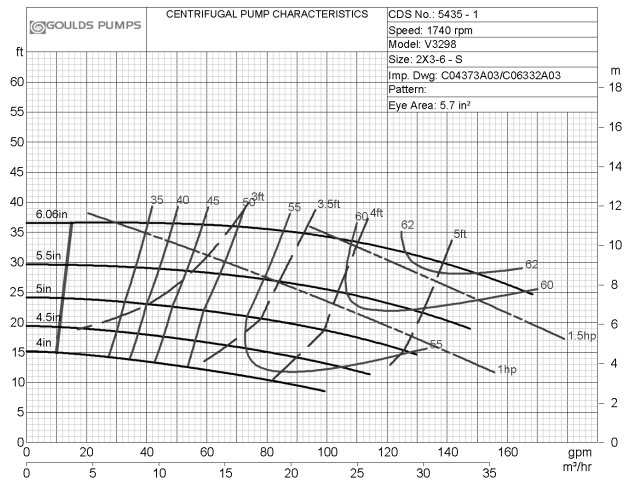
1.5X2-6 **3510rpm**



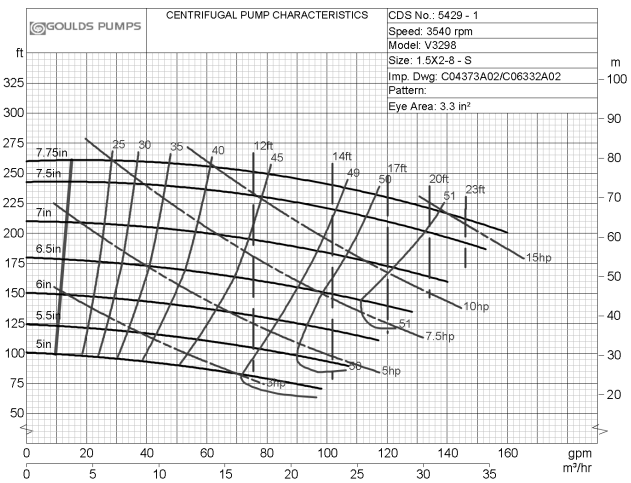
1.5X2-6 **1740rpm**



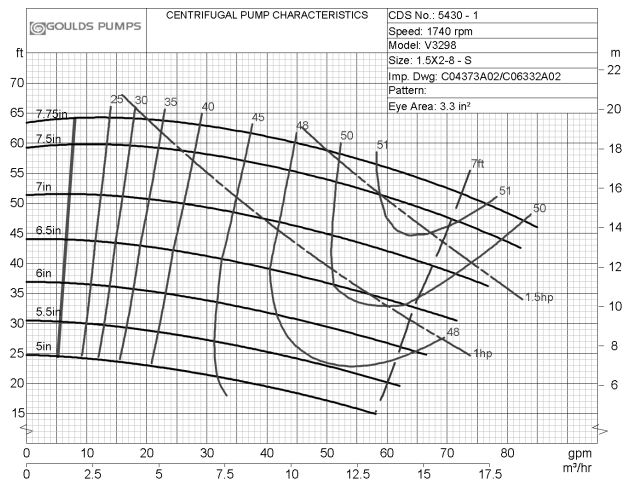
2X3-6 **3540rpm**



2X3-6 **1740rpm**



1.5X2-8 **3540rpm**

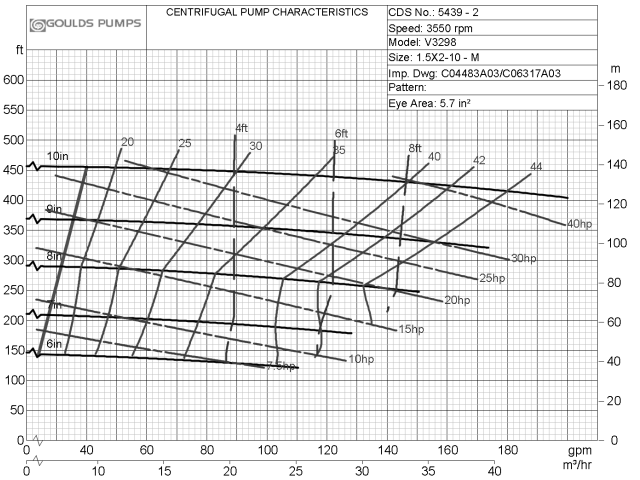


1.5X2-8 **1740rpm**

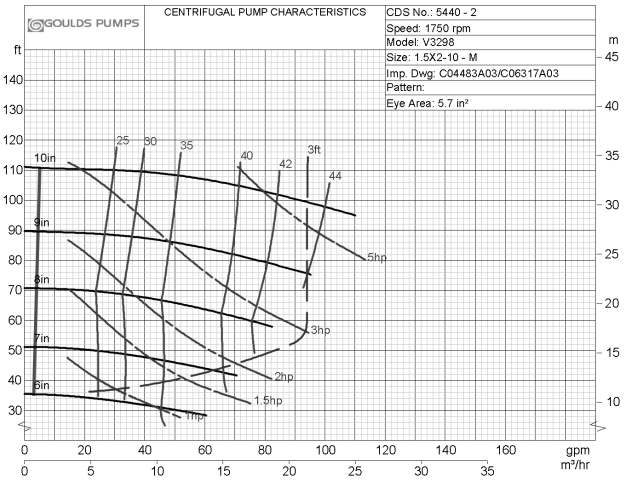
60Hz Curves

Model V3298

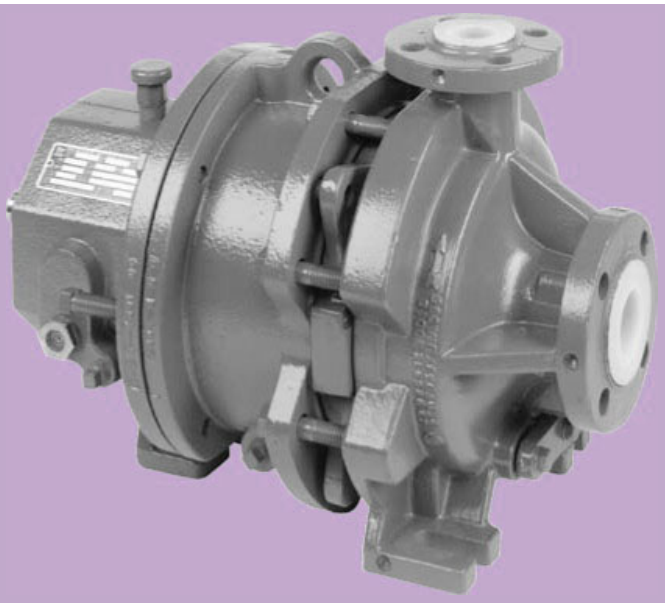
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



1.5X2-10 **3550rpm**



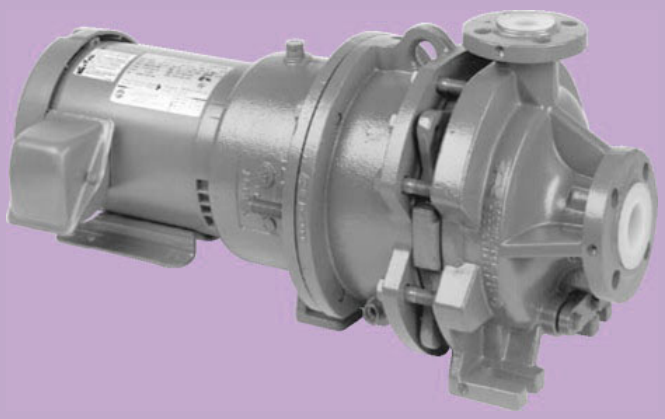
1.5X2-10 **1750rpm**



Frame-Mounted

The 3299 is designed specifically to handle corrosives that require the universal corrosion resistance of Virgin PFA. As a sealless design, it's an effective alternative to pumps with mechanical seal problems. Meets strictest EPA regulations.

The standard frame-mounted configuration provides rugged dependable service for the most severe applications.



Close-Coupled

Teflon® and Kalrez™ are trademarks of E.I. DuPont.

Goulds Model 3299

Heavy Duty Lined Pumps for Chemical Services

- Capacities to 425 GPM (95 m^3/h)
- Heads to 490 feet (149 m)
- Temperatures to 360°F (180°C)
- Pressures to 275 PSIG (1,896 kPa)

Performance Features for Chemical Services

Extended Pump Life

- Virgin PFA Construction
- Sealless Design
- PFA Lined Solid 316 Stainless Steel Shaft
- Dryguard™ Bearings

Optimum Performance

- Non-slip Synchronous Drive with Neodymium Iron Boron Outer Magnets and Samarium Cobalt Inner Magnets
- Optional Samarium Cobalt Outer Magnets
- Efficiency Equivalent to Sealed ANSI Pumps, 30% Higher than Metal Sealless Pumps

Ease of Maintenance

- Minimum Parts
- ANSI Dimensional
- Optional Close-Coupled Design
- No Mechanical Seal

Safety

- Drive Magnet Assembly Bump Ring
- Adapter Drain Connection
- Optional Casing Drain
- Zero Emissions

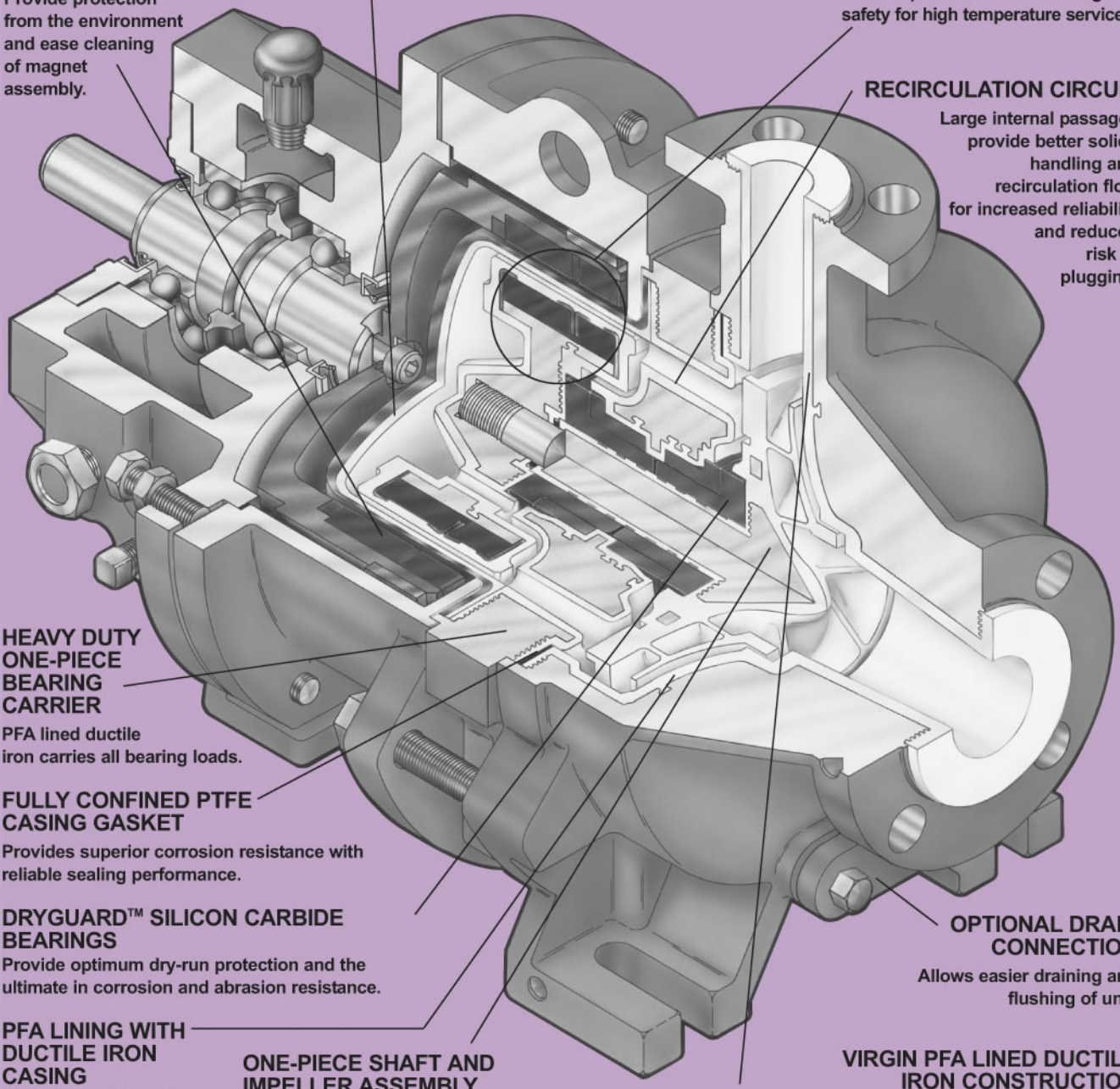
Applications

- Hot Acids
- Acetic Acid
- Chlorinated Solvents
- Chloroform
- Freon 113
- Acetone
- Hydrofluoric Acid
- Sodium Hypochlorite
- Nitric Acid
- Amines
- Carbon Tetrachloride
- Dichloroehtylene
- Ethers
- Bromine
- Chlorine Dioxide

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3299 Heavy Duty Lined Chemical Pumps

Design Features for Wide Range of High Temperature/High Pressure Services



ANSI DIMENSIONS
Allow easy retrofit of problem ANSI pumps.

FULLY ENCAPSULATED OUTER MAGNETS
Provide protection from the environment and ease cleaning of magnet assembly.

CONTAINMENT SHELLS
PFA lining with carbon fiber reinforced plastic outer shell. Optional bonded shells for added safety on vacuum services. Non-metallic construction eliminates heat generated by eddy current losses common in metallic designs. 30% higher efficiencies than magnetic drive pumps with metallic containment shells.

RARE EARTH MAGNETS
High-strength Neodymium Iron Boron drive and Samarium Cobalt driven assemblies, provide high torque and hard start capability without slipping. Synchronous drive. Optional Samarium Cobalt drive magnets provide additional margin of safety for high temperature services.

RECIRCULATION CIRCUIT
Large internal passages provide better solids handling and recirculation flow for increased reliability and reduced risk of plugging.

HEAVY DUTY ONE-PIECE BEARING CARRIER
PFA lined ductile iron carries all bearing loads.

FULLY CONFINED PTFE CASING GASKET
Provides superior corrosion resistance with reliable sealing performance.

DRYGUARD™ SILICON CARBIDE BEARINGS
Provide optimum dry-run protection and the ultimate in corrosion and abrasion resistance.

OPTIONAL DRAIN CONNECTION
Allows easier draining and flushing of unit.

PFA LINING WITH DUCTILE IRON CASING
One-piece solid casing lined with minimum 3/16" (4 mm) transfer molded PFA. Ensures lining integrity, longer life and decreased maintenance costs.

ONE-PIECE SHAFT AND IMPELLER ASSEMBLY
Enclosed impeller minimizes axial thrust. PFA lined 316 stainless steel shaft and impeller core provide increased mechanical strength while retaining corrosion resistance.

TRANSFER MOLDED CASING
Proprietary process ensures uniform thickness of lining throughout casing. Produces consistent lining integrity needed for severe services.

VIRGIN PFA LINED DUCTILE IRON CONSTRUCTION
Provides superior corrosion resistance; inert to most chemicals. Temperatures to 360°F (182°C).

Heavy Duty Lined Chemical Pump

PFA Construction for Universal Corrosion Resistance to 360˚F (182˚C)

Virgin PFA® is virtually inert to all chemicals and has excellent permeation resistance. PFA lined casing, bearing carrier, and one-piece impeller/shaft assembly provide superior corrosion resistance and long life, unequalled by alloy pumps.

Non-Sparking Rub Ring

Assures containment shell integrity in the unlikely event of a ball bearing failure. Provides safe support of drive carrier in the clamp ring during assembly and disassembly.

Designed for Safe Operation

DUAL CONTAINMENT SHELL

PFA lining with carbon fiber reinforced plastic (CFRP) shell. Non-metallic construction provides efficiencies the same or better than sealed ANSI pumps; 30% higher efficiencies than metal sealless pumps. Non-metallic construction eliminates magnet losses or heat generation. CFRP shell provides rigid support for the liner and acts as a secondary method of containment should the primary liner fail.

Integral Shaft and Impeller

Enclosed design minimizes axial thrust, extends thrust bearing life. One-piece construction eliminates front shroud failures possible with two-piece impellers. Large metal core improves mechanical strength. Integral PFA lined shaft and impeller optimizes corrosion resistance, strength, and durability of a stainless steel shaft, eliminating the chances of stress fractures associated with silicon carbide shafts.

Solids Handling

Standard configuration features large internal clearances allow the passage of solids up to 0.06 inches with a maximum concentration of 2%. Concentrations of up to 10% and sizes up to 0.1875 inches in diameter can be pumped with the External Bearing Flush option offered by Goulds Pumps.

High Pressure Capability

The ductile iron casing and adapter with the carbon fiber reinforced containment shell are designed for pressure containment to 275 PSIG. The PFA lining resists permeation of the most corrosive materials in high pressure applications.

Exceptional Performance for Chemical Services

Dry Run Protection with Dryguard

DRYGUARD™ BEARINGS AND SHAFT

Goulds unique Dryguard™ diamond-like carbon coating provides extra protection for the silicon carbide bearings, allowing the pump to withstand tough conditions and system upsets. If your system cannot guarantee fluid 100% of the time, Goulds recommends Dryguard™.

PUMP LOAD MONITORS

PS20 Pump Load Monitors measure the motor input power in combination with a propreitary algorithm to accurately determine the pump's load.

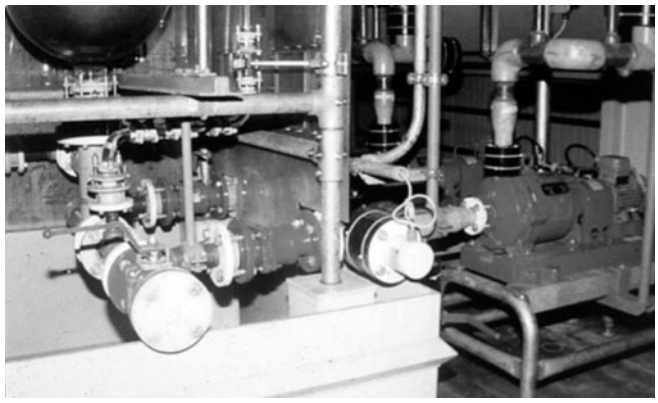
During dry-run conditions, pump power is reduced and recognized by the PumpSmart Pump Load Monitor. During run-out conditions, power increases, which is also a recognizable condition. Power increase is also experienced when internal war results from upset conditions. Customers may configure the devices to automatically shutdown the pump or warn the operator via integrated relay output(s).

PS20 Pump Load Monitor

The PS20 Offers two underload and two overload condition protection functions (four total) as well as the ability to output pump load through and integrated 4-20 mA output. A six-button keypad and LCD readout enable greater congifuration and operation options. The PS20 can be applied on motors up to 999 F.L. Amps.

Ultimate Protection

Magnetic drive pump failures are often due to dry running and closed discharge valve conditions. With Dryguard™ silicon carbide bearings and a power monitor, you have the best protection technology can offer. Goulds always recommends the use of a power monitor because… **FAILURE IS NOT AN OPTION!**

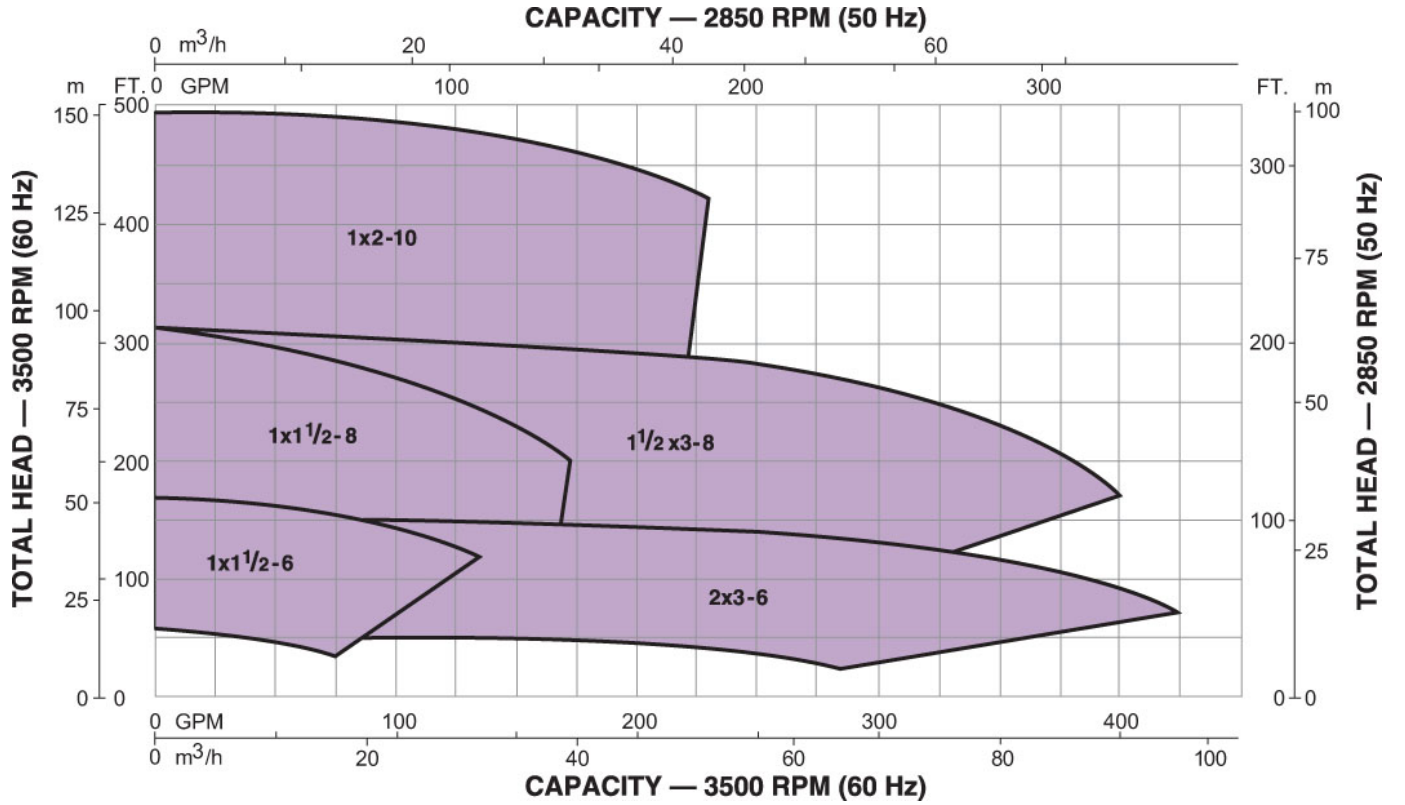


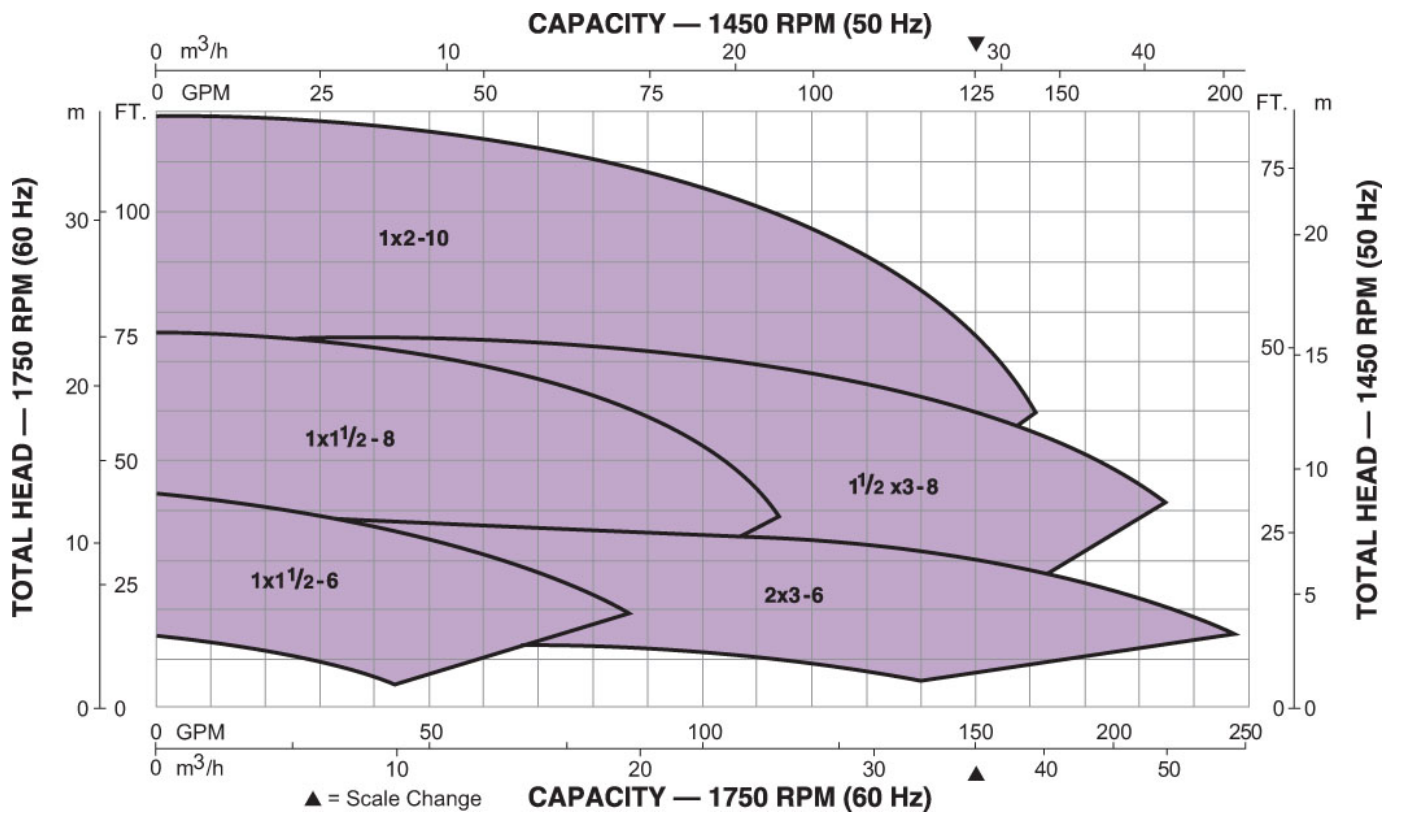
Zero Leakage on Hard to Seal Hot Corrosives

The 3299 is sealless and environmentally responsive.

No mechanical seal assures zero leakage on moderate to severe corrosives and hazardous liquids. A great solution to a pump with mechanical seal problems.

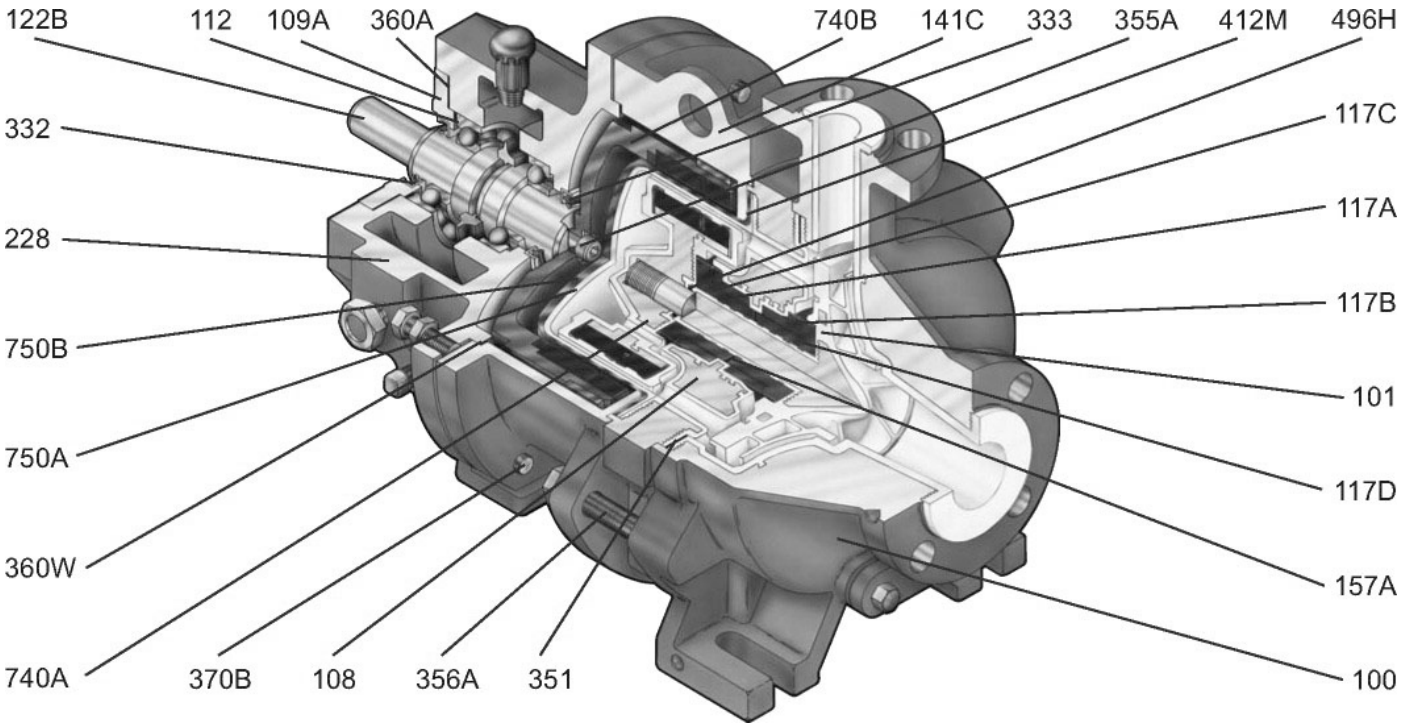
Hydraulic Coverage Model 3299





Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

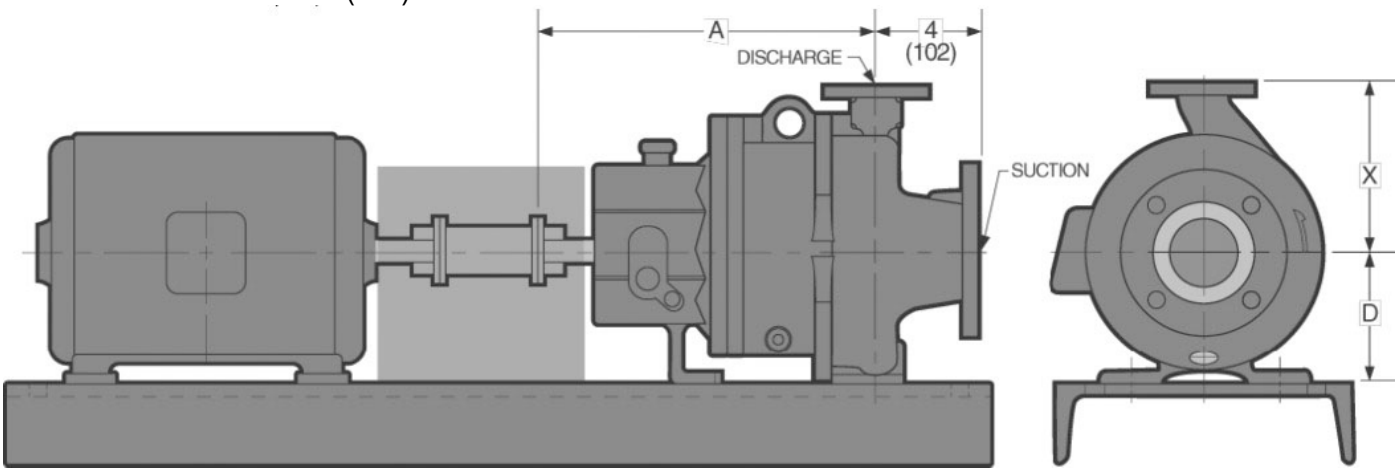
Sectional View **Model 3299**

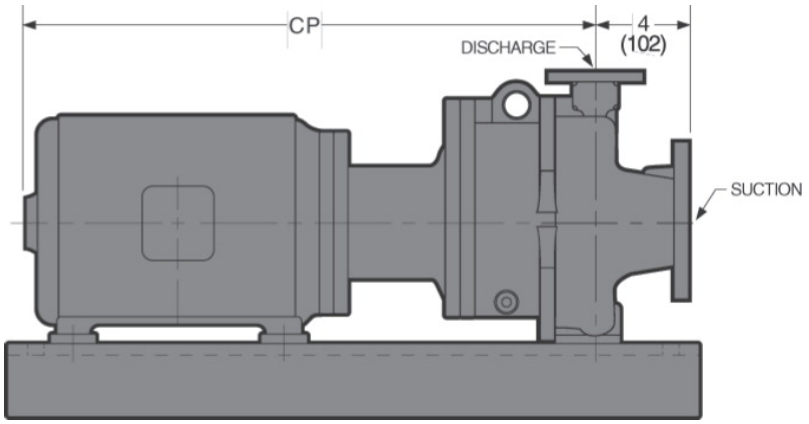


Parts List and Materials of Construction		
Item Number	**Part Name**	**Material**
100	Casing	Ductile Iron/PFA
101	Impeller/Shaft Assembly	316 Stainless Steel/PFA
108	Bearing Carrier	Ductile Iron/PFA
109A	Bearing End Cover (Frame-Mounted)	Steel
112	Ball Bearing (Frame-Mounted)	Steel
117A	Stationary Bearing, Outboard	Alpha Sintered Silicon Carbide with Dryguard™
117B	Stationary Bearing, Inboard	Alpha Sintered Silicon Carbide with Dryguard™
117C	Radial Bearing, Outboard	Alpha Sintered Silicon Carbide with Dryguard™
117D	Radial Bearing, Inboard	Alpha Sintered Silicon Carbide with Dryguard™
122A	Stub Shaft (Close-Coupled) *not illustrated*	Steel
122B	Drive Shaft (Frame-Mounted)	Steel
141C	Clamp Ring	Ductile Iron
157A	Bearing Spacer	PTFE
222L	Set Screw (Close-Coupled) *not illustrated*	Steel
228	Frame (Frame-Mounted), Motor Adapter (Close-Coupled)	Ductile Iron
332	Lip Seal, Outboard (Frame-Mounted)	Steel/Nitrile
333	Lip Seal, Inboard (Frame-Mounted)	Steel/Nitrile
351	Casing Gasket	PTFE
355A	Socket Head Cap Screw–Drive magnet assy to shaft	Steel
356A	Hex Cap Screw–Clamp Ring to Casing	304 Stainless Steel
356B	Hex Cap Screw–Clamp Ring to Bearing Carrier *not illustrated*	304 Stainless Steel
360A	Gasket–Bearing End Cover to Frame (Frame-Mounted)	Kraft Paper
360W	Gasket–Frame or Motor Adapter to Clamp Ring	Nitrile Buna Rubber Bound Aramid Fiber
370B	Hex Cap Screw–Frame or Motor Adapter to Clamp Ring	Steel
370C	Hex Cap Screw–End Cover to Frame (Frame-Mounted) *not illustrated*	Steel
412M	Support Ring	PTFE
496H	Inner Shaft O-Ring	Kalrez ® or Equal
740A	Driven Carrier Assembly	Steel/Samarium Cobalt/PFA
740B	Drive Carrier Assembly	Std.–Ductile Iron/Neodymium Iron Boron, Opt.–Ductile Iron/Samarium Cobalt
750A	Containment Shell, Inner	PTFE
750B	Containment Shell, Outer	CFRP

Dimensions Model 3299

All dimensions in inches and (mm). Not to be used for construction.



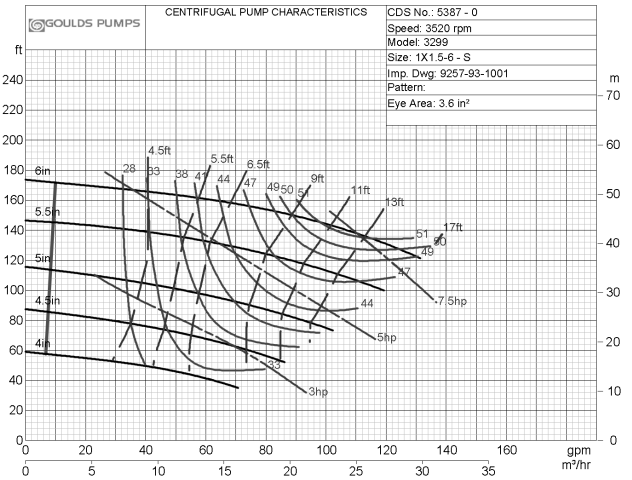


BARE PUMP DIMENSIONS						
					Weight, lbs (kg)	
Group	Size	A	D	X	Close-Coupled	Frame-Mounted
S	1×1.5-6	13.5 (343)	5.25 (133)	6.5 (165)	161 (73)	171 (78)
	2×3-6				173 (79)	183 (83)
	1×1.5-8				175 (80)	180 (82)
M	1.5×3-8	19.5 (495)	8.25 (210)	8.5 (216)	225 (103)	243 (110)
	1×2-10				245 (111)	263 (120)

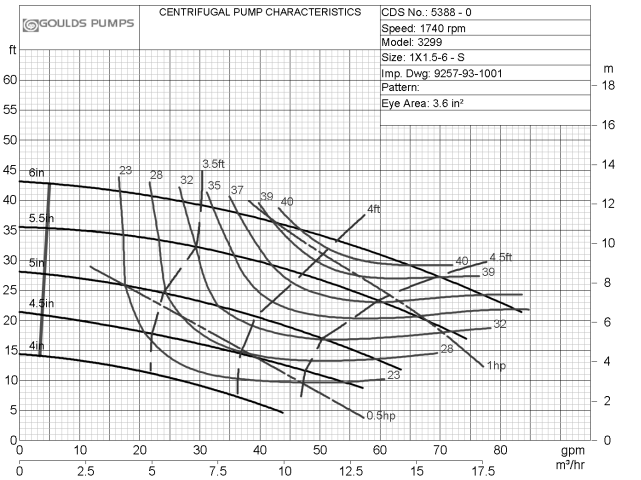
CLOSE-COUPLED		
Motor Frame	Group	CP (Approx.)
143TC	S	24.96 (634)
	M	28.73 (730)
145TC	S	25.96 (659)
	M	29.73 (755)
182TC	S	28.09 (713)
	M	30.23 (768)
184TC	S	29.09 (739)
	M	31.23 (793)
213TC	S	30.89 (785)
	M	33.03 (839)
215TC	S	32.39 (823)
	M	34.53 (877)
254TC	S	35.06 (891)
	M	37.2 (945)
256TC	S	36.76 (934)
	M	38.9 (988)
284TSC	S	40.95 (1040)
	M	43.09 (1094)
286TSC	S	N/A (N/A)
	M	43.09 (1094)
324TSC	S	N/A (N/A)
	M	44.91 (1141)
326TSC	S	N/A (N/A)
	M	44.91 (1141)

NOTES

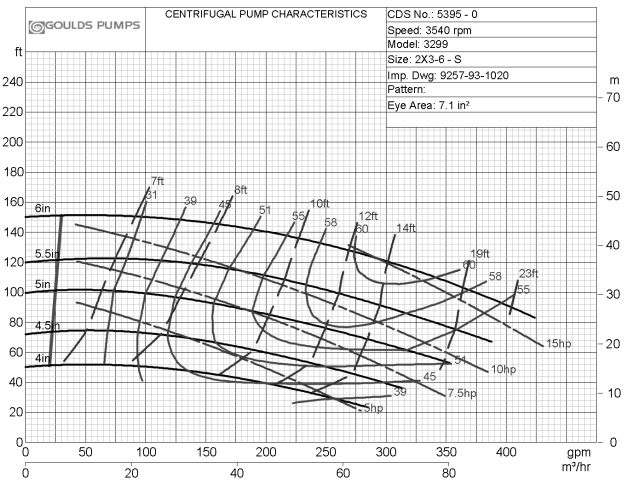
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



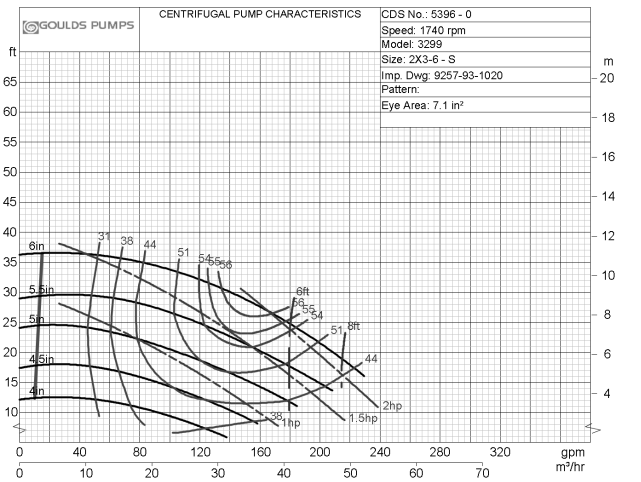
1X1.5-6 **3520rpm**



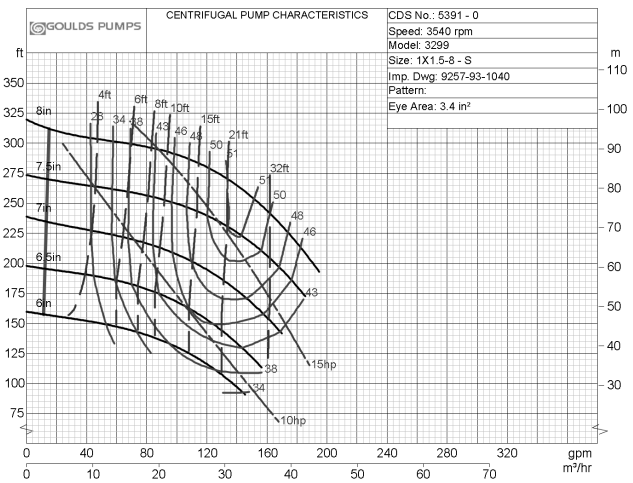
1X1.5-6 **1740rpm**



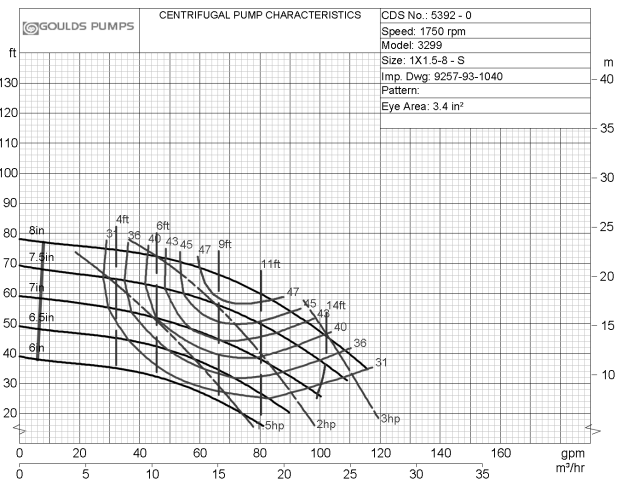
2X3-6 **3540rpm**



2X3-6 **1740rpm**



1X1.5-8 **3540rpm**

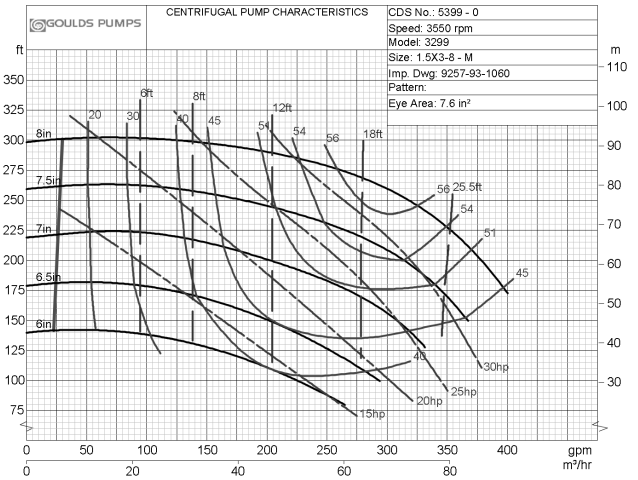


1X1.5-8 **1750rpm**

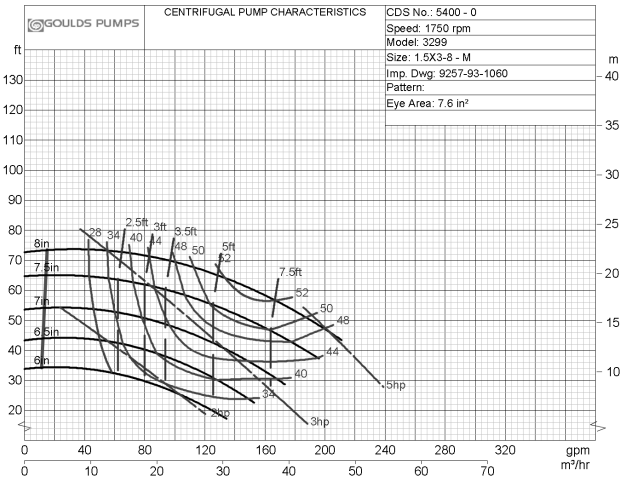
60Hz Curves

Model 3299

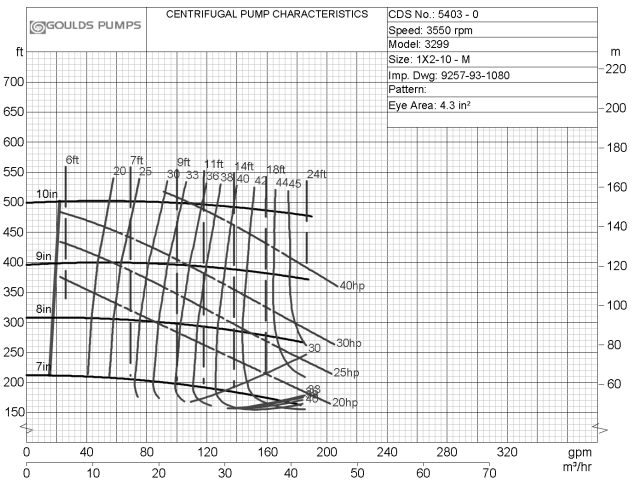
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



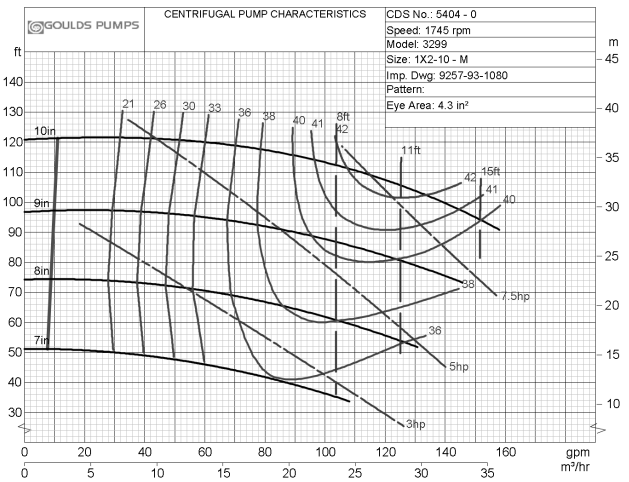
1.5X3-8 **3550rpm**



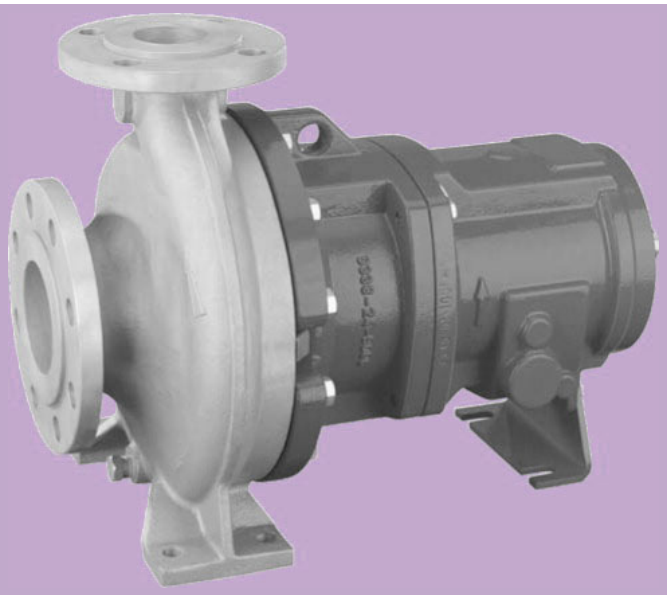
1.5X3-8 **1750rpm**



1X2-10 **3550rpm**



1X2-10 **1745rpm**



Model ICM

The model ICM/ICMB is a metallic magnetic drive chemical process pump made of Ductile Iron, 316 Stainless Steel, Duplex SS, Alloy 20, Hastelloy and Titanium designed for normal and demanding chemical process applications.

Goulds Models ICM/ICMB

ISO Dimensional Metallic Magnetic Drive Chemical Process Pump

- Capacities to 340 m^3/h (1,490 USgpm) at 2,900 rpm and 400 m^3/h (1,760 USgpm) at 3,500 rpm
- Heads to 160 m (525 feet) at 2,900 rpm and 210 m (685 feet) at 3,500 rpm
- Temperature Range -40° C to 180° C (-40° F to 360° F), optional as ICMP up to 280° C (530° F)
- Pressures to 16 Bar (235 PSIG), optionally 25 bar (360 psi); sizes 65-40-315 and 80-50-315: 25 bar (360 psi) standard

Design Features

- Single-stage, magnetic drive centrifugal pump
- Dimensions and technical design in accordance with EN 22858/ ISO 2858/ ISO 5199, ISO 15783
- Standard frame-mounted design, alternatively close coupled
- Sealless design eliminates the need for shaft sealing
- Flanges drilled to DIN/ISO, ANSI, BS, JS

Ease of Maintenance

- Modular Design for Maximum Interchangeability Between All 18 Pump Sizes
- Back Pull-Out Design Makes Maintenance Safe and Simple
- Complies With ISO 2858/EN 22858 For Retrofit Capability

Services

- Chemical Process
- Pharmaceutical and Petrochemical Industry
- Food Technology
- Pulp Preparation
- Metal Processing
- General Industry
- Nuclear Power Plants
- Waste Disposal/Recycling Industries
- Water Treatment
- OEM

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Goulds Models ICM/ICMB

Design Features For a Wide Range of Applications in the Chemical Process Industry

IMPELLER
- Precision-cast stainless steel, optionally Hastelloy and other materials
- Back vanes or balance holes reduce axial thrust
- Optional suction inducer:
  - reduces the NPSHr by 35-50 %
  - permits smaller pumps at higher speeds = lower costs
  - is advantageous for media with gas content

INNER MAGNET ASSEMBLY
- Inner magnet assembly with encapsulated magnets
- Integral axial vanes assure positive pressurized flushing flow to both lubricate and cool the plain bearings

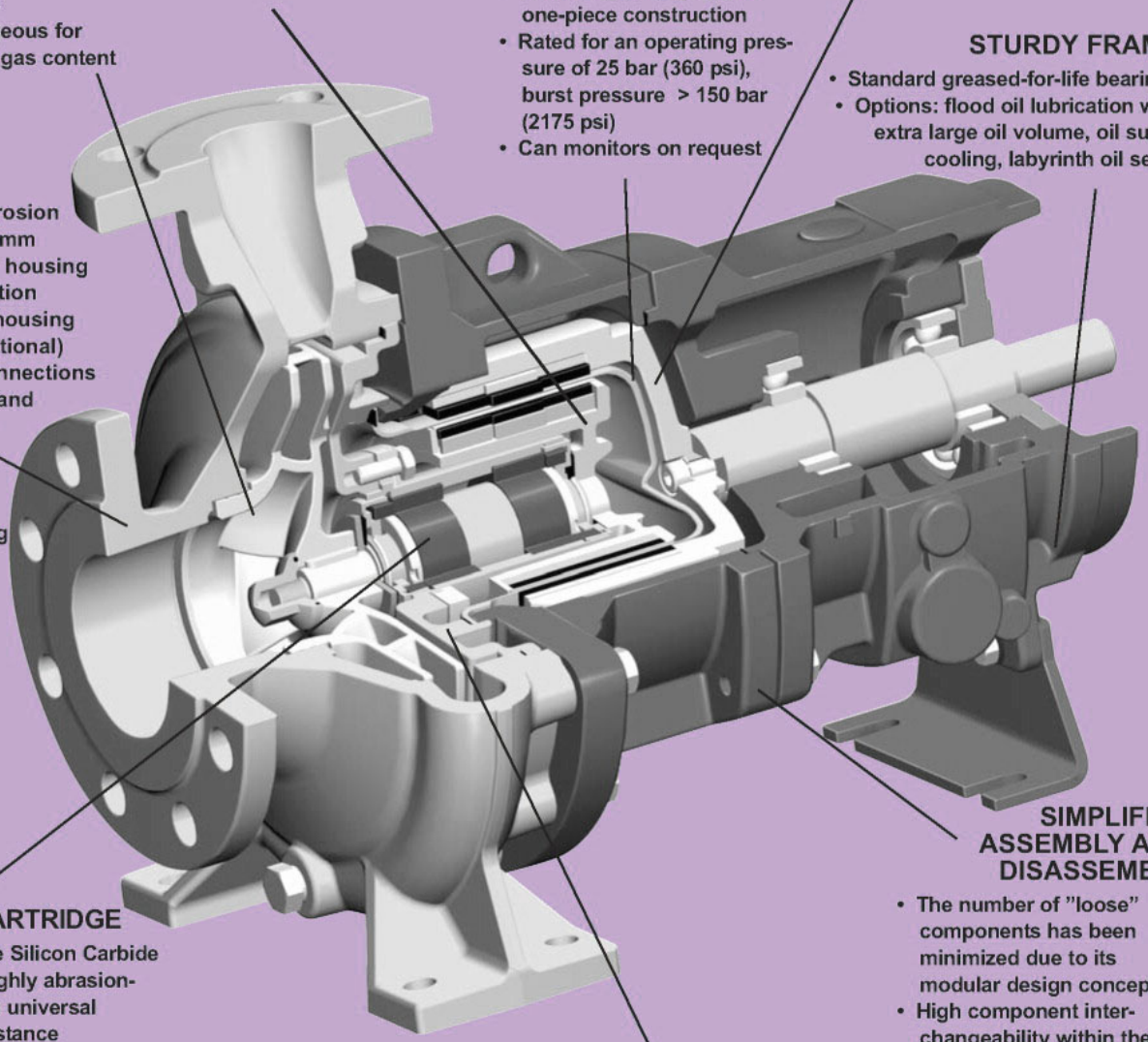
PUMP CONDITION MONITORING
The ICM is prepared for the attachment/installation of a veriety of monitoring and control devices.

CAN
- Hastelloy C4 (2.4610) as standard
- Non-welded, deep-drawn one-piece construction
- Rated for an operating pressure of 25 bar (360 psi), burst pressure > 150 bar (2175 psi)
- Can monitors on request

DRIVE MAGNET ASSEMBLY WITH HIGH-PERFORMANCE PERMANENT MAGNETS
- Coupling ratings of up to 330 Nm (² 100 kW at 2900 rpm), variable through modular design
- Integral outer thrust ring prevents against contact with the can in the event of a roller bearing failure. Spark-free as an option

STURDY FRAME
- Standard greased-for-life bearings
- Options: flood oil lubrication with extra large oil volume, oil sump cooling, labyrinth oil seals

CASING
- Minimum corrosion allowance: 3 mm
- Standard 3/8" housing drain connection
- Replaceable housing wear ring (optional)
- Integrated connections for pressure and temperature monitors
- Jacketed housing for media heating or cooling on request



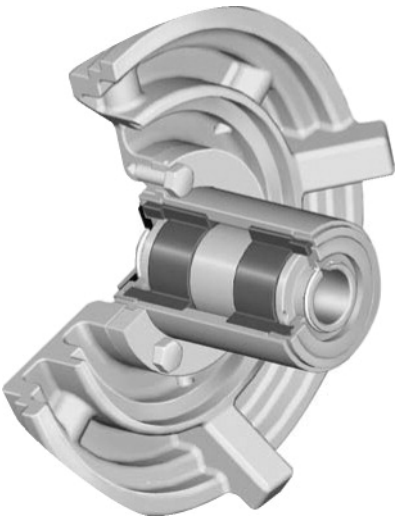
BEARING CARTRIDGE
- Standard Pure Silicon Carbide SiC (SSiC), highly abrasion-resistant, with universal chemical resistance
- Cartridge design eliminates measurements and fitting for simplified maintenance
- Optional Dryguard™ PLUS dry-running bearing system provide added safety during upset conditions
- High level of safety even in the event of plain bearing failure

EXCELLENT PUMP HYDRAULICS
The ICM utilizes the same hydraulic components offered on the mechanically sealed IC Series. Users benefit from reduced repair parts inventories due to this hydraulic design standardization.

BACKPLATE
Integrated possibilities for connecting
- plain bearing flushing feature with external medium, on request with can drain
- temperature monitoring

SIMPLIFIED ASSEMBLY AND DISASSEMBLY
- The number of "loose" components has been minimized due to its modular design concept
- High component interchangeability within the frame size groups
- No special tools required
- No fitting measurements
- Split lantern/bearing pedestal design: Allows for maintenance of the drive side while keeping the liquid end assembled and pressurized ("back pull out design")

Reliable Bearing Cartridge



Plain bearings must run reliably. If, however, pump maintenance is required, it must be performed correctly and often as quickly as possible. The cartridge plain bearing system of the ICM is designed accordingly:

- Fast and simple installation and replacement of the plain bearings, no need for installation settings.
- Cartridge design can be rebuilt/refurbished with individual components to minimize spare parts and repair costs.
- Radial and thrust plain bearings made of highly abrasion-resistant pure silicon carbide (SSiC) with universal chemical resistance
- In case of a plain bearing failure the encapsulated cartridge design both will act to contain possible silicon carbide (SSiC) fragments and to prevent the inner magnet assembly from contacting the can.
- Optionally the Dryguard™ PLUS bearing system can be supplied to provide an optimized dry-running capability. Dryguard™ PLUS has proven its worth in thousands of operating chemical process pumps.

Hastelloy Containment Shell

The can is the most important sealing element against the atmosphere.

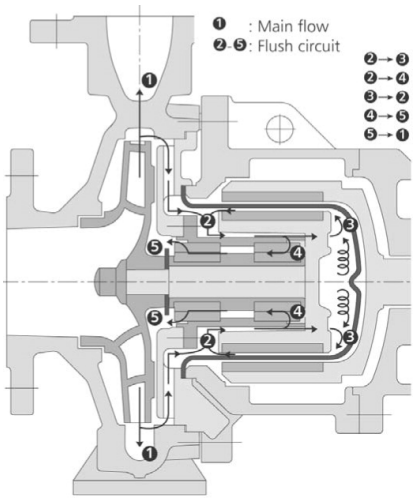
This component was thus carefully examined during the development phase.

The pressure and flow conditions inside the can were illustrated, simulated and analyzed using a computer.

The can is therefore optimally designed.

- Hastelloy C4 (2.4610) as standard, deep-drawn non-welded design for reliable corrosion resistance
- Vortex breaking bead at the bottom of the can prevents against erosion of the can
- Burst pressure >150 bar (> 2,175 psi)
- Large clearances (1.5 mm/ 1/16”) between the can and the inner magnet assembly allow for greater reliability in solid laden services or with higher viscous media

Engineered Flush Circuit



A reliable flush circuit is important for heat dissipation, lubrication of the plain bearings and solids handling without clogging. The heat produced in the metallic can by eddy currents must be controlled to prevent against flashing because dry-running/inadequate lubrication and overheating are the most important causes of sealless pump downtimes and failures.

Coupling years of ITT’s sealless pump experience and using modern CFD (computational fluid dynamics) methods, an effective and reliable flush circuit has been designed during the development stages of the ICM. The flush circuit is enhanced by special design features in the inner magnet assembly, can and plain bearing cartridge to guarantee reliable pumping even under the most demanding applications. Rigorous testing has been completed to confirm its reliability.

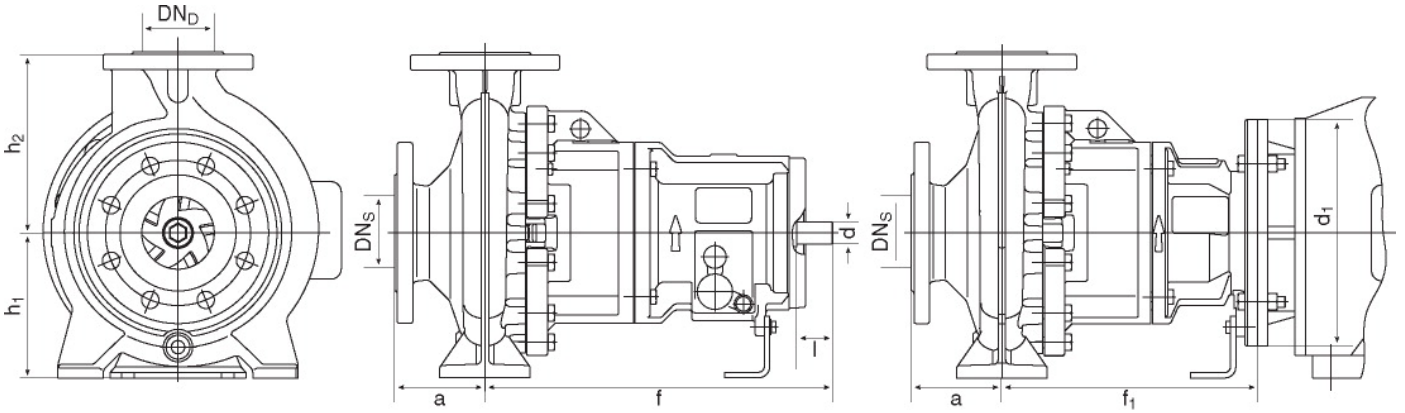
Solids Handling Capability

Based on extensive testing the ICM has shown to be capable of pumping liquids which contain highly abrasive powders without any breakdowns or detectable signs of wear. Admissible solids contents need to be checked case by case.

Pump Dimensions

Model ICM/ICMB For Frame-Mounted and Close-Coupled Designs

Material Comparison Tables



Frame-mounted design

Close-coupled design

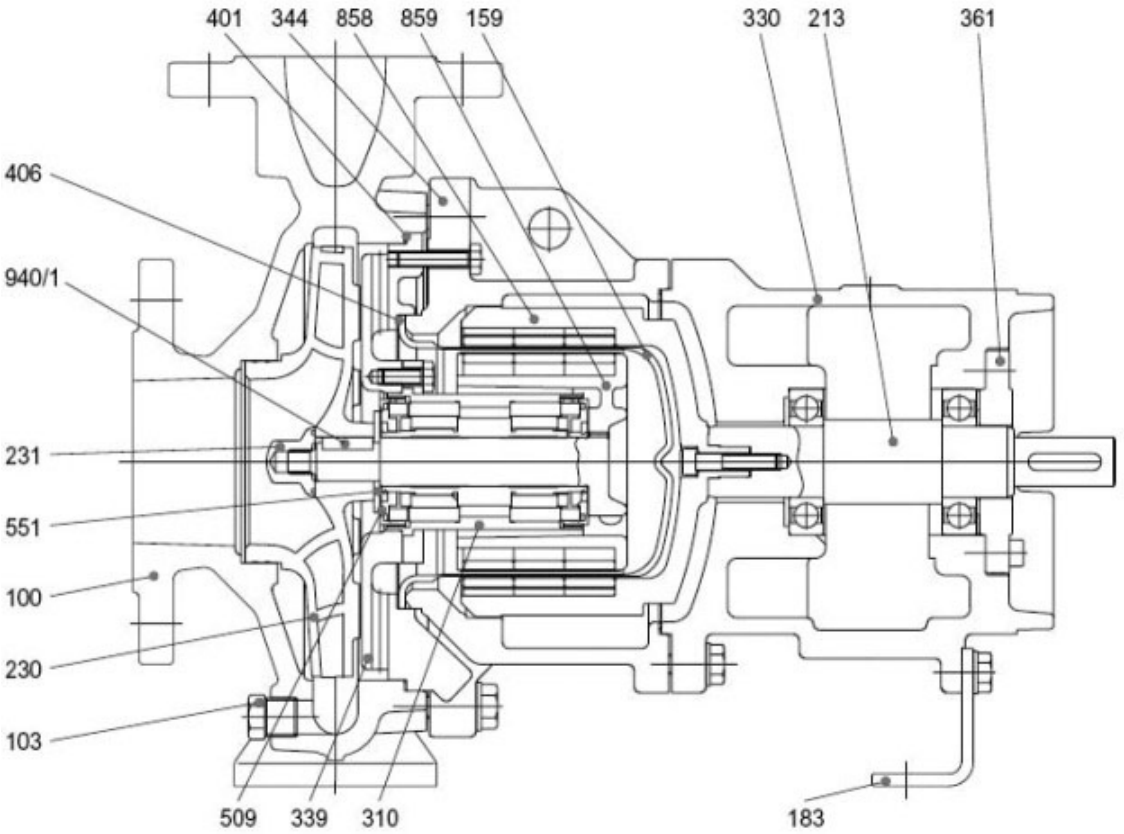
All dimensions in mm

Pump size	Flanges		Pump				Shaft end		Weight min (kg)
	DN_S	DN_D	a	f	h_1	h_2	d	l	
40-25-160	40	25	80	385	132	160	24	50	58
40-25-200	50	32	80	385	132	160	24	50	59
40-25-250	50	32	80	385	160	180	24	50	67
50-32-160	50	32	100	500	180	225	32	80	119
50-32-200	40	25	80	385	160	180	24	50	64
50-32-250	40	25	100	500	180	225	32	80	115
50-32-315	50	32	125	500	200	250	32	80	145
65-40-160	65	40	80	385	132	160	24	50	60
65-40-200	65	40	100	385	160	180	24	50	69
65-40-250	65	40	100	500	180	225	32	80	119
65-40-315	65	40	125	500	200	250	32	80	155
80-50-160	80	50	100	385	160	180	24	50	63
80-50-200	80	50	100	385	160	200	24	50	70
80-50-250	80	50	125	500	180	225	32	80	121
80-50-315	80	50	125	500	225	280	32	80	160
100-65-160	100	65	100	500	160	200	32	80	107
100-65-200	100	65	100	500	180	225	32	80	112
100-65-250	100	65	125	500	200	250	32	80	132
125-80-160	125	80	125	500	180	225	32	80	114
125-80-200	125	80	125	500	180	250	32	80	120
125-80-250	125	80	125	500	225	280	32	80	143
125-100-200	125	100	125	500	200	280	32	80	126

Motor-dependent pump dimensions for close-coupled version			
Pump size	Motor size	f_1	d_1
40-25-160	80	275.5	200
50-32-160	90	275.5	200
65-40-160	100	275.5	250
80-50-160	112	275.5	250
40-25-200	132	295.5	300
50-32-200	160	325.5	350
65-40-200	180	325.5	350
80-50-200	200	325.5	400

Material comparison table			
Cast materials	ICM standard	Equivalent standards	
		DIN	ASTM
Cast iron	EN-GJL-250 (JL1040)	0.6025	A48, Class 35 B
Duct. cast iron	(JS1025) 400-18-LT EN-GJS-	0.7043	A395,grade 60-40-18
Stainless steel	1.4408	1.4408	A743, CF-8M
Duplex	1.4517	1.4517	A744 CD4-MCu
Alloy 20	1.4536	1.4536	A743 CN-7M
Hastelloy C	V2.4811	2.4811	A494N-12MV
Hastelloy B	V2.4810	2.4810	A494CX 2MV

Parts List and Materials Model ICM/ICMB

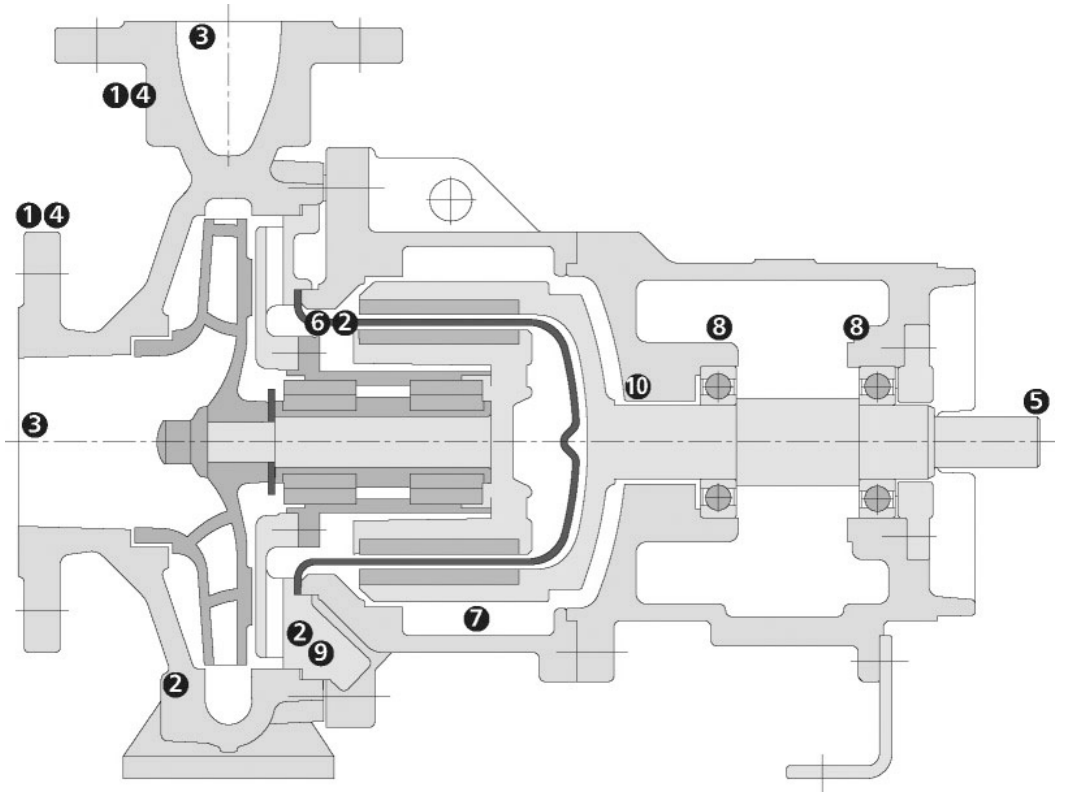


Item No	Part designation	Stainless steel (W)	Duplex (WW)	Ductile cast iron (NL)	Ductile cast iron/stainl. steel	Hastelloy (CC)	Alloy 20 (AA)
100	Housing	1.4408	1.4517	0.7043		Hastelloy	Details
230	Impeller	1.4408	1.4517	0.6025	1.4408	Hastelloy	on request
339	Plain bearing pedestal	1.4408	1.4517	1.4408		Hastelloy	
310	Plain bearing cartridge	Duplex 1.4462/SSiC				Hastelloy	
859	Inner mag. ass./Magnets	Duplex 1.4517/NdFeB				Hastelloy	
159	Can	Hastelloy C4 2.4610					
231	Impeller nut	Duplex 1.4517				Details on	
551	Distance washer	1.4571				request	
940/1	Key (impeller)	1.4571					
401	Housing gasket	Asbestos-free aramide fibre					
406	Can gasket	Asbestos-free aramide fibre					
509	Intermediate ring	Graphite					
344	Lantern	0.7043					
858	Drive mag. ass./Magnets	0.6020/NdFeB					
330	Bearing pedestal	0.6025					
213	Drive shaft	1.4021					
361	Rear bearing cover	1.0601					
183	Support bracket	1.0037					
103	Housing drain plug	Stainless steel				Details on request	
	Screws, nuts etc.	Stainless steel					

Options not shown:

236	Inducer	Duplex 1.4462			Hastelloy	Details on
502	Housing wear ring	1.4410	Duplex 1.4439	1.4410	Hastelloy	request
642	Oil level sight glass	Plastic/glass				

Safety First Pump Control and Monitoring



When a sealless pump is specified the Number One user concern is safe and leak free operation, especially when noxious, toxic, carcinogenic and other hazardous materials are conveyed.

The ICM has been designed such that most condition monitoring and speed control devices can be easily and economically installed and retrofitted. The following condition monitoring options are available:

1 Pump speed control (PumpSmart ®, etc)
2 Temperature monitor
3 Flow and filling level monitor
4 Pressure monitor
5 Motor load monitor
6 Can temperature monitor
7 Can leakage sensor in the lantern
8 Rolling bearing monitor
9 Connection for external flush supply.
10 Secondary sealing: The space around the can can be sealed against the rolling bearings by means of special shaft or labyrinth seals.

Customized solutions on request.

If the can is damaged, the drive side and atmosphere would be protected against the medium for a certain time. Therefore, in conjunction with one of the can monitors, this results in an effective preventive environmental protection in the case of critical media.

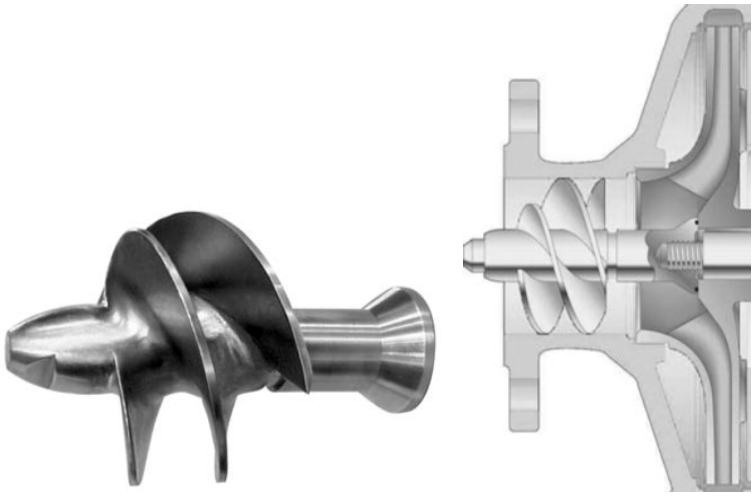
Inducer

As an option all ICM pumps can be fitted with a suction inducer.

The inducer

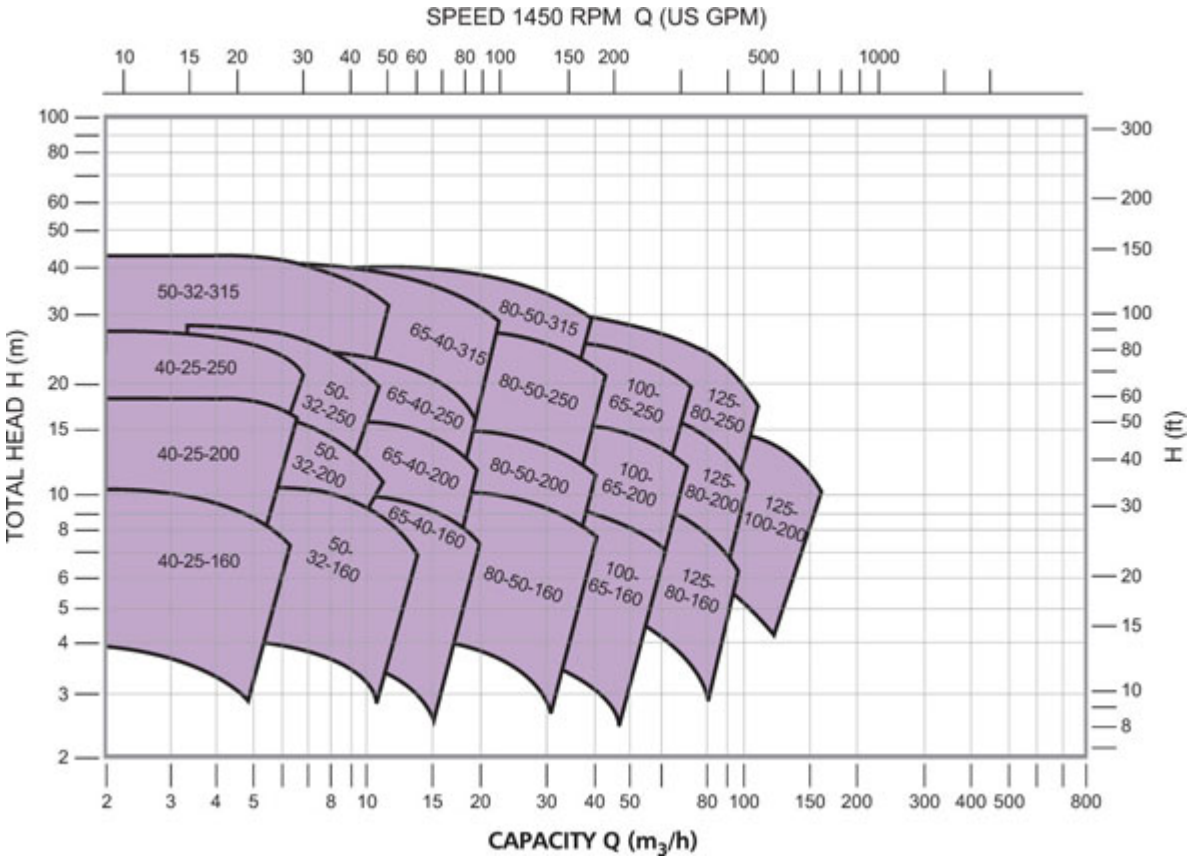
- reduces the NPSHr by 35-50 %
- permits smaller pumps at higher speeds for lower installation costs
- is advantageous for media with entrained gas, high vapor pressures or specific heats

ITT's inducer technology has been proven in practice for over thirty years.

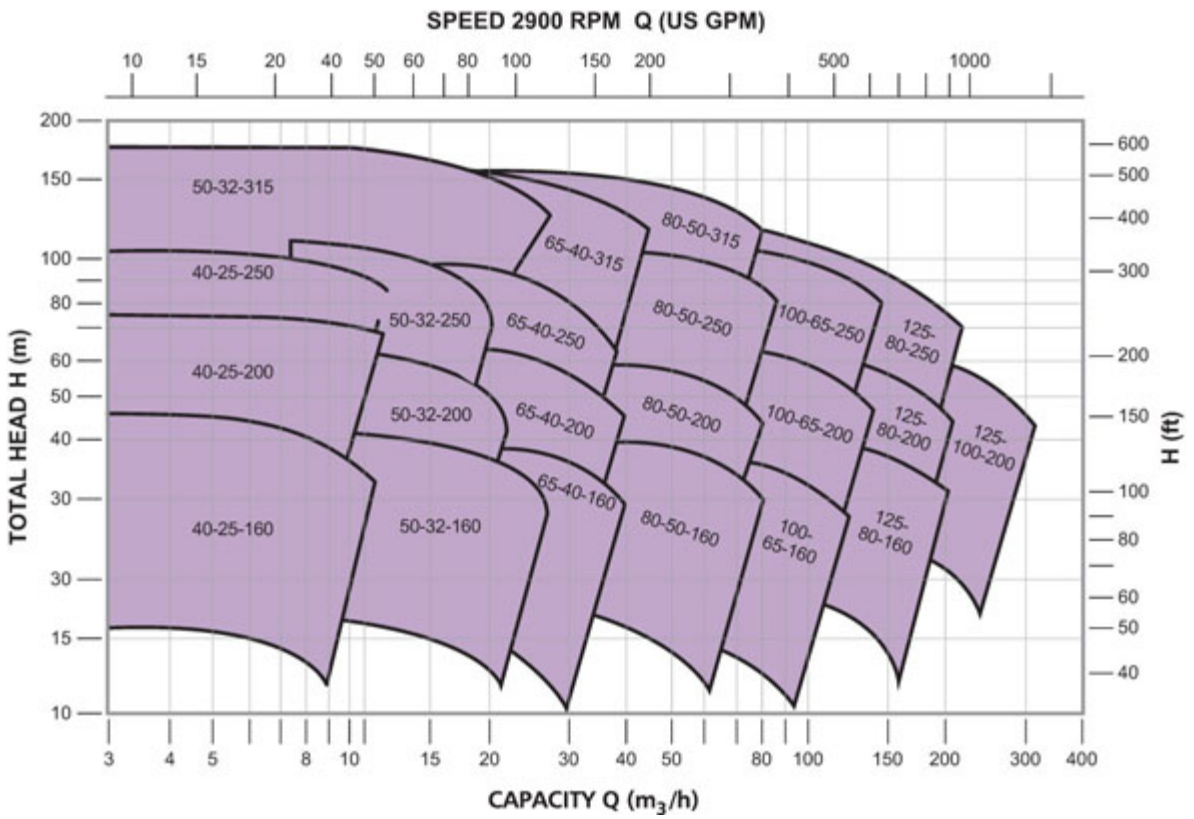


Hydraulic Coverage Model ICM/ICMB

1450/1750 RPM



2900/3500 RPM



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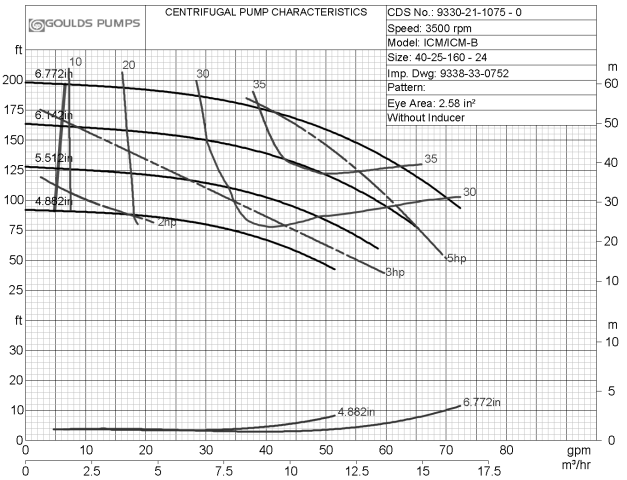
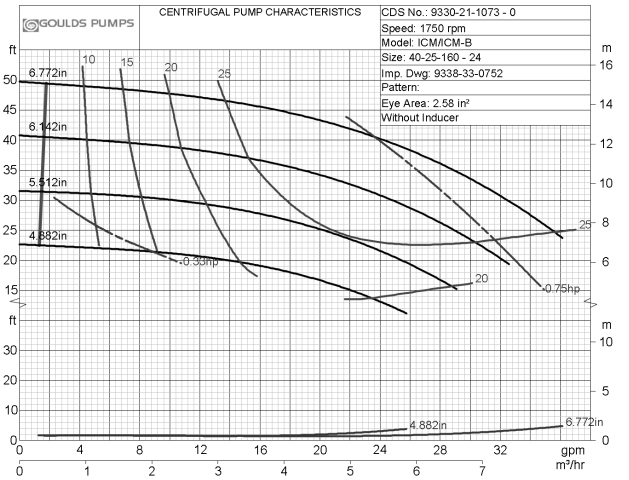
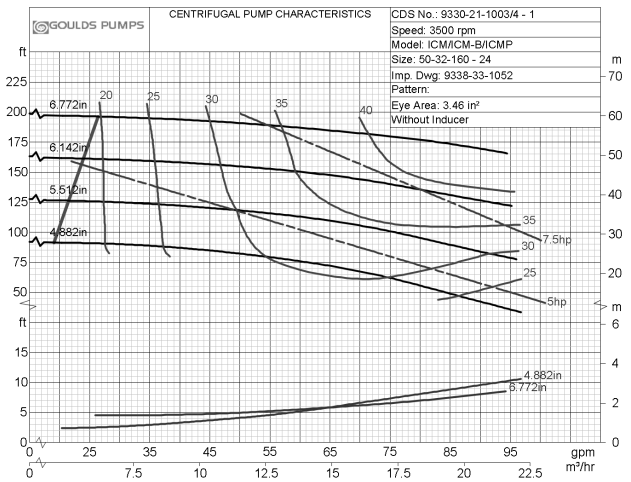


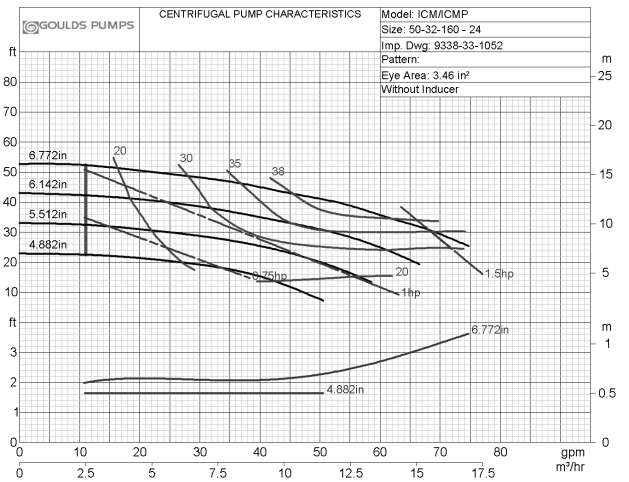
40-25-160 **3500rpm**



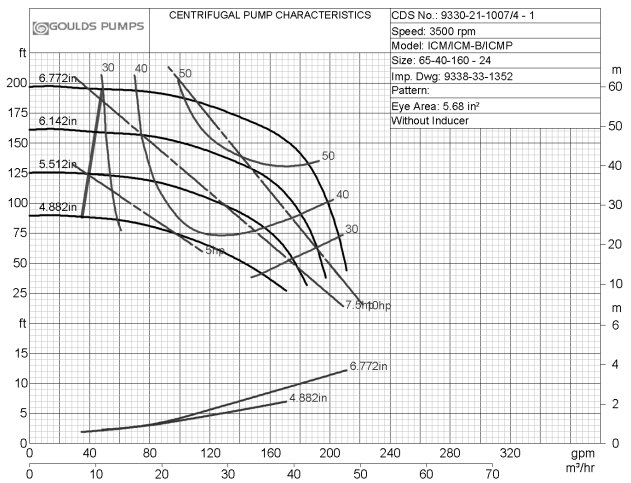
40-25-160 **1750rpm**



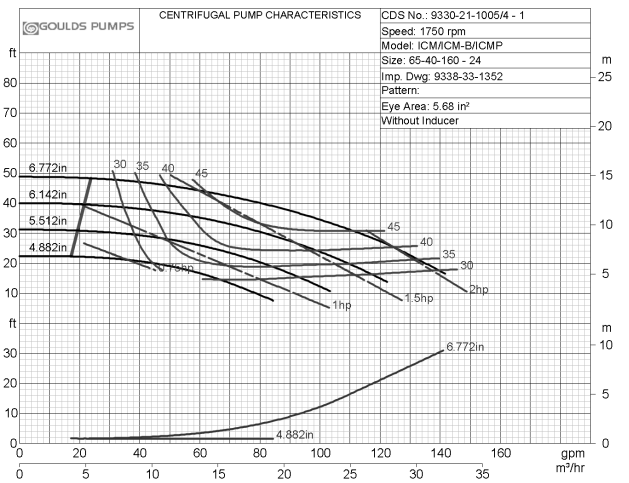
50-32-160 **3500rpm**



50-32-160 **1750rpm**

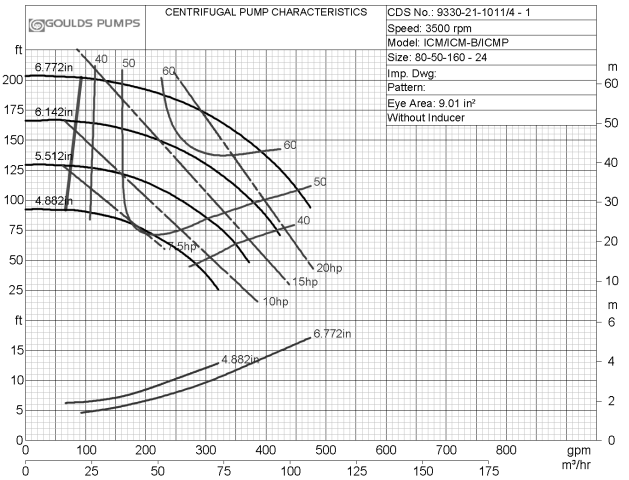


65-40-160 **3500rpm**

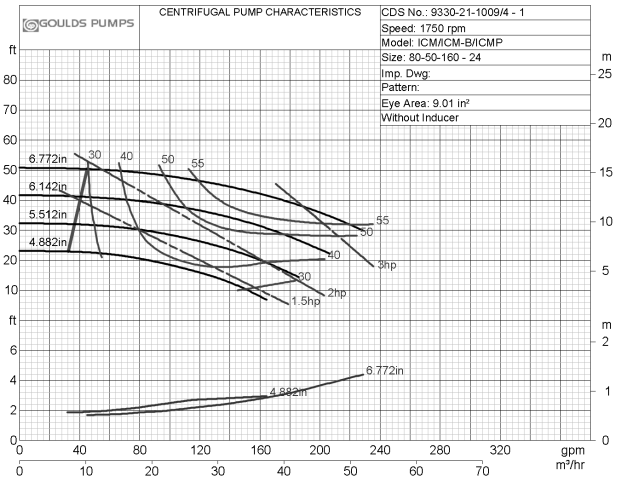


65-40-160 **1750rpm**

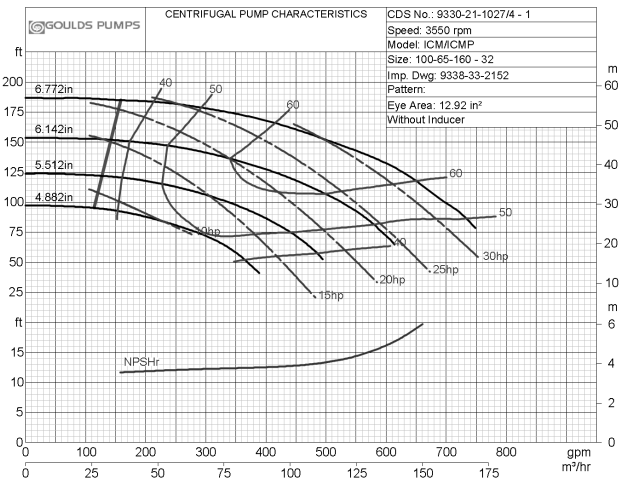
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



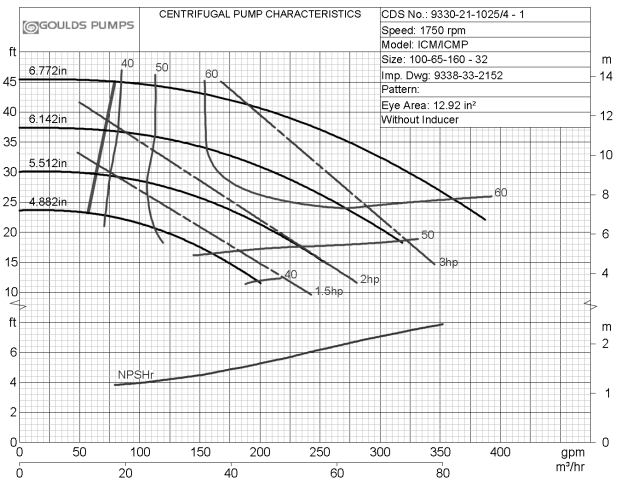
80-50-160 **3500rpm**



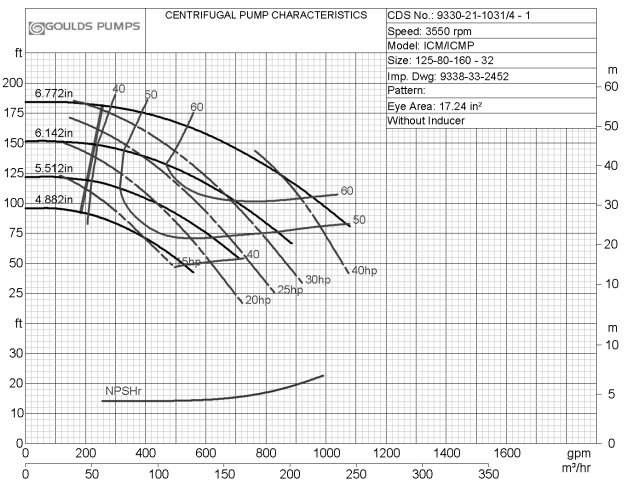
80-50-160 **1750rpm**



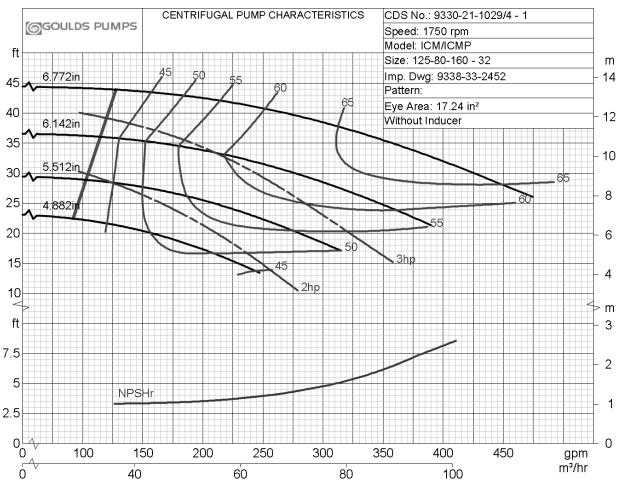
100-65-160 **3550rpm**



100-65-160 **1750rpm**



125-80-160 **3550rpm**



125-80-160 **1750rpm**

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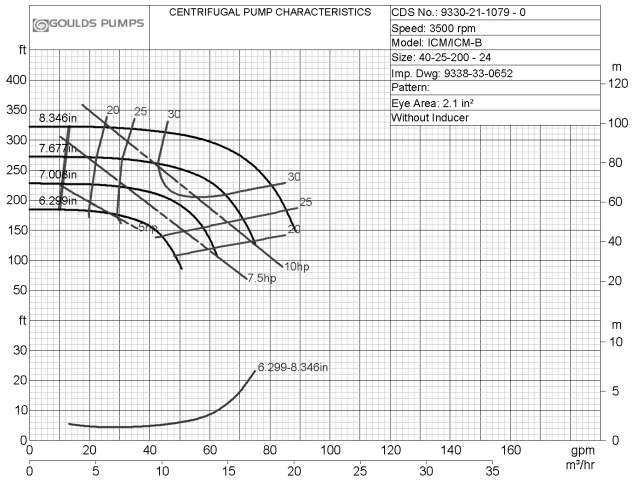
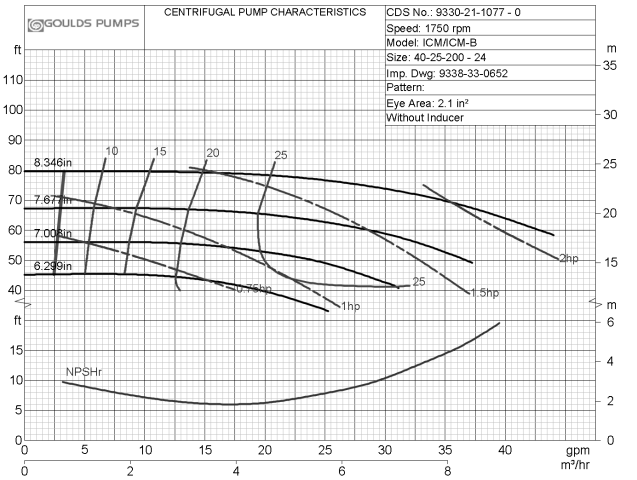
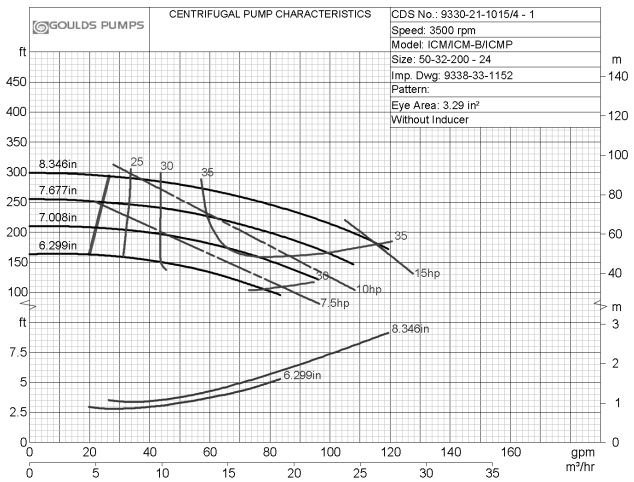


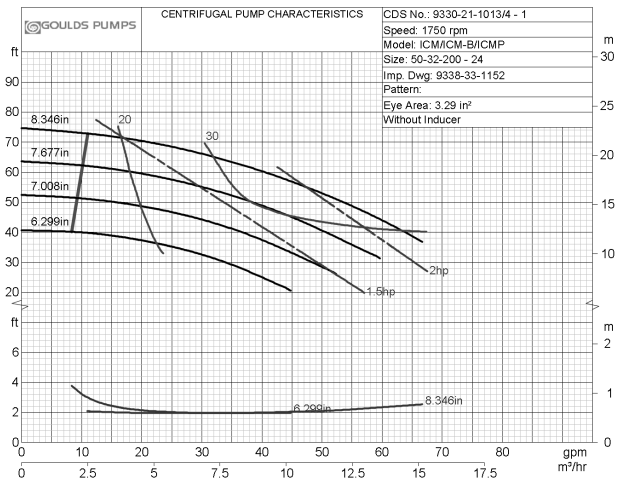
40-25-200 **3500rpm**



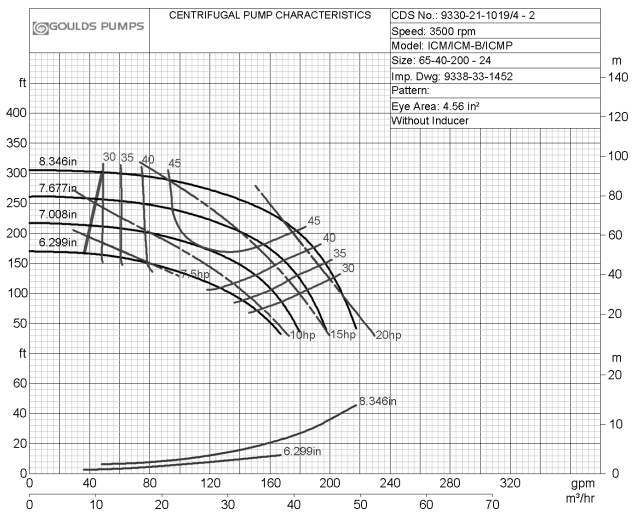
40-25-200 **1750rpm**



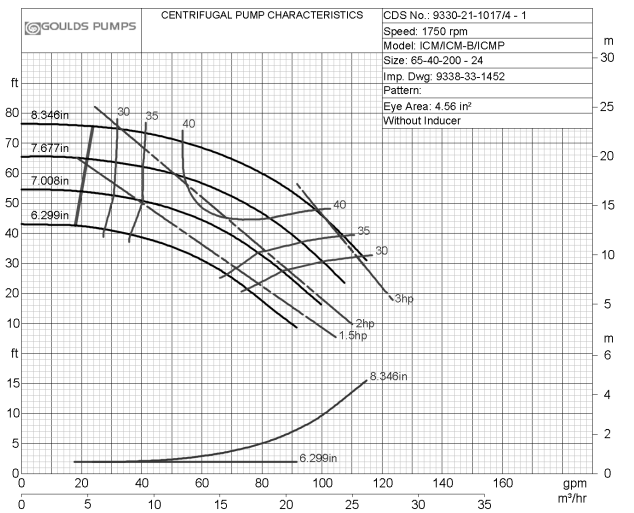
50-32-200 **3500rpm**



50-32-200 **1750rpm**



65-40-200 **3500rpm**



65-40-200 **1750rpm**

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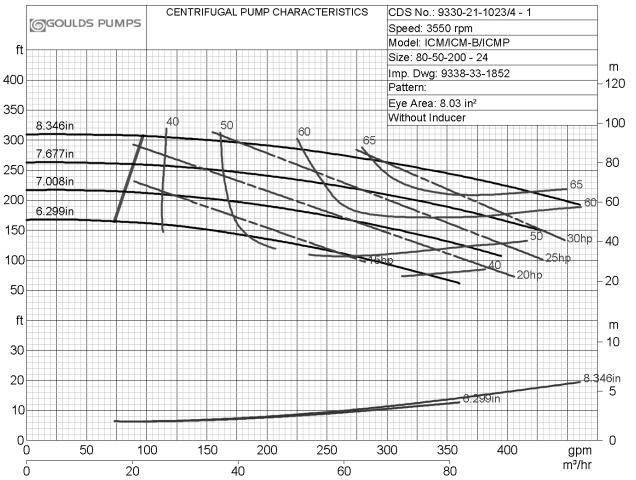
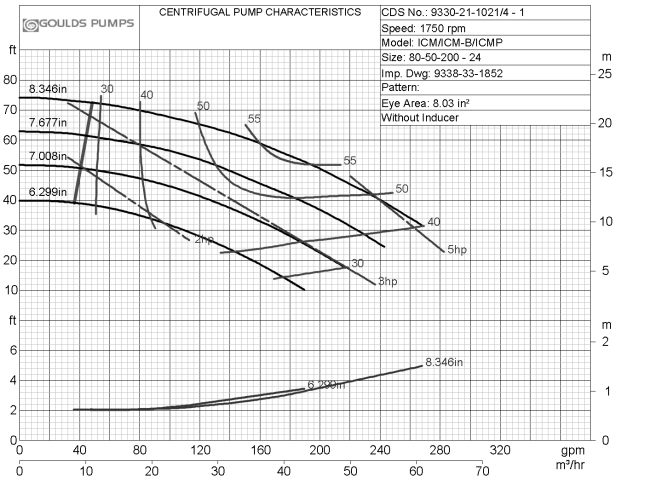
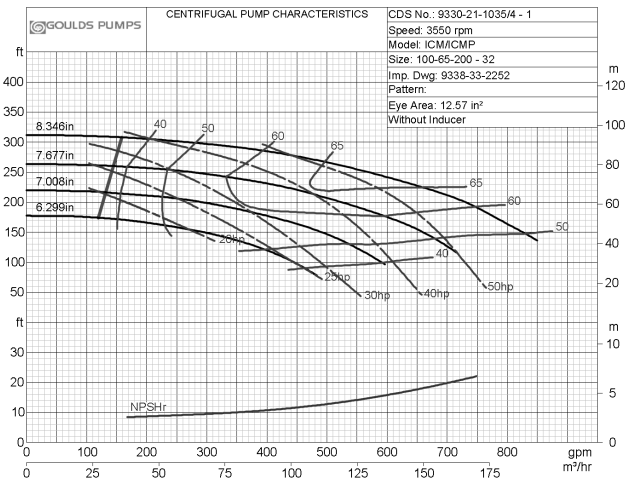


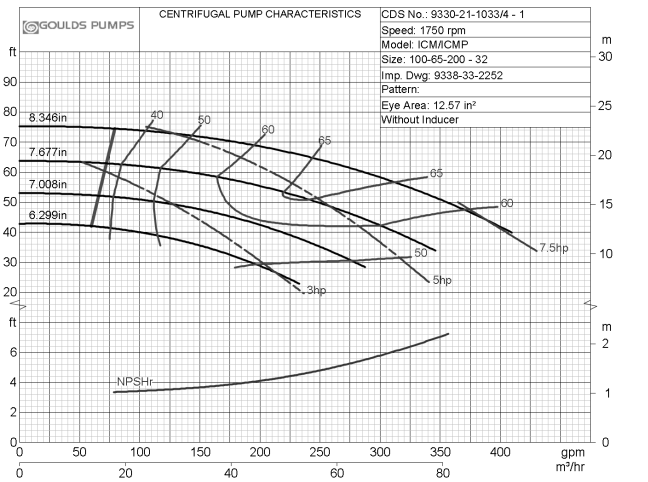
80-50-200 **3550rpm**



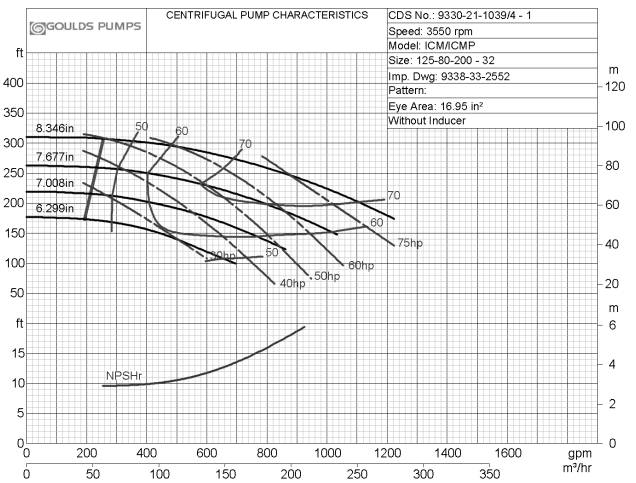
80-50-200 **1750rpm**



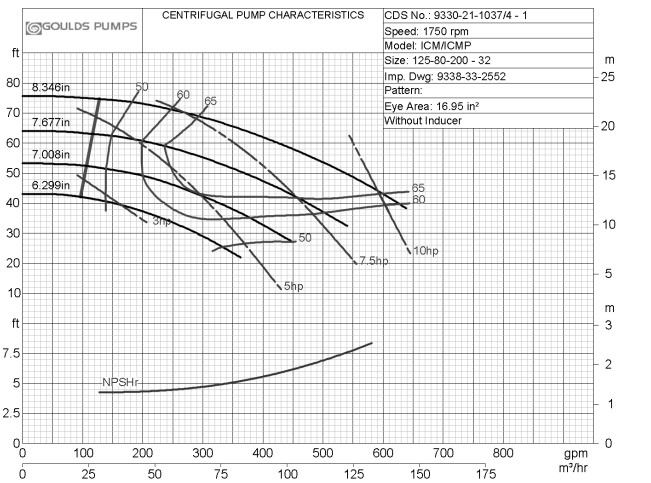
100-65-200 **3550rpm**



100-65-200 **1750rpm**



125-80-200 **3550rpm**



125-80-200 **1750rpm**

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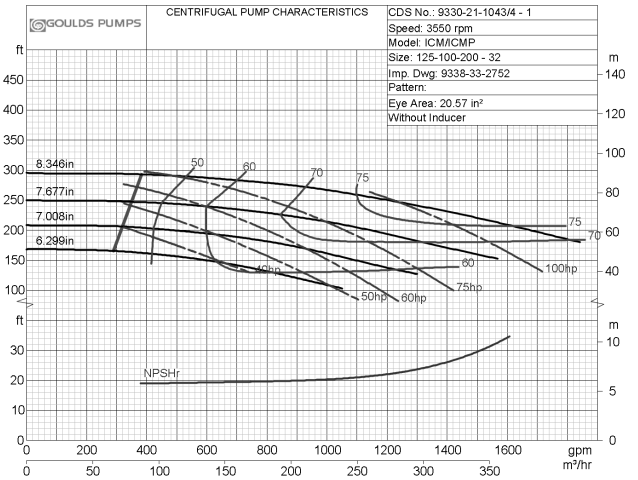
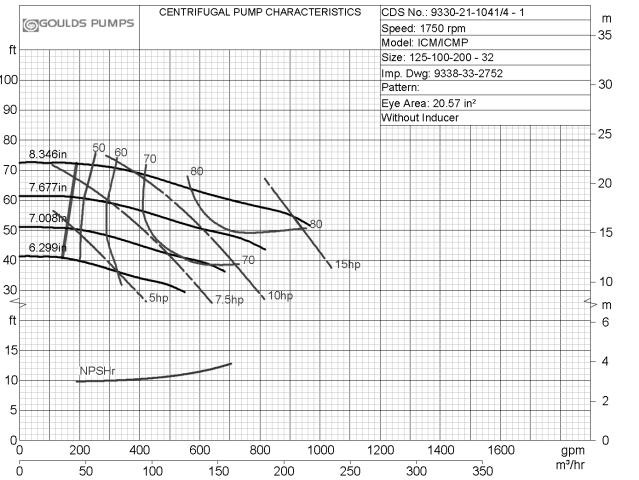
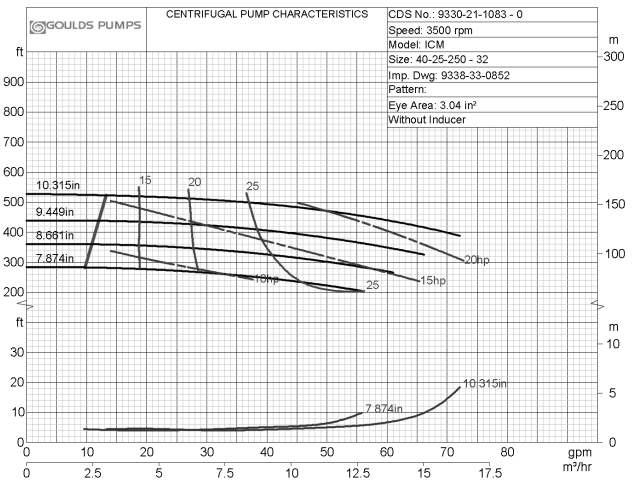


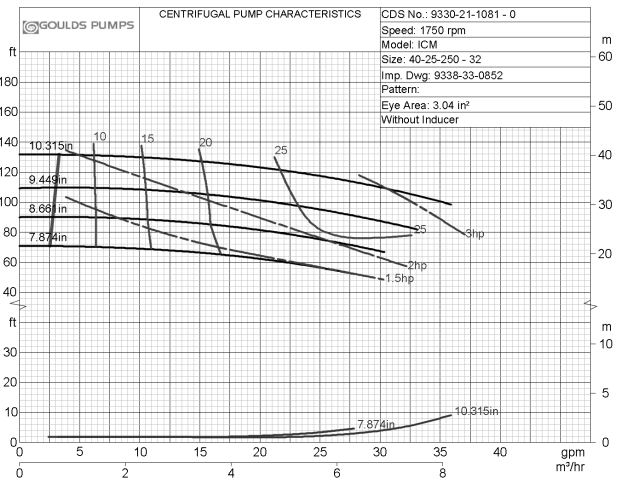
125-100-200 **3550rpm**



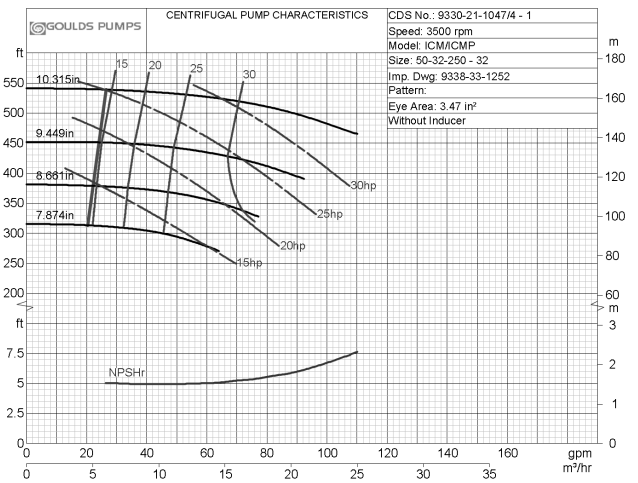
125-100-200 **1750rpm**



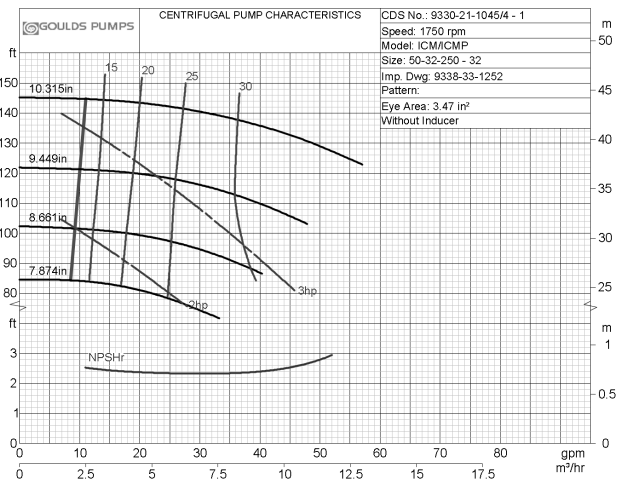
40-25-250 **3500rpm**



40-25-250 **1750rpm**



50-32-250 **3500rpm**



50-32-250 **1750rpm**

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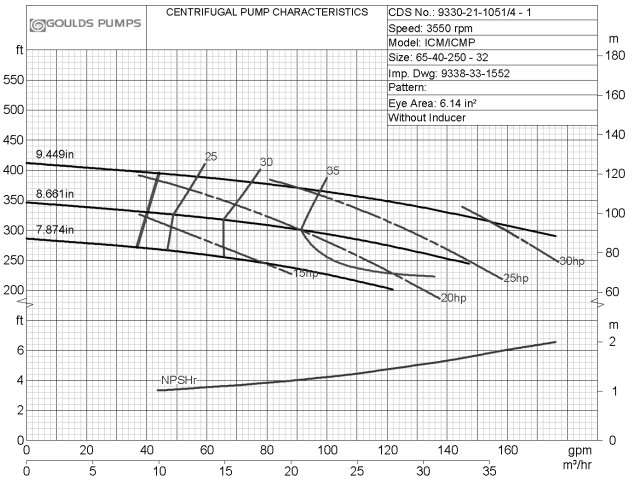
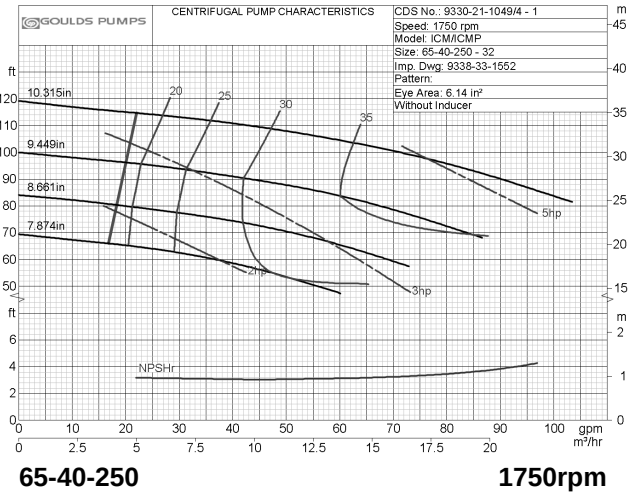
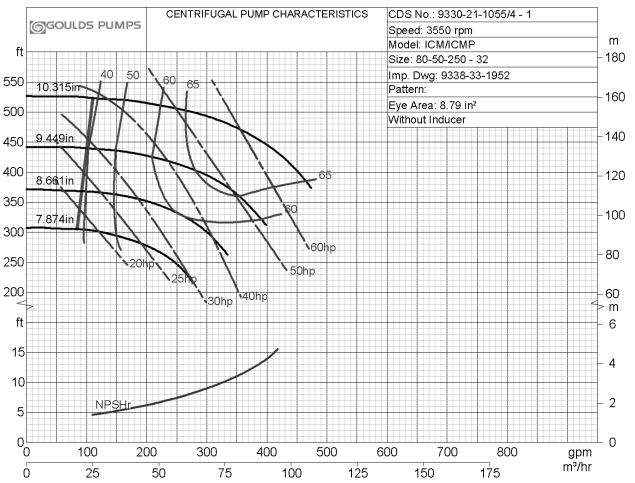


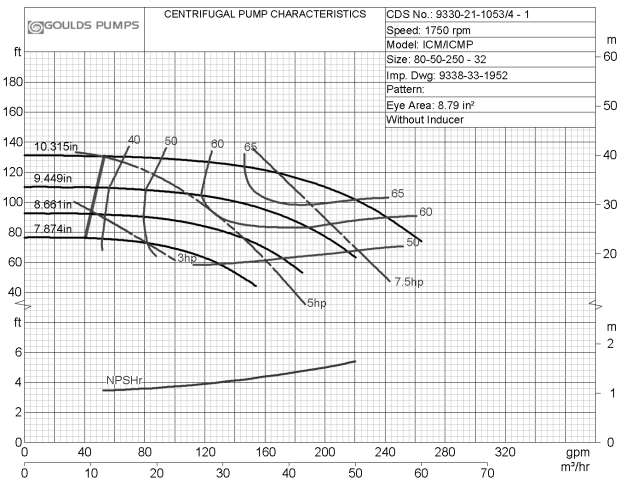
65-40-250 **3550rpm**



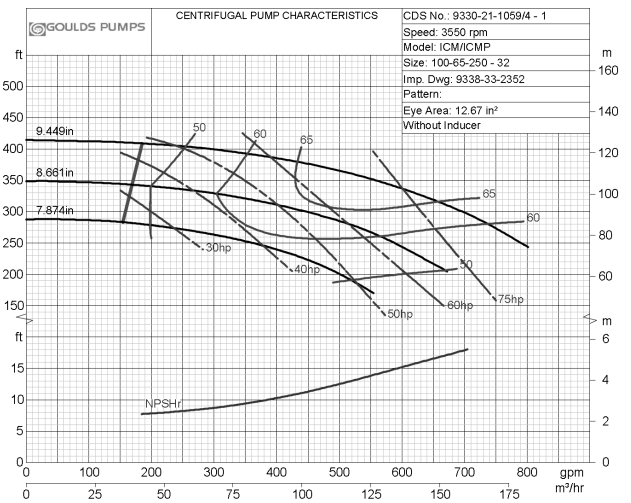
65-40-250 **1750rpm**



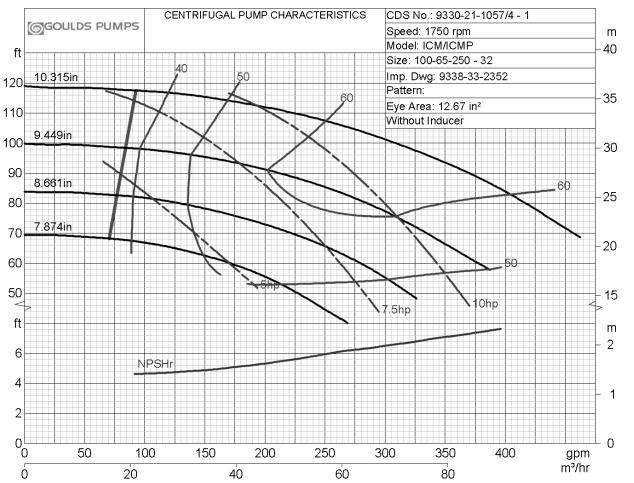
80-50-250 **3550rpm**



80-50-250 **1750rpm**



100-65-250 **3550rpm**



100-65-250 **1750rpm**

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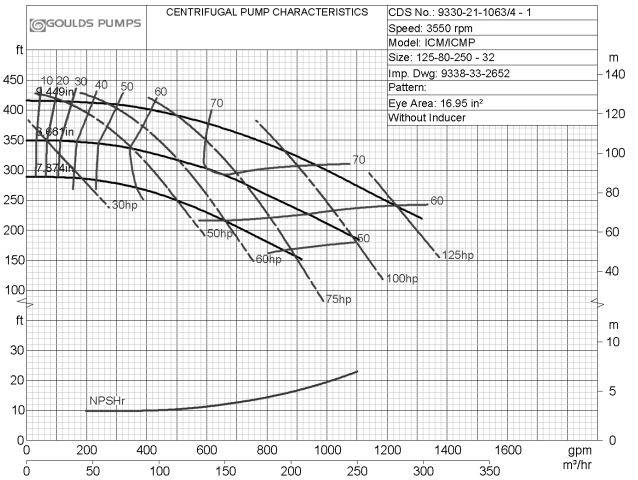
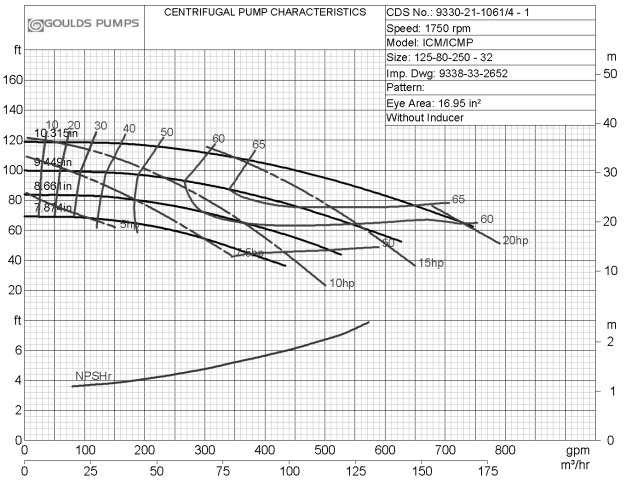
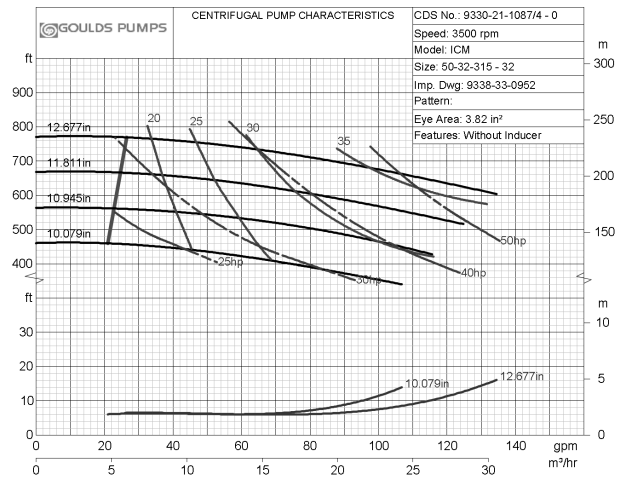


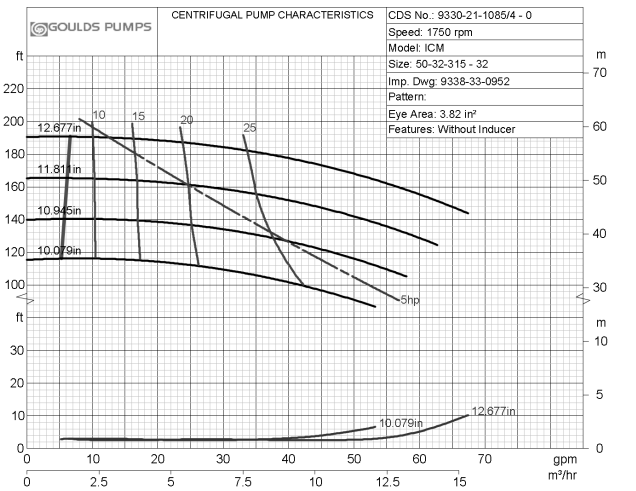
125-80-250 **3550rpm**



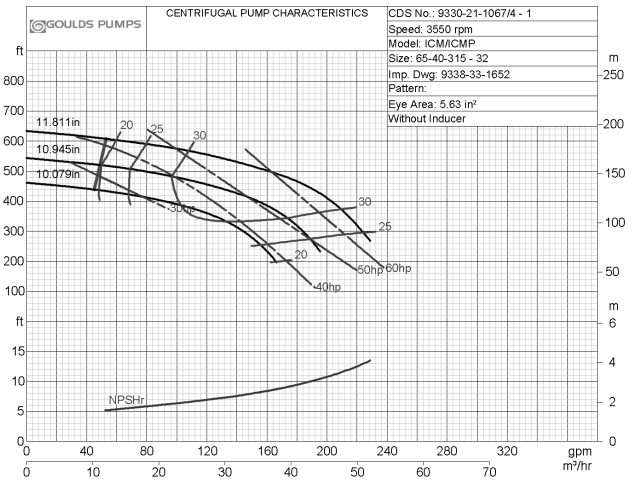
125-80-250 **1750rpm**



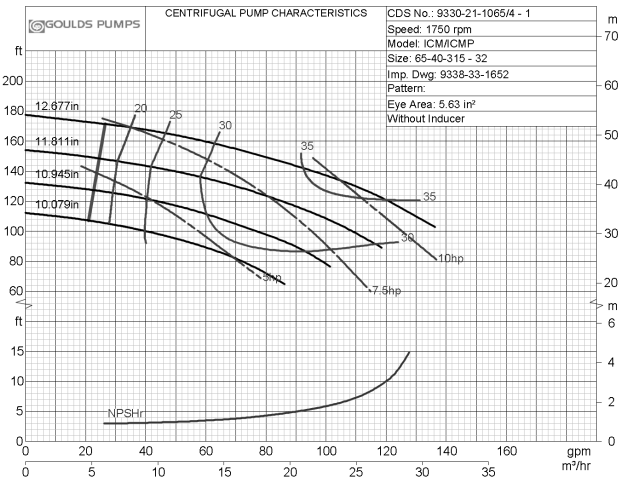
50-32-315 **3500rpm**



50-32-315 **1750rpm**



65-40-315 **3550rpm**



65-40-315 **1750rpm**

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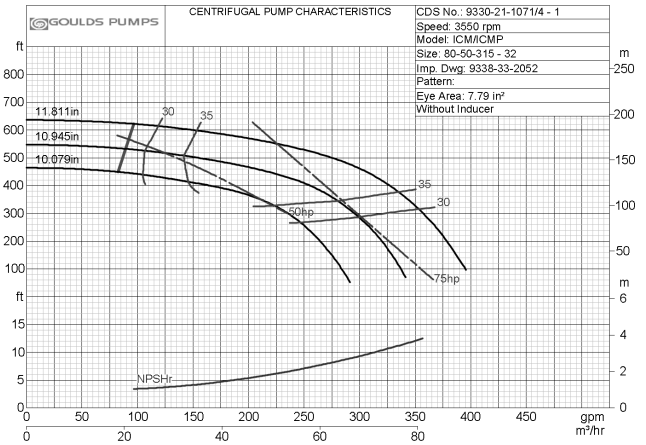
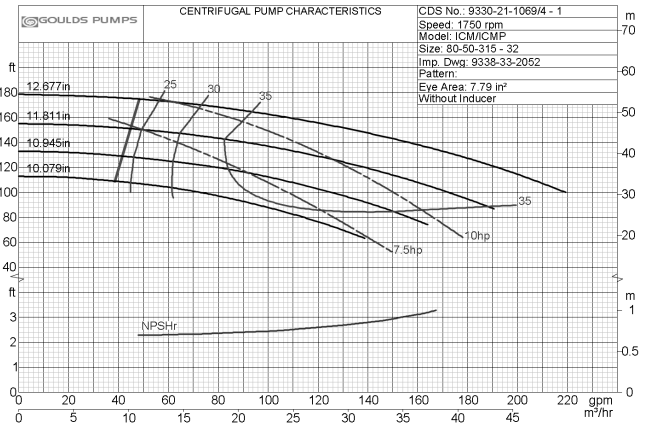


80-50-315 **3550rpm**



80-50-315 **1750rpm**

The "Veteran" vertical sump and process pump. Thousands of installations—industrial process, sump drainage, corrosive liquids, pollution control, molten salts—attest to the 3171's remarkable performance. Simple mounting .

Goulds Model 3171

Vertical Sump and Process Pumps Designed for the Total Range of Industry Services

- Capacities to 3180 GPM (722 m^3/h)
- Heads to 344 feet (105 m)
- Temperatures to 450° F (232° C)
- Pit Depths to 20 feet (6 m)

Design Features

- Self-Priming
- Rugged Double Row Thrust Bearing
- Heavy Duty One-piece Shaft
- External Impeller Adjustment
- Available in a Wide Range of Alloys
- Open Impeller Design
- Vapor Proof Option: Choice of packing, or mechanical seal for containing sump vapors

Services

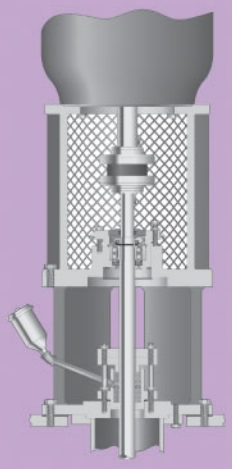
- Industrial Process
- Industrial Sump Wastes
- Molten Sulfur
- Tank Unloading
- Corrosive and Non-Corrosive Liquids

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3171 Vertical Sump and Process Pumps

Heavy Duty Design Features for a Wide Range of Services

LABYRINTH BEARING SEAL
Prevents premature bearing failure due to lubricant contamination.



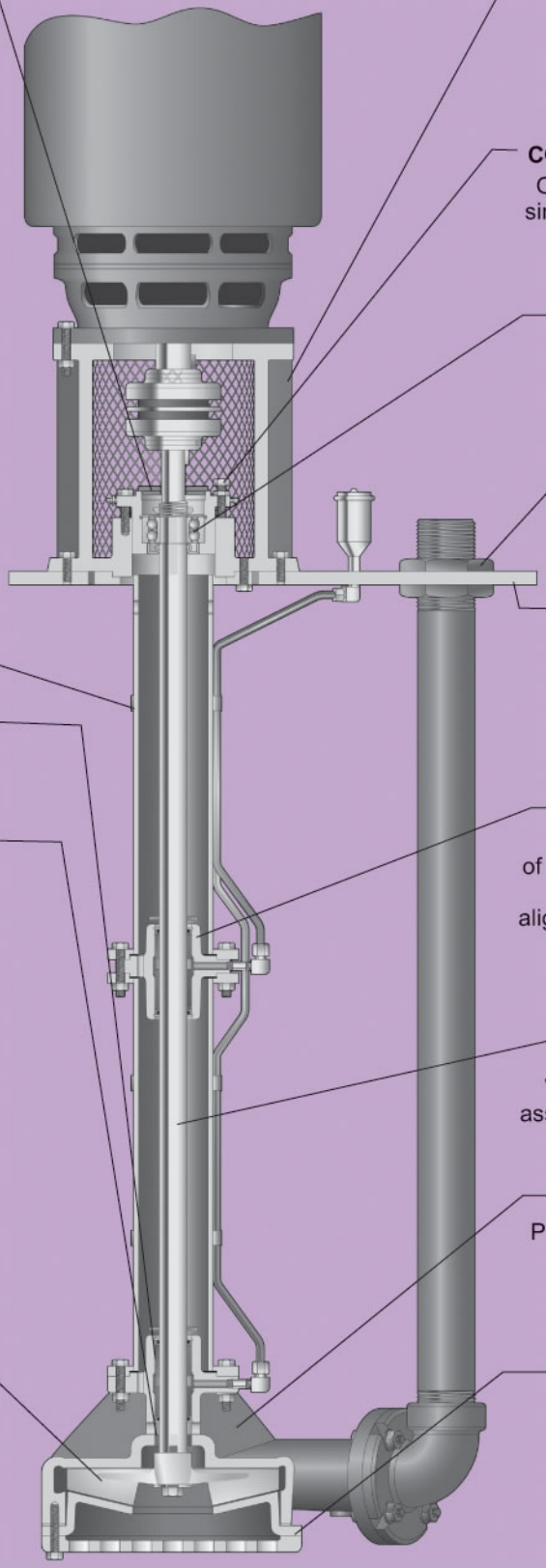
OPTIONAL UPPER STUFFING BOX

HEAVY COLUMN PIPE
Provides rigid support for pump and bearings.

LINESHAFT STEADY BEARING
Self-lubricating carbon/graphite bearing furnished as standard—best for handling water, corrosives, solvents and high temperature liquids.

RESTRICTOR BUSHING
Close running bushing to prevent pressure loss from casing.

FULLY OPEN IMPELLER WITH BACK PUMP-OUT VANES
Acknowledged best design for process services—solids handling, stringy material, corrosives, abrasives.



C-FACE MOTOR MOUNTING
Accommodates readily available C-face motors. Also available for P-base and IEC motors.

CONTINUOUS HIGH PERFORMANCE
Original high efficiency maintained by simple external adjustment resulting in long-term energy savings.

DOUBLE ROW THRUST BEARING
Grease lubricated—carries pump thrust load; sealed for outdoor installation.

DISCHARGE LOCKED TO PUMP SUPPORT PLATE FOR STRENGTH

ANY MOUNTING REQUIREMENTS
Met by support plate and optional pit cover. Float switches, alternators and other control devices can be easily mounted.

STEADY BEARING HOUSING
Precision machined register fit of column, bearing housing and casing assures positive bearing and shaft alignment. Completely interchangeable with all lineshaft bearing options.

HEAVY DUTY ONE-PIECE SHAFT
With closely spaced steady bearings assures long life and low maintenance.

HEAVY DUTY CASING
Provides rigid support for shaft–closer to impeller load–resulting in longer steady bearing life.

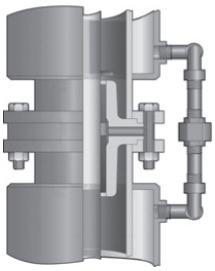
REMOVABLE SUCTION COVER
Replaceable wear part for low operational costs.

Optional Features for Application Flexibility

Goulds offers a variety of options to meet users' specific plant and application requirements. Your Goulds representative will be glad to recommend the features best suited to your particular service conditions to assure safe, efficient and reliable operation.

Molten Sulfur Pumps

- Jacketed column and discharge pipes (tested to 150 PSIG [1034 kPa])
- Available in all principal alloys
- One-piece, self-lubricating, graphite impregnated steady bearing
- Vapor-proof construction to seal sump vapors
- Balanced, low NPSH, semi-open impeller for optimum performance
- Multiple intermediate bearings permit overall settings to 20 feet (6 m)

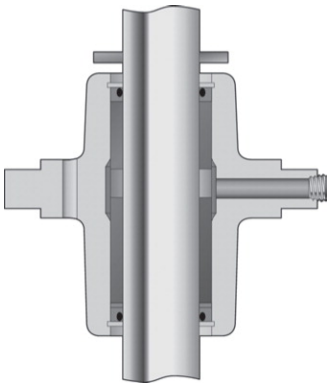


JACKETED COLUMN

JACKETED DISCHARGE PIPE

Abrasive Liquids

Goulds sealed bearing arrangement is recommended for applications where abrasive solids are in the pumpage and no clean flush is available. A carbon bearing and lip seal is used for sealing the bearing housing. Spring loaded grease cup is provided.



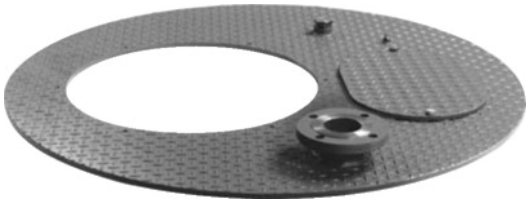
SEALED BEARING ARRANGEMENT

Optional Bearings

Goulds offers the best choice of steady bearings to meet service requirements... optional fluted rubber with rigid shell, bronze, and (standard) carbon.

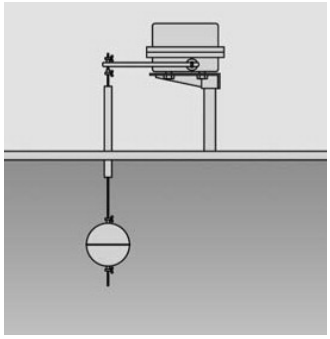
Mounting Systems

Goulds can provide optional mounting systems to meet specific user requirements including pit covers fabricated with float control mounting points, man holes for access, vapor-proof designs, and lube line holes.

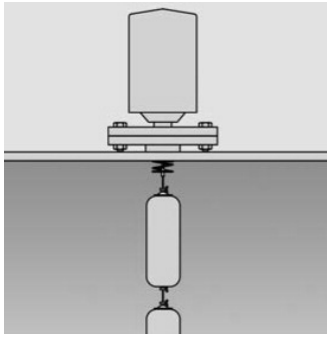


Float Controls

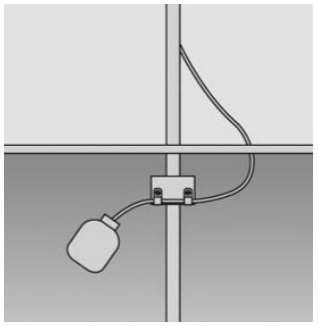
The widest range of float controls is offered to suit the individual requirements of every installation. Ask your Goulds representative for a complete list of options.



BALL-OPERATED FLOAT SWITCH



DISPLACER TYPE LIQUID LEVEL SWITCH



PIPE-MOUNTED, DIRECT ACTING FLOAT SWITCH

Other Options

- Complete line of controls and starters
- Enclosed lineshaft
- Other types of float controls
- ANSI tank mounting
- Flanged discharge connections

3171 Parts List and Materials of Construction

		Material					
Item Number	**Part Name**	**Cast Iron**	**Bronze Fitted**	**Carbon Steel**	**316SS**	**Alloy 20**	**Hastelloy B & C**
100	Casing	Cast Iron		Steel	316SS	Alloy 20	Hastelloy
101	Impeller	Ductile Iron	Bronze	Steel	316SS	Alloy 20	Hastelloy
105	Upper Stuffing Box Lantern Ring	Teflon					
106	Upper Stuffing Box Packing	Acrylic Graphite					
107	Upper Stuffing Box Gland	316SS					
112	Ball Bearing	Double Row Angular Contact					
122	Pump Shaft	Steel			316SS	Alloy 20	Hastelloy
123	Deflector	EPDM					
134	Bearing Shell	Cast Iron					
136	Bearing Locknut	Steel					
178	Impeller Key	316SS				Alloy 20	Hastelloy
155	Restrictor Bushing	Carbon-Filled Teflon ®					
182	Suction Cover	Cast Iron		Steel	316SS	Alloy 20	Hastelloy
187	Strainer	Cast Iron		316SS		Alloy 20	Hastelloy
189	Pump Support Plate	Steel					
190	Lubrication or Flush Pipe	Steel		316SS		Alloy 20	Hastelloy
192	Head Column	Steel			316SS	Alloy 20	Hastelloy
195	Discharge Pipe	Steel			316SS	Alloy 20	Hastelloy
197	Steady Bearings	Carbon					
198	Impeller Screw	316SS				Alloy 20	Hastelloy
199	Impeller Washer	316SS				Alloy 20	Hastelloy
213	Steady Bearing Housing	Cast Iron			316SS	Alloy 20	Hastelloy
221	Upper Stuffing Box (When Used)	Cast Iron					
240	Motor Support	Cast Iron					
242	Pipe Collar (Discharge Pipe)	Steel			316SS	Alloy 20	Hastelloy
306	Column Extension	Steel			316SS	Alloy 20	Hastelloy
315	Discharge Elbow	Cast Iron		Steel	316SS	Alloy 20	Hastelloy
332A	Labyrinth Seal	Carbon-Filled Teflon ® with Viton O-ring					
351	Gasket—Suction Cover to Casing	Nitrile Acrylic					
369	Retaining Ring—Steady Bearing	Stainless				Alloy 20	Hastelloy

Construction Details All dimensions in inches and (mm).

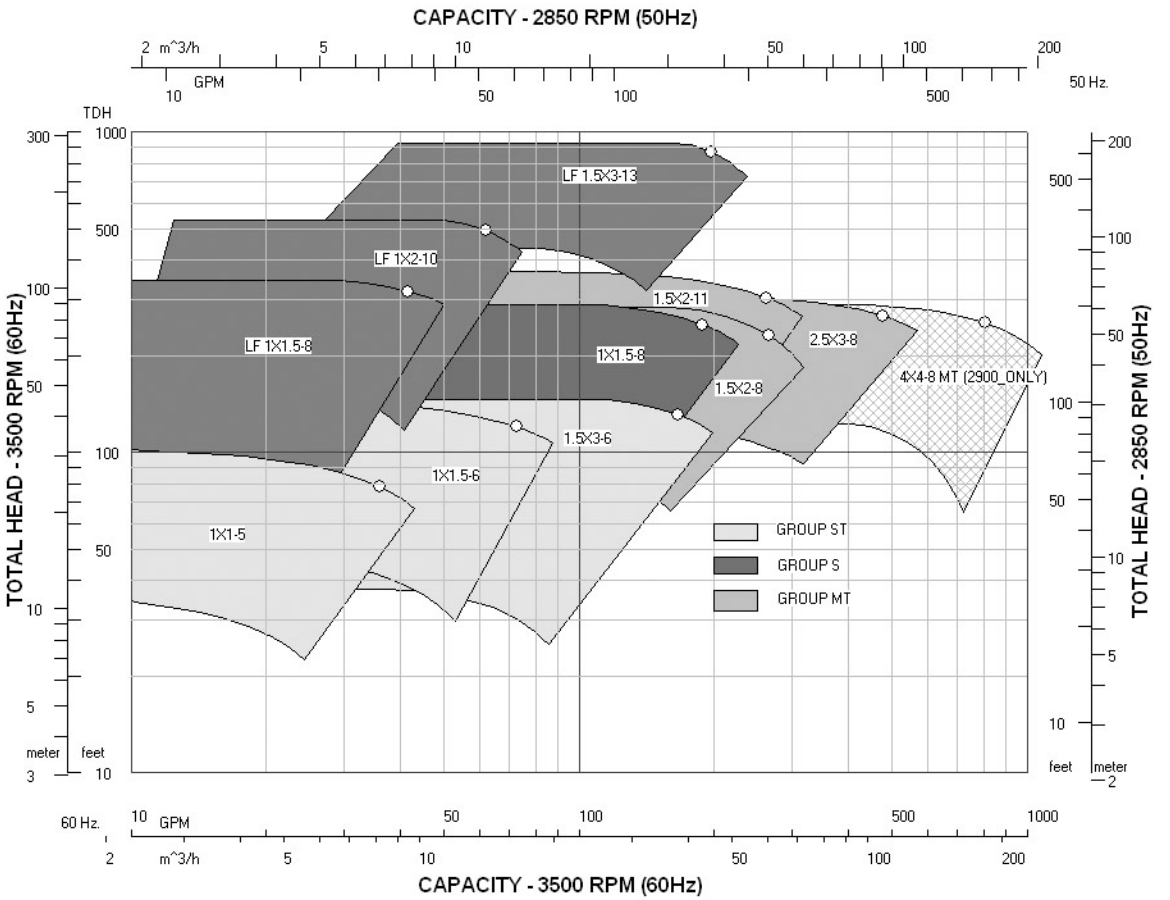
		ST			S						S/MT		MT	
		1X1-5	1X1.5-6	1.5X3-6	1X1.5-8	1.5X2-8	2.5X3-8	4X4-8	1.5X2-11	2.5X3-11	1.5X2-11	4X4-8	1.5X2-8	2.5X3-8
Pump	Weight (2 Foot Depth)	275	280	295	305	315	325	390	385	425	385	390	325	335
	Less Motor Lb (kg)*	(125)	(127)	(134)	(139)	(143)	(138)	(177)	(175)	(193)	(175)	(177)	(148)	(152)
	Weight--Add to Each 6"	13	14	15	14	14	15	17	14	15	14	17	14	15
	of Length Lb (kg)*	(6)	(6)	(7)	(6)	(6)	(7)	(8)	(6)	(7)	(6)	(8)	(6)	(7)
	Maximum Diameter	0.188	0.250	0.500	0.281	0.281	0.938	0.938	0.344	0.594	0.344	0.938	0.281	0.938
	of Solids	(5)	(6)	(13)	(7)	(7)	(24)	(24)	(9)	(15)	(9)	(24)	(7)	(24)
Shaft	Diameter at Impeller	0.6875 (17)			Tapered 1.1118 (28) Large End						Tapered 1.1118 (28) Large End		Tapered 1.585 (40) Large End	
	Diameter at Coupling End	0.875 (22)									1.375 (35)			
	Diameter at Steady Bearing	1.125 (29)											1.625 (41)	
Bearings	Ball Bearing	5305 or Equal												
	Steady Bearing	1.125 I.D.x1.625 O.D.									1.125 I.D.x1.625 O.D.		1.625 I.D.X2.125 O.D.	
	(Sleeve Type)	(29x41)									(29X41)		(41X54)	
General	Maximum Total Working	150 PSI												
	Pressure--Casing	(1035 kPa)												
	Max. Liquid Temp.--	210°F												
	Without Upper Stuffing Box	(99°C)												
	Max. Liquid Temp.--	450°F												
	Upper Stuffing Box	(232°C)												

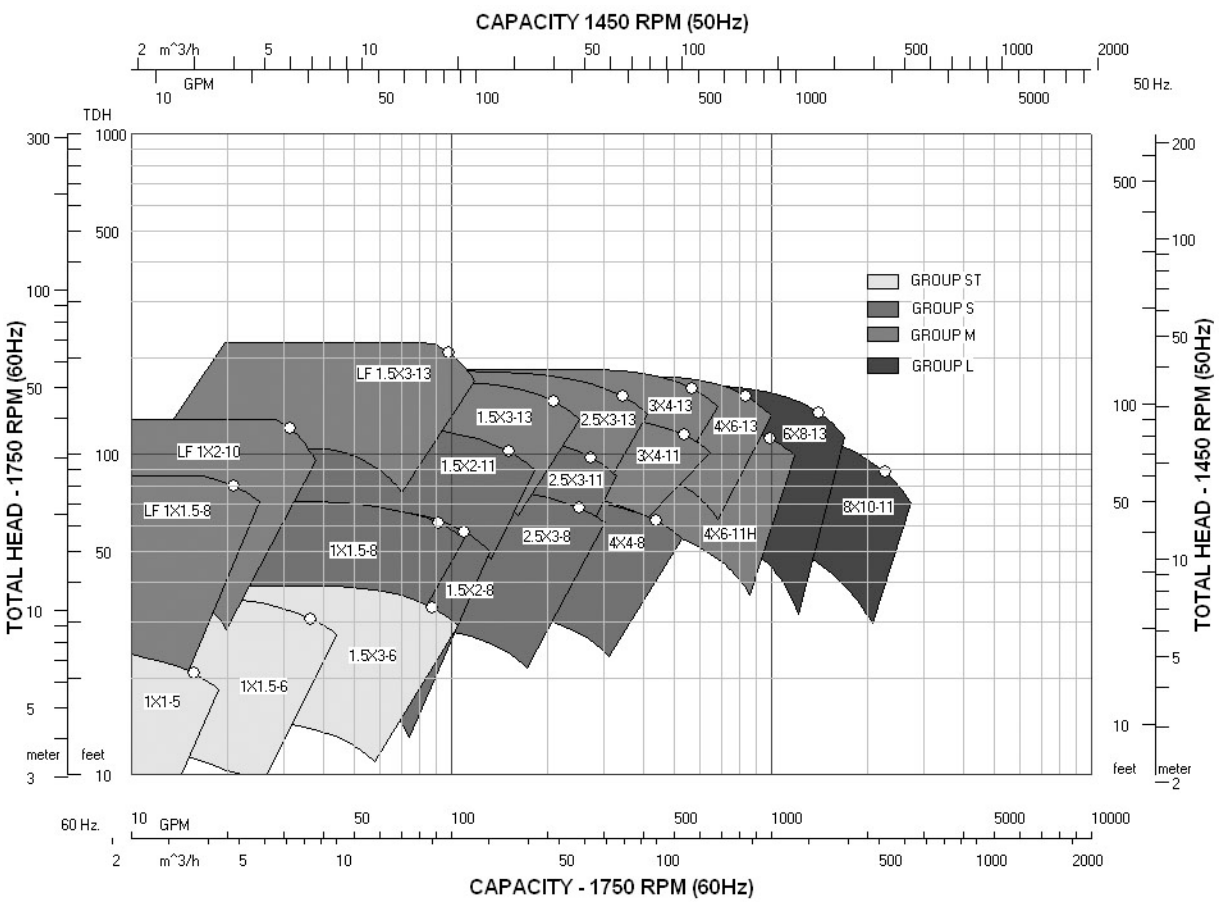
Construction Details All dimensions in inches and (mm).

		M										L		
			3X4-11	4X6-11H	1.5X3-13	2.5X3-13	3X4-13	4X6-13	LF 1X1.5-8	LF 1X2-10	LF1.5X3-13M	LF1.5X3-13L	6X8-13	6X8-13
Pump	Weight (2 Foot Depth)		540	590	535	550	570	600	305	385	550	550	830	910
	Less Motor Lb (kg)*		(245)	(268)	(243)	(250)	(259)	(273)	(139)	(175)	(250)	(250)	(377)	(414)
	Weight--Add to Each 6"		20	20	19	19	20	20	14	15	19	19	35	40
	of Length Lb (kg)*		(9)	(9)	(9)	(9)	(9)	(9)	(6)	(7)	(9)	(9)	(16)	(18)
	Maximum Diameter		0.594	1.125	0.250	0.594	0.594	0.594	0.250	0.250	0.250	0.250	0.594	1.188
	of Solids		(15)	(13)	(6)	(15)	(15)	(15)	(6)	(6)	(6)	(6)	(15)	(30)
Shaft	Diameter at Impeller	Tapered 1.585 (40) Large End							Tapered			Tapered 2.222 (56) Large End		
									0.75 (19)	1 (25.4)	1.25 (31.75)			
	Diameter at Coupling End	1.375 (35)										1.875 (48)		
	Diameter at Steady Bearing	1.625 (41)										2.25 (57)		
Bearings	Ball Bearing	5308 or Equal										5311 or Equal		
	Steady Bearing	1.625 I.D.x2.125 O.D.										2.25 I.D.x3.3 O.D.		
	(Sleeve Type)	(41x54)										(57x75)		
General	Maximum Total Working	150 PSI							250 PSI		450 PSI	450 PSI	150 PSI	
	Pressure--Casing	(1035 kPa)							(1724 kPa)		(3102 kPa)	(3102 kPa)	(1035 kPa)	
	Max. Liquid Temp.--	210°F												
	Without Upper Stuffing Box	(99°C)												
	Max. Liquid Temp.--	450°F												
	Upper Stuffing Box	(232°C)												

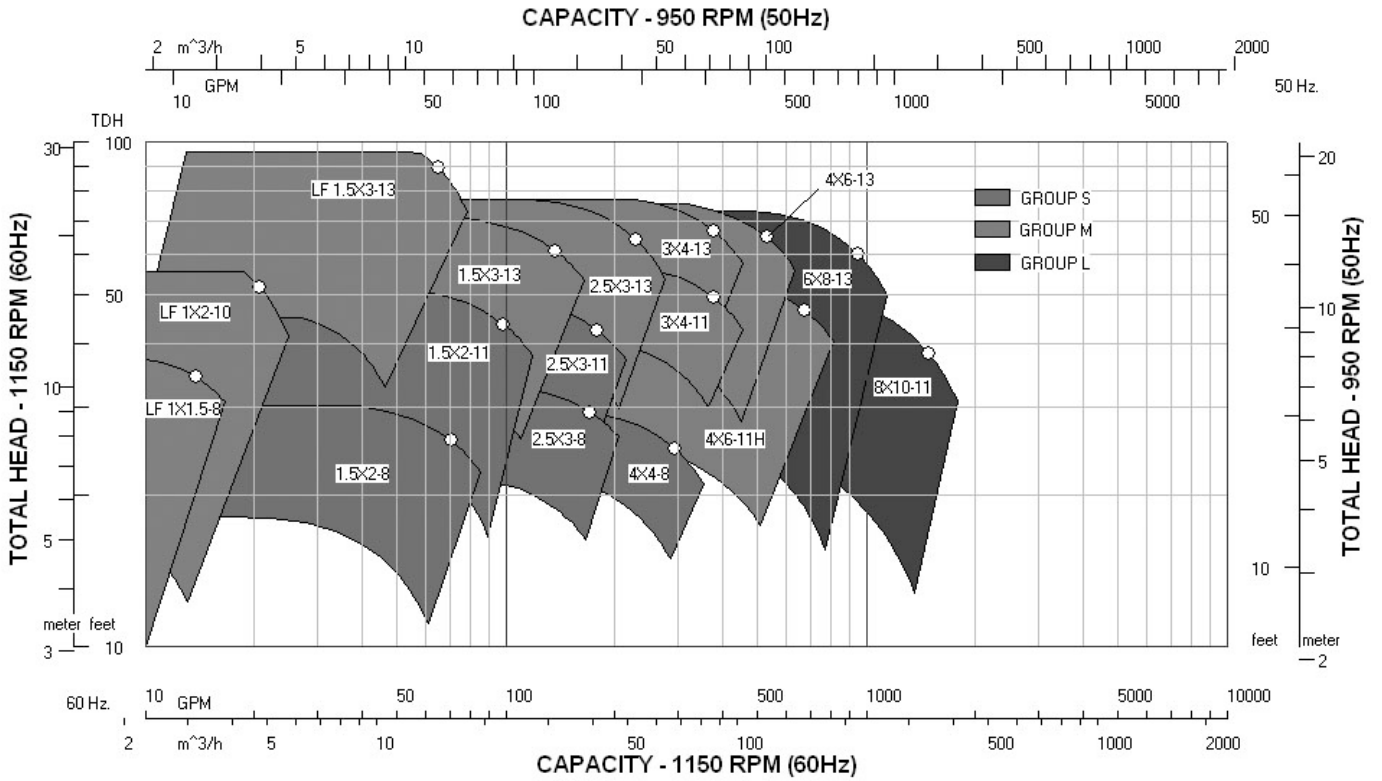
* L Group Pump Weights are based on a 3ft (.9m) Setting

3171 Hydraulic Coverage





3171 Hydraulic Coverage

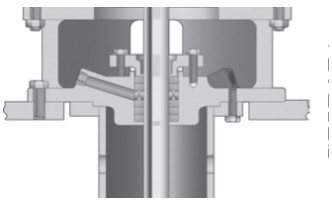


Maximum Sealing Flexibility

Vapor-Proof Construction

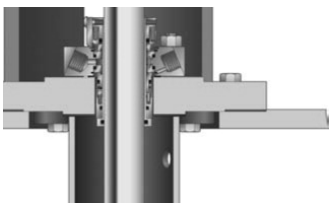
Optional upper stuffing box allows use of wide range of sealing arrangements to meet specific user requirements for sealing toxic, hazardous, noxious or corrosive fumes. With this option, the discharge pipe and all fittings are sealed at the support plate.

Your Goulds representative will gladly recommend the best sealing solution for your service, some of which are illustrated here.



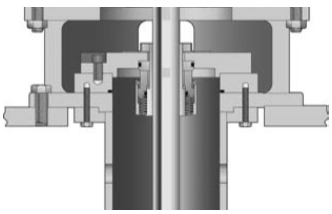
PACKED BOX

Standard vapor-proof sealing option. Includes packing, lantern ring and grease lubricator (not illustrated).



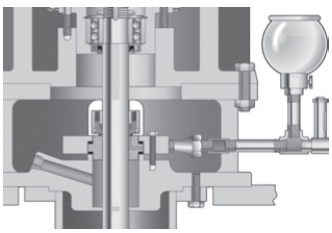
DOUBLE CARTRIDGE SEAL

Available in wet or dry versions to control emissions.



DRY RUNNING SEAL

Dry running, non-contacting cartridge gas seal. Pressurized air barrier between seal faces prevents vapor leakage.

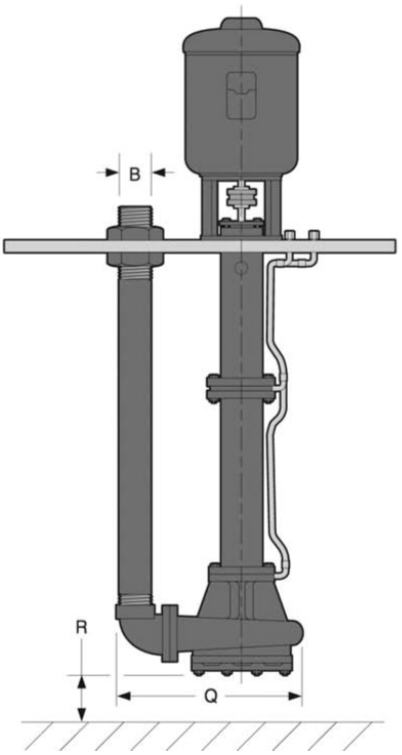


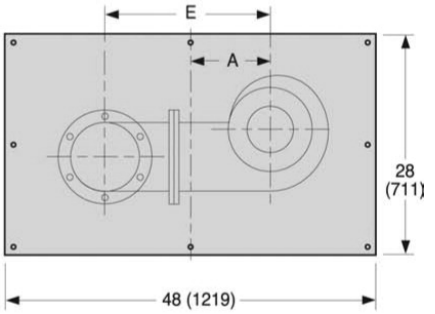
SINGLE OUTSIDE SEAL

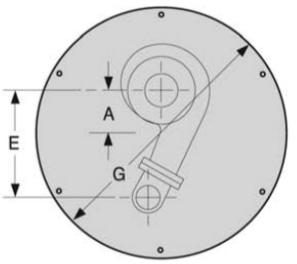
Mechanical seal with oil lubricator and sight glass. Outside mount has no metal parts in contact with vapors.

Dimensions Model 3171

All dimensions in inches and (mm). Not to be used for construction.







DIMENSIONS

	ST			S						S/MT		MT	
	1×1-5	1X1.5-6	1.5X3-6	1X1.5-8	1.5X2-8	2.5X3-8	4X4-8	1.5X2-11	2.5X3-11	1.5X2-11	4X4-8	1.5X2-8	2.5X3-8
A	3.6 (92)	3.6 (92)	3.6 (92)	3.6 (92)	3.6 (92)	3.6 (92)	4 (102)	4 (102)	4 (102)	4 (102)	4 (102)	4 (102)	4.5 (114)
B	1.5 (38)	2 (51)	3 (76)	2 (51)	2 (51)	3 (76)	4 (102)	2 (51)	3 (76)	3 (76)	4 (102)	3 (76)	4 (102)
E	8.1 (205)	8.4 (213)	9.2 (232)	10.1 (256)	9.6 (244)	10.3 (262)	12.1 (306)	11.4 (289)	12.1 (306)	12.37 (314)	12.1 (362)	11.4 (289)	13.6 (346)
G	22 (559)	22 (559)	22 (559)	22 (559)	22 (559)	22 (559)	26.5 (673)	26.5 (673)	26.5 (673)	31 (787)	26.5 (673)	26.5 (673)	31 (787)
R	6 (152)	5.8 (147)	5.3 (135)	4.3 (109)	4.4 (112)	3.8 (97)	3.3 (84)	4.6 (117)	4.2 (107)	4.56 (116)	3.3 (84)	4.4 (112)	3.8 (97)
Q *	14.3 (362)	15.3 (387)	16.8 (425)	17 (432)	17 (432)	18.5 (467)	22.5 (572)	20.5 (521)	22.5 (572)	22 (599)	22.5 (572)	20 (508)	22.8 (578)

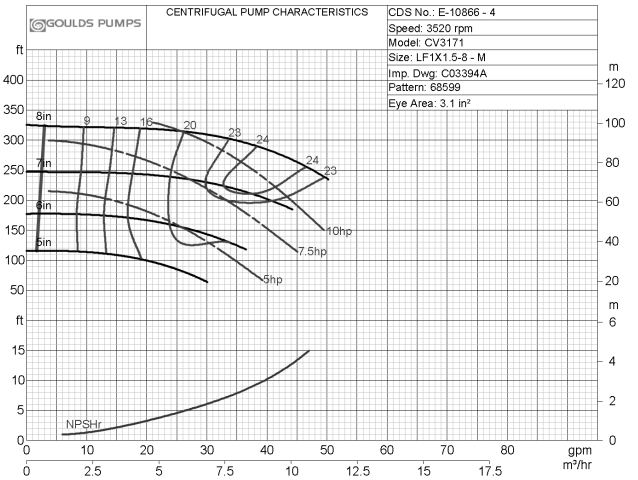
*Add 3 in. (76) for float mounted option.

DIMENSIONS

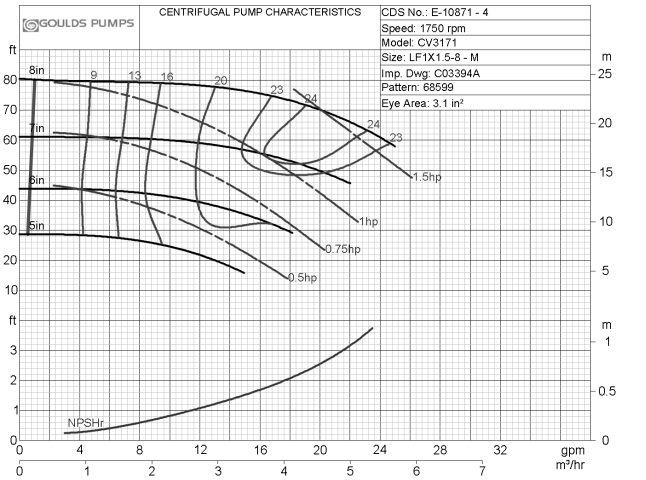
	M									L				
	3X4-11	4X6-11H	1.5X3-13	2.5X3-13	3X4-13	4X6-13	LF 1X1.5-8	LF 1X2-10	LF1.5X3-13M	LF1.5X3-13L	6X8-13	6X8-13	8X10-11	8X10-11
A	4.5 (114)	4.5 (114)	4.5 (114)	4.5 (114)	4.5 (114)	4.5 (114)	2.88 (73)	4 (102)	2.75 (70)	2.75 (70)	10.4 (264)	10.4 (264)	10.4 (264)	10.4 (264)
B	4 (102)	4 (102)	3 (76)	3 (76)	4 (102)	4 (102)	2 (51)	2 (51)	2 (51)	2 (51)	6 (152)	8 (203)	8 (203)	10 (254)
E	12.8 (325)	14.3 (362)	13.6 (346)	13.2 (335)	13.8 (351)	14.8 (375)	9.54 (242)	11.5 (292)	14 (356)	14 (356)	21.5 (546)	21.5 (546)	24.3 (616)	24.3 (616)
G	31 (787)	31 (787)	31 (787)	31 (787)	31 (787)	31 (787)	22 (559)	31 (787)	31 (787)	31 (787)	--	--	--	--
R	4 (102)	3.7 (94)	4.8 (122)	4.7 (119)	4.3 (109)	3.7 (94)	6.19 (157)	5.44 (138)	5.44 (138)	5.44 (138)	6.9 (175)	6.9 (175)	5.3 (135)	5.3 (135)
Q *	24 (610)	26.5 (673)	25 (635)	25 (635)	25.5 (648)	27.5 (699)	17 (432)	19.8 (503)	23.8 (605)	23.8 (605)	38.5 (978)	39.5 (1003)	42.5 (1080)	43.5 (1105)

* Add 3 in. (76) for float mounted option.

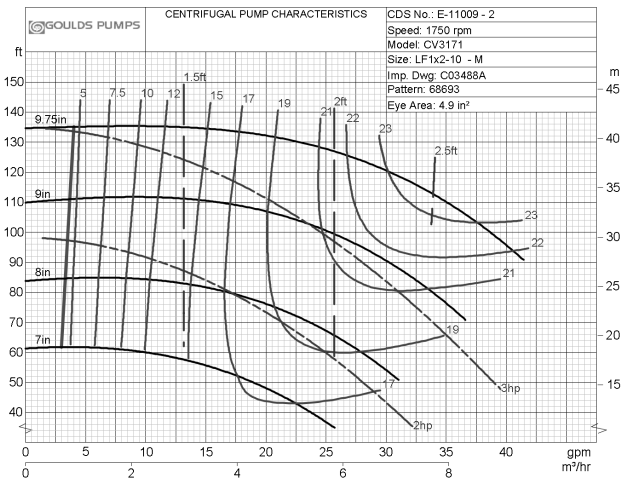
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



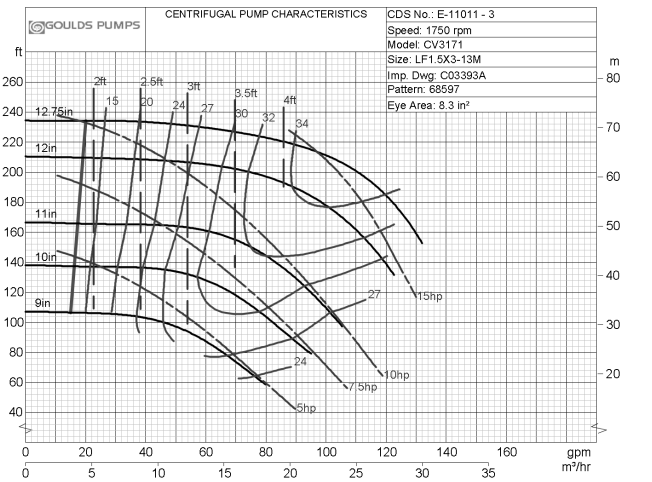
LF1X1.5-8 **3520rpm**



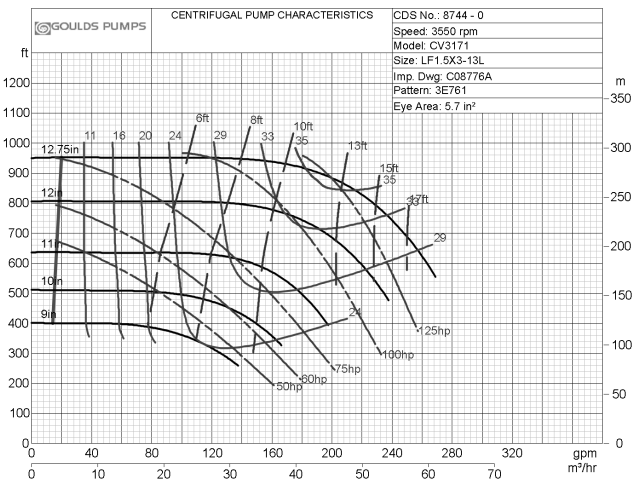
LF1X1.5-8 **1750rpm**



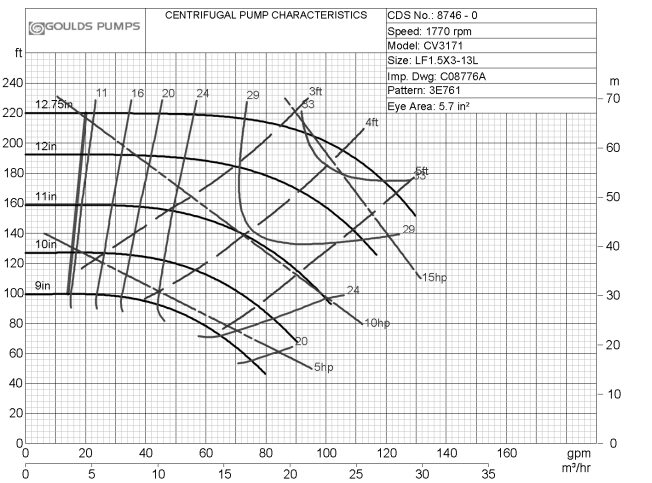
LF1x2-10 **1750rpm**



LF1.5X3-13M **1750rpm**

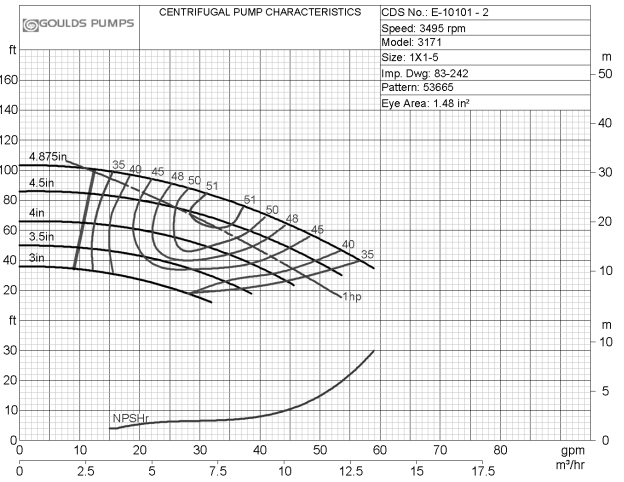


LF1.5X3-13L **3550rpm**

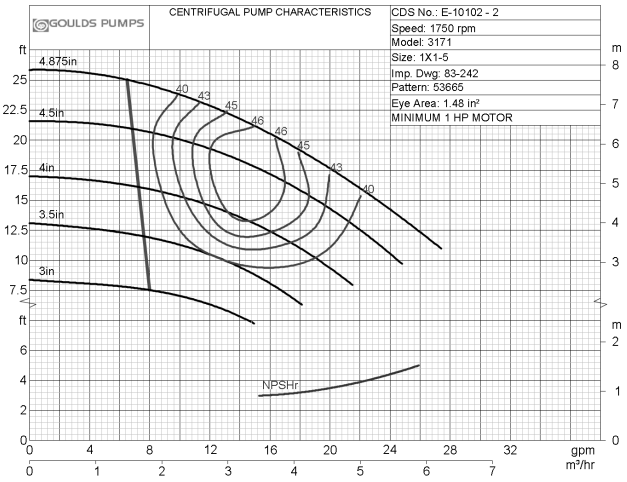


LF1.5X3-13L **1770rpm**

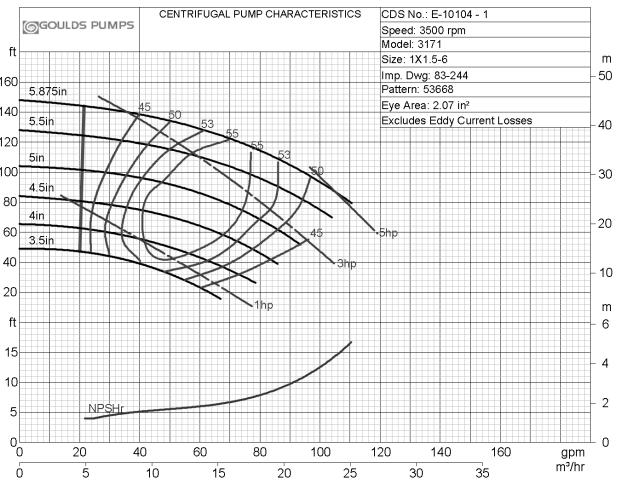
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



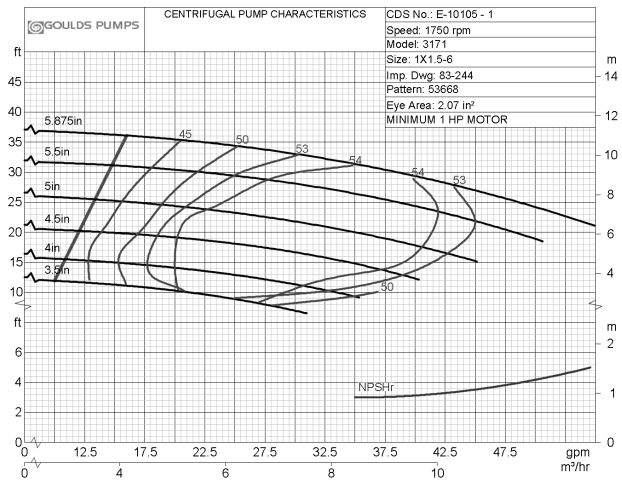
1X1-5 **3495rpm**



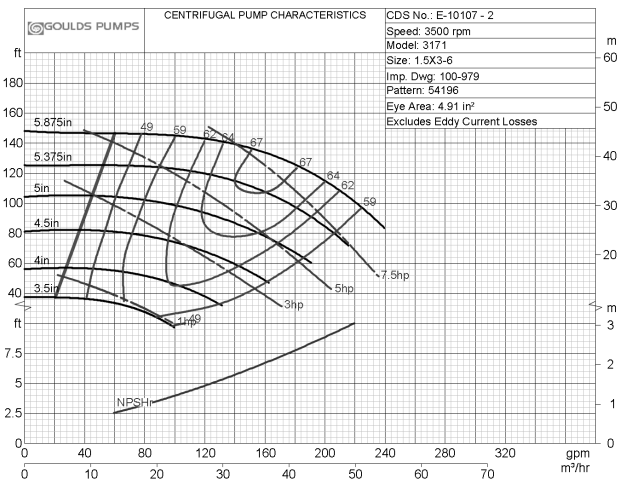
1X1-5 **1750rpm**



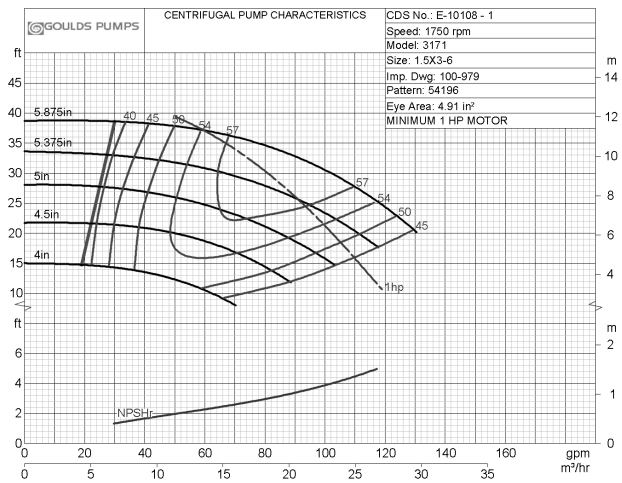
1X1.5-6 **3500rpm**



1X1.5-6 **1750rpm**

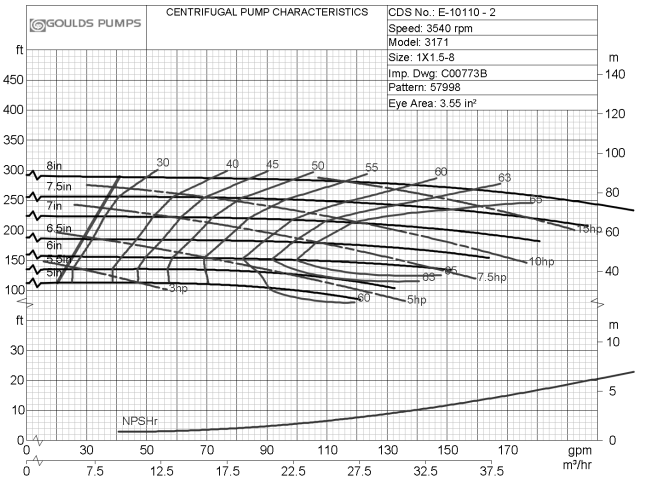


1.5X3-6 **3500rpm**

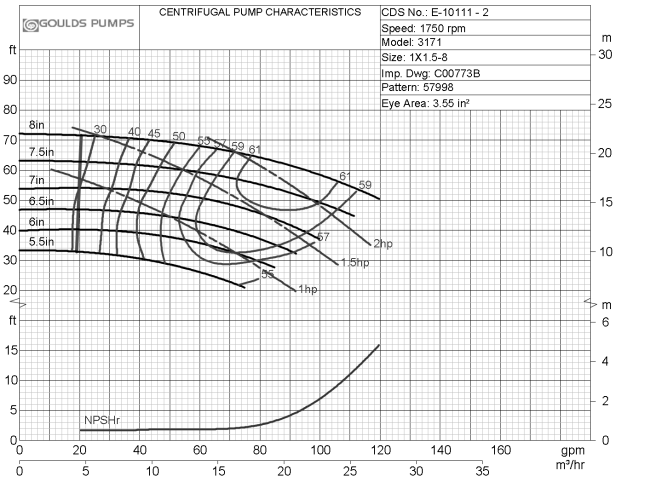


1.5X3-6 **1750rpm**

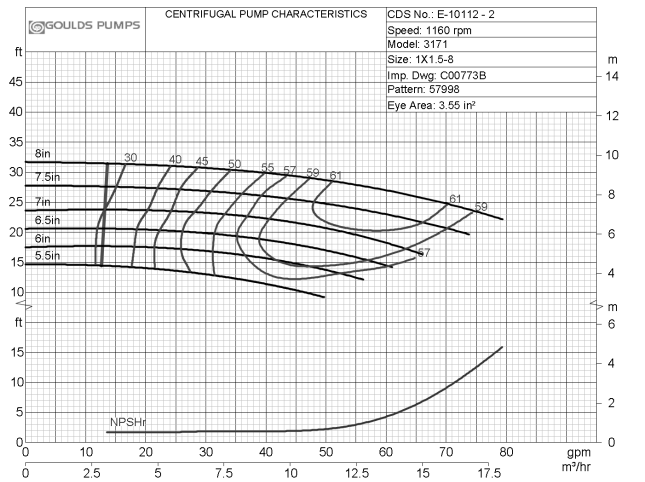
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



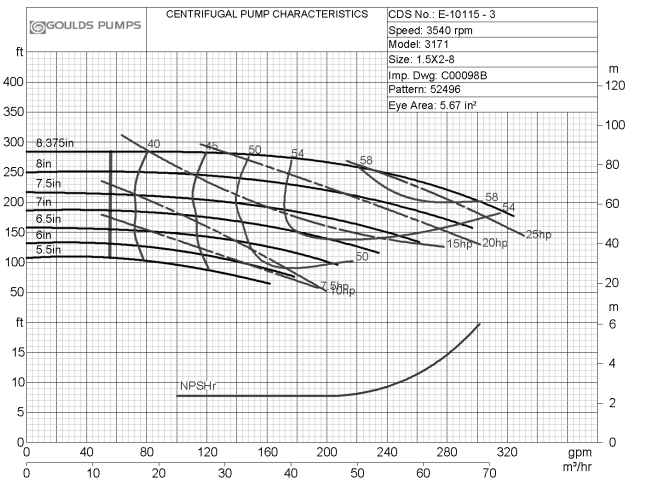
1X1.5-8 **3540rpm**



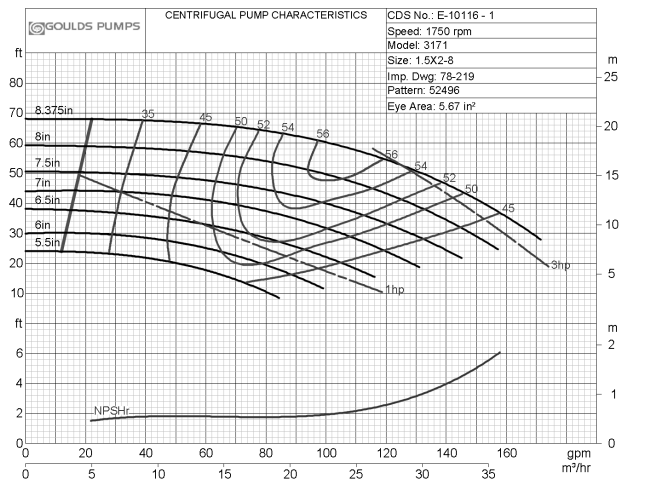
1X1.5-8 **1750rpm**



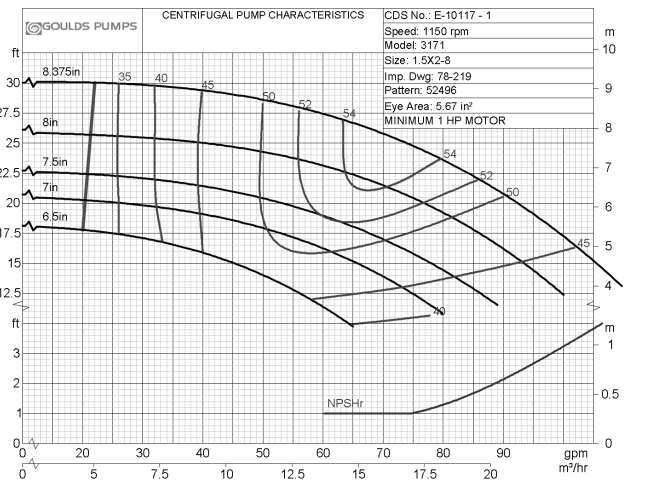
1X1.5-8 **1160rpm**



1.5X2-8 **3540rpm**



1.5X2-8 **1750rpm**

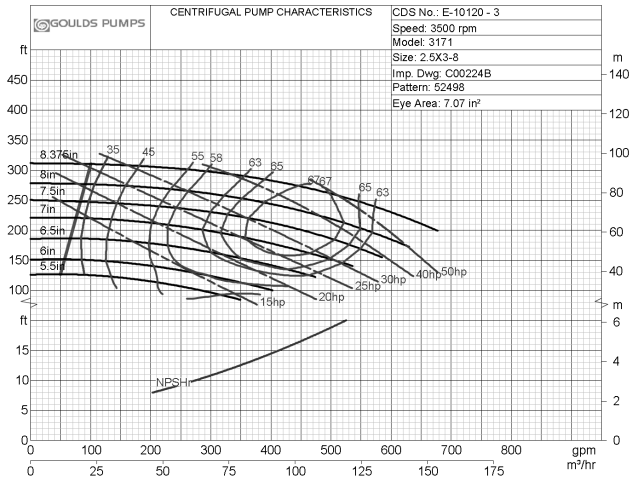


1.5X2-8 **1150rpm**

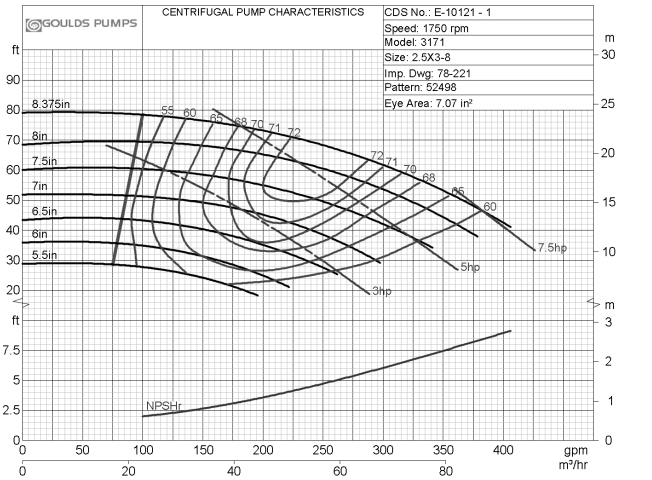
60Hz Curves

Model 3171

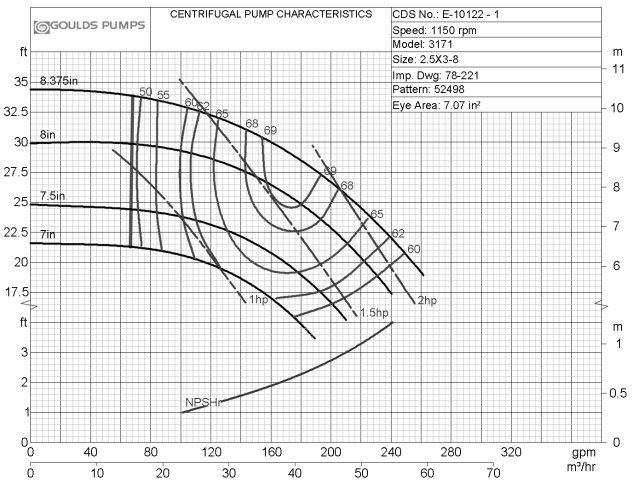
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



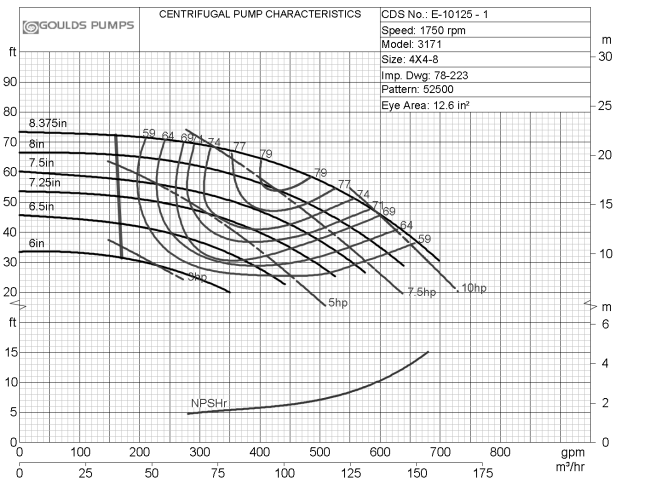
2.5X3-8 **3500rpm**



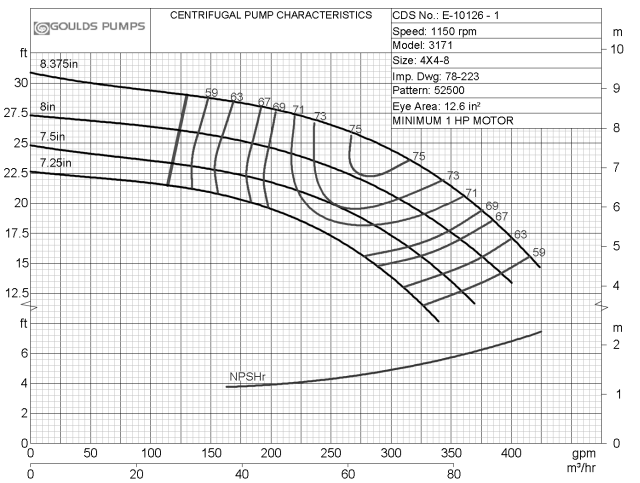
2.5X3-8 **1750rpm**



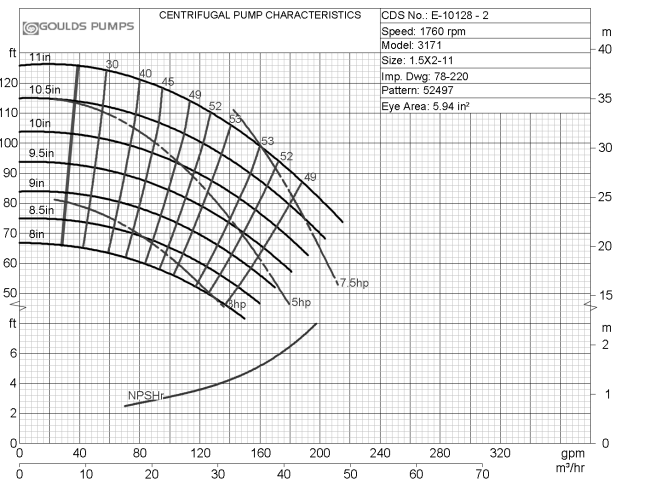
2.5X3-8 **1150rpm**



4X4-8 **1750rpm**

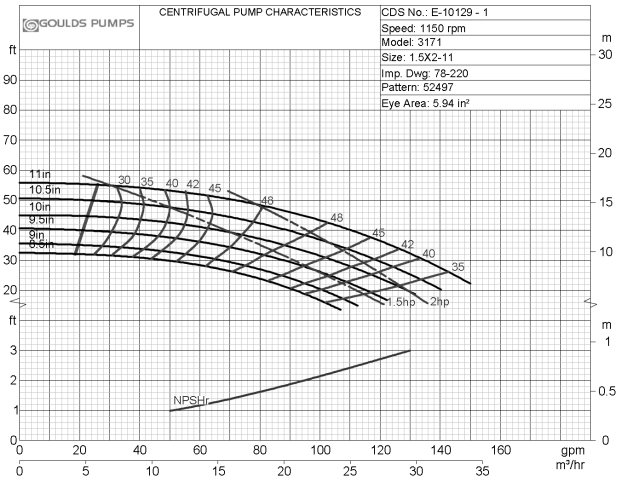


4X4-8 **1150rpm**

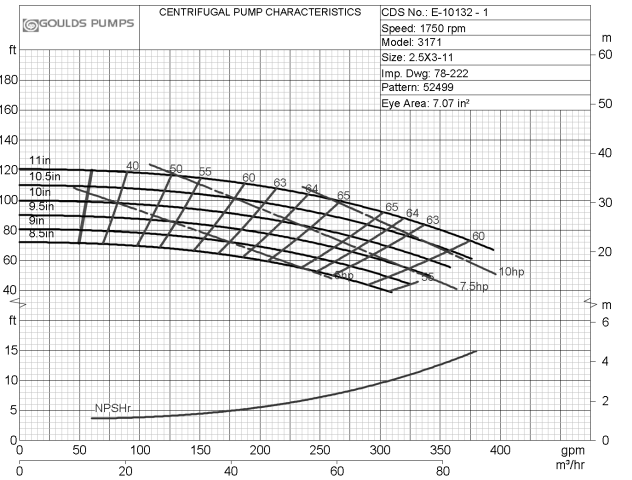


1.5X2-11 **1760rpm**

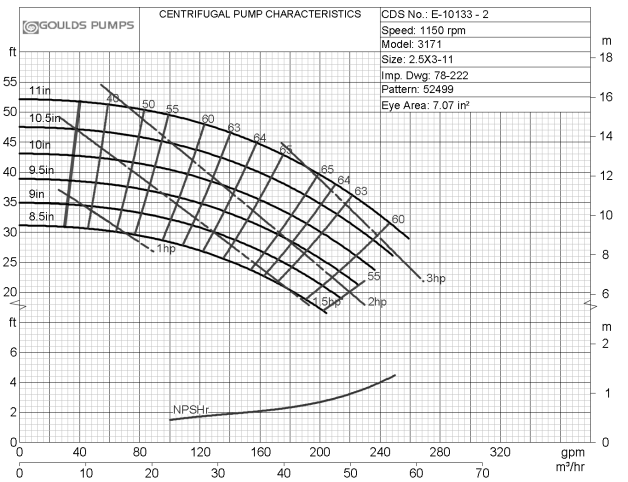
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



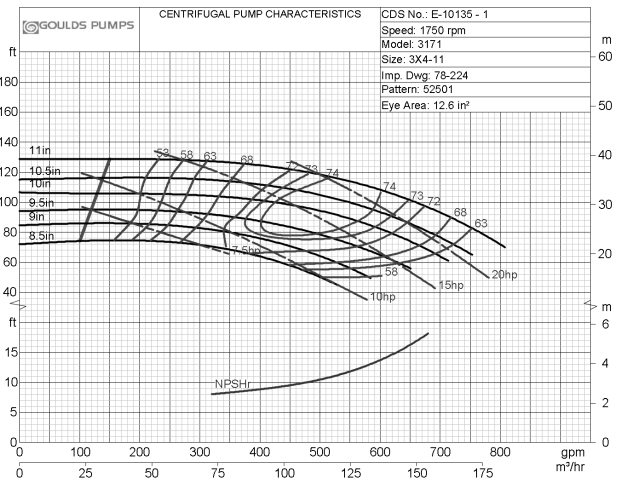
1.5X2-11 **1150rpm**



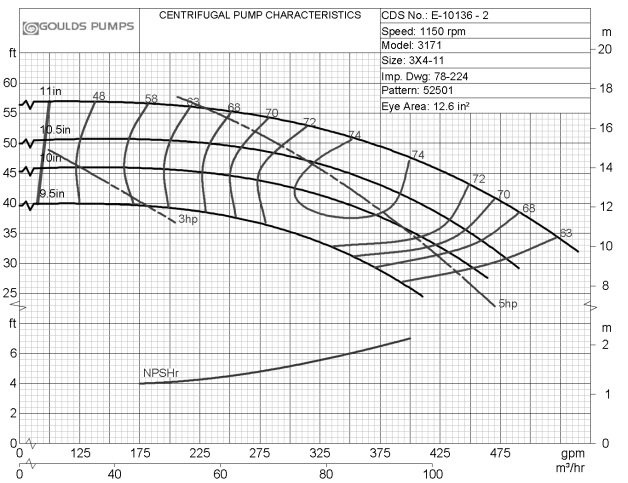
2.5X3-11 **1750rpm**



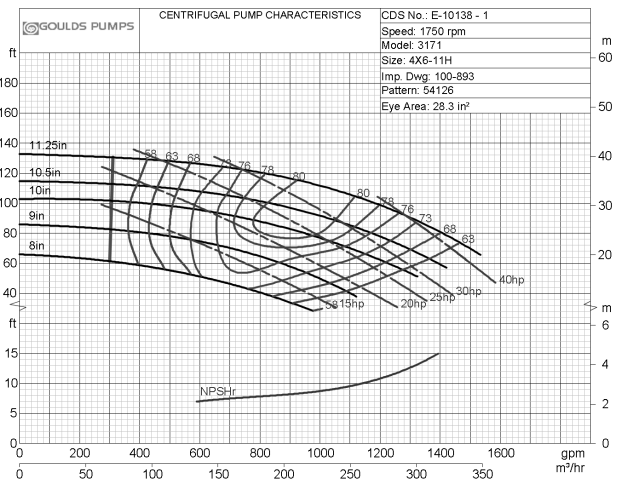
2.5X3-11 **1150rpm**



3X4-11 **1750rpm**



3X4-11 **1150rpm**

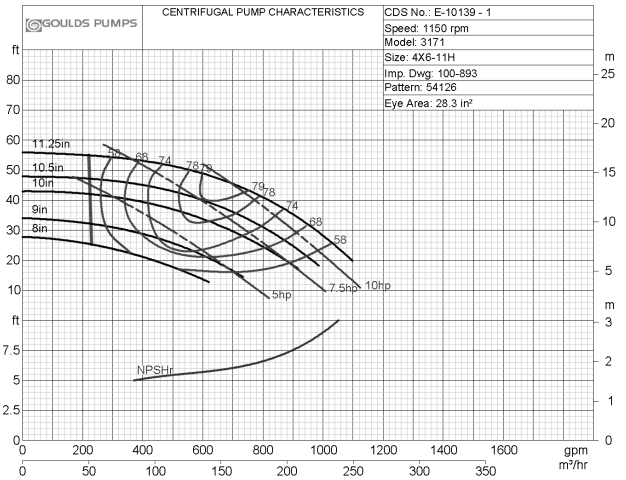


4X6-11H **1750rpm**

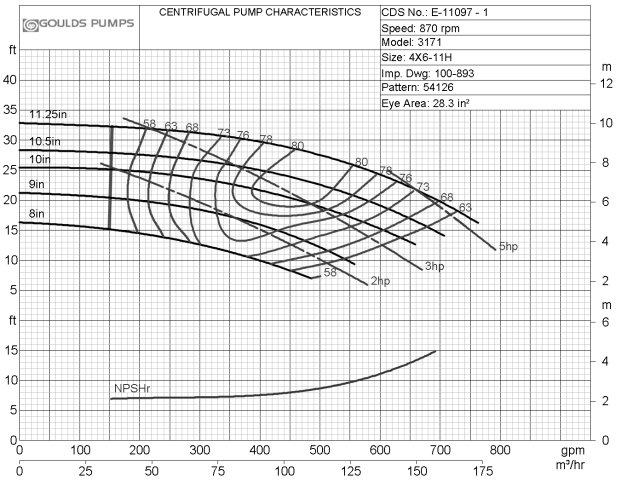
60Hz Curves

Model 3171

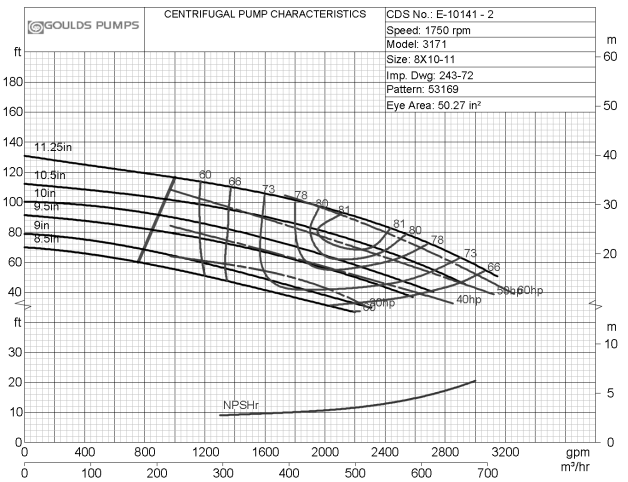
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



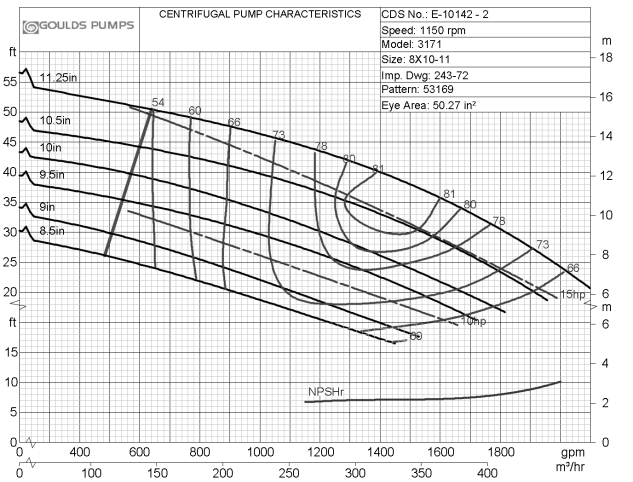
4X6-11H **1150rpm**



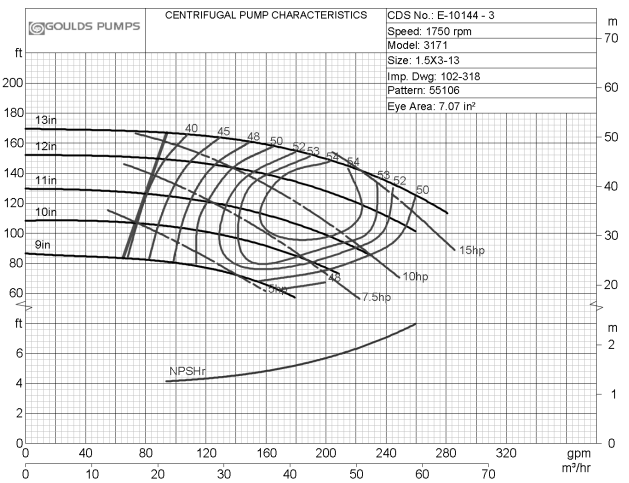
4X6-11H **870rpm**



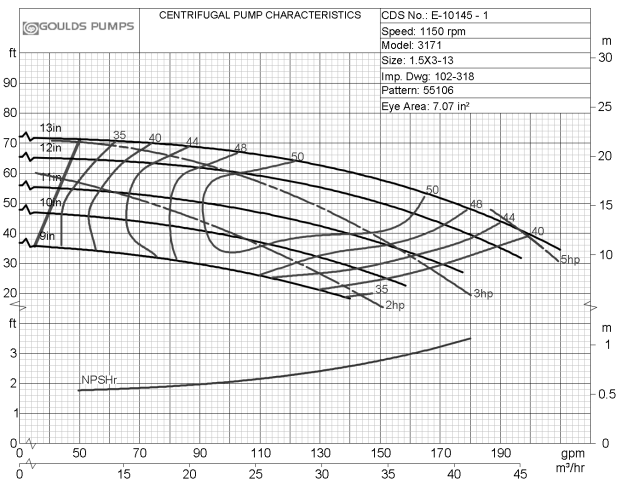
8X10-11 **1750rpm**



8X10-11 **1150rpm**

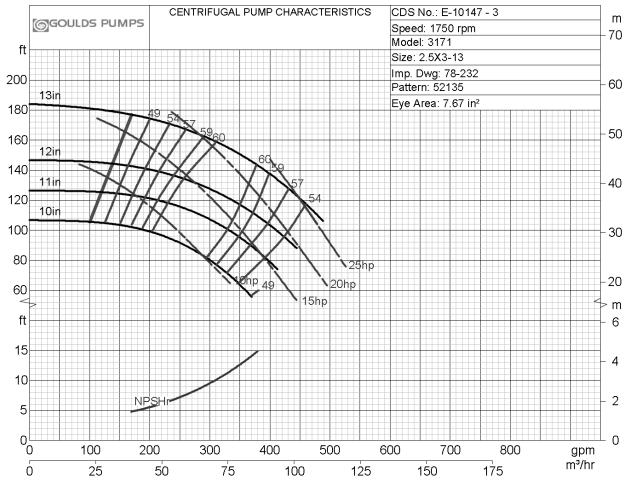


1.5X3-13 **1750rpm**

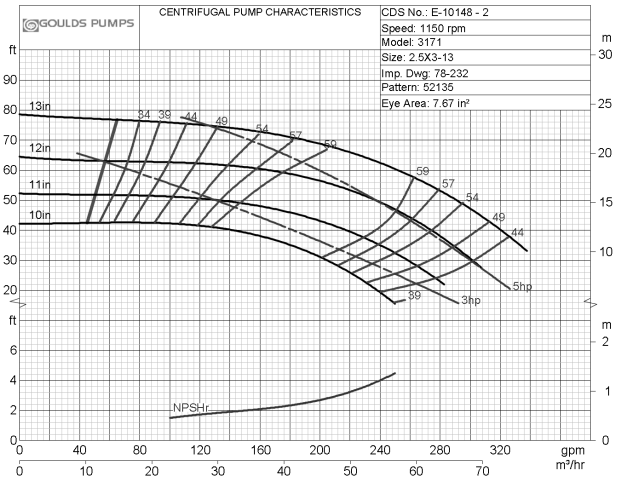


1.5X3-13 **1150rpm**

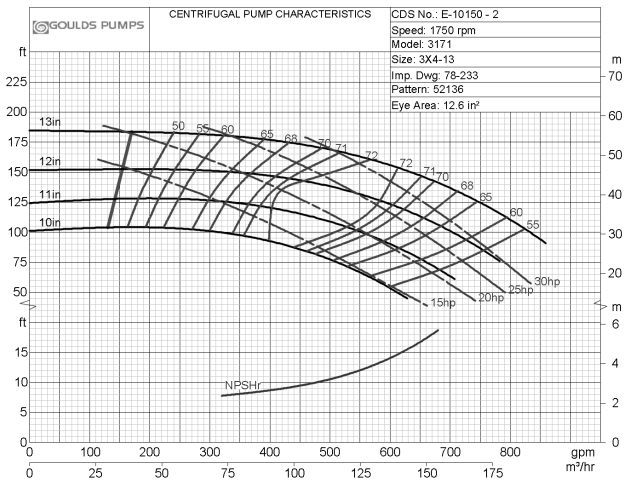
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



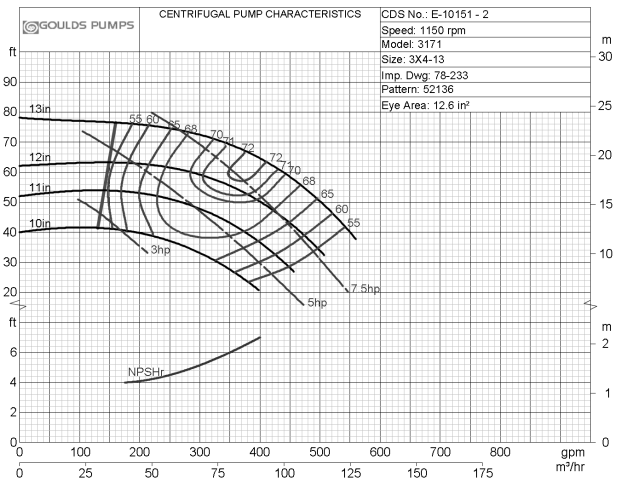
2.5X3-13 **1750rpm**



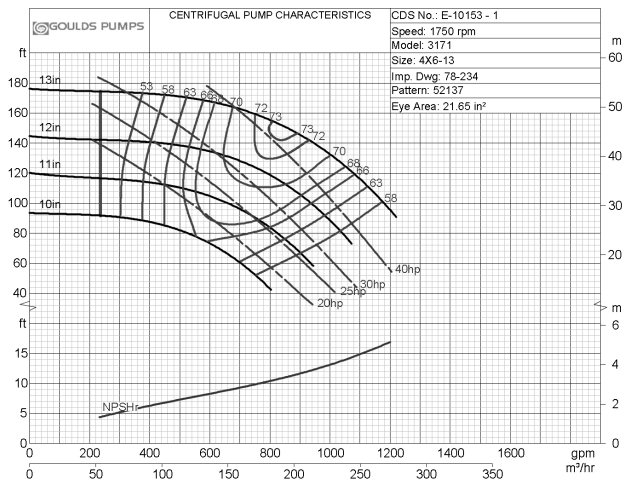
2.5X3-13 **1150rpm**



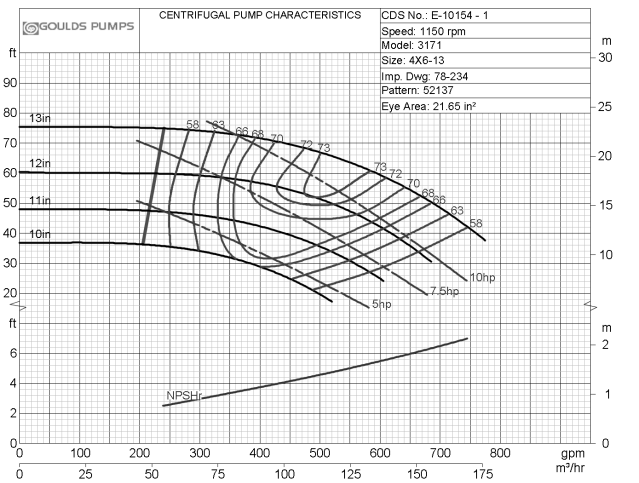
3X4-13 **1750rpm**



3X4-13 **1150rpm**

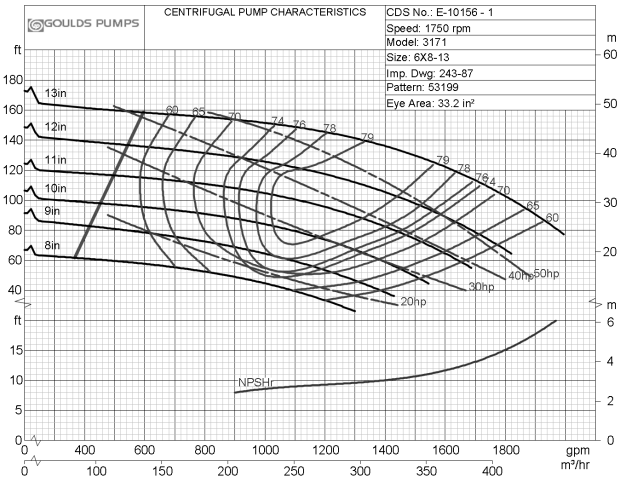


4X6-13 **1750rpm**

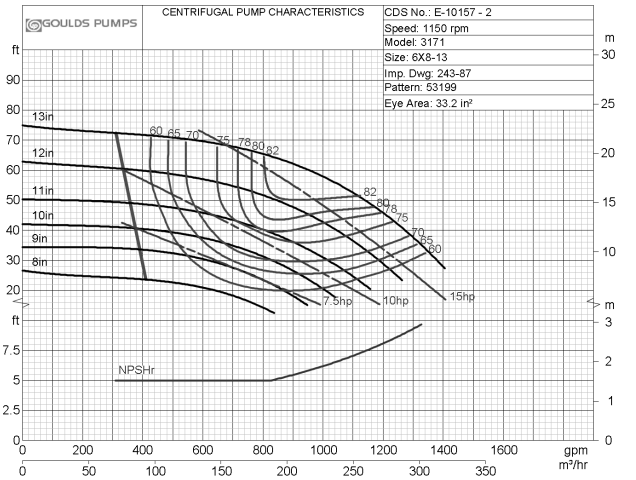


4X6-13 **1150rpm**

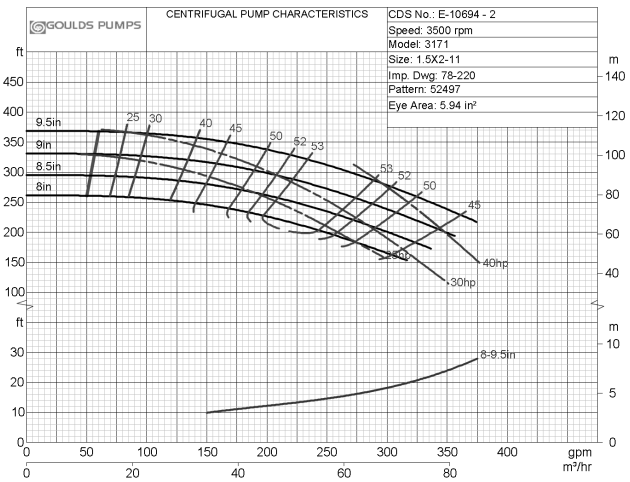
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



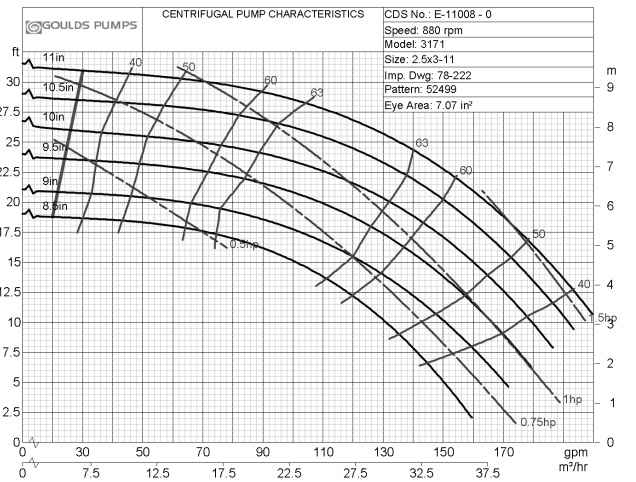
6X8-13 **1750rpm**



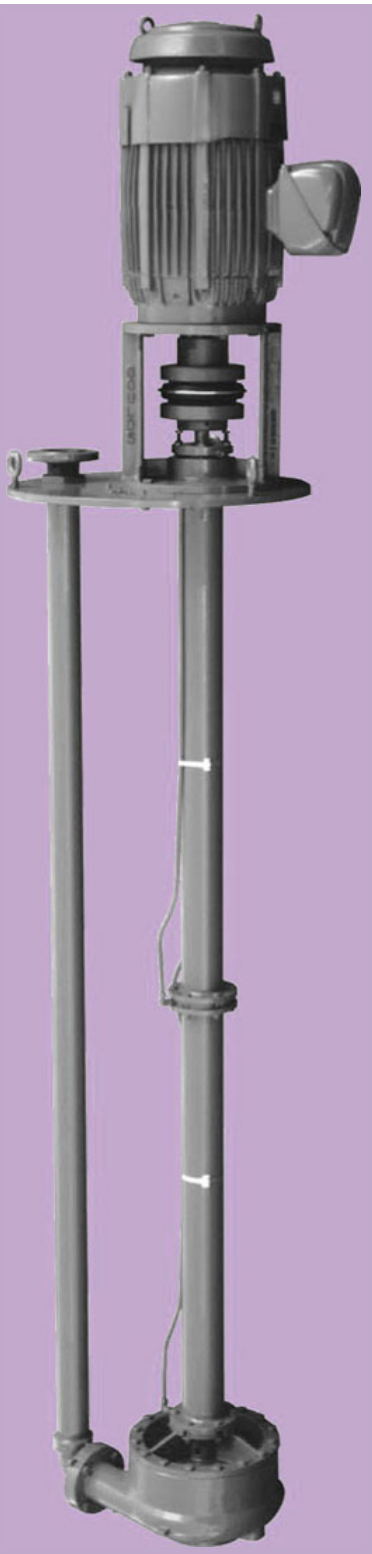
6X8-13 **1150rpm**



1.5X2-11 **3500rpm**



2.5x3-11 **880rpm**



The CV 3171 is a recessed impeller, circular volute type sump pump. Ideal for large solids and shear sensitive fluids. It will pass any solid that will pass through the discharge pipe. Circular volute minimizes radial loads making this the ideal pump for low flow process applications.

Goulds Model CV 3171

Vertical Sump and Process Pumps Designed for the Total Range of Industry Services

- Capacities to 1300 GPM (295 m^3/h)
- Heads to 230 feet (126 m)
- Temperatures to 450° F (232° C)
- Pit Depths to 20 feet (6 m)

Design Features

- Self-Priming
- Rugged Double Row Thrust Bearing
- Heavy Duty One-piece Shaft
- External Impeller Adjustment
- Available in a Wide Range of Alloys
- Recessed Impeller Design
- Sealless Design
- Optional Vapor Proof Construction

Services

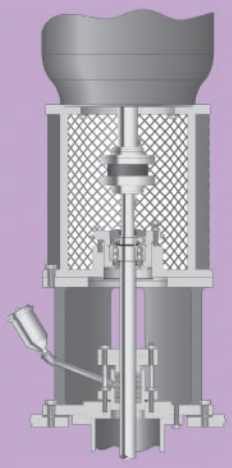
- Fiberous Wastewater
- Industrial Process
- Industrial Sump Wastes
- Tank Unloading
- Corrosive and Non-Corrosive Liquids
- Food Processing
- Chemical Slurries

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model CV 3171 Vertical Sump and Process Pumps

Heavy Duty Design Features for a Wide Range of Services

LABYRINTH BEARING SEAL
Prevents premature bearing failure due to lubricant contamination.



OPTIONAL UPPER STUFFING BOX

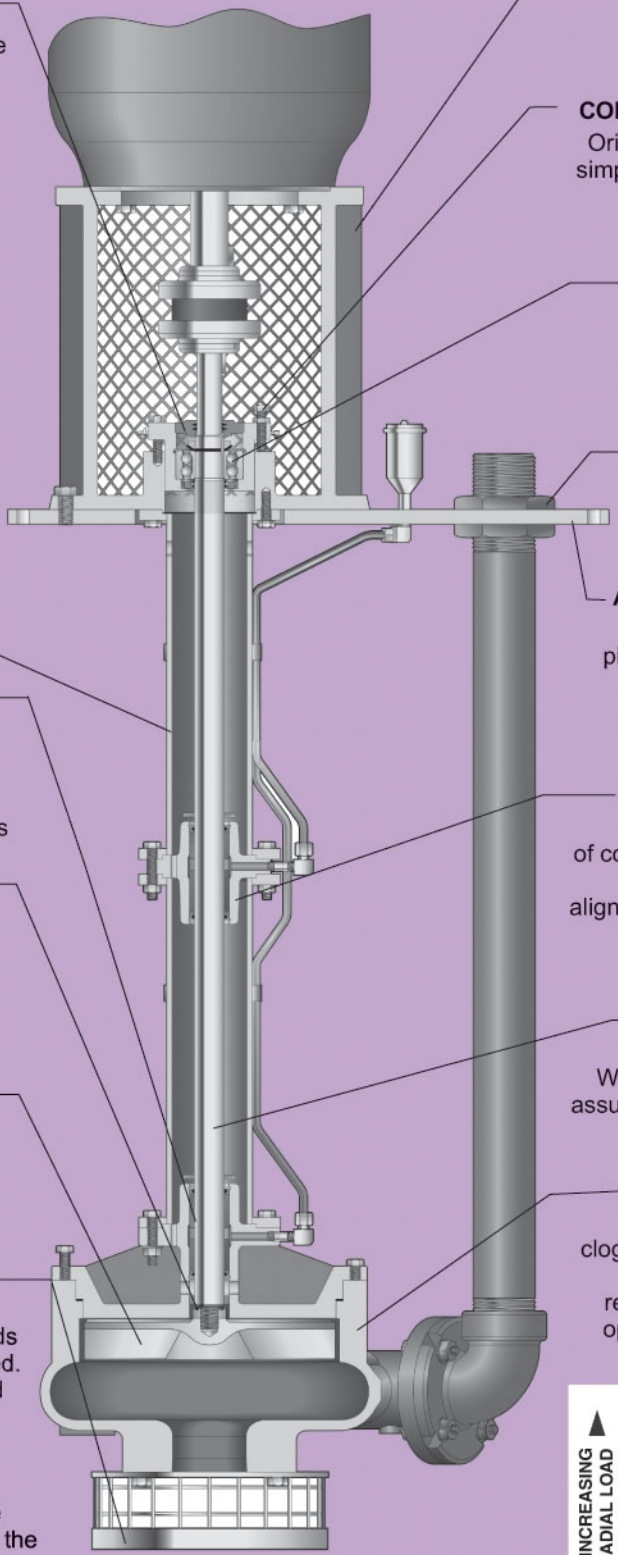
HEAVY COLUMN PIPE
Provides rigid support for pump and bearings.

LINESHAFT STEADY BEARING
Grease lubricating sealed bearings furnished as standard—best for handling fluids with solids.

RESTRICTOR BUSHING
Close running bushing to prevent pressure loss from casing.

RECESSED IMPELLER
Since impeller is recessed in the casing, velocities are low and solids contact with the casing are reduced. Wear rate, solids degradation, and shearing of liquids are minimized.

OPTIONAL STRAINER
Recommended for services where solids larger than the discharge of the pump can potentially enter the casing.



C-FACE MOTOR MOUNTING
Accommodates readily available C-face motors. Also available for P-base and IEC motors.

CONTINUOUS HIGH PERFORMANCE
Original high efficiency maintained by simple external adjustment resulting in long-term energy savings.

DOUBLE ROW THRUST BEARING
Grease lubricated—carries pump thrust load; sealed for outdoor installation.

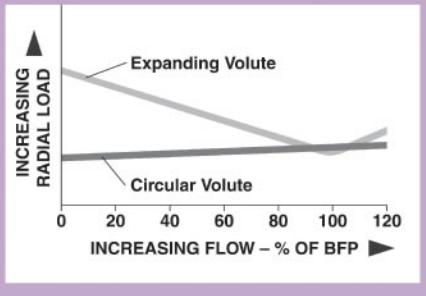
DISCHARGE LOCKED TO PUMP SUPPORT PLATE FOR STRENGTH

ANY MOUNTING REQUIREMENTS
Met by support plate and optional pit cover. Float switches, alternators and other control devices can be easily mounted.

STEADY BEARING HOUSING
Precision machined register fit of column, bearing housing and casing assures positive bearing and shaft alignment. Completely interchangeable with all lineshaft bearing options.

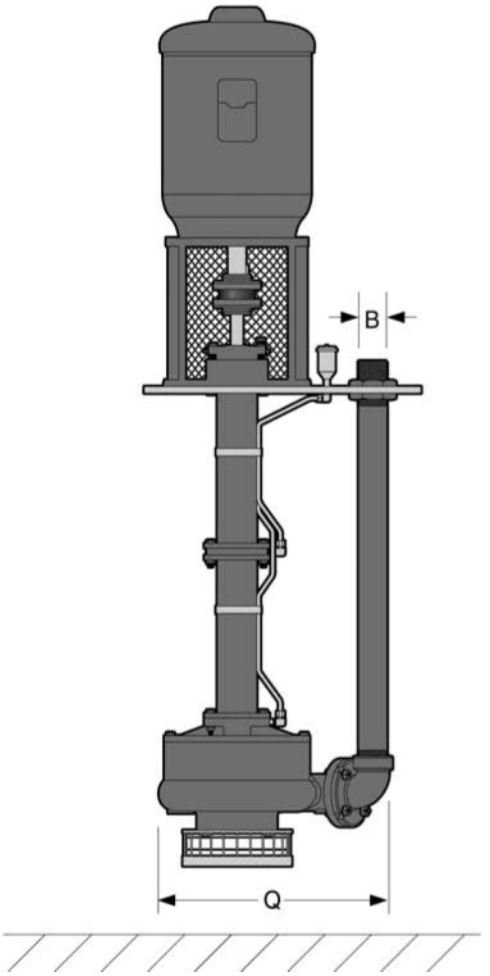
HEAVY DUTY ONE-PIECE SHAFT
With closely spaced steady bearings assures long life and low maintenance.

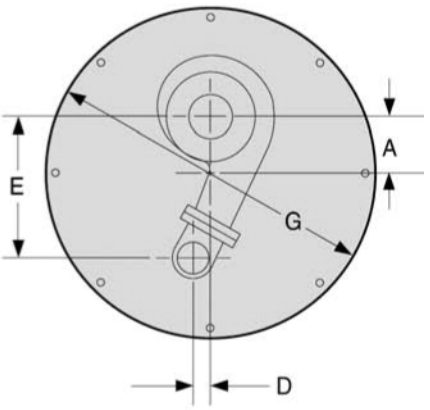
NON-CLOG CIRCULAR CASING
Large open passageways prevent clogging when handling bulky, fibrous, or stringy liquids. Circular Volute reduces radial loads during low flow operation, extending steady bearing life.



Dimensions Model CV 3171

All dimensions in inches and (mm). Not to be used for construction.





DIMENSIONS					
	2 × 2-8	**2 × 2-10**	**3 × 3-10**	**2 × 3-13**	**3 × 4-13**
A	4.00 (102)	4.50 (114)	4.50 (114)	4.50 (114)	4.50 (114)
B	2.00 (51)	2.00 (51)	3.00 (51)	2.00 (51)	3.00 (76)
D	1.32 (34)	1.45 (37)	1.69 (43)	1.27 (32)	1.14 (29)
G	26.50 (673)	31.00 (787)	31.00 (787)	31.00 (787)	31.00 (787)
E	10.79 (274)	13.01 (330)	13.17 (335)	15.44 (392)	15.22 (387)
Q * 18.11	(460) 21.47	(545) 22.97	(583) 25.24	(641) 26.32	(669)

* Add 3 in. (76) for float mounted option.

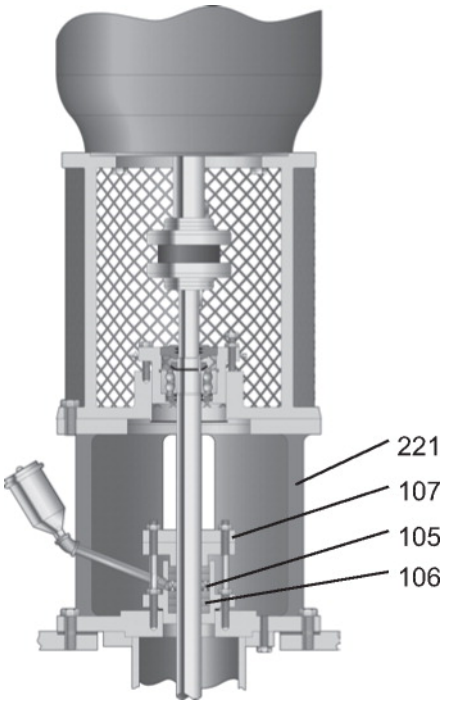
CV 3171 Parts List and Materials of Construction

		Material		
Item Number	Part Name	Cast Iron	CD4	GA-20
100	Casing	D.I.	CD4	GA-20
101	Impeller	CD4	CD4	GA-20
105	Lantern Ring	Teflon	Teflon	Teflon
106	Packing	Acrylic Yarn	Acrylic Yarn	Acrylic Yarn
107	Gland	316SS or as Specified	316SS or as Specified	316SS or as Specified
108A	Adapter, Casing	D.I.	CD4	GA-20
112	Bearing, Ball	Steel	Steel	Steel
122	Shaft	Steel	316SS	C-20
123	Deflector	EPDM	EPDM	EPDM
134	Shell, Bearing	C.I.	C.I.	C.I.
136	Locknut, Bearing	Steel	Steel	Steel
155	Bushing (casing)	Carbon Teflon	Carbon Teflon	Carbon Teflon
187	Strainer (OPTIONAL)	Steel	316SS	C-20
189	Plate, Support	Steel or as Specified	Steel or as Specified	Steel or as Specified
190	Tubing, Lube Line	Steel	316SS	C-20
192	Column, Head	Steel	316SS	C-20
195	Pipe, Discharge	Steel	316SS	C-20
197	Steady Bearing	Carbon/Bronze/Rubber/Viton	Carbon/Bronze/Rubber/Viton	Carbon/Bronze/Rubber/Viton
213	Steady Bearing Housing	C.I.	316SS	GA-20
221	Upper Stuffing Box	Cast Iron or as Specified	Cast Iron or as Specified	Cast Iron or as Specified
240	Support, Motor	C.I.	C.I.	C.I.
242	Nut, Pipe	Steel	316SS	C-20
306	Extension, Column	Steel	316SS	C-20
315	Elbow, Discharge	D.I.	CD4	GA-20
332A	Seal, Labyrinth	Teflon/Viton	Teflon/Viton	Teflon/Viton
333	Seal, Housing	Steel/Nitrile	Steel/Nitrile	Steel/Nitrile
333H	Seal, Lip	Nitrile	Viton	Viton
351	Gasket, Casing	Nitrile/Acrylic	Nitrile/Acrylic	Nitrile/Acrylic
351A	Gasket, Elbow	Nitrile Acrylic	Nitrile/Acrylic	Nitrile/Acrylic
361A	Ring, Retaining Ball Bearing	Steel	Steel	Steel
369	Ring, Retaining Steady Bearing	316SS	316SS	C-20
369A	Ring, Retaining Shaft	Steel	Steel	Steel
382	Washer Lock Nut	Steel	Steel	Steel
412A	O-Ring, Impeller	Teflon	Teflon	Teflon

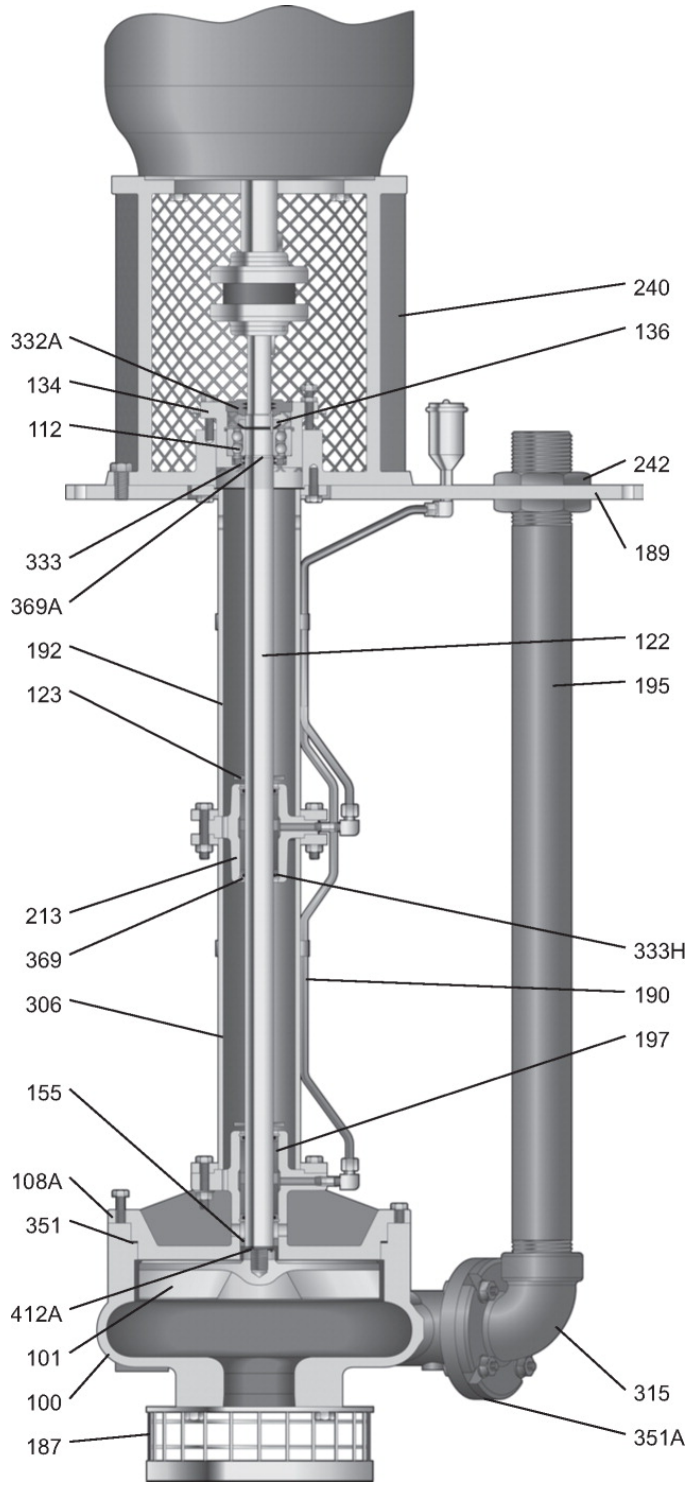
Construction Details All dimensions in inches and (mm).

		2 × 2-8	2 × 2-10	3 × 3-10	2 × 3-13	3 × 4-13
Pump	Weight (3 Foot Depth) Less Motor Lb (kg) *	484 (220)	531 (241)	559 (254)	565 (257)	616 (280)
	Weight—Add fo Each 6" of Length Lb (kg)	20 (9)	20 (9)	20 (9)	20 (9)	20 (9)
	Maximum Diameter of Solids	1.75 (45)	1.75 (45)	2.75 (70)	1.75 (45)	2.75 (70)
Shaft	Diameter at Impeller	0.6309 (16)	0.9008 (23)	0.9008 (23)	0.9008 (23)	0.9008 (23)
	Diameter at Coupling End	1.375 (35)				
	Diameter at Steady Bearing of Solids	1.625 (41)				
Bearings	Ball Bearing	5308 or Equal				
	Steady Bearing (Sleeve Type)	1.625 I.D. × 2.125 O.D. (41 I.D. × 54 O.D.) 4.00 LG. (102 LG.)				
General	Maximum Total Working Pressure—Casing	285 PSIG (1965 kPa)				
	Max. Liquid Temp.— Without Upper Stuffing Box	180° F (82° C)				
	Max. Liquid Temp.— With Upper Stuffing Box	450° F (232° C)				

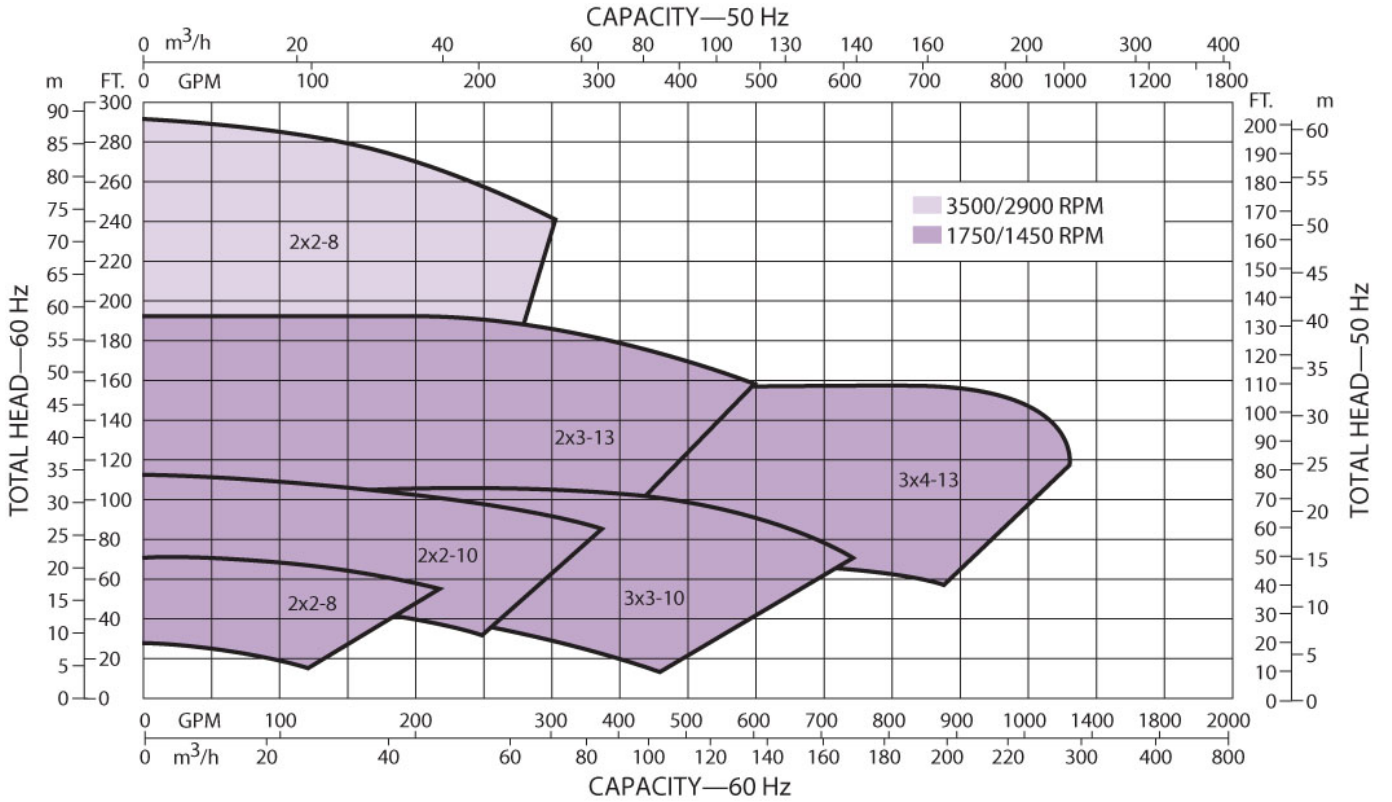
Sectional View Model CV 3171

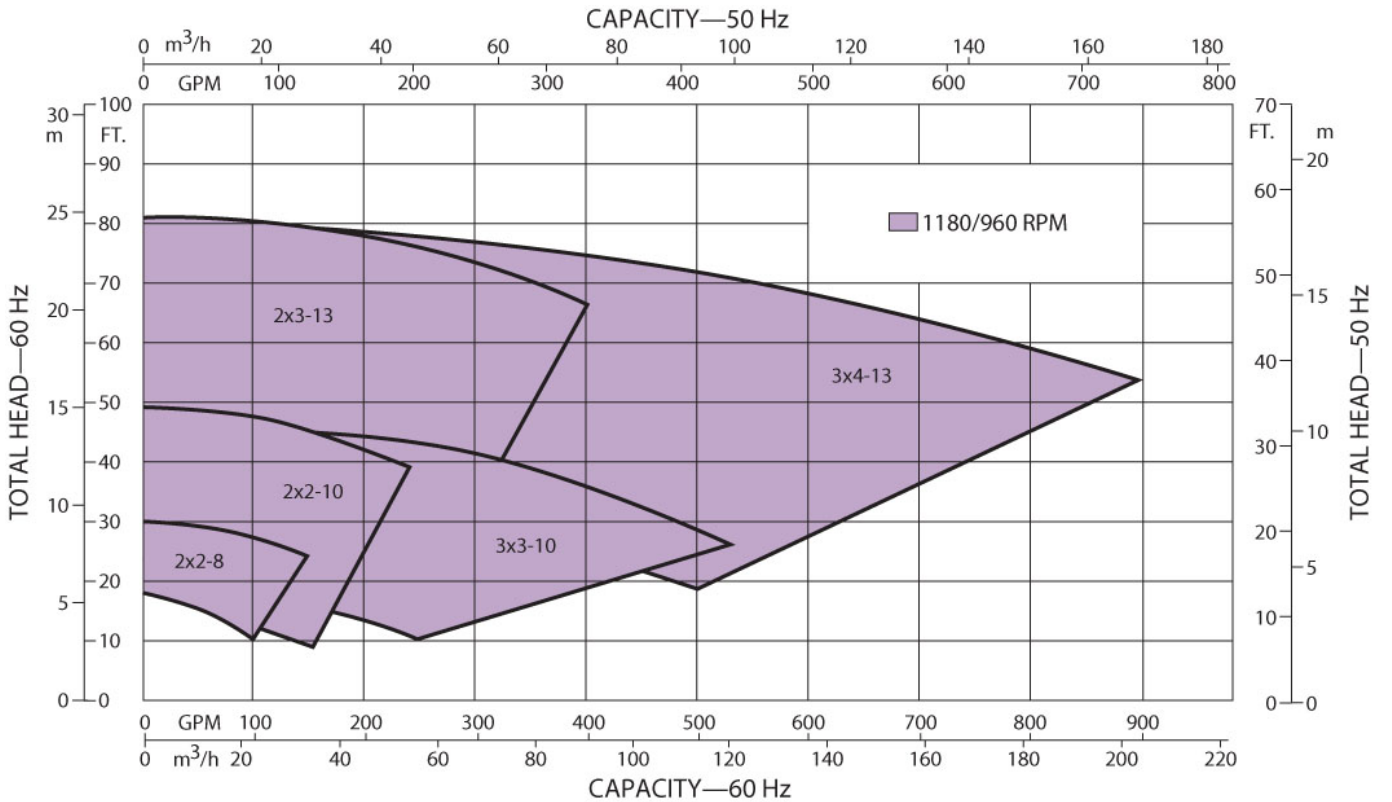


Upper Stuffing Box

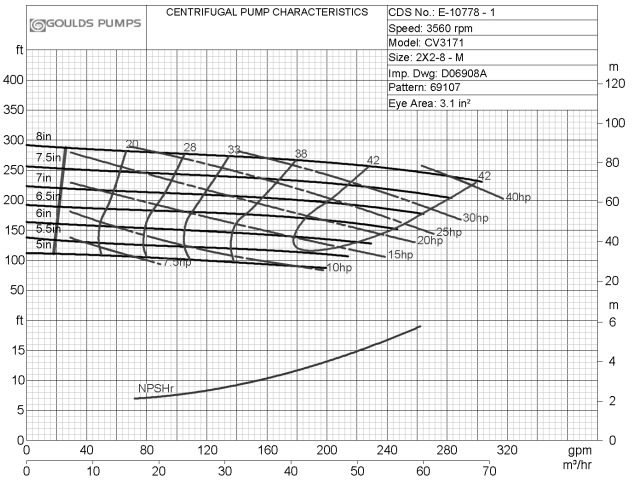


CV 3171 Hydraulic Coverage

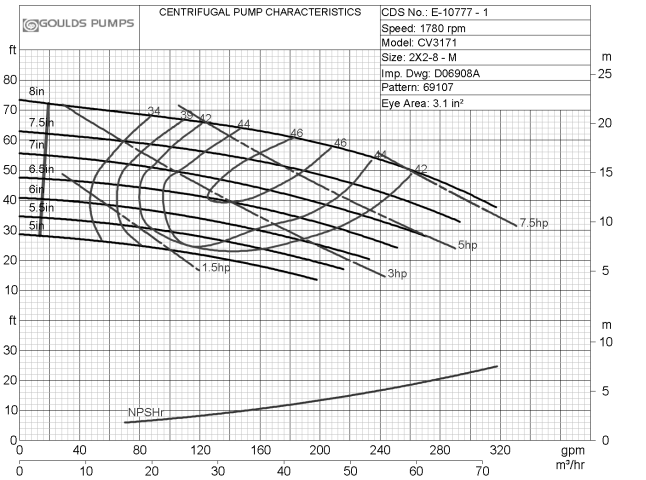




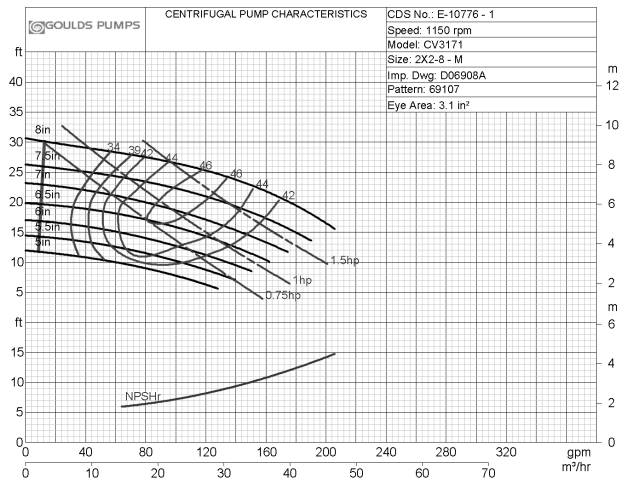
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



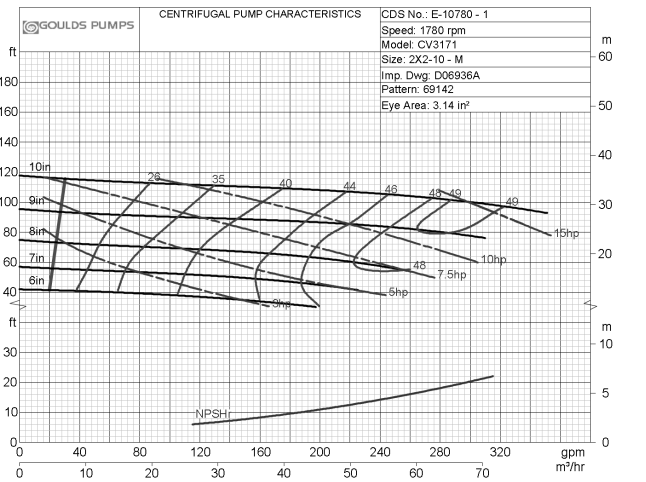
2X2-8 **3560rpm**



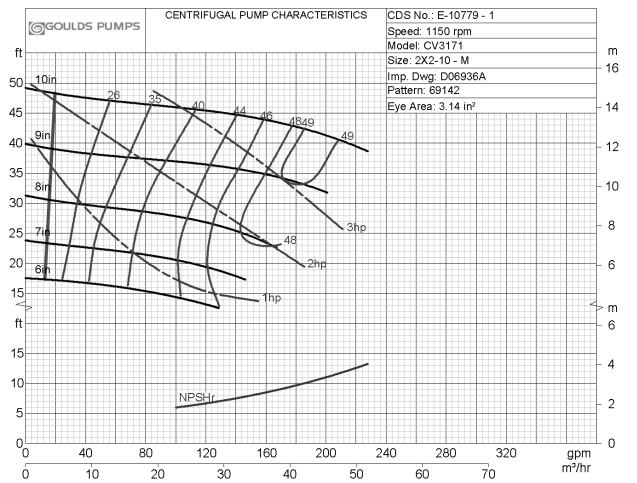
2X2-8 **1780rpm**



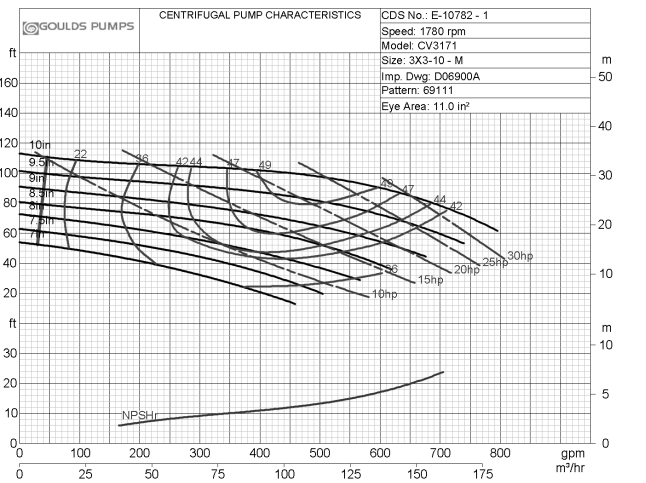
2X2-8 **1150rpm**



2X2-10 **1780rpm**

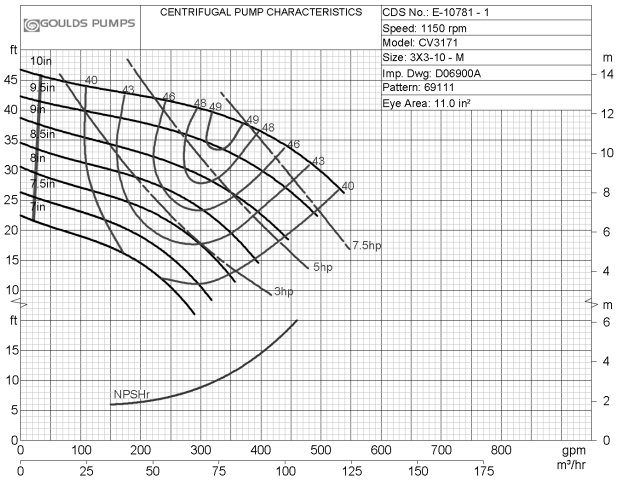


2X2-10 **1150rpm**

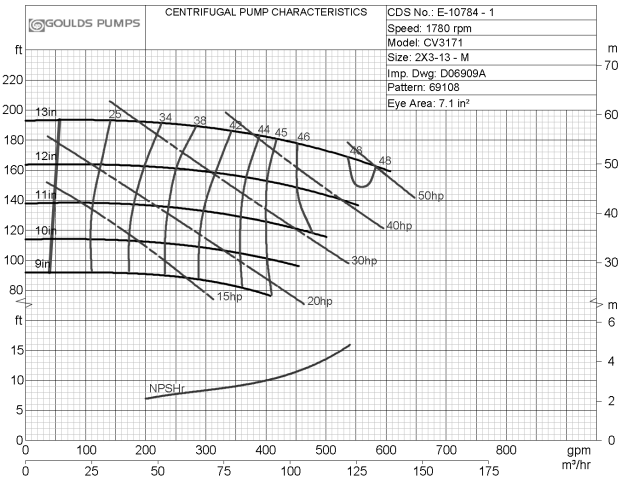


3X3-10 **1780rpm**

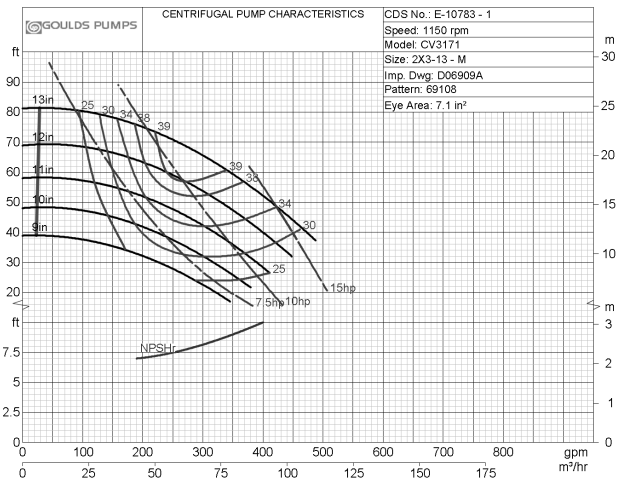
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



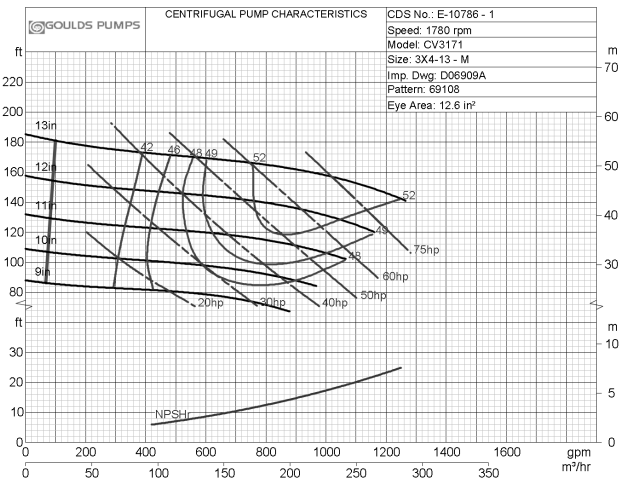
3X3-10 **1150rpm**



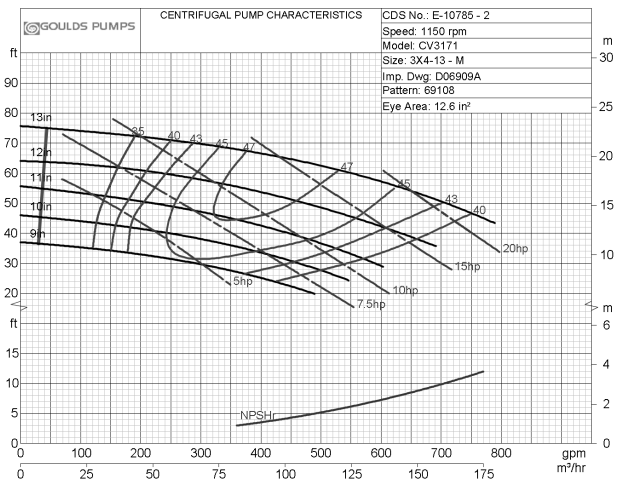
2X3-13 **1780rpm**



2X3-13 **1150rpm**



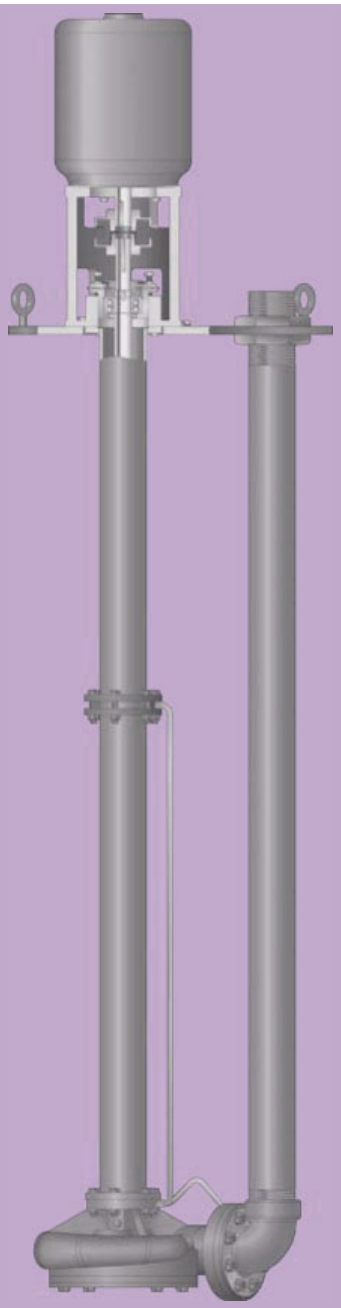
3X4-13 **1780rpm**



3X4-13 **1150rpm**

NOTES

NOTES



API 3171—The reliable performer for all API sump services

Goulds Model API 3171

API 610 Compliant VS4 Vertical Sump Pumps

- Capacities to 3180 GPM (722 m^3/h)
- Heads to 525 feet (160 m)
- Temperatures to 450° F (232° C)
- Pit Depths to 20 feet (6 m)

Design Features

- **Compliant Thrust Bearing Arrangement**
  - Grease or oil mist compatible
  - Duplex single row with machined brass cages
  - INPRO® bronze labyrinth seals
- **Compliant Disc Coupling Balanced to AGMA 9**
- **Fully Compliant Bearing Spans**
- **300# Discharge Flanges as Standard**
- **1/2" Diameter Lubelines for Steady Bearings**
- **Integral Lifting Eyes**
- **Many Interchangeable Parts with Model 3171**

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

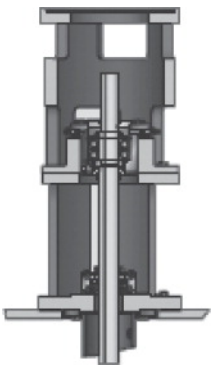
Parts List and Materials of Construction

Part Name	S-1/S-4	S-3	S-5	S-6	S-8	A-8	D-1	D-2
Casing	A216 WCB					A743 CF8M	A890 Gr. 4A	A890 Gr. 5A
Impeller	A536 65-45-12	A436 Type 2	A216 WCB	A487 CA6NM	A743 CF8M	A743 CF8M	A890 Gr. 4A	A890 Gr. 5A
Thrust Bearings	40 Degree Angular Contact with Machined Brass Cage							
Shaft	A582 S41600					A276 S31600	A276 S31803	A479 S32750
Bearing Shell	A216WCB							
Suction Cover	A216 WCB					A743 CF8M	A890 Gr. 4A	A890 Gr. 5A
Strainer	316 Plate						A890 Gr. 4A	A890 Gr. 5A
Support Plate	Carbon Steel							
Flush Tubing	As Specified							
Column	Carbon Steel					A312 316L	A790 S31803	A790 S32750
Discharge Pipe	Schedule 40, A53 Gr. F					A312 316L	A790 S31803	A790 S32750
Steady Bearings	Carbon or As Specified							
Motor Support	A48 Cast Iron							
Discharge Elbow	A216 WCB					A351 CF3M	A890 Gr. 4A	A890 Gr. 5A
Labyrinth Seals	Bronze INPRO®							
Gaskets	Nitrile Acrylic							
Bolt - Column to Casing	A193 B8M						B574 S10276	
Bolt - Elbow to Casing								

Optional Features

Single Seal Vaporproof Construction

- Used where emissions control is required
- Gasketed fits and dry-running seal keep vapors in the sump



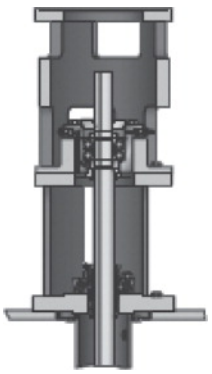
Single Seal

Double Seal Vaporproof Construction

- Double seal offers additional protection for critical services
- Optional flush plans are available

Common Options

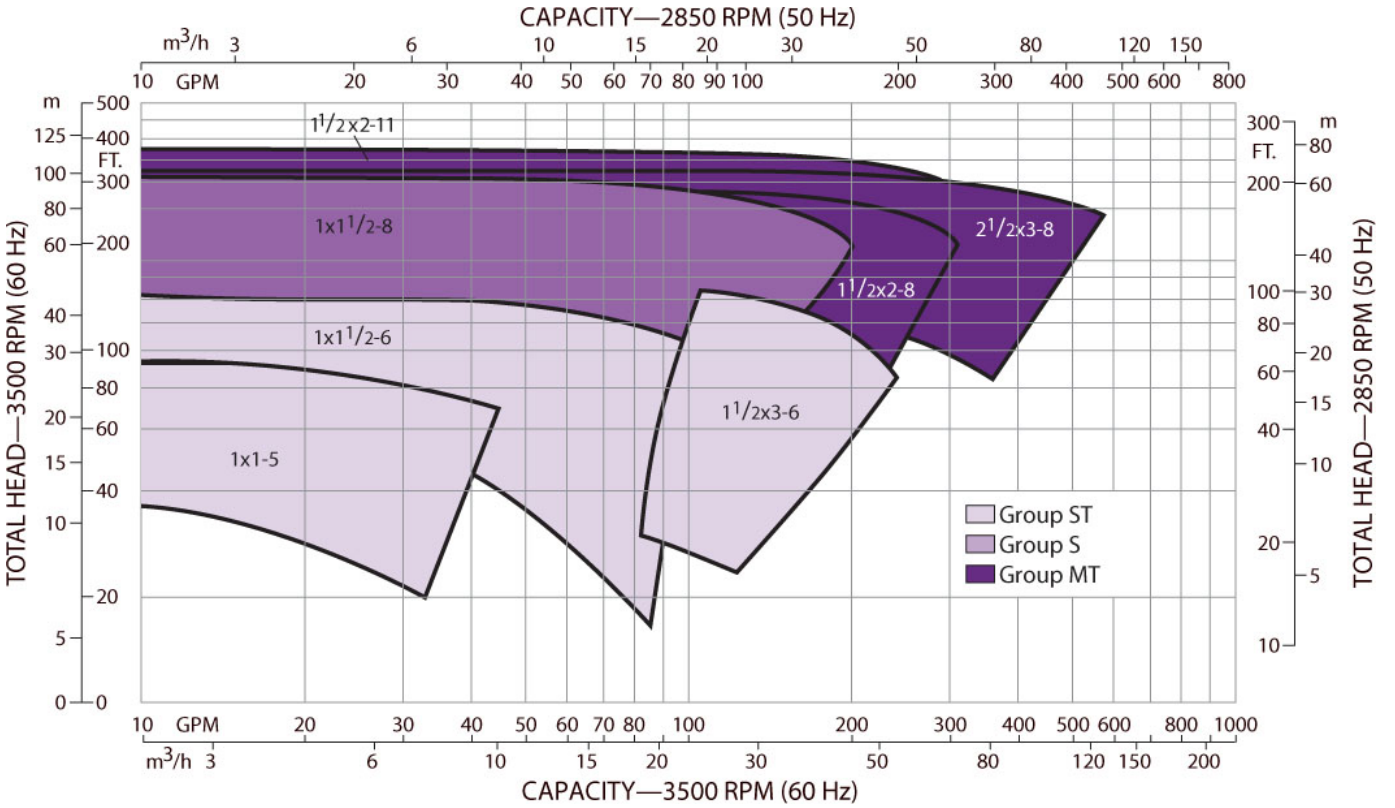
- Optional bearings
- Optional soleplate (pit cover)
- Jacketed construction
- Tank flange support plate



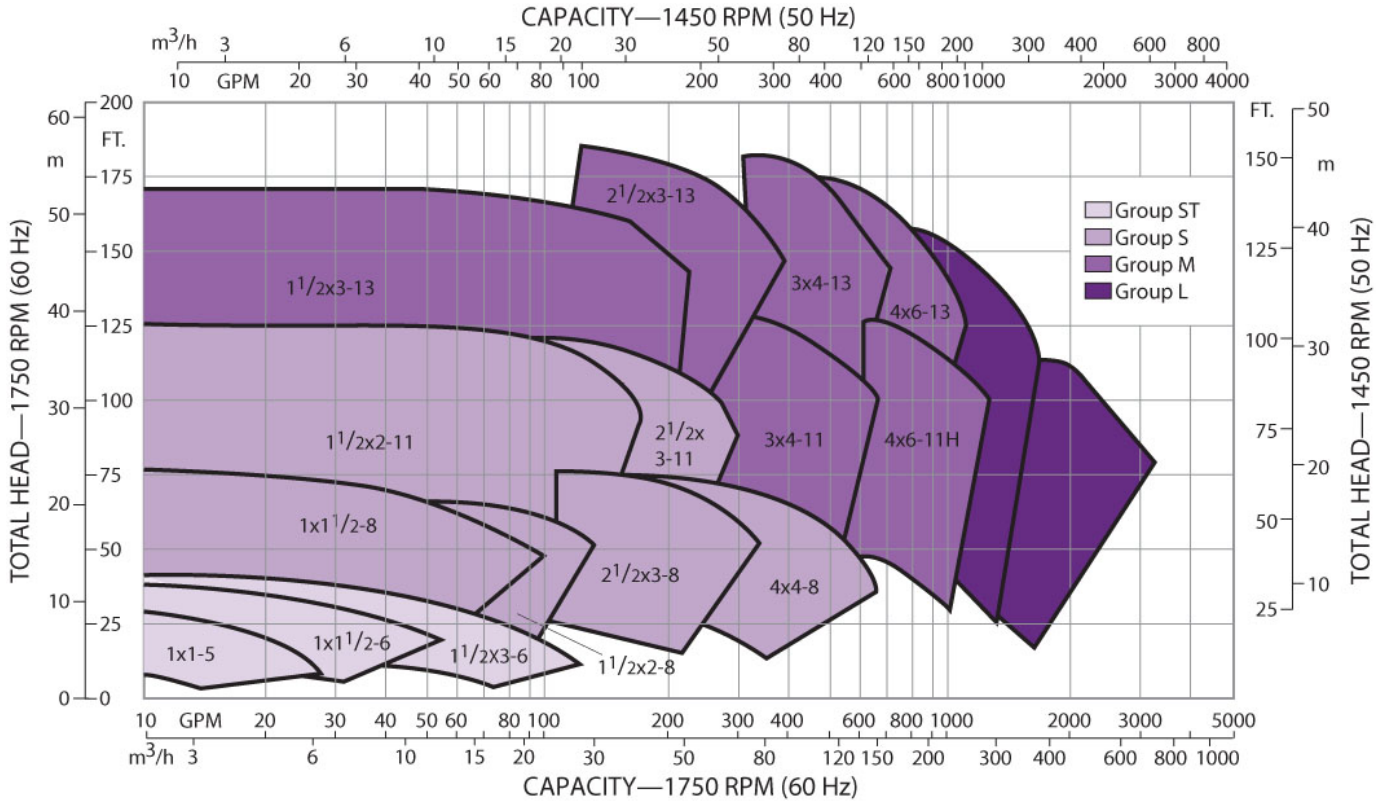
Double Seal

Tank Mount Flange

Hydraulic Coverage 3500/2850 RPM



Hydraulic Coverage 1750/1450 RPM



NOTES

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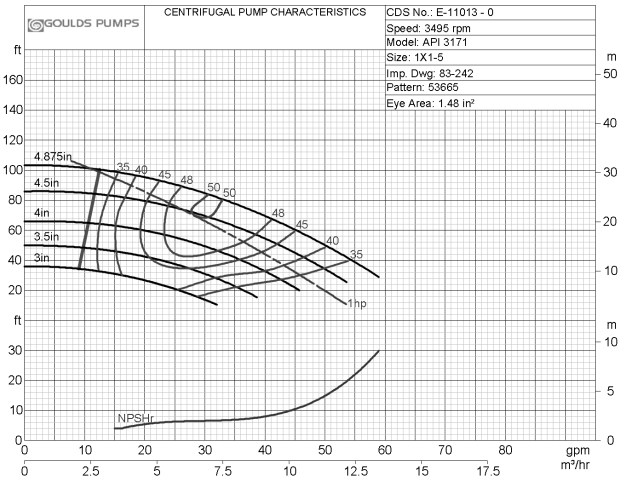
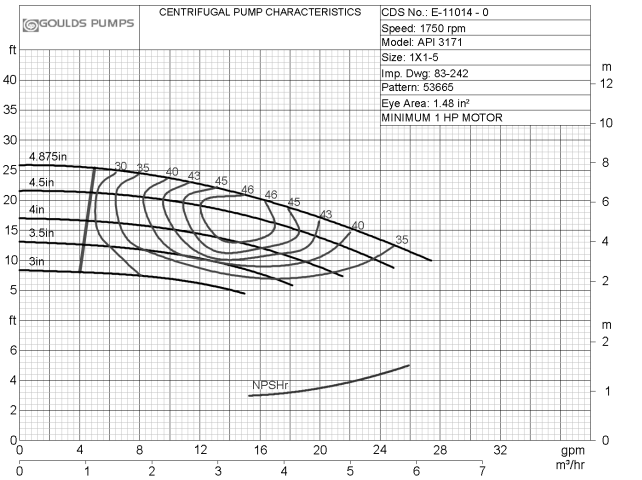
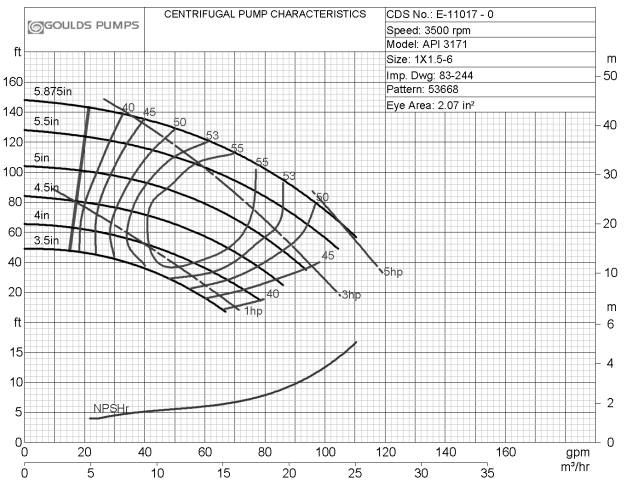


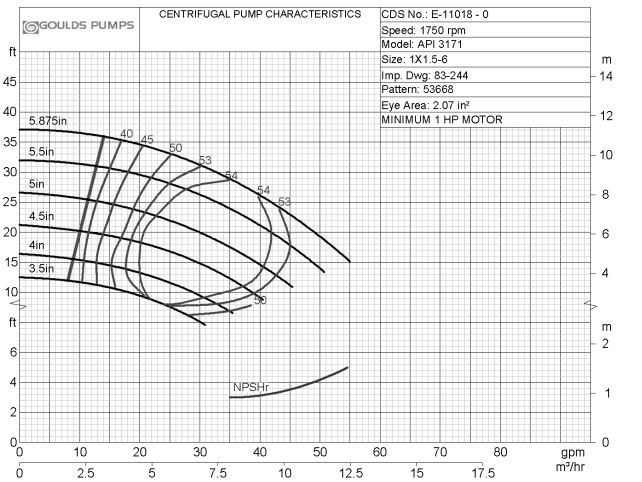
1X1-5 **3495rpm**



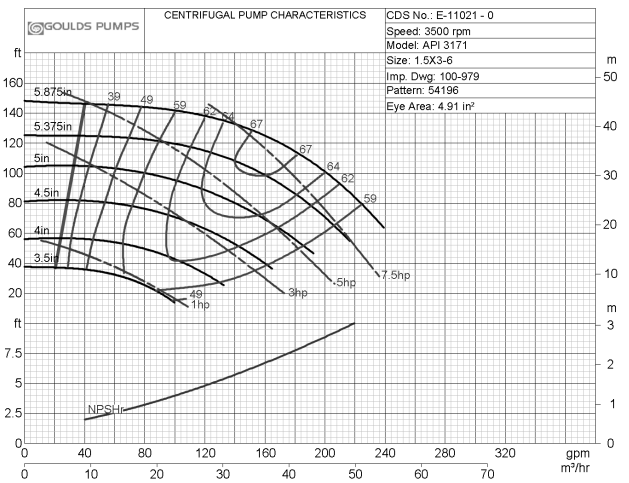
1X1-5 **1750rpm**



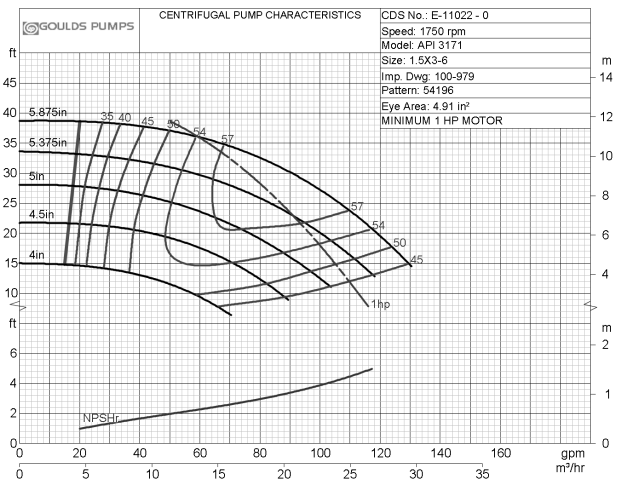
1X1.5-6 **3500rpm**



1X1.5-6 **1750rpm**



1.5X3-6 **3500rpm**



1.5X3-6 **1750rpm**

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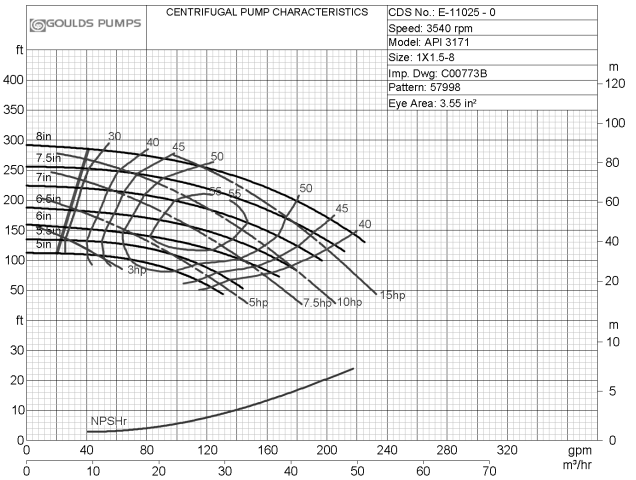
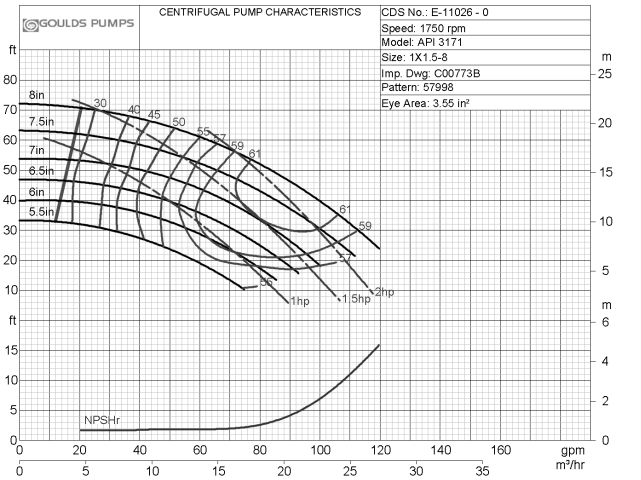
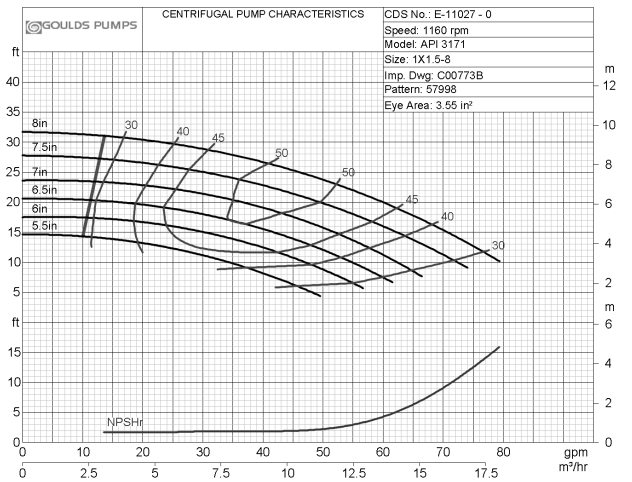


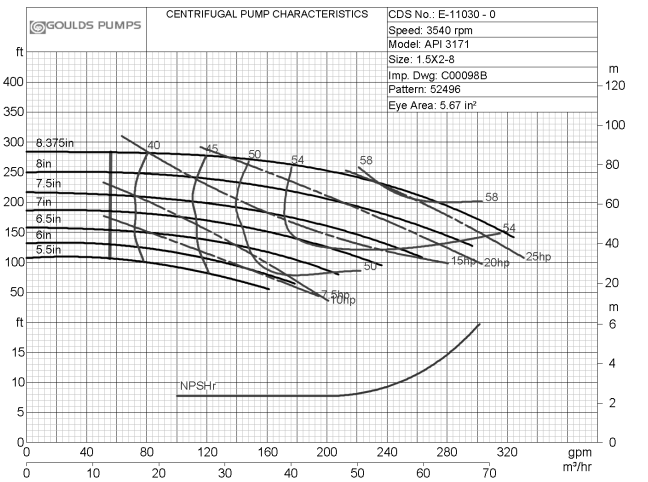
1X1.5-8 **3540rpm**



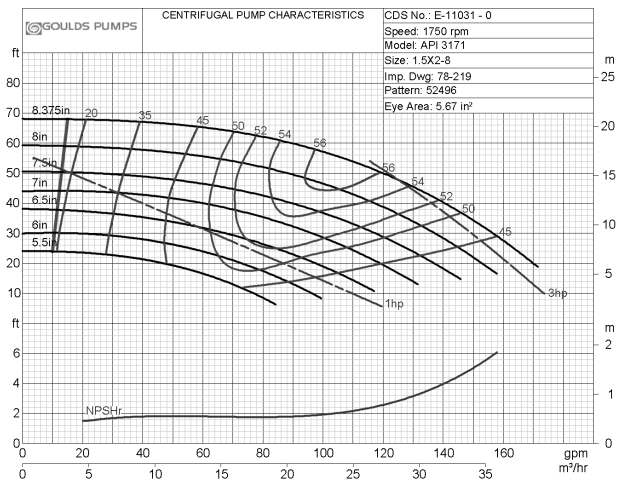
1X1.5-8 **1750rpm**



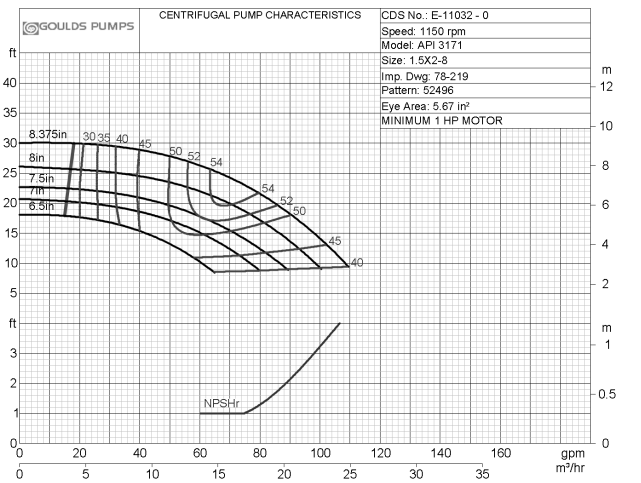
1X1.5-8 **1160rpm**



1.5X2-8 **3540rpm**



1.5X2-8 **1750rpm**



1.5X2-8 **1150rpm**

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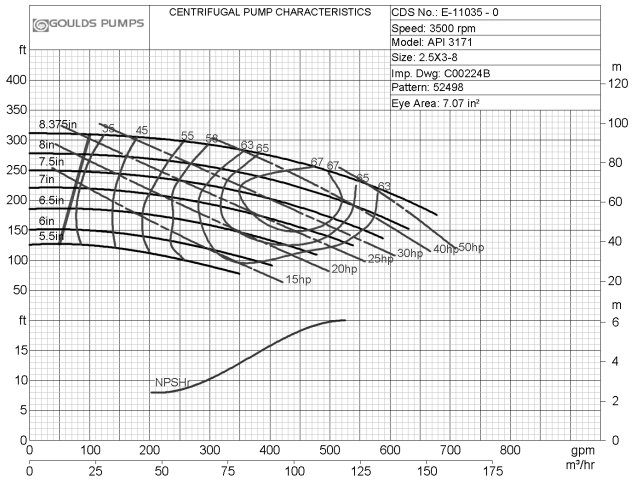
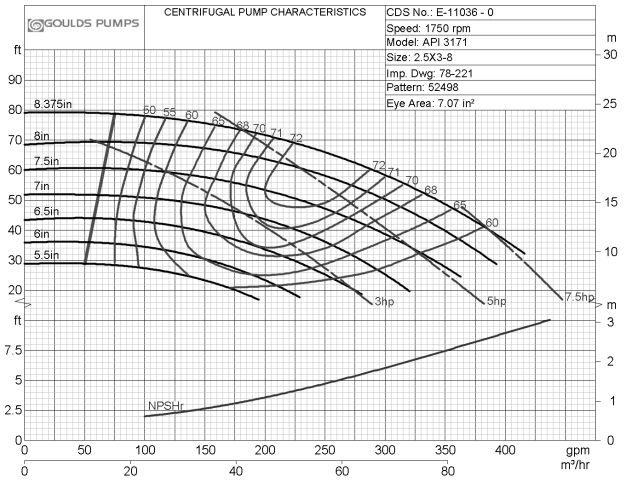
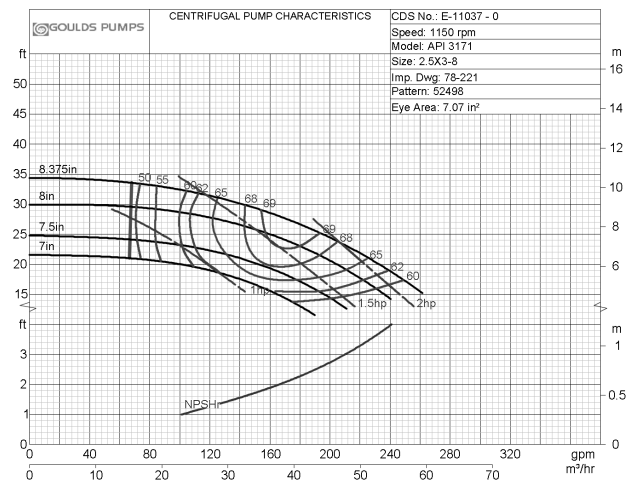


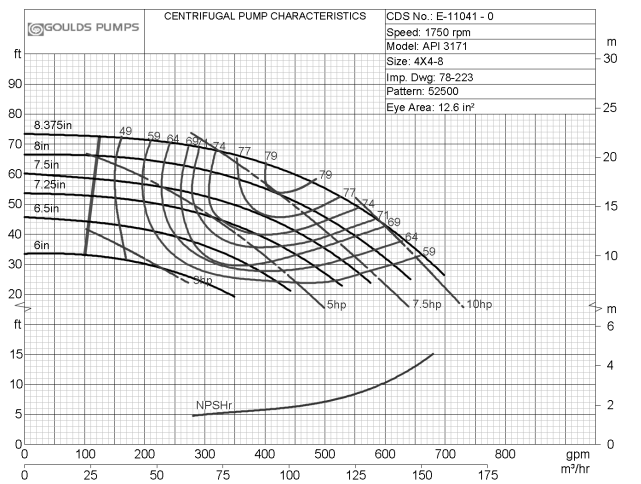
2.5X3-8 **3500rpm**



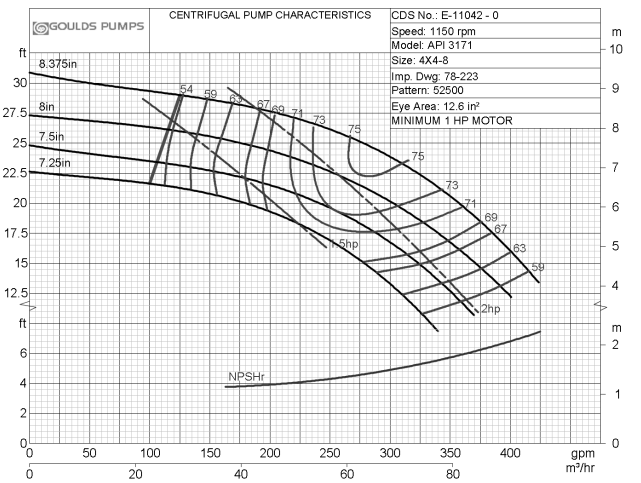
2.5X3-8 **1750rpm**



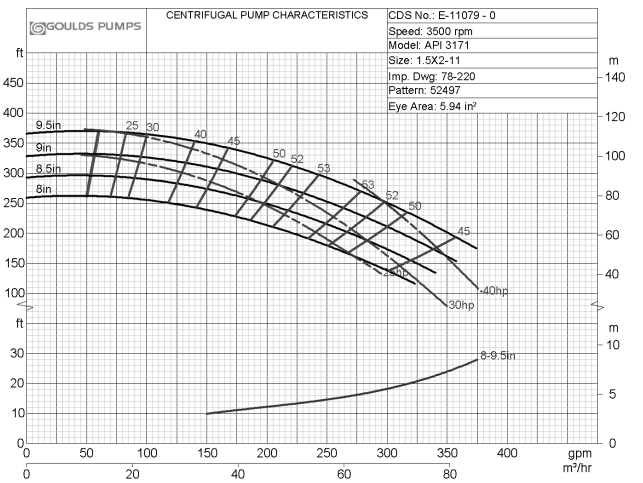
2.5X3-8 **1150rpm**



4X4-8 **1750rpm**



4X4-8 **1150rpm**



1.5X2-11 **3500rpm**

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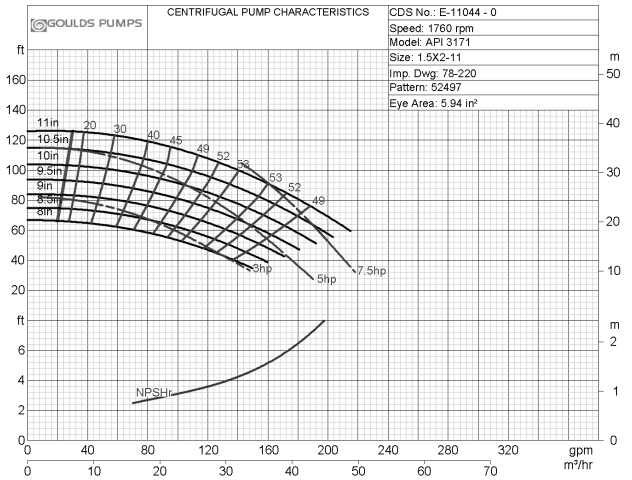
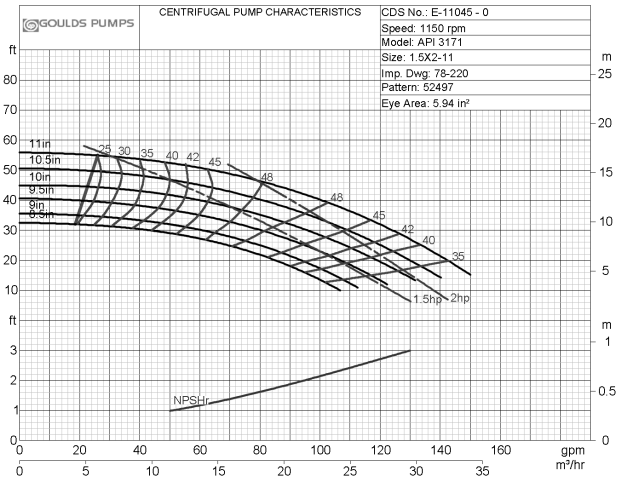
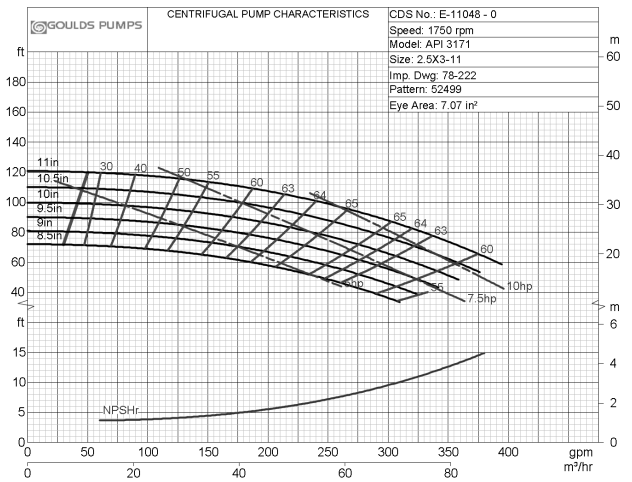


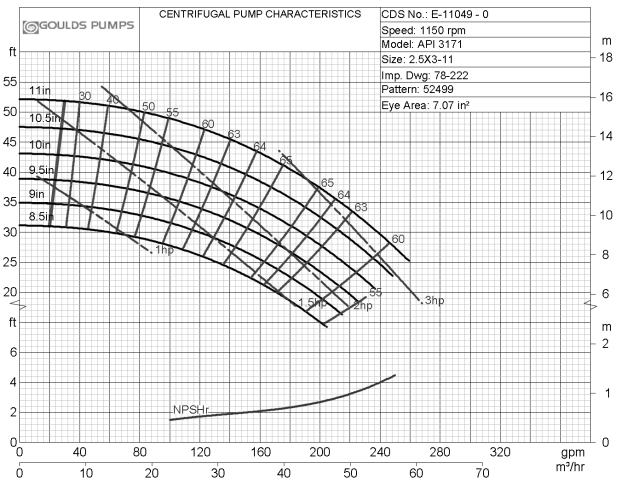
1.5X2-11 **1760rpm**



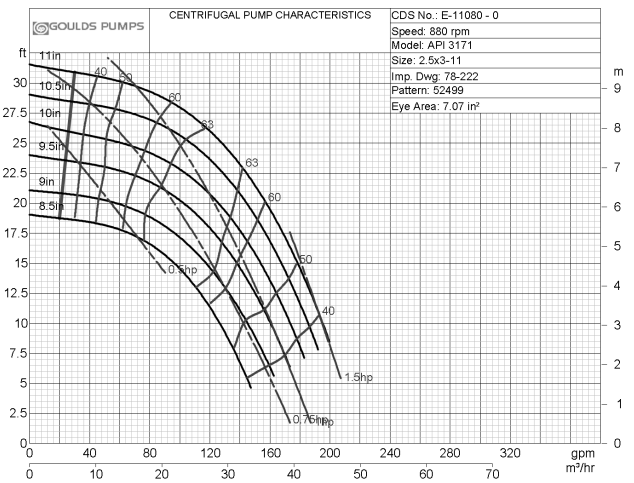
1.5X2-11 **1150rpm**



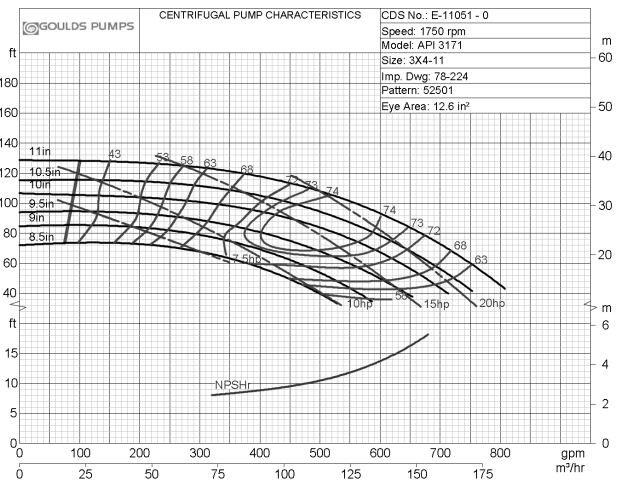
2.5X3-11 **1750rpm**



2.5X3-11 **1150rpm**

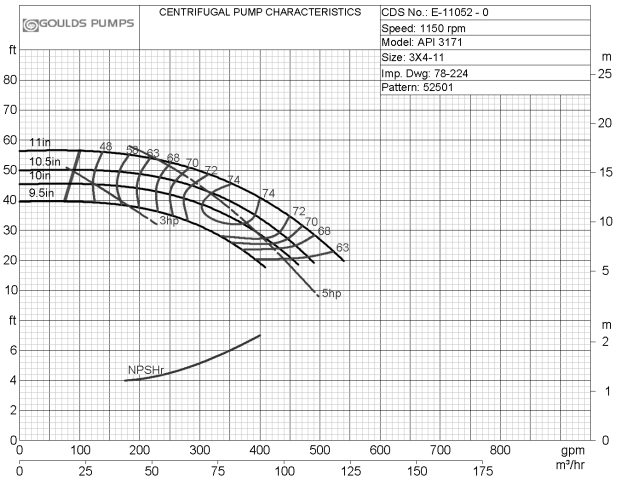


2.5x3-11 **880rpm**

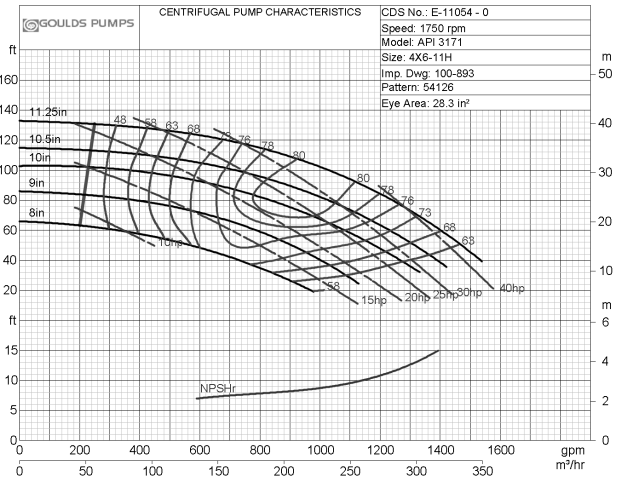


3X4-11 **1750rpm**

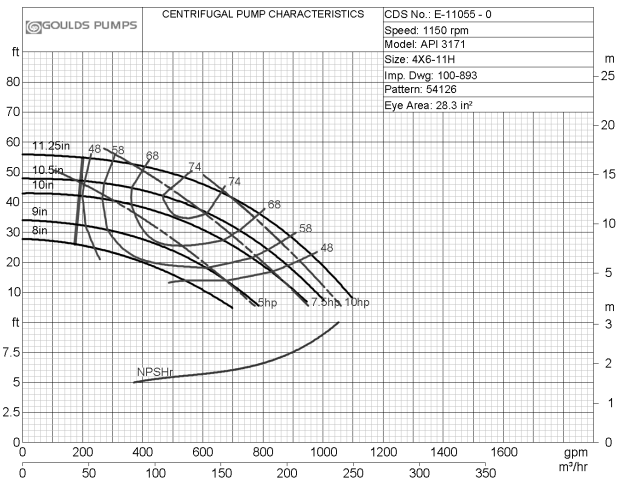
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



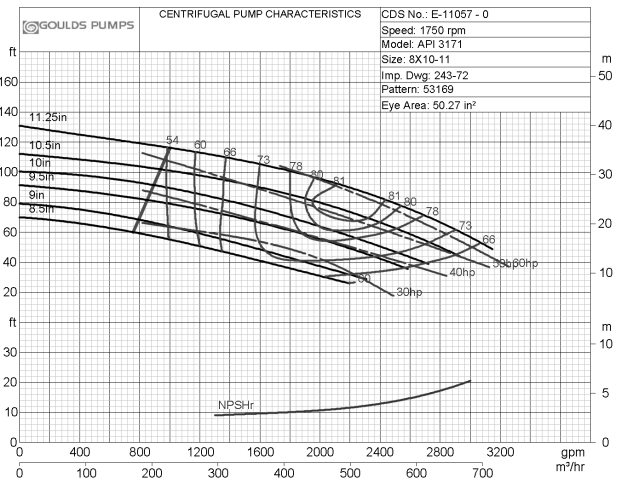
3X4-11 **1150rpm**



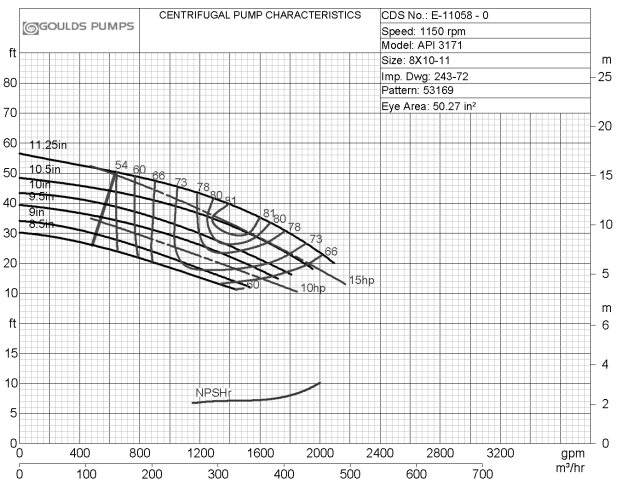
4X6-11H **1750rpm**



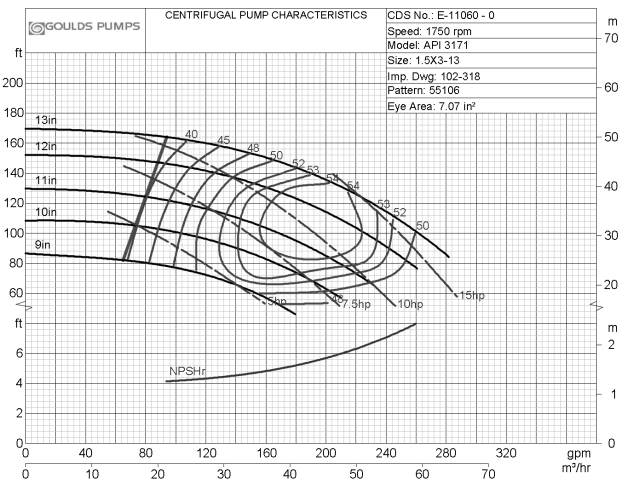
4X6-11H **1150rpm**



8X10-11 **1750rpm**



8X10-11 **1150rpm**



1.5X3-13 **1750rpm**

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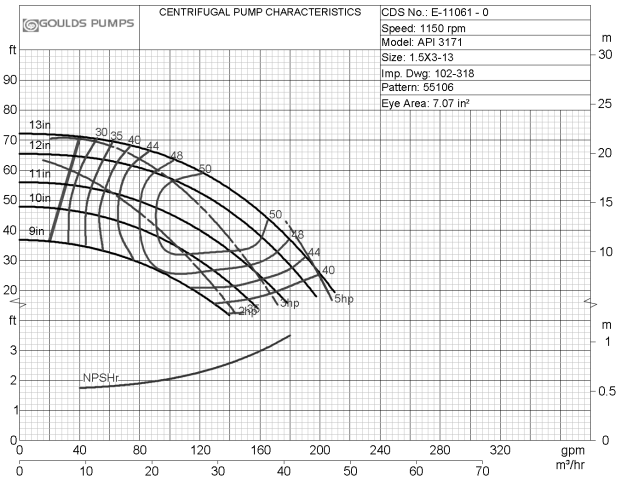
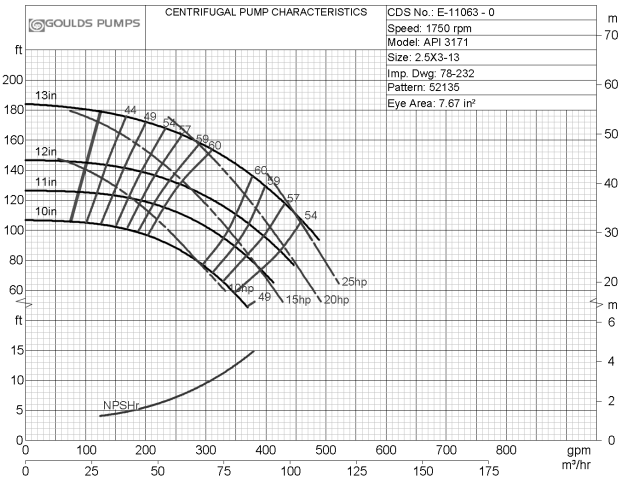
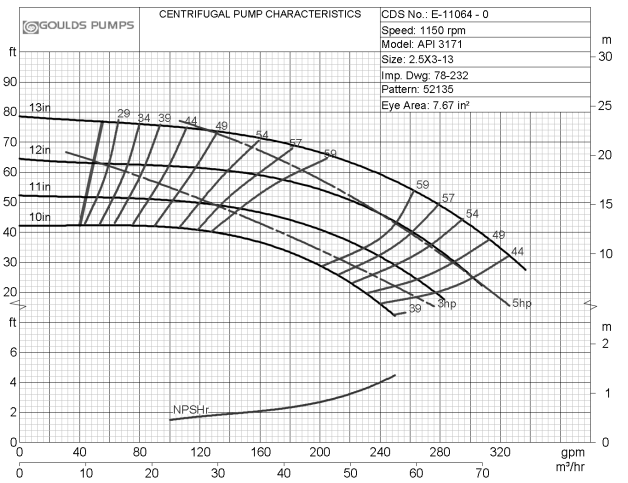


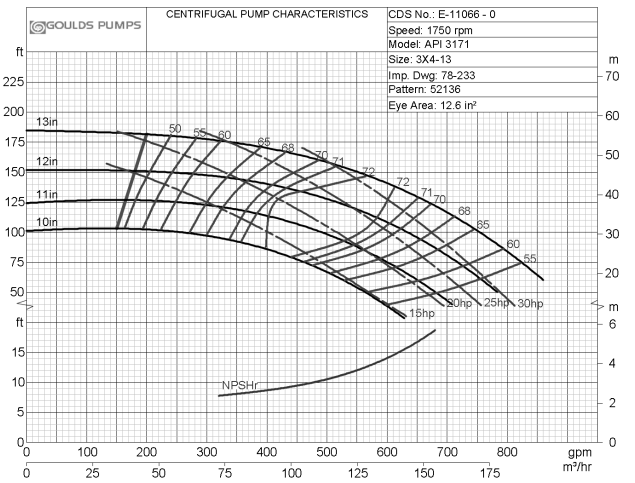
1.5X3-13 **1150rpm**



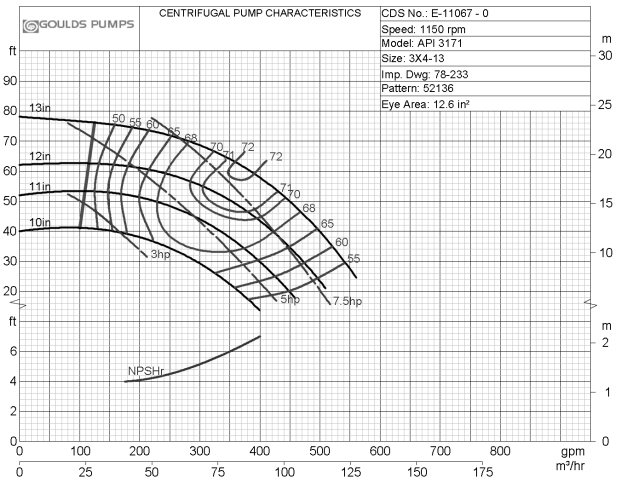
2.5X3-13 **1750rpm**



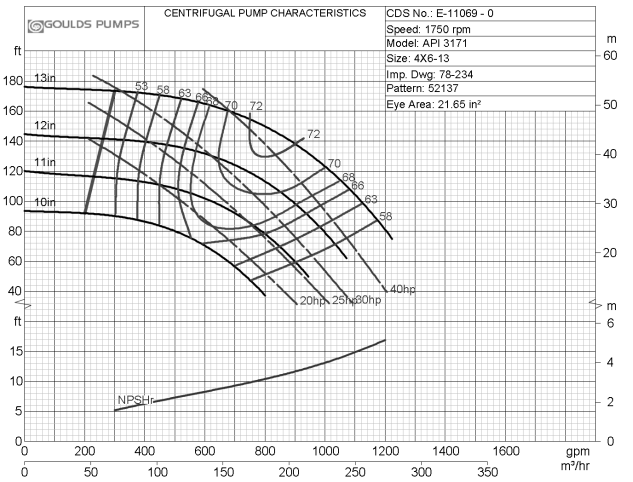
2.5X3-13 **1150rpm**



3X4-13 **1750rpm**

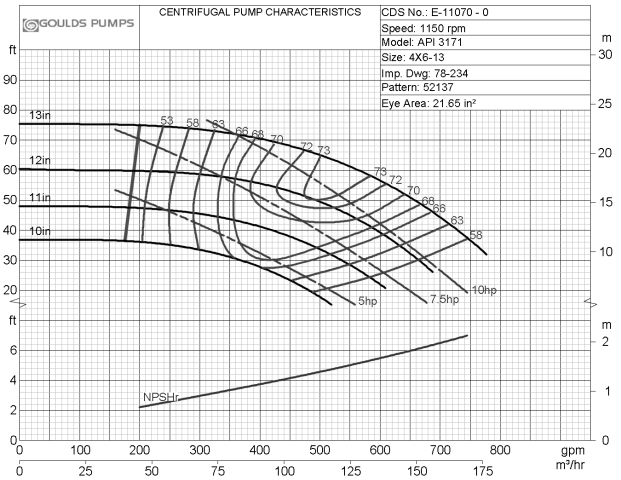


3X4-13 **1150rpm**

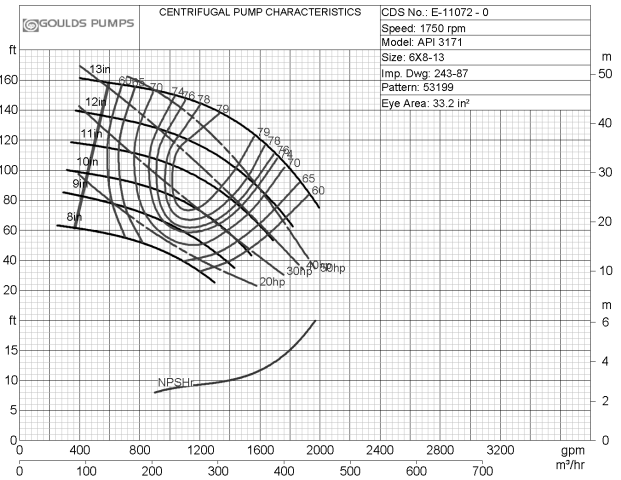


4X6-13 **1750rpm**

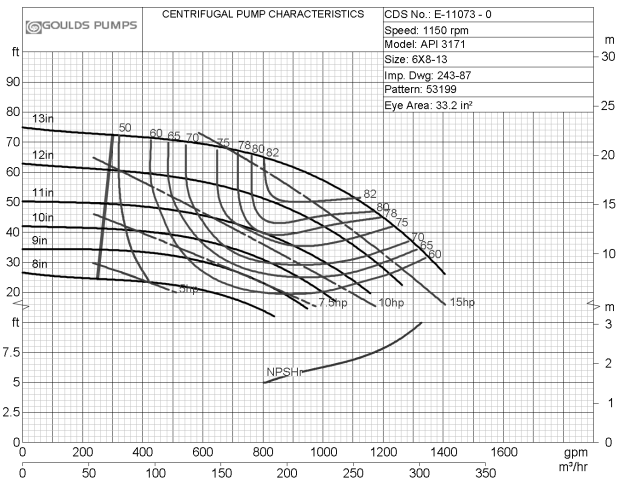
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



4X6-13 **1150rpm**



6X8-13 **1750rpm**



6X8-13 **1150rpm**

NOTES

Goulds Model NM 3171

FRP Vertical Sump and Process Pumps Designed for Severe Corrosive Services

- Capacities to 1250 GPM (284 m^3/h)
- Heads to 300 Feet (92 m)
- Temperatures to 200° F (93° C)
- Pit Depths to 16 Feet (5 m)

Design Features

- Cost Effective Alternative to High Alloys
- Corrosion Resistant RULON® Column Bearings
- Casing and Impeller Molded with High Strength, Corrosion Resistant GMP-2000*
- Casing and Impeller Interchangeable with Goulds Model NM 3196
- Rugged Double Row Thrust Bearing
- Thrust Bearing Sealed Against External Contamination
- Heavy Duty One-Piece Solid Shaft
- External Impeller Adjustment

Services

- **Chemical/Petrochemical**-Waste Acid, Hydrochloric Acid, Sodium Hydroxide; Ferric Chloride, Sulfuric Acid, Spinfinish Wastes
- **Utility**-Coal pile runoff, Sea water, Demineralized water
- **Metal Finishing**-Spent pickling solutions, Electroplating rinses, Nickel plating bath
- **General**-Industrial process; Deionized water, Pollution control, Sump services

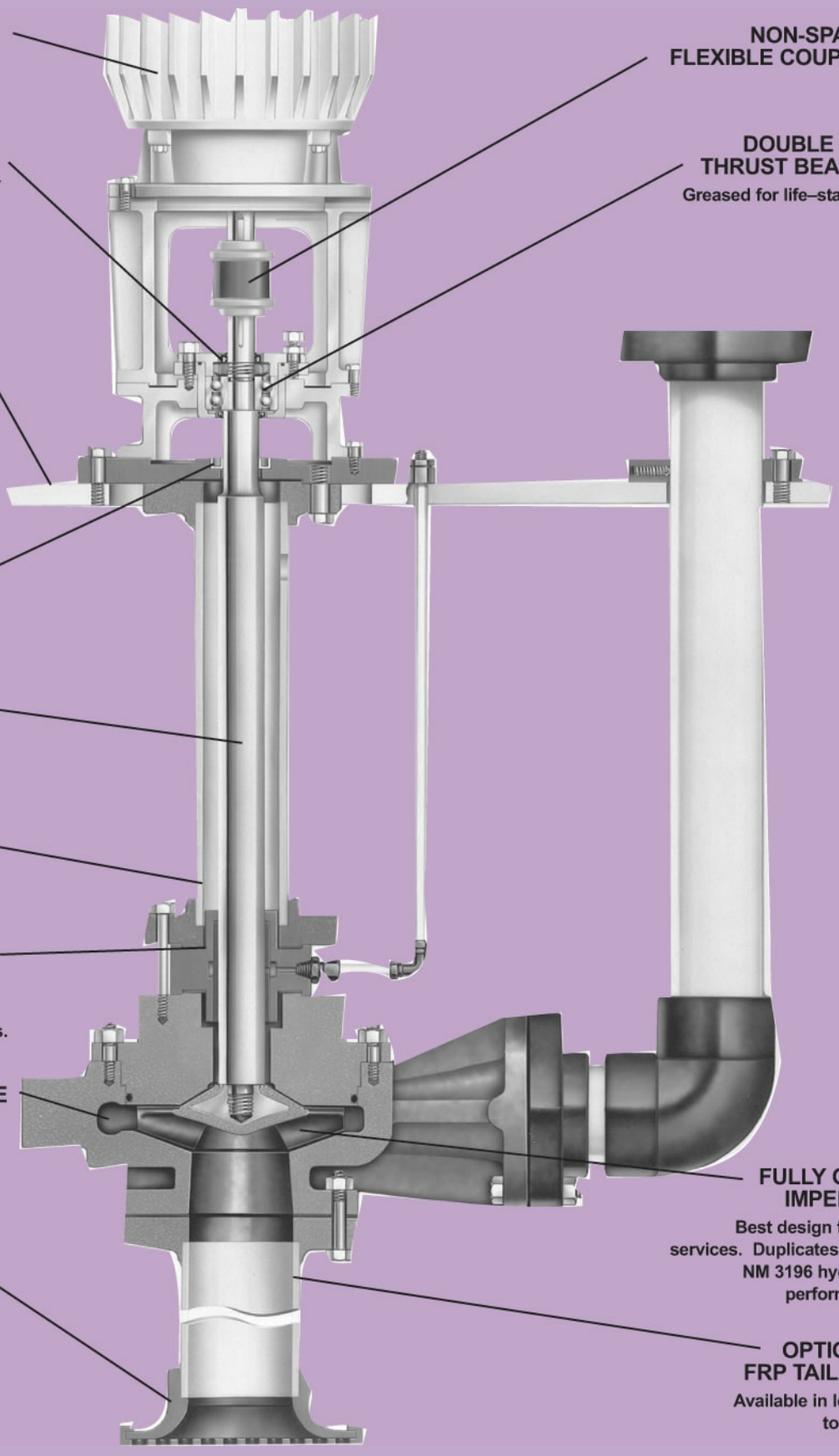
® RULON is a registered trademark of Dixon Industries Corp.

*** Proprietary molding process/material GMP-2000**

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model NM 3171 FRP Vertical Process Pumps

Design Features for Severe Corrosive Services



STANDARD NORMAL THRUST MOTORS
P-base, C-Face, I.E.C.

SEALED SELF-CONTAINED THRUST BEARING ASSEMBLY
Sealed at both ends to protect bearing from corrosive vapors.

HEAVY DUTY FRP MOUNTING PLATE

VAPOR SEAL CONSTRUCTION
TEFLON® U-cup seal assures product vapors are contained in column.

OVERSIZED SHAFT
Available in 316 stainless steel, Alloy 20, Hastelloy B and C, Titanium.

HIGH STRENGTH FRP COLUMN PIPE

CORROSION RESISTANT RULON® BEARINGS
Designed specifically for non-metallic pump services.

HIGH PERFORMANCE VOLUTE DESIGN
High efficiency, true volute design achieved by exclusive Greg Molding Process.

SUCTION BELL AND STRAINER
Supplied as standard.

NON-SPACER FLEXIBLE COUPLING

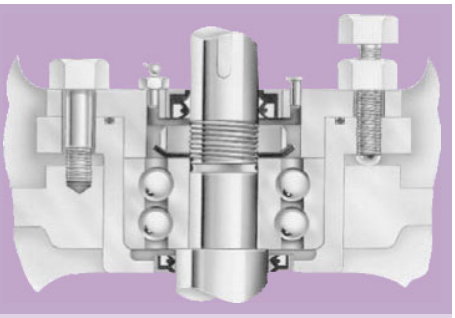
DOUBLE ROW THRUST BEARING
Greased for life–standard.

FULLY OPEN IMPELLER
Best design for CPI services. Duplicates Model NM 3196 hydraulic performance.

OPTIONAL FRP TAIL PIPE
Available in lengths to 6 feet.

Designed for Reliability

Thrust Bearing Design

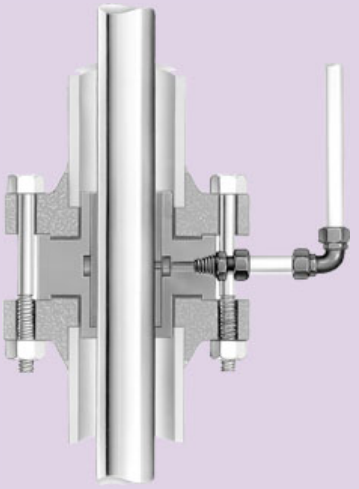


Mechanical Reliability Oversized double row thrust bearing accommodates entire range of NM 3171 sizes. Bearing is greased-for-life as standard for minimum maintenance.

Protected from Contamination Three-way bearing protection:

- Double lip shaft seals installed top and bottom.
- O-ring seal between bearing housing and end cover.
- Teflon U-cup vapor seal installed in shaft column.

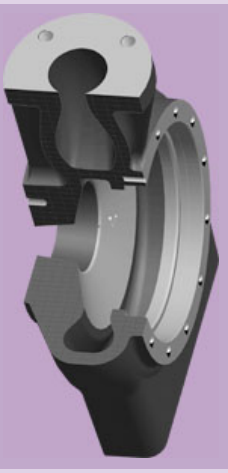
Column Bearing Design



Superior column bearing performance is assured by a special RULON ® bearing...a polymetric fluoropolymer material designed specially for use with high alloy shafting. RULON provides significant advantages:

- Extremely low coefficient of friction.
- Chemically inert.
- Low wear rate.
- Minimum lubrication requirements.
- Ideal for non-metallic pumps and severe corrosive services.

Corrosion Resistant Construction



The NM 3171 casing and impeller are constructed of vinylester thermoset resin–industry's choice for moderate corrosives. Maximum strength is achieved by fiber reinforcement. No fillers are used which reduce corrosion resistance.

Goulds utilizes our proprietary Process which permits a true volute to be molded in the casing, just like a metal ANSI pump. Other materials available upon request.

Application Flexibility

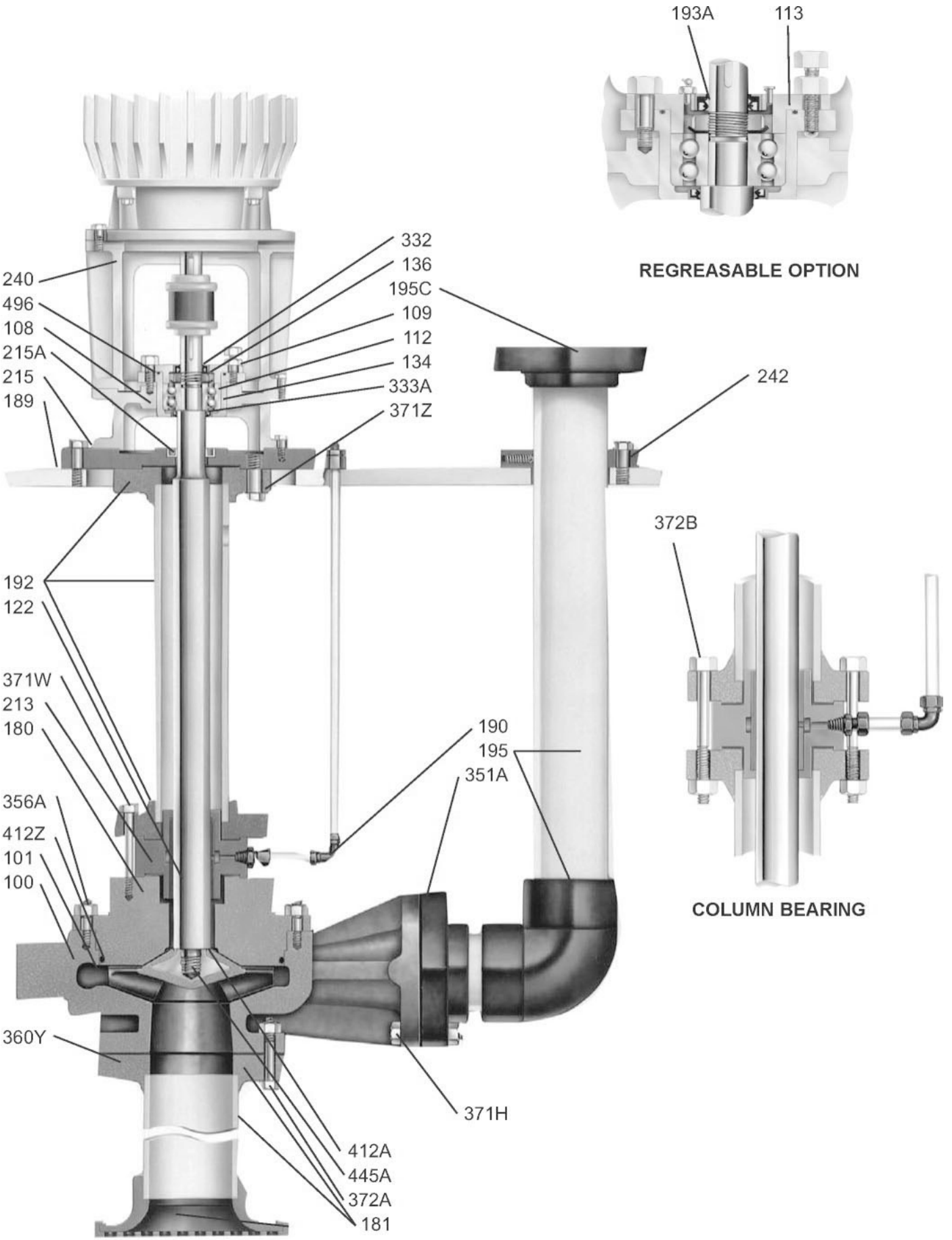
Goulds NM 3196 is a horizontal version of the Model NM 3171. Liquid end parts are made of the same material–high strength, corrosion resistant fiber reinforced vinylester. Performance and efficiency are the same. (Refer to Section CHEM-2A).

Parts List and Materials of Construction

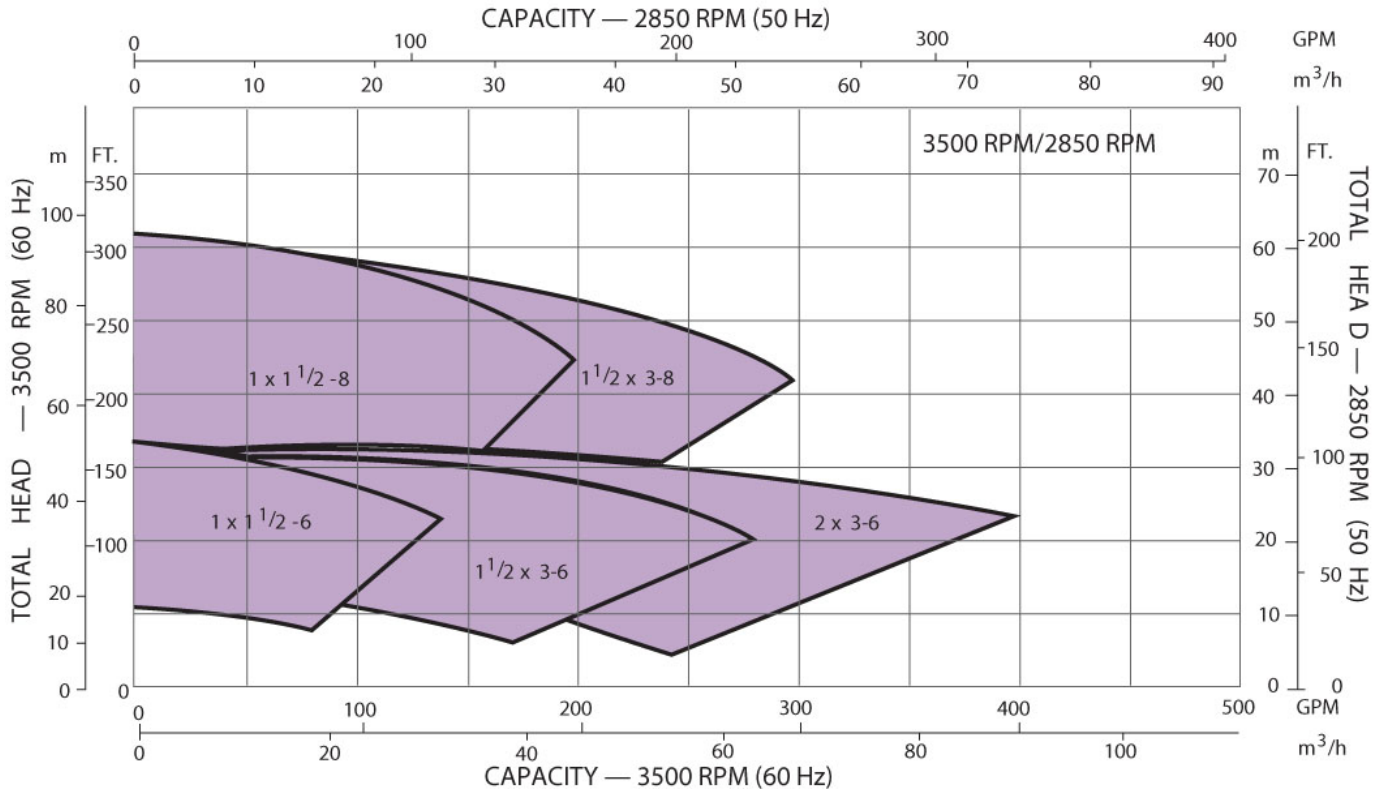
Part No.	Qty. per Pump	Part Name	Material				
100	1	Casing	Fiberglass Reinforced Vinylester				
101	1	Impeller with insert	Fibergalss Reinforced Vinylester/Hastelloy C				
108	1	Adapter	Cast Iron				
109	1	Bearing End Cover	Cast Iron				
112	1	Ball Bearing	Steel				
113	1	Grease Relief Fitting (Optional)	Steet				
122	1	Shaft	316 SS	AAlloy 20	Hastelloy B	Hastelloy C	Titanium
134	1	Bearing Housing	Cast Iron				
136	1	Bearing Locknut/Lockwasher	Steel				
180	1	Pump Cover	Polyester				
181	1	Suction Tail Pipe Assembly	Polyester				
189	1	Mounting Plate	Polyester				
190	1-4	Flush Tubing	Polypropylene				
192	1-4	Column Pipe Assembly	Vinyl Ester				
193A	1	Grease Fitting (Optional)	Steel				
195	1	Discharge Pipe Assembly	Vinyl Ester				
195C	1	Flange-Discharge Pipe	Vinyl Ester				
213	1-4	Column Bearing Assembly	Polyester/Rulon ®				
215	1	Protector Plate	Polyester				
215A	1	Vapor Seal	Teflon				
240	1	Motor Support	Cast Iron				
242	1	Pipe Collar	Polyester				
332	1	Lip Seal-Upper	Steel/Buna				
333A	1	Lip Seal/Lower	Steel/Buna				
351A	1	Gasket-Casing/Discharge Pipe Assembly	Non-Asbestos				
356A	4-16	Stud/Nut-Casing/Pump Cover	316 SS	Alloy 20	Hastelloy B	Hastelloy C	Titanium
360Y	1	Gasket-Casing/Tail Pipe Assembly	Non-Asbestos				
371H	4-8	H Cap Screw-Casing/Discharge Pipe Assembly	316 SS	Alloy 20	Hastelloy B	Hastelloy C	Titanium
371W	4	H Cap Screw-Column Pipe Assembly/Pump Cover	316 SS	Alloy 20	Hastelloy B	Hastelloy C	Titanium
371Z	4	H Cap Screw-Column Pipe Assembly/Protector Plate	316 SS	Alloy 20	Hastelloy B	Hastelloy C	Titanium
372A	4-8	H Cap Screw-Casing Suction Tail Pipe Assembly	316 SS	Alloy 20	Hastelloy B	Hastelloy C	Titanium
372B	4-12	H Cap Screw-Column/Column Tail	316 SS	Alloy 20	Hastelloy B	Hastelloy C	Titanium
412A	1	O-Ring-Impeller	Acid-Resistant Viton ®				
412Z	1	O-Ring-Pump Cover	Acid-Resistant Viton ®				
445A	1	Pin-Anti-Rotation	Nylon				
496	1	O-Ring-Bearing Housing	Buna				

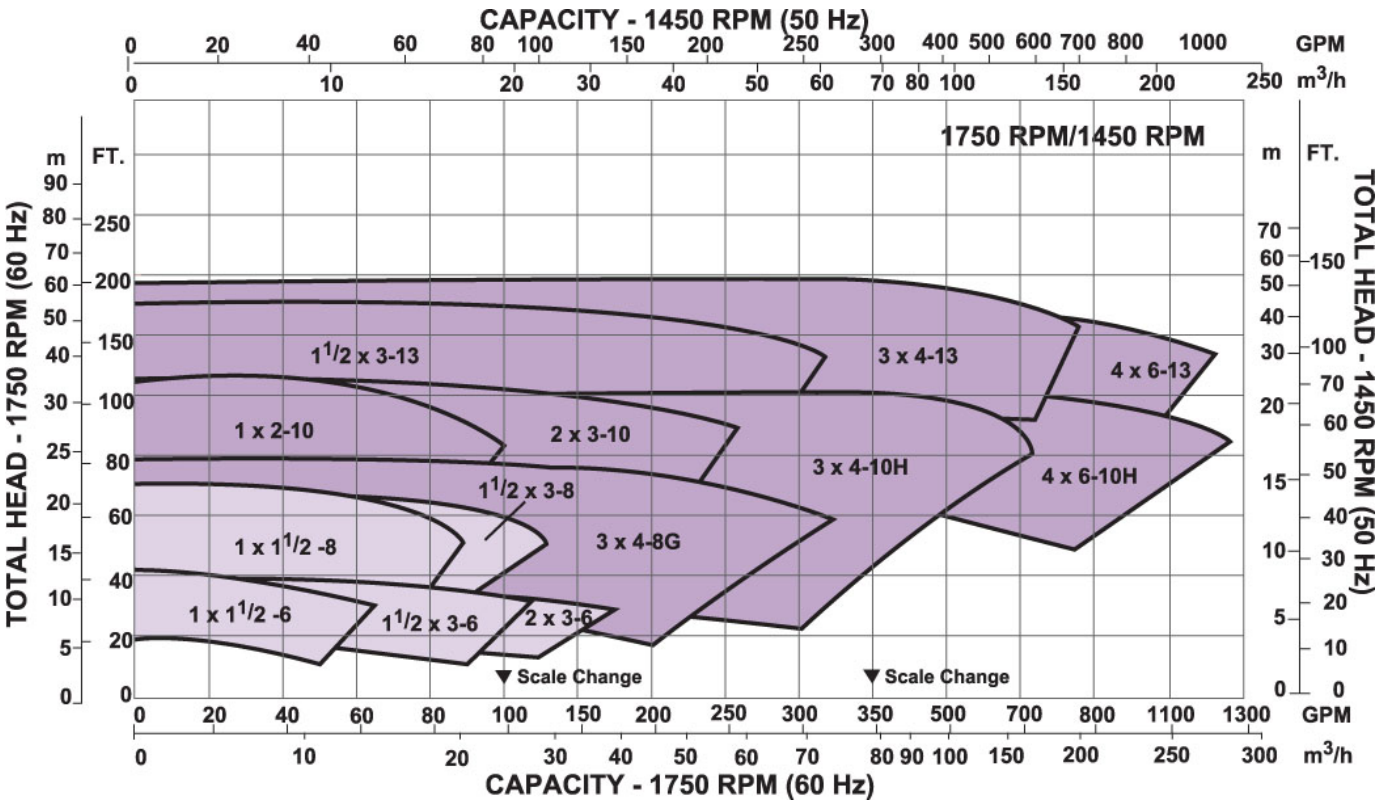
All hardware above mounting plate is 304 stainless steel.

Sectional View **Model NM 3171**

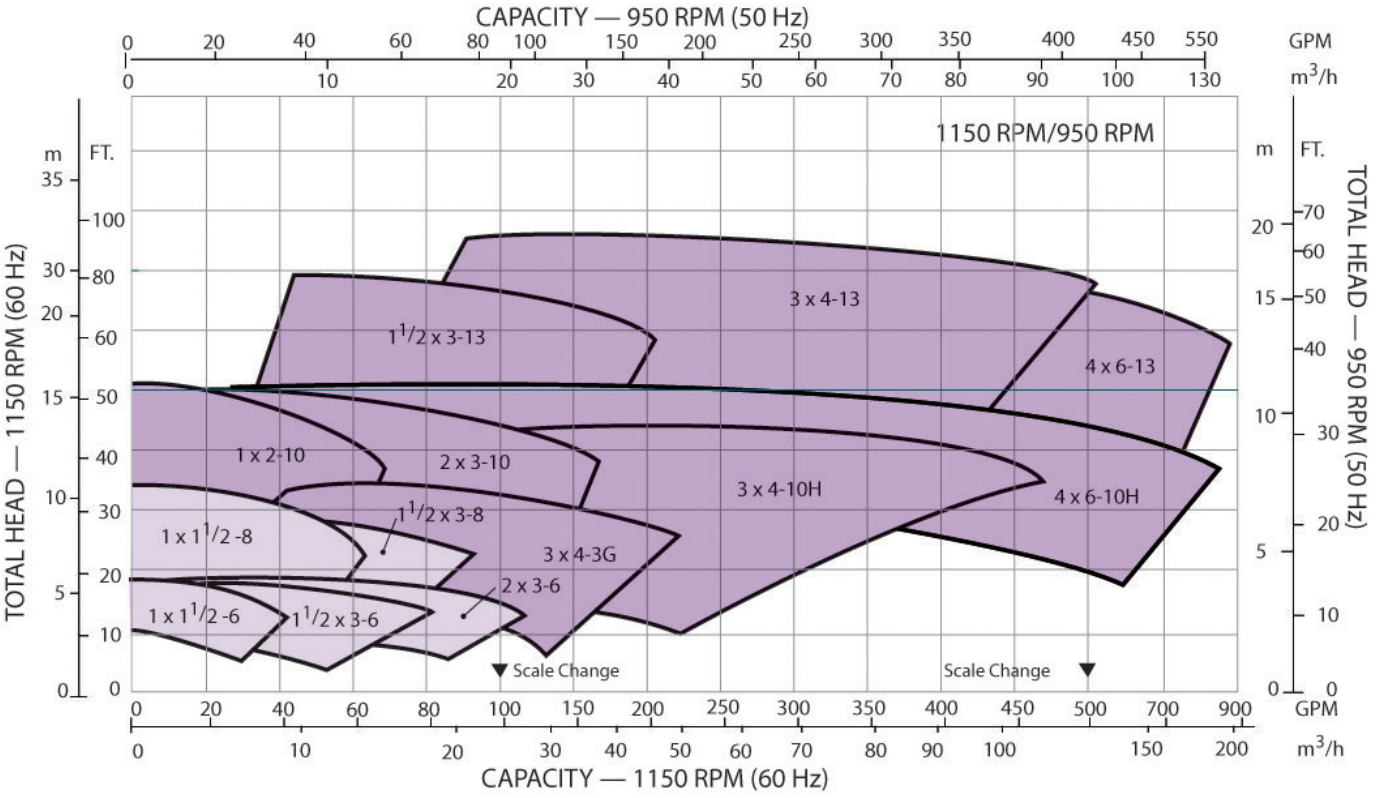


Hydraulic Coverage 50 & 60 Hz





Hydraulic Coverage 50 & 60 Hz



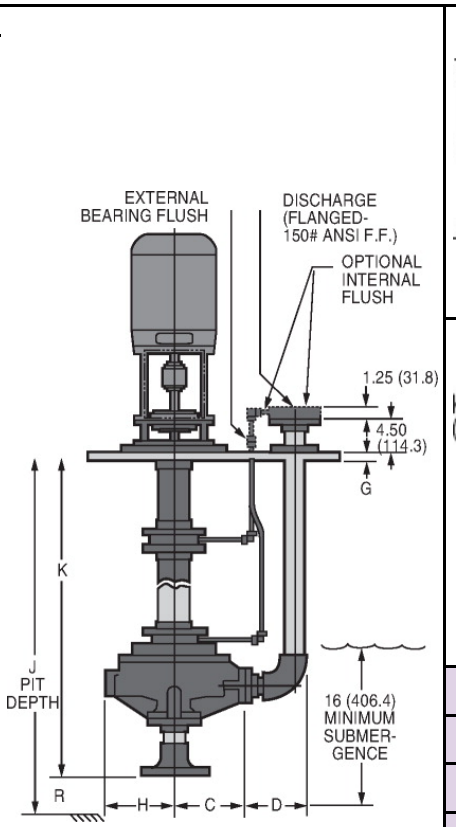
Parts List and Materials of Construction

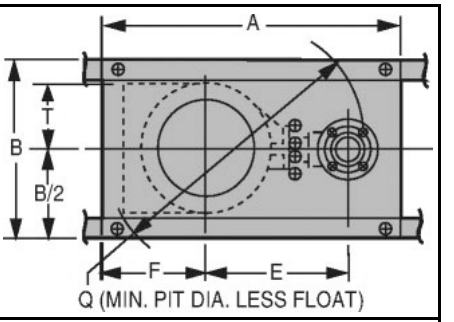
	Group ▶	ST					MT							
	Pump Size ▶	1×1½-6	1½×3-6	2×3-6	1×1½-8	1½×3-8	3×4-8G	1×2-10	2×3-10	3×4-10H	4×6-10H	1½ 3-13	3×4-13	4×6-13
Pump	Weight–3 Ft. Depth Less Motor–Lb. (kg)	125 (57)			135 (61)		140 (64)	155 (70)		160 (73)	170 (77)	200 (91)		210 (95)
	Weight–Add For Each 6 In. Length–Lb. (kg)	15 (7)												
Casing	Maximum Diameter Solids–In. (mm)	11/32 (8.7)	7/16 (11.1)	3/8 (9.5)	11/32 (8.7)	7/16 (11.1)	11/16 17.5)	7/32 (5.6)	3/8 (9.5)	5/8 (15.9)	21 (25.4)	7/32 (5.6)	5/8 (15.9)	1 (25.4)
	Maximum Discharge–Head–Ft. (m)	170 (52)			290 (88)		76 (23)	122 (37)		180 (55)				
Shaft	Diameter At Coupling End–In. (mm)	1 (25.4)												
	Diameter At Steady Bearings–In. (mm)	1 3/8 (34.9)					1 3/4 (44.4)							
	Diameter At Impeller–In. (mm)	3/4 (19.1)					1 (25.4)							
	First Critical Speed (minimum)	4500 RPM												
Bearings	Thrust Bearing	5306												
	Steady Bearing–Sleeve Type–In. (mm)	1 3/8 I.D.×4 L. (34.9 I.D.×101.6.L.)					1 3/4 I.D.×4 L. (44.4 I.D.×101.6.L.)							
	Maximum Spacing–Center-To-Center–In. (mm)	32 (813)												
	Maximum Liquid Temperature	200°F (79°C)												

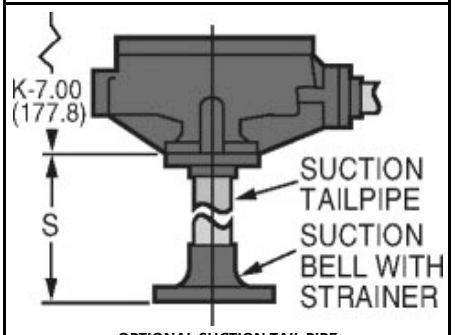
Dimensions Model NM 3171

All dimensions in inches and (mm). Not to be used for construction.

DIMENSIONS-PUMP SETTING				
Set No.	Pit Depth J in Ft(m)	No. of Steady Bearings	K	R
01	3.00 (9.14)	1	28.50 (723.9)	7.50 (190.5)
02	3.50 (1.067)		34.50 (876.3)	
03	4.00 (1.219)		46.50 (1028.7)	
04	4.50 (1.372)		46.50 (1181.1)	
05	5.00 (1.524)	2	54.50 (1384.3)	5.50 (139.7)
06	5.50 (1.676)		60.50 (1536.7)	
07	6.00 (1.829)		66.50 (1689.1)	
08	6.50 (1.981)		72.50 (1841.5)	
09	7.00 (2.134)		78.50 (1993.9)	
10	7.50 (2.286)	3	83.50 (2120.9)	6.50 (165.1)
11	8.00 (2.438)		89.50 (2273.3)	
12	8.50 (2.591)		95.50 (2425.7)	
13	9.00 (2.743)		101.50 (2578.1)	
14	9.50 (2.896)		107.50 (2730.5)	
15	10.00 (3.048)	4	112.50 (2857.5)	7.50 (190.5)







OPTIONAL SUCTION TAIL PIPE

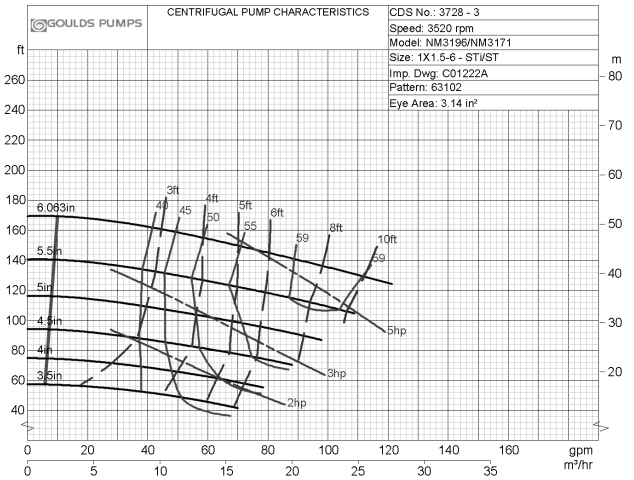
S	
12.00 (304.8)	48.00 (1219.2)
18.00 (457.2)	54.00 (1371.6)
24.00 (609.6)	60.00,(1524.0)
30.00 (762.0)	66.00 (1676.4)
36.00 (914.4)	72.00 (1818.8)
42.00 (1066.8)	

DIMENSIONS DETERMINED BY PUMP													
Grp.	Size	Disch.	A	B	C	D	E	F	G	H	T	Weight* Lbs/(kg)	Q
ST	1x1½-6	2	24.00 (609.6)	15.00 (381)	6.50 (165.1)	8.00 (213.2)	12.88 (327.2)	7.25 (184.2)	.75 (19.1)	5.25 (133.4)	4.50 (114.3)	125 (57)	22.00 (558.8)
	1½x3-6	2									4.88 (123.9)		
	2x3-6	2									4.88 (123.0)		
	1x1½-8	2		18.00 (457.2)							5.50 (139.7)	135 (61)	
	1½x3-8	2									5.50 (139.7)		
ST	3x4-8G	3	36.00 (914.4)	18.00 (457.2))	11.00 (279.4)	9.12 (231.6)	18.00 (457.2)	11.75 (298.5)	1.00 (25.4)	8.25 (209.6)	6.88 (174.7)	140 (64)	31.00 (787.4)
	1X2-10	2			8.50 (215.9)	11.2 (282.4)					6.75 (171.5)	155 (70)	
	2x3-10	2			9.50 (241.3)	10.12 (257.1)					7.00177.8)	155 (70)	
ST	3x4-10H	3	36.00 (914.4)	30.00 (762)	12.50 (317.5)	9.12 (231.6)	19.50 (495.3)	12.00 (304.8)		10.00 (254)	7.62 (193.5)	175 (79)	35.00 (889)
	1½x3-13	2			10.50 (266.7)	11.12 (282.4)					8.62 (218.9)	200 (91)	34.00 (863.6)
	3x4-13	3			12.50 (317.5)	9.12 (231.6)					9.62 (244.3)	200 (91)	
ST	4x6-10H	4	40.00 (1016)	30.00 (762)	13.50 (342.9)	10.25 (260.4)	21.12 (536.4)	13.00 (330.2)			8.00 (203.2)	155 (70	36.00) (914.4)
	4x6-13	4									10.38 (263.7)	250 (113)	

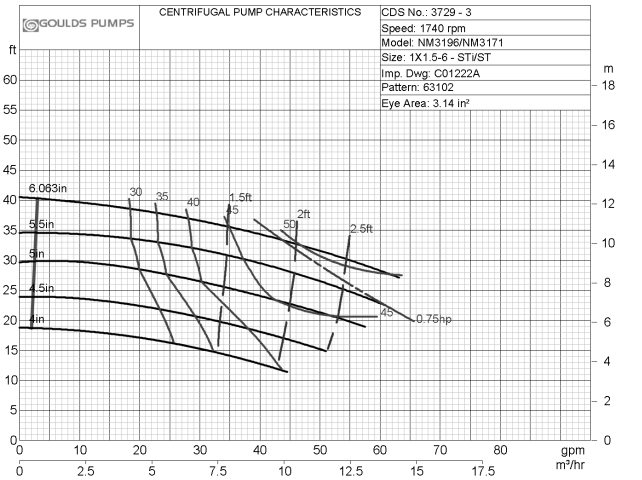
* Weight shown is for 36 in. pit depth. Weight increases by 30 lb. (13.6) for each additional 1 foot increment. Weights are approximate.

For detailed hydraulic curves for the NM 3171, please refer to the 3196 curves in section CHEM-1A.

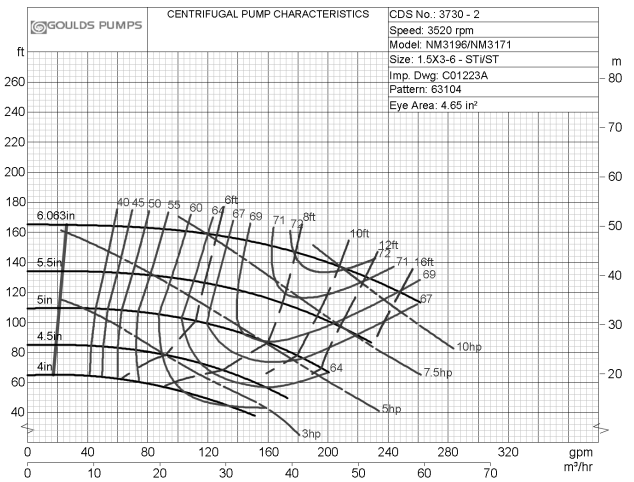
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



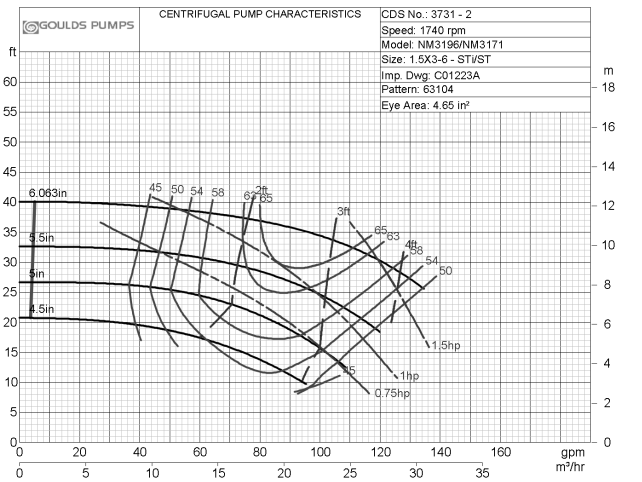
1X1.5-6 **3520rpm**



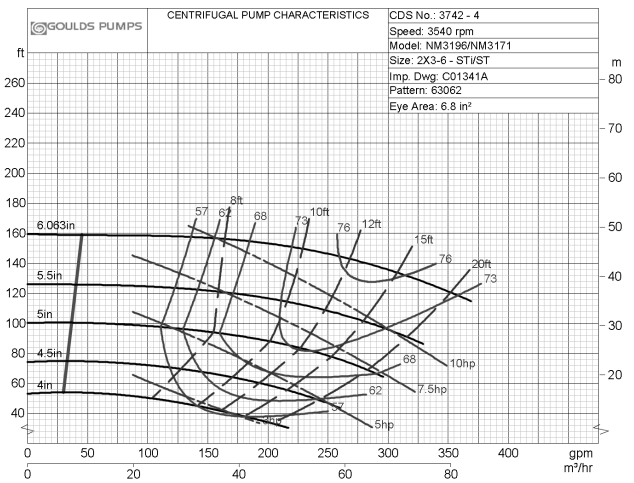
1X1.5-6 **1740rpm**



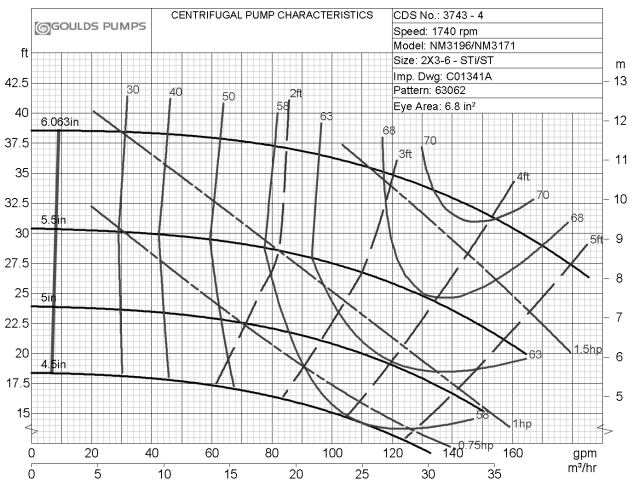
1.5X3-6 **3520rpm**



1.5X3-6 **1740rpm**



2X3-6 **3540rpm**

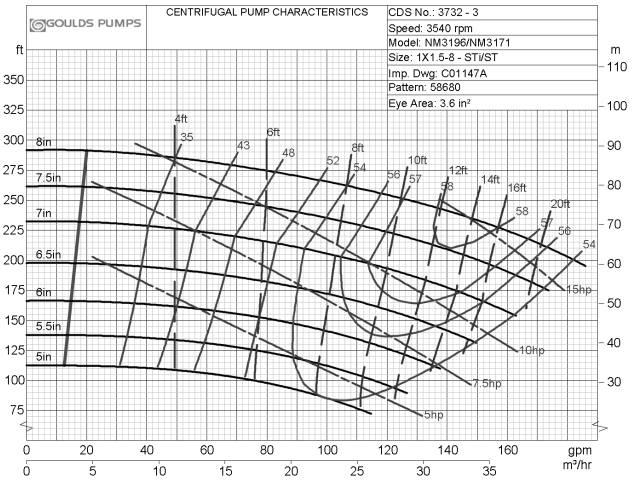


2X3-6 **1740rpm**

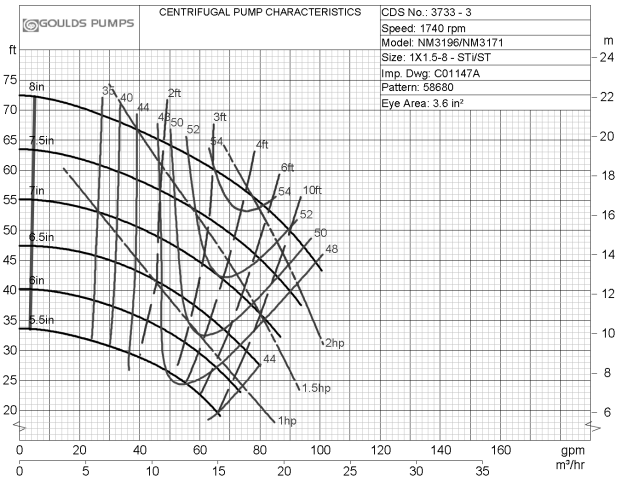
60Hz Curves

Model NM3171/NM3196

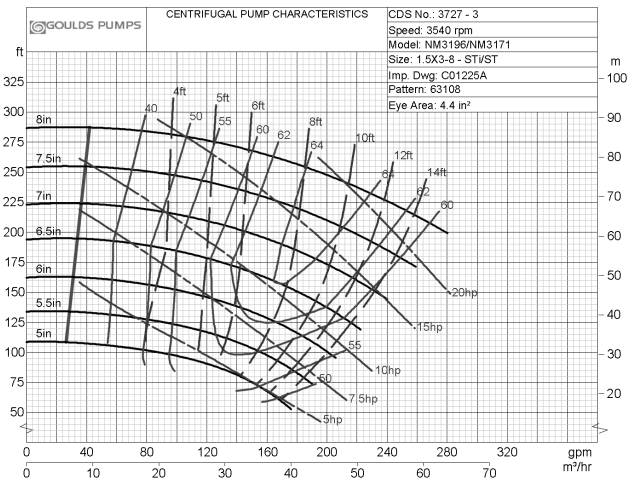
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



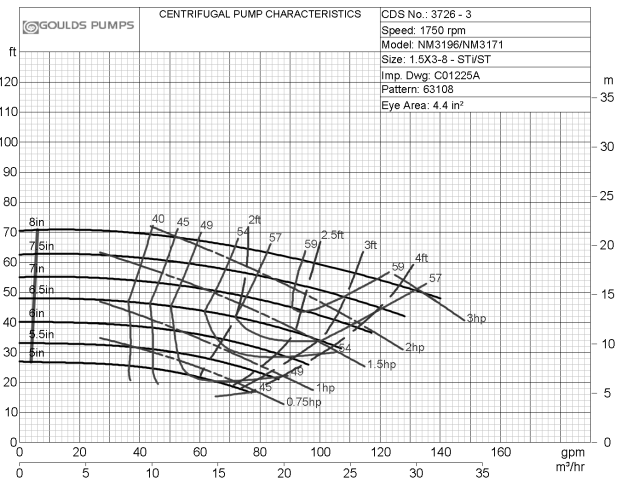
1X1.5-8 **3540rpm**



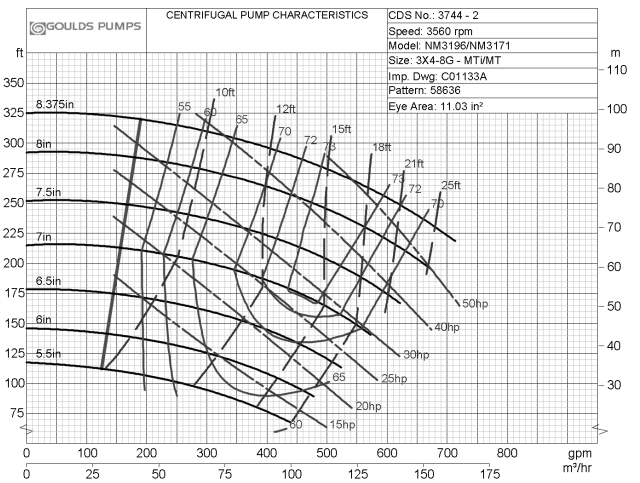
1X1.5-8 **1740rpm**



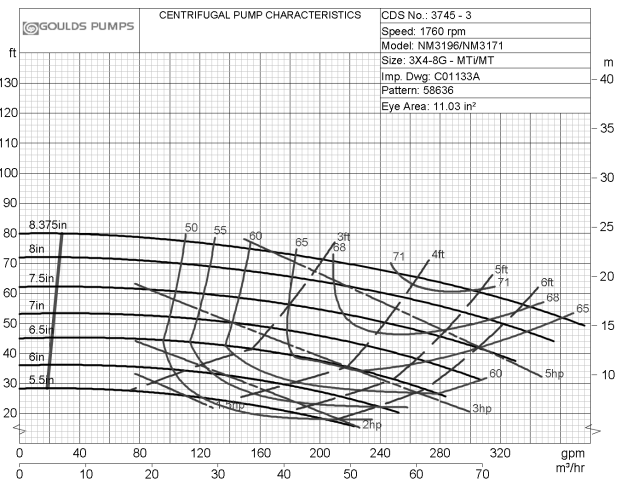
1.5X3-8 **3540rpm**



1.5X3-8 **1750rpm**

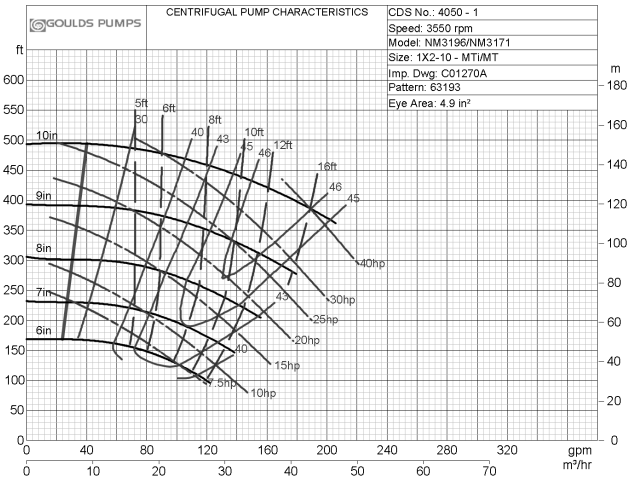


3X4-8G **3560rpm**

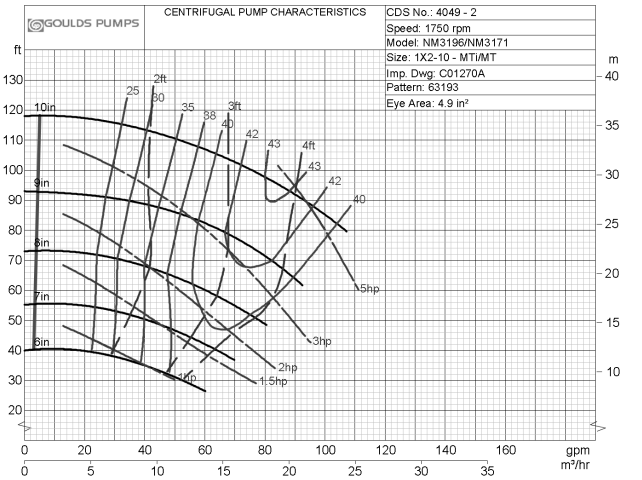


3X4-8G **1760rpm**

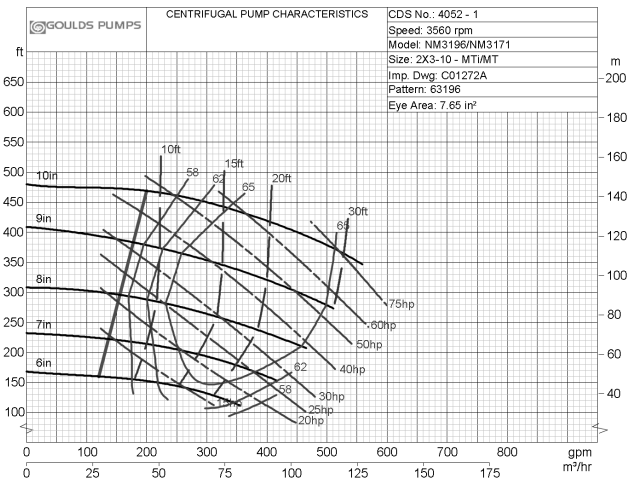
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



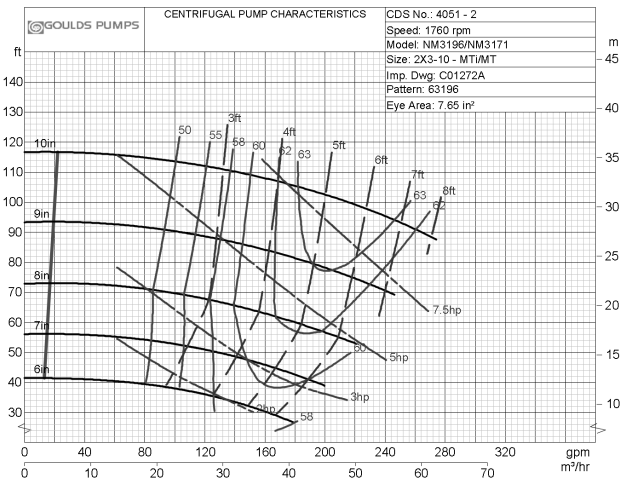
1X2-10 **3550rpm**



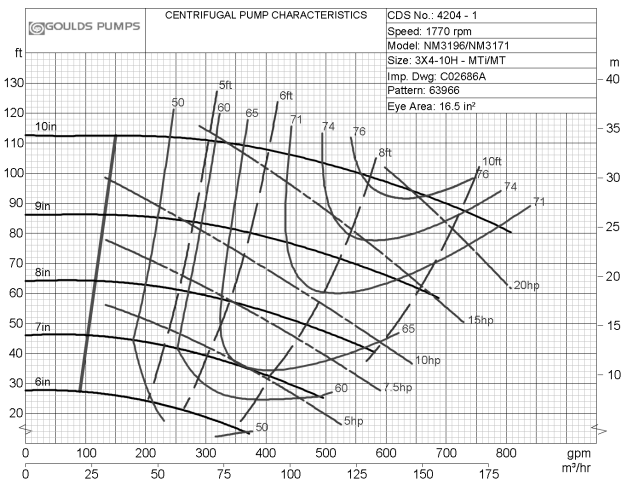
1X2-10 **1750rpm**



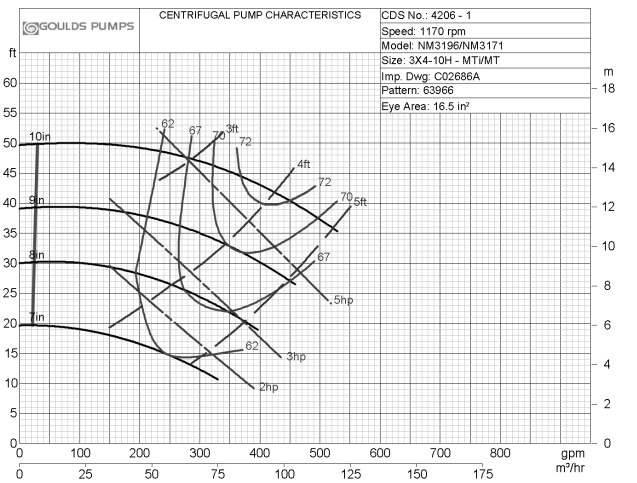
2X3-10 **3560rpm**



2X3-10 **1760rpm**

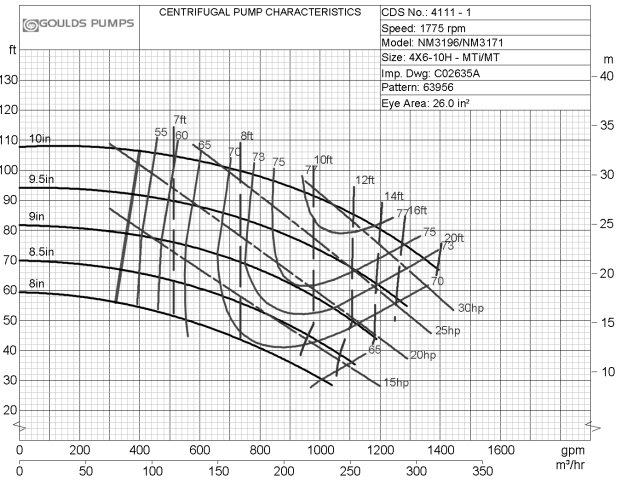


3X4-10H **1770rpm**

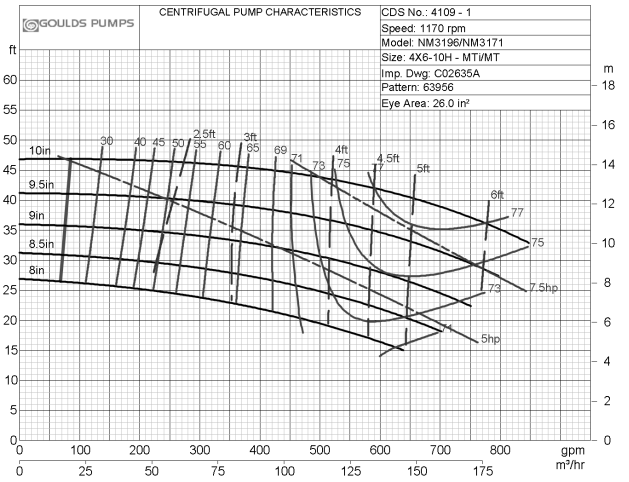


3X4-10H **1170rpm**

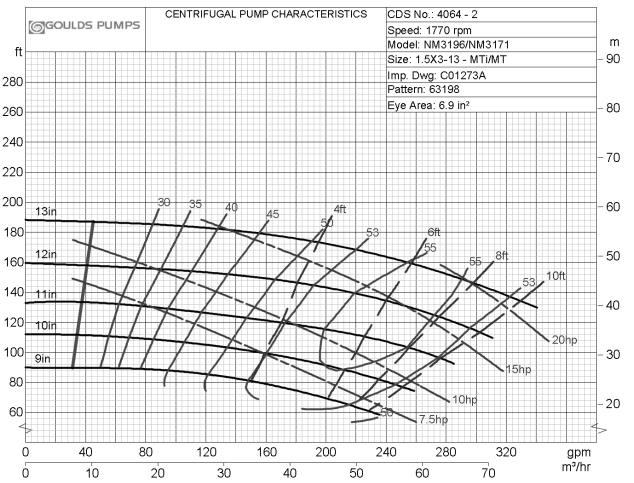
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



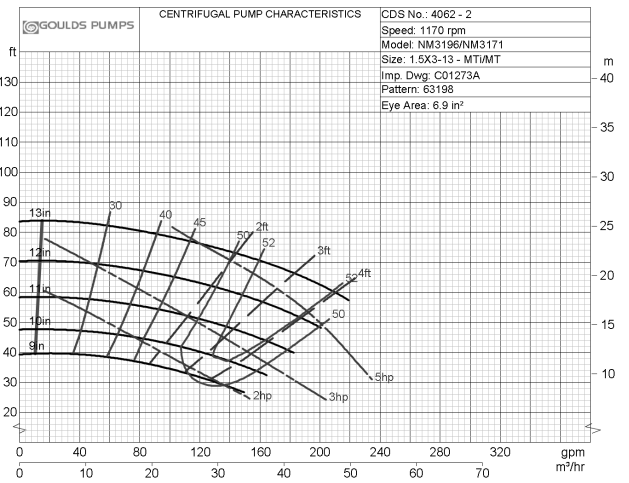
4X6-10H **1775rpm**



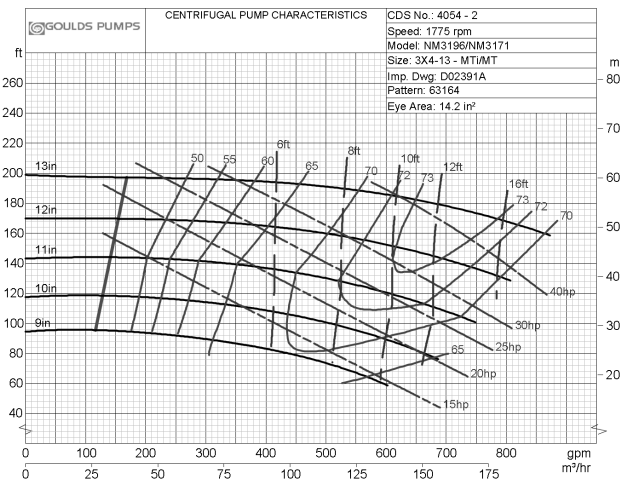
4X6-10H **1170rpm**



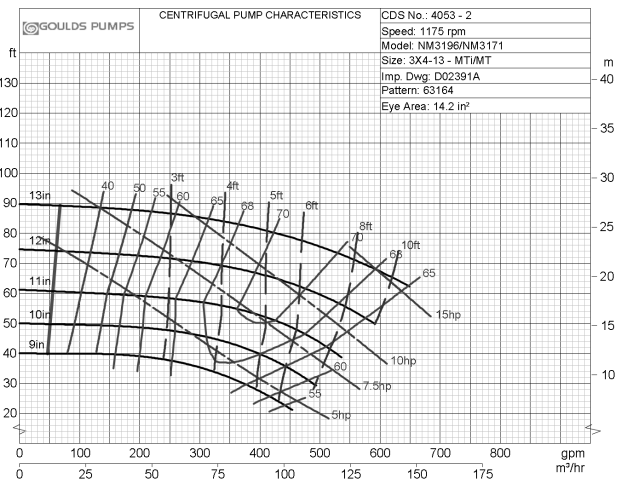
1.5X3-13 **1770rpm**



1.5X3-13 **1170rpm**

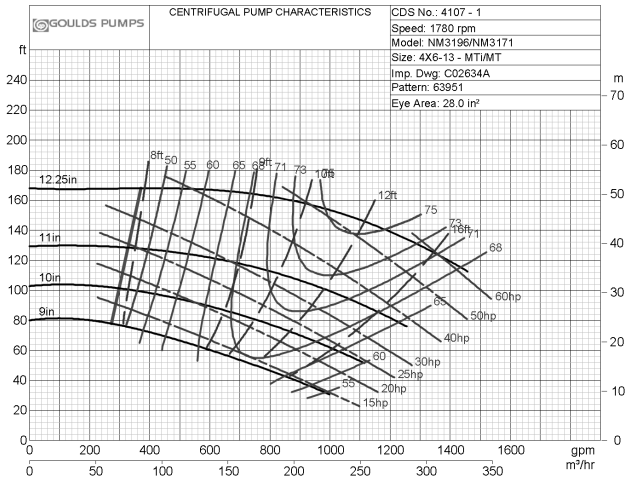


3X4-13 **1775rpm**

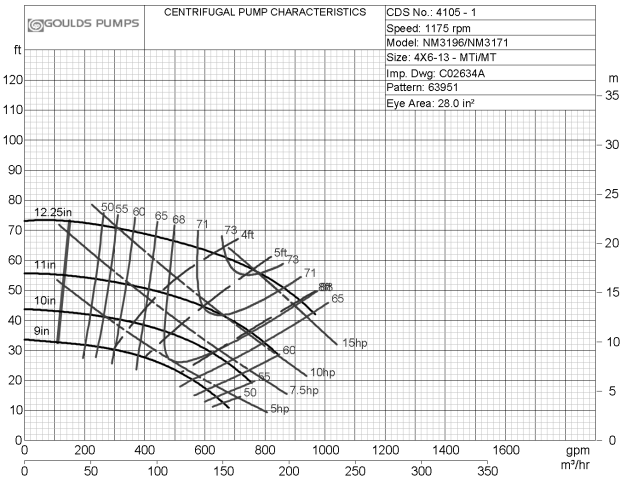


3X4-13 **1175rpm**

The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.

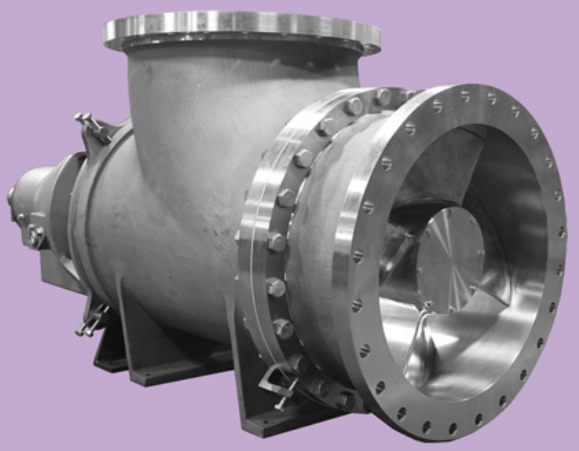


4X6-13 **1780rpm**



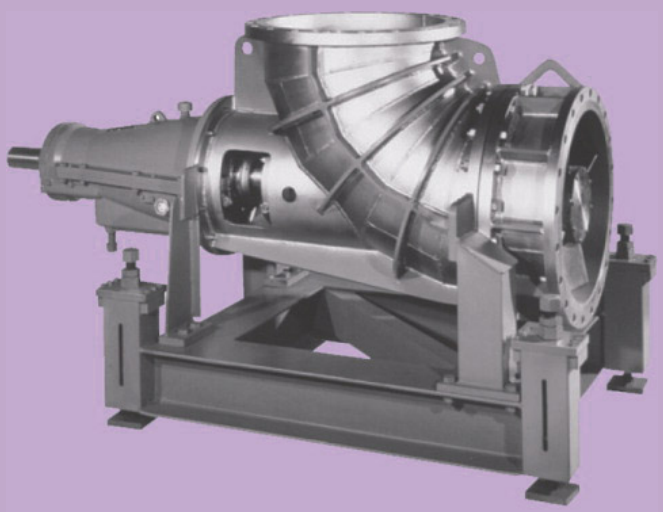
4X6-13 **1175rpm**

NOTES



Cast design 6" - 36"

Shown above is a pipe-hung unit with an underslung motor/baseplate arrangement.



Fabricated design 42 inch and larger

Shown above is 42" size with optional spring mounted base. Fabricated designs can be built in larger and smaller sites if required.

Goulds Model AF

Axial Flow Pumps Designed for Continuous Circulation of Corrosive/Abrasive Solutions, Slurries and Process Wastes

- Capacities to 300,000 GPM GPM (68,000 m^3/h)
- Heads to 30 feet (9.2 m)
- Temperatures to 350°F (176°C)
- Available in cast iron, austenitic stainless steels, duplex alloys, nickel, nickel-chrome alloys, nickel-chrome-moly alloys, titanium, and other alloys as required for the service
- Available in 6 - 66 inch sizes (larger sizes on application)

Design Features

- Multiple impeller selections for optimum performance and efficiency.
- Tapered bore stuffing box for longest mechanical seal life.
- Dual lantern ring configuration available for packed stuffing box.
- Back pullout construction on sizes through 36 inch (900 mm)
- Robust bearing frame and shaft for long life on critical, continuous duty services.

Applications

- **Chemical** - Evaporator and Crystallizer Circulation
- **Mining and Minerals** - Phosphate, Soda Ash, Potash and Sodium Chloride Processing.
- **Petrochemical** - Polymerization Reactors, Xylene
- **Pulp & Paper** - Black Liquor Evaporator, Chlorine Dioxide Generators
- **Municipal** - Sewage Digesters
- **General -** Raw Water Pumping, Flood Control, Marine Ballast Transfer

Goulds line of axial flow pumps is unmatched in the industry for low head/high capacity pumping requirements, especially when corrosive and/or abrasive solutions are involved. Extended service life, mechanical reliability, custom engineering and a wide range of materials allow the Model AF to stand out as the leader in the field.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model AF Axial Flow Pumps

Rugged Design Features for Wide Range of Services

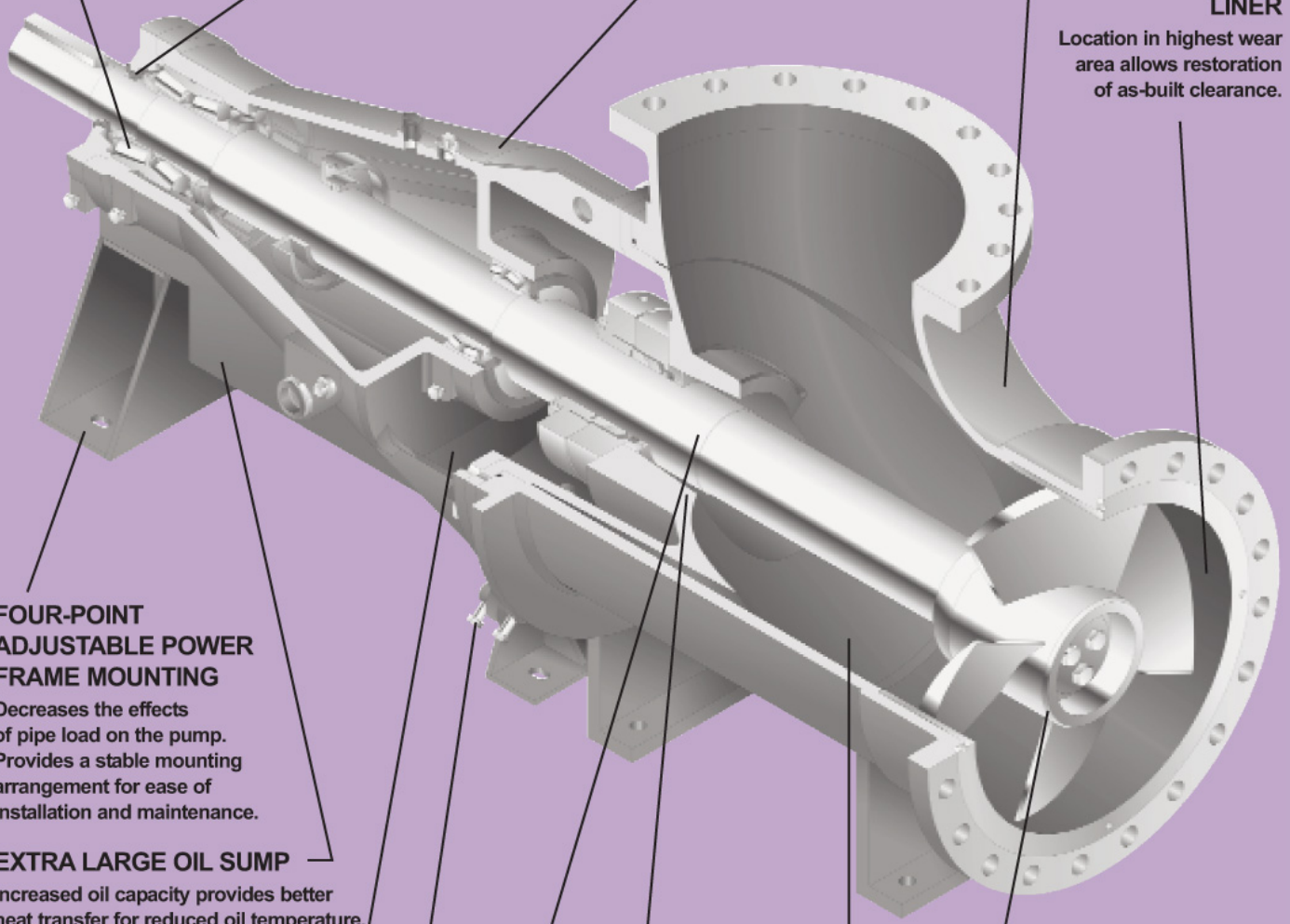
BI-DIRECTIONAL THRUST BEARING
Allows standardized frame for both Top and End Suction arrangements (through 36 inch size)

NON-CONTACTING LABYRINTH OIL SEALS
Bronze standard - optional metallic and non-metalic materials are available.

ONE PIECE BEARING FRAME
Ensures accurate alignment for optimum life.

THICK METAL SECTIONS
Elbow, stuffing box, and Impeller have extra thick metal sections for extended wear life.

OPTIONAL REPLACEABLE LINER
Location in highest wear area allows restoration of as-built clearance.



FOUR-POINT ADJUSTABLE POWER FRAME MOUNTING
Decreases the effects of pipe load on the pump. Provides a stable mounting arrangement for ease of installation and maintenance.

EXTRA LARGE OIL SUMP
Increased oil capacity provides better heat transfer for reduced oil temperature. Bearings run cooler and last longer.

STAINLESS DRIP PAN
Standard pan catches any drips and connects to drain piping to eliminate damage from leaks.

BUILT-IN ADJUSTING LUGS
Allow precise easy adjustment of impeller clearance and stuffing box run out.

EXTRA HEAVY DUTY SHAFT
Long bearing span and large diameters reduce shaft deflection, extend mechanical seal and bearing life.

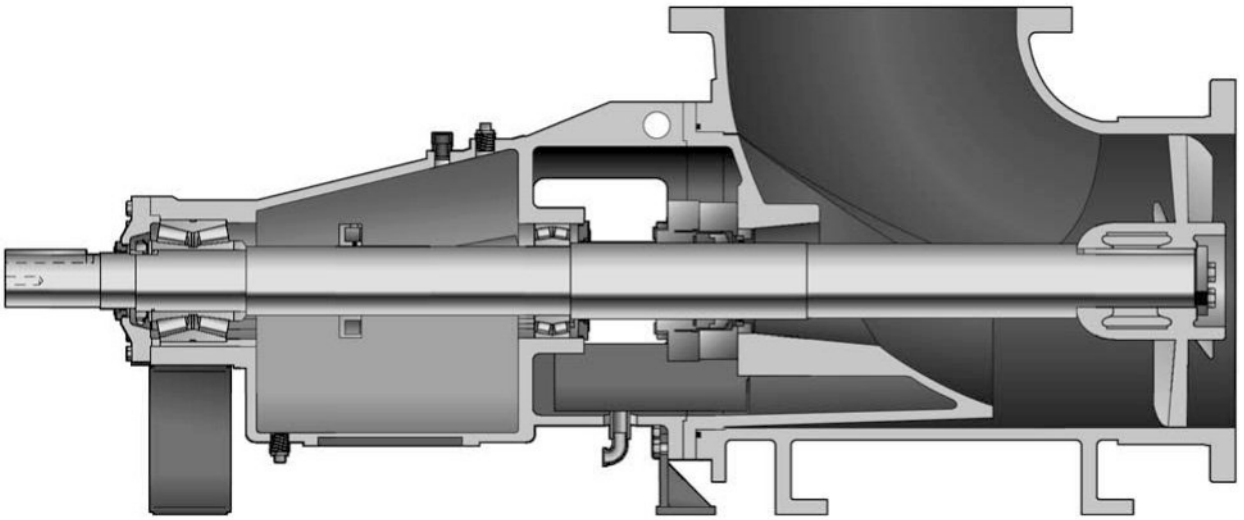
OPTIONAL CLEANOUT HOLE
Allows removal of stringy contaminants.

TAPERBORE™ STUFFING BOX
Designed specifically for today's cartridge seals. Optional packed box with sleeve available.

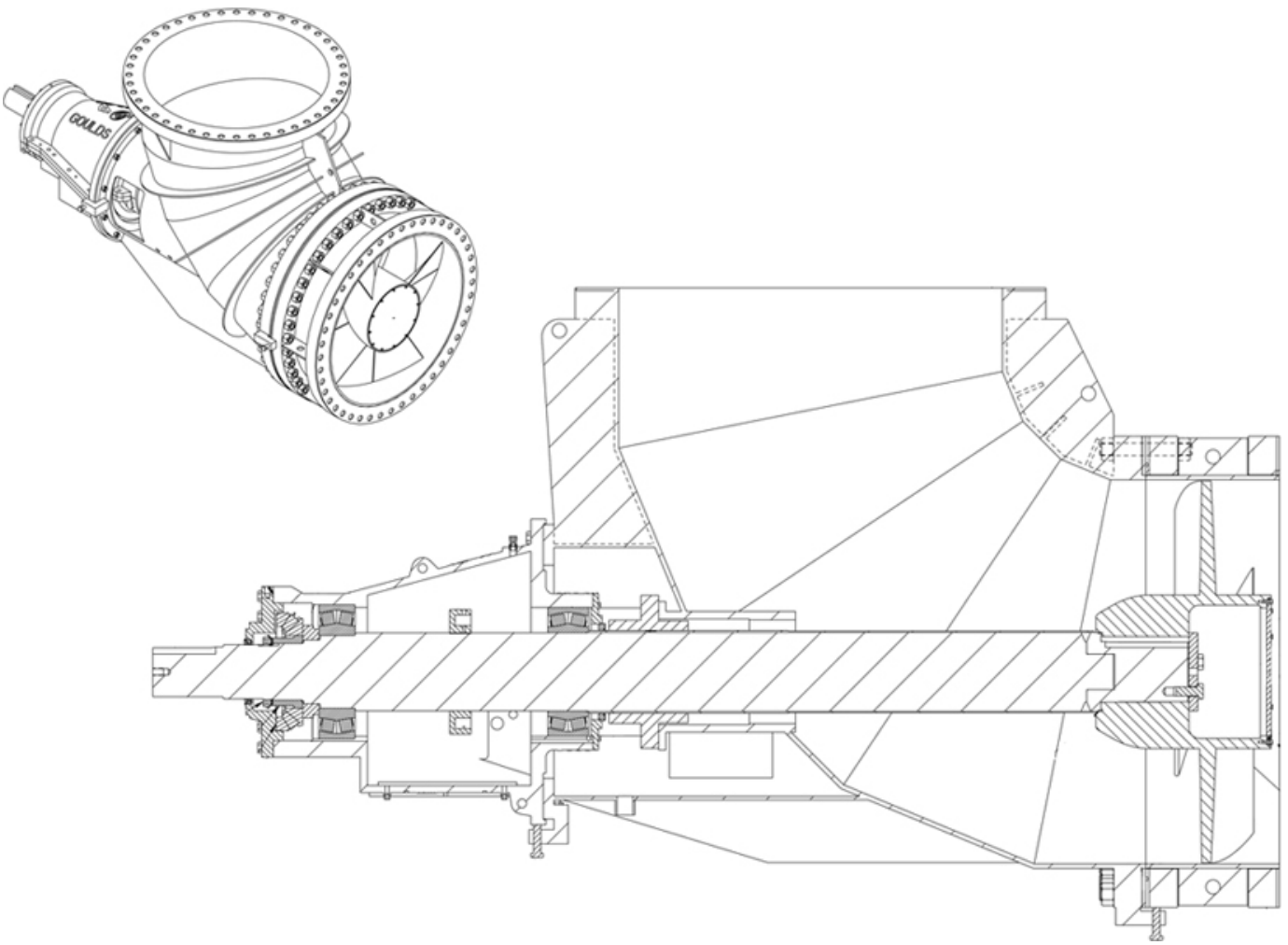
HIGH EFFICIENCY IMPELLER
Available in a wide variety of vane angles. Available in Top or End Suction configurations.

Note: the cross-sectional illustrates the cast design with the back pullout feature.

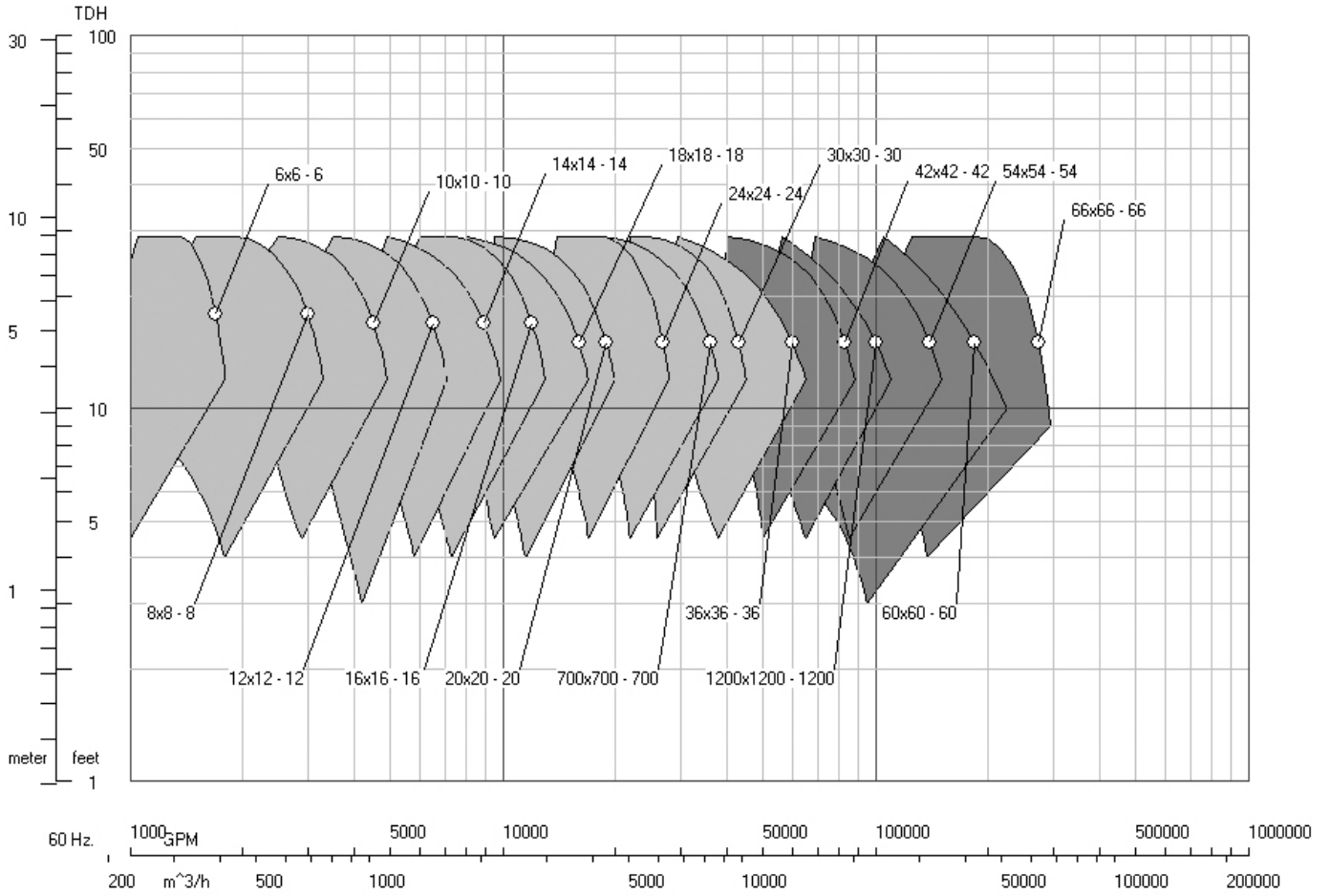
Sectional View Model AF (6 - 36 inch sizes)



Sectional View Model AF (42 inch and larger)



Hydraulic Coverage



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

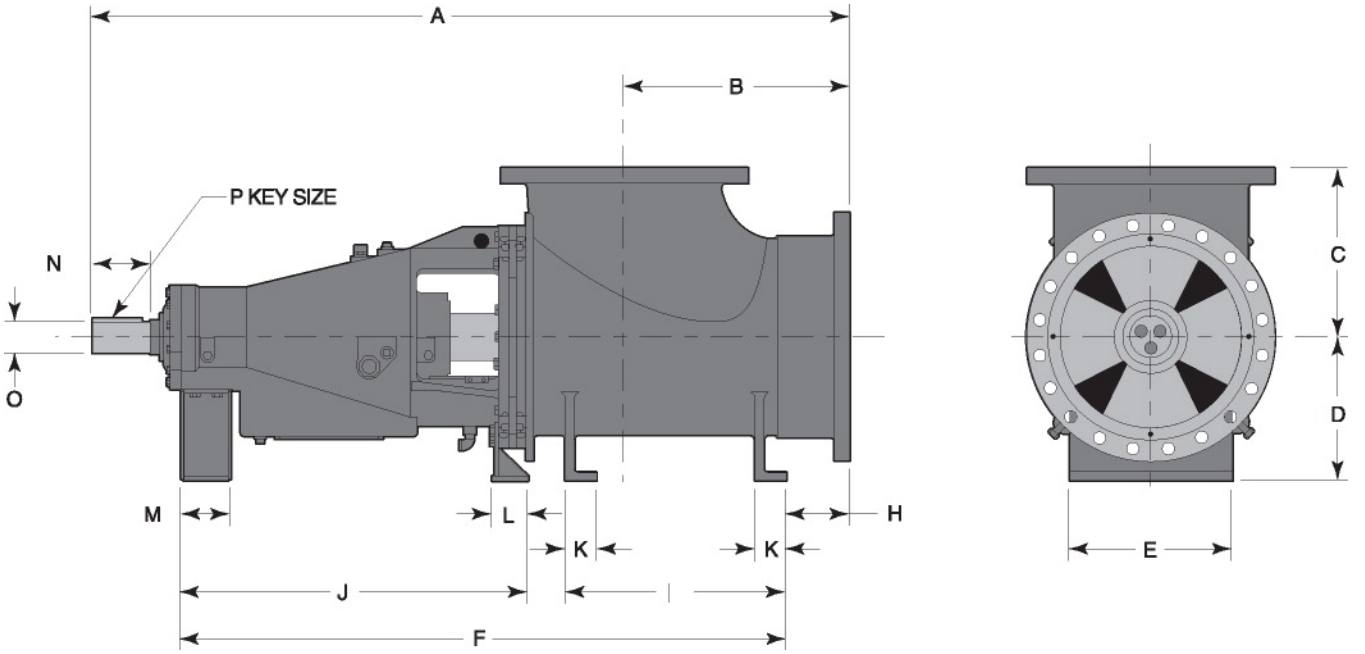
Construction Details

Description	6	8	10	12	14	16	18	20	24	700 mm	30	36	42	1200 mm	54
Impeller															
Number of Vanes	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Sphere Size (in.)	1.5	2	2.5	3	3.5	4	4.5	5	6	7	7.5	9	10.5	12	13.5
WR^2 (Lb-Ft^2)	0.054	0.67	1.74	3.5	6.64	10.2	21.9	36.8	89.5	197	311	653	1302	2131	3550
Shaft Diameter (in.)															
At Impeller	1.25	1.38		2.00		2.62		3.62	4.00		4.75	5.12	8.00	8.50	
At Stuffing Box w/Sleeve (for reference only)	1.69			2.44		3.25		5.19		6.19		6.94	11.62		
At Stuffing Box w/o Sleeve (for reference only)	1.75			2.5		3.25		5.25		6.25		7.00	11.62		
Drive End Dia.	1.5			2.25		2.62		3.5		4.38		5.12	6	7	
Between bearings	2.19			2.88		3.625		4.7		5.89		6.68	11		
Shaft Dimensions (in.)															
Between Bearings	7.88			14.28		16.06		24.62		24.53		27.16	32.11		
Overhang (radial bearing to impeller)	16.22	17.44	19.47	28.12	30.5	34.82	37.19	44.06	50.94	64.41		61.9	89.08	90.83	93.26
Keyway (sq.)	0.375			0.5		0.625		0.875		1		1.25	1.5	1.75	
Bearing Configuration	1MXR			2MXR		3MXR		4MXR		5MXR		6MXR	7LM		
Inboard	210-S			213-S		217-S		23124W33		23130W33		23134 W33	23156W33		
Outboard	2X7309			2X7313		2X7316		HH224340-90073		HH926749-90023		HH932 145-902A4	22252W33 & 29352E (thrust)		
Oil Lube (Standard)	YES														
Grease Lube (Optional)	YES							NO							
Packed Box															
Bore Diameter (in.)	2.875			3.75		4.75		7.5		8.625		9.25	14.875		
Sleeve Diameter (in.)	2.125			3		3.75		6		7.125		7.75	12.875		
Shaft Diameter Under Sleeve (in.)	1.69			2.44		3.25		5.19		6.19		6.94	11.625		
Depth (in.)	3			3.25		4		5.75		6.12		5.12	14		
Packing Size (in.)	3/8					1/2		3/4					1		
No. of Rings	5 (with single flush)												5 (with dual flush)		
Lantern Ring Width (in.)	0.88			1.00		1.25		1.50		1.62			3.00		
Bolt Quantity	2												4 (30^{O} from horiz centerline)		
Bolt Size	1/2 - 13			5/8 - 11				3/4 - 10					1 - 8		
Bolt Circle Diameter (in.)	3.88			5.50		7.00		9.50		10.00		10.50	19.00		
Mechanical Seal Box															
Bore (in.)	2.75			3.75		4.375		7.25		8.25		9	14.875		
Shaft Diameter for Cartridge Seal (in.)	1.75			2.5		3.25		5.25		6.25		7	11.625		
Depth (To flow path) (in.)	1.5	2.69		4.5	4.25	4	4.38	5.63	5	5.5		6.88	14		
Taper	5 degrees												No taper		
Bolt Quantity	2	4 (straddle centerlines - equally spaced)											4 (30O from horiz centerline)		
Bolt Size	1/2 - 13			5/8 - 11				3/4 - 10					1 - 8		
Bolt Circle Diameter (in.)	3.88			5.50		7.00		9.50		10.00		10.50	19.00		
Nearest Obstruction	2.74	6.18	6.06	7	7.99	8.43	8.93	10.18	11.05	13.5	13.75	11.49	10.00		11.00
Elbow															
Cast	Standard												N/A		
Fabricated	N/A												Standard		
Wall Thickness	3/8			1/2	5/8			3/4			7/8	3/4	Application dependent		
Flange Thickness*	1	1.06	1.13	1.19	1.31	1.38		1.48	1.65	1.5	1.87	2.08	2.63	2.75	3
Back—Pullout	YES												NO		
Space Required for Back Pullout (in.)	13	16	19	22	26	30	34	37	44	48	55	60	N/A		

Cast AF casing flanges are per ANSI B16.5 / Cl 150 for dimensions only. Flanges are flat faced with smooth finish as standard.
Flanges for fabricated sizes (42 inch, 1200 mm and 54 inch) are per ANSI B16.1 / Cl 125 for dimensions only. Flat faced, smooth finish is standard.

For 60-inch and 66-inch sizes, refer to factory.

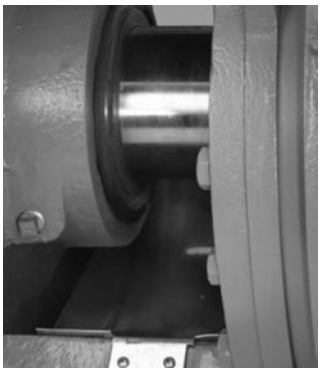
Dimensions Model AF (6 - 36 inch)



Dimensions															
Pump Size	A	B	C	D	E	F	H	I	J	K	L	M	N	O	P
6	31.62	7.75	6.13	9.00	6.00	24.03	3.00	7.00	~	1.50	~	2.25	3.00	1.50	.375
8	34.56	10.00	7.50	9.00	8.00	26.10	4.00	8.00	~	2.00	~	2.25	3.00	1.50	.375
10	37.81	12.50	9.38	9.00	10.00	33.34	5.00	10.00	~	2.00	~	2.25	3.00	1.50	.375
12	51.38	15.00	11.25	11.00	12.00	39.27	6.00	12.00	24.14	2.75	2.75	2.75	4.00	2.25	.500
14	55.18	17.50	13.12	11.00	14.00	42.03	7.00	14.00	24.14	2.75	2.75	2.75	4.00	2.25	.500
16	62.47	20.00	15.00	13.00	16.00	47.14	8.00	16.00	26.58	3.00	3.00	3.00	5.00	2.62	.625
18	65.75	22.50	16.88	13.00	18.00	58.40	9.00	18.00	26.58	3.00	3.00	3.00	5.00	2.62	.625
20	84.37	25.00	18.75	16.00	18.00	74.19	7.00	24.50	38.50	3.50	4.00	5.00	6.50	3.50	.875
24	91.12	30.00	22.50	17.00	24.00	70.19	11.00	24.00	39.63	5.00	5.00	5.00	6.50	3.50	.875
700mm	107.12	36.81	25.50	20.00	24.00	76.00	17.56	28.00	43.50	4.00	5.00	5.00	9.75	4.38	1.000
30	109.31	36.50	25.00	22.00	30.00	81.00	15.00	30.00	43.50	5.00	5.00	5.00	9.75	4.38	1.000
36	114.47	39.94	28.00	26.00	33.00	102.59	18.44	33.00	45.77	5.00	5.00	5.75	8.50	5.12	1.250

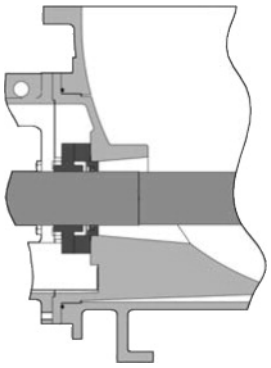
*Cast AF casing flanges per ANSI B16.5 150# for OD, bolt hole diameter, # of bolts and bolt circle diameter only. Flanges are flat faced with smooth finish as standard.
Dimensions are not certified and are not to be used for construction. Consult factory for larger sizes.

Performance Features for Extended Pump Life



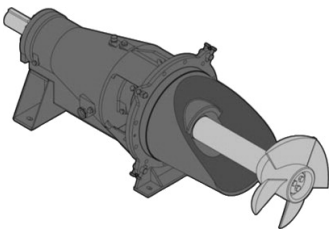
LABYRINTH SEALS

For maximum chemical resistance, prevents premature bearing failure caused by lubricant contamination or loss of oil. Non-contacting unitized design for ease of maintenance assembly.



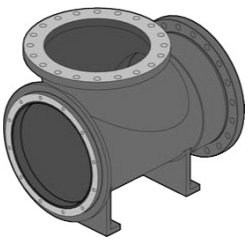
TAPERBORE™ SEAL CHAMBER

Enlarged, tapered bore for increased life of mechanical seals through improved lubrication and cooling. Accommodates current cartridge designs.



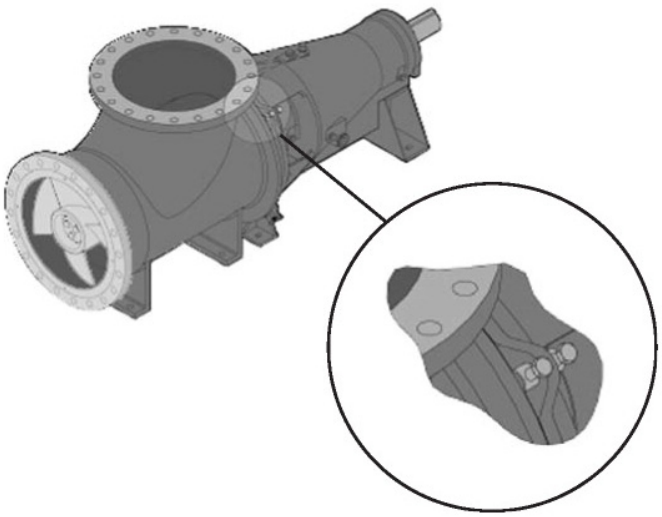
BACK PULLOUT

Back pullout feature provided as standard on sizes through 36" (914 mm). Allows for ease of maintenance.



MULTIPLE IMPELLERS FOR OPTIMUM PERFORMANCE

Impellers are available in 0° and 5° vane pitch along with CW or CCW rotation.

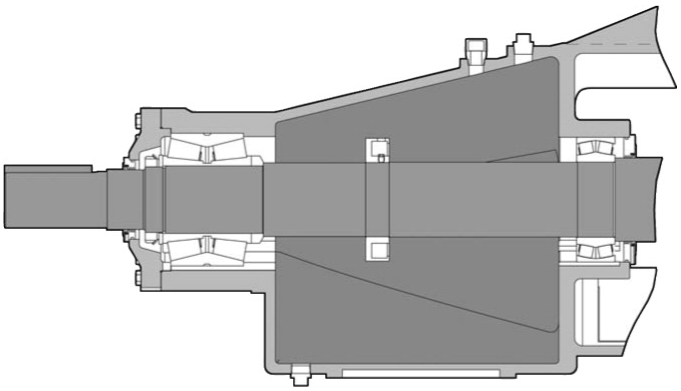


ADJUSTING LUGS FOR EASE OF ADJUSTMENT

Adjusting bolts allow for precise, easy adjustment of both the impeller clearance and stuffing box runout. Precise alignments minimize pump life cycle cost.

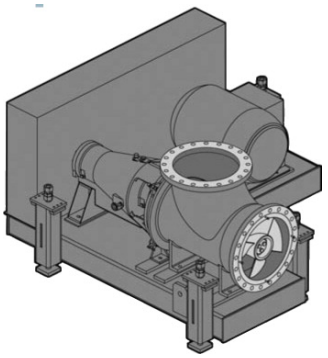
LARGER OIL SUMP WITH BI-DIRECTIONAL THRUST BEARINGS (6 - 36 inch sizes)

The bearing frame is designed as a one piece unitized frame with extra large capacity oil sump to provide optimum cooling. Bearing arrangement is now identical for top and end suction allowing for pump operation in either direction.



6 - 36 inch only. Larger sizes have uni-directional thrust bearings.

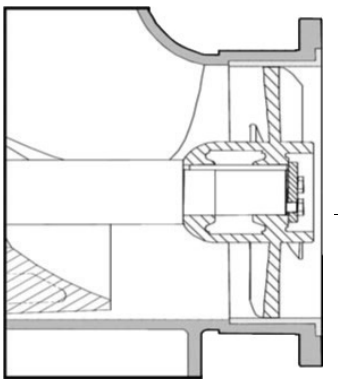
Optional Features

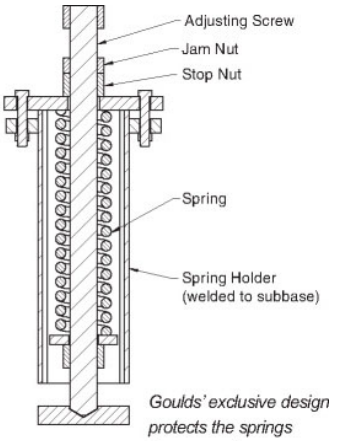


SPRING MOUNTED SUB-BASE

Goulds' exclusive enclosed design protects the springs from corrosion and spillage. Springs are used to protect the pump from large flange loads imposed by thermal expansion of the piping.

ENCLOSED SPRING POCKET

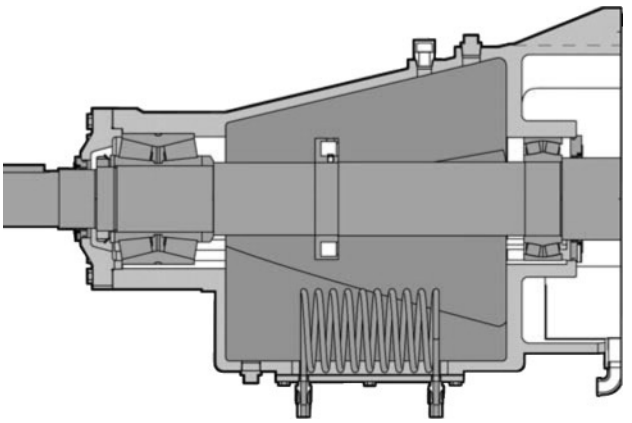




Goulds' exclusive design protects the springs from corrosion

ELBOW LINER

Precision-made replaceable liners between impeller and casing are offered as an option to ensure continuous high efficiency.

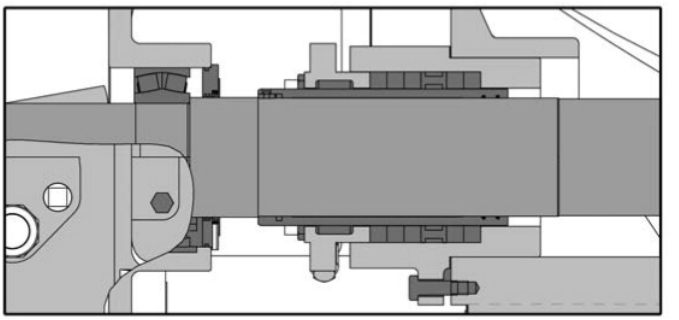


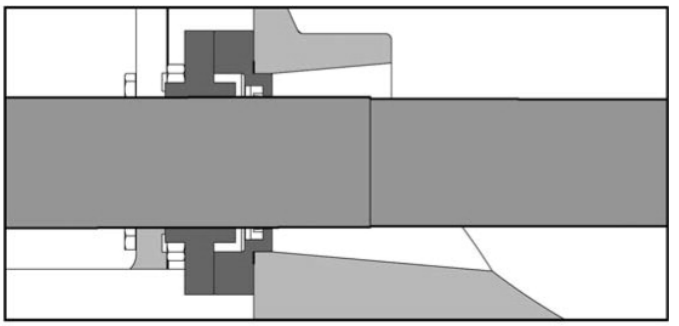
OIL COOLING

An oil cooling option is available on 12" and larger sizes. A coiled tube mounted inside the bearing housing circulates water to cool the oil bath. Used when process temperatures cause excessive heat build-up in the bearing housing and or bearings.

PACKED BOX

Optional packed stuffing box with replaceable wear sleeve is available as a low cost alternative to mechanical seals.

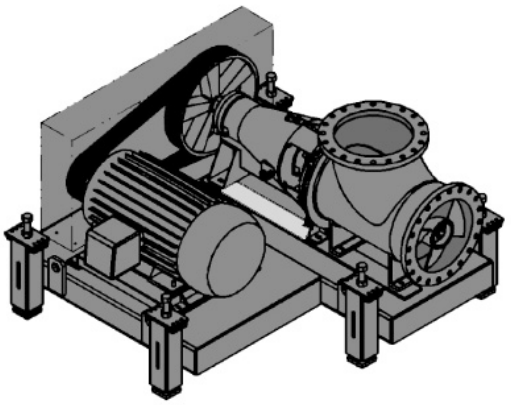




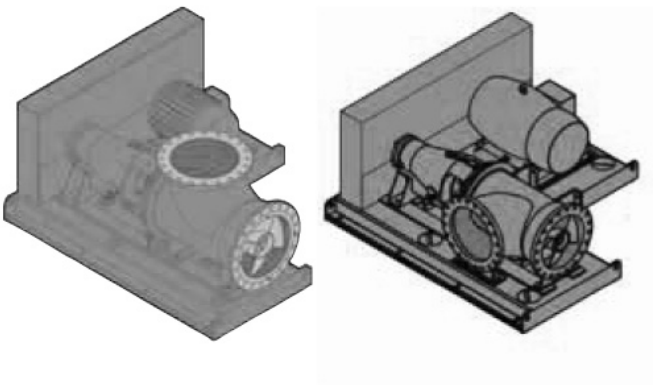
RESTRICTOR BUSHING ADAPTER

An optional adapter is used for single mechanical seals requiring a restrictor bushing. The restrictor bushing minimizes product dilution that may be detrimental to the process.

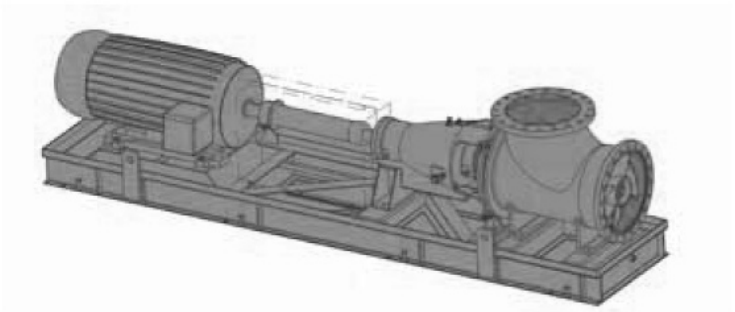
Construction Options



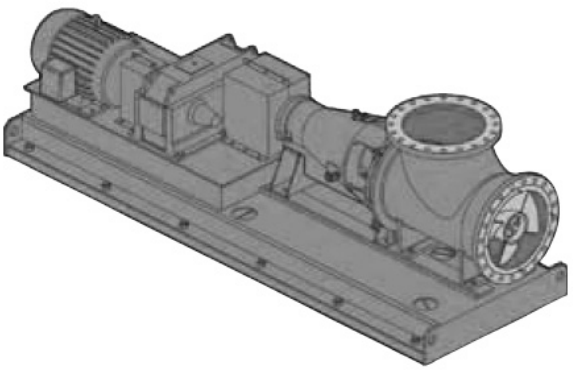
Side by Side
Spring Loaded Baseplate



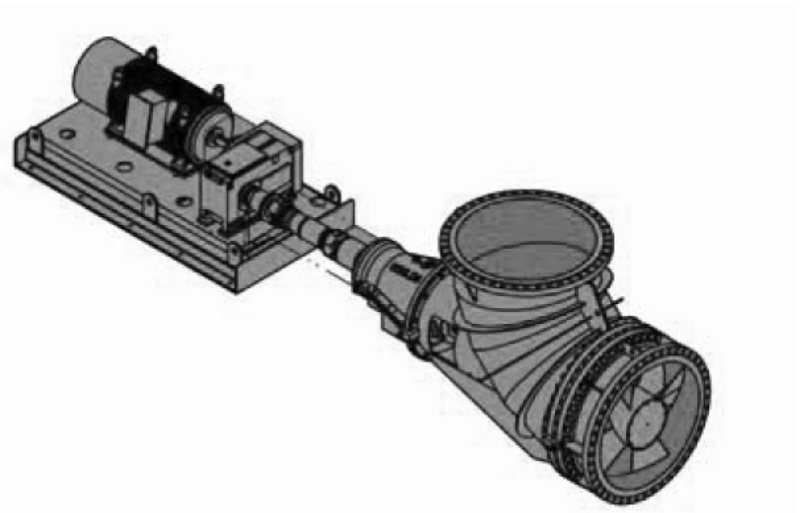
Side by Side



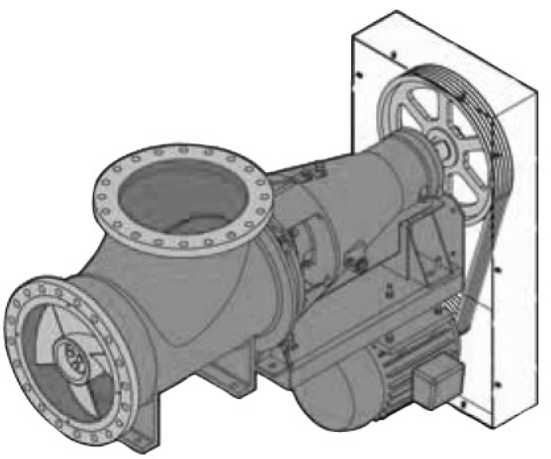
Direct Connect



Gear Driven



Pipe Hung
Gear Driven

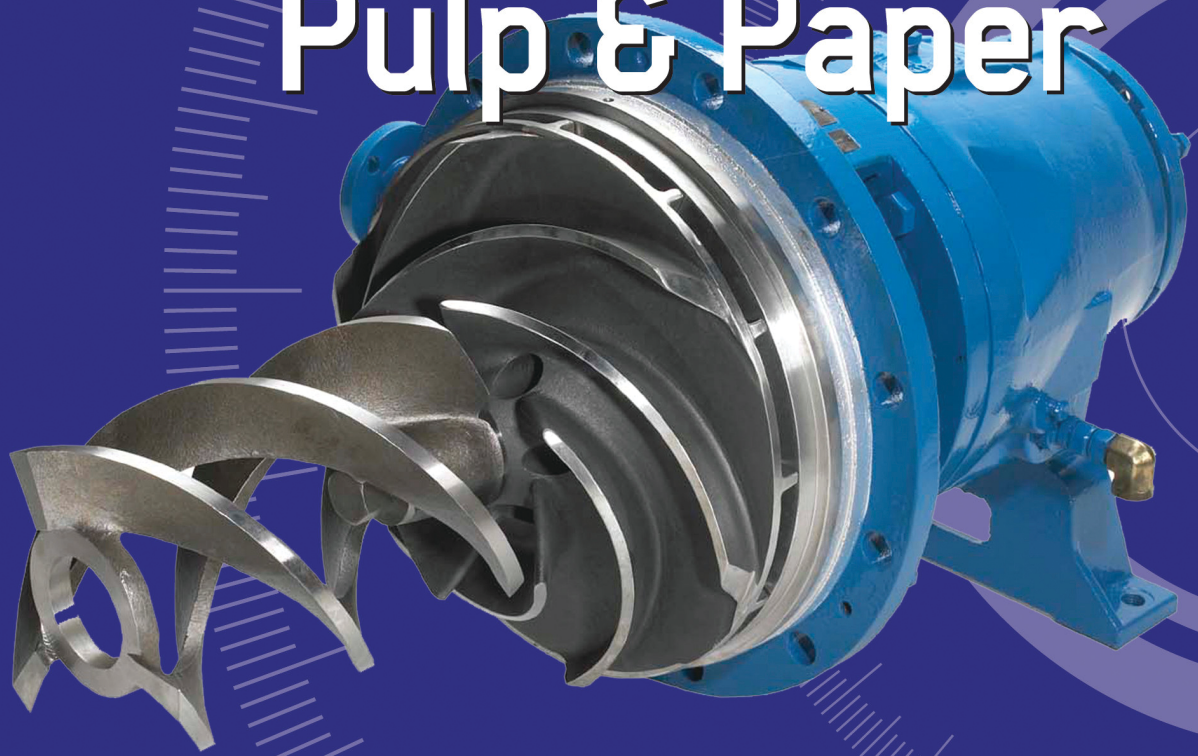


Pipe Hung
Under Slung

NOTES

2

Pulp & Paper



Wide Range of Materials

Stocked in Cast Iron and 316 Stainless Steel. Available in any machinable alloy including 317SS, 317LSS, 316LSS, Alloy 20, CD4MCuN, 6 - 7% moly, Titanium, Hastelloy B and C.

Goulds Model 3175

Designed to Handle the Toughest Jobs in the Pulp & Paper and Process Industries

- Capacities to 28,000 GPM (6360 m3/h)
- Heads to 350 feet (107 m)
- Temperatures to 450°F (232° C)
- Pressures to 285 PSIG (1965 kPa)

Design Features

- **Back Pullout**
- Fully Open Impeller
- External Impeller Adjustment
- Renewable Wear parts
- Maximum Sealing Flexibility
- Heavy-duty Construction
- Maximum Parts Interchangeability

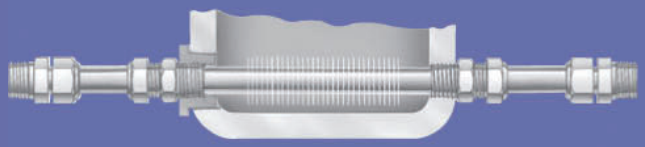
Applications

- **Pulp & Paper** Paper Stock through 6% Consistency, Black Liquor, Hydropulper and Broke Service, Low NPSH Digester Circulation, Blow Tank to Screens, Primary Screens Rejects, High Density Chlorine Tower to Washer, Flotation Cell Circulation
- **Chemical** Evaporator and Reboiler Circulation, Slurry Services
- **Petroleum** Corrosive/Abrasive Crude, Catalyst Slurry, Coke Fines
- **Steel** Mill Descaling, Waste Treatment, Venturi Scrubber, Electro-Galvanizing Recirculation
- **Food** Fruit Pulps, Grain Mash and Spent Grains, Evaporator Recirculation, Beet and Cane Sugar, Corn Products
- **General** Waste Treatment, Air Pollution Abatement, Acid Mine Water, Textile Slurries

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3175 Paper Stock/Process Pumps

Heavy Duty Design Features for Handling the Toughest Services



OPTIONAL HIGH EFFICIENCY FINNED COOLER
Requires minimum cooling water; easily cleaned to maintain bearing cooling efficiency. Corrosion resistant materials standard.

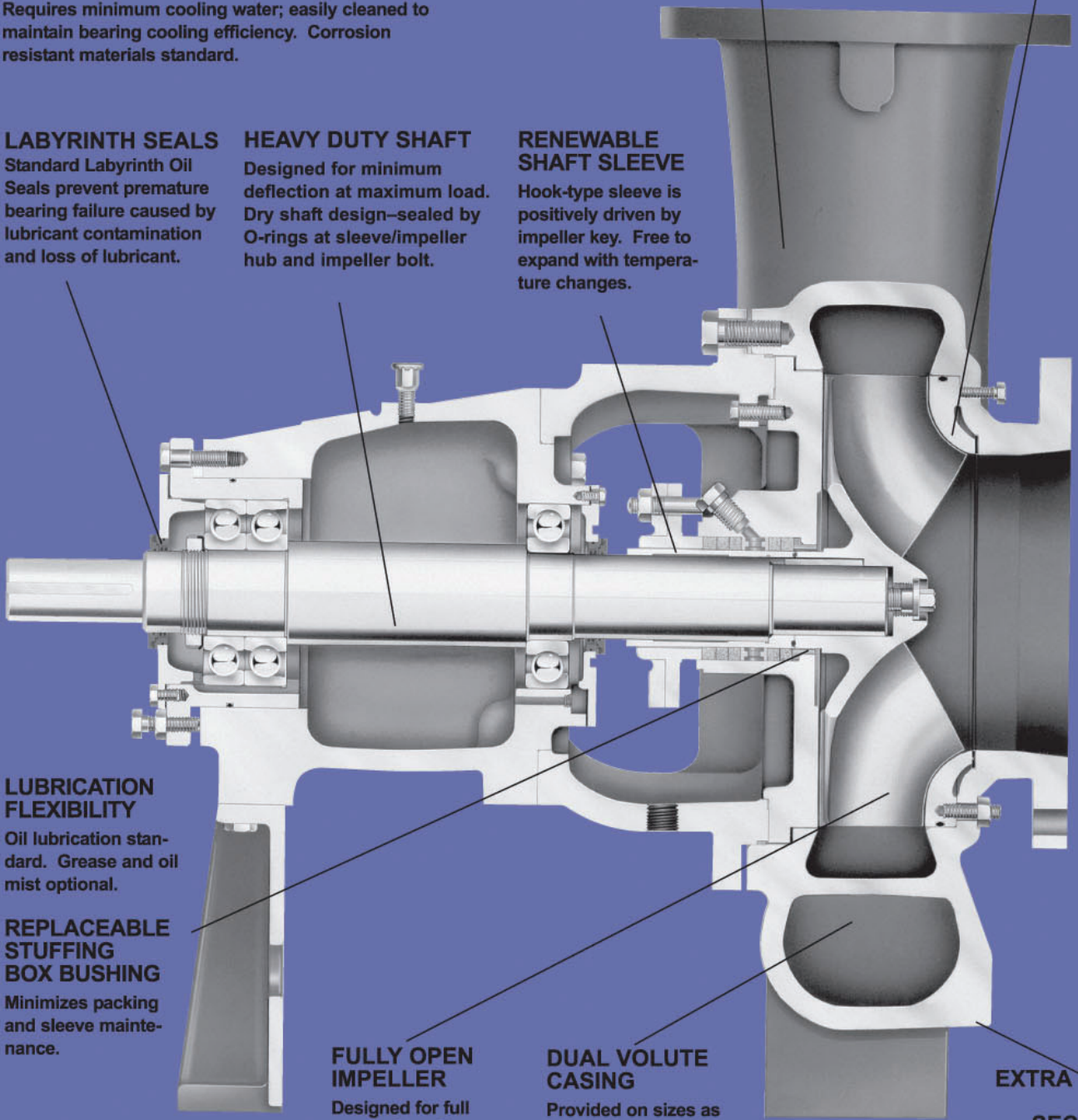
VERTICAL CENTERLINE DISCHARGE
Self-venting design for air handling. Casing provides maximum piping support.

RENEWABLE SIDEPLATE
Heavy suction sideplate minimizes maintenance costs. Positively sealed with O-ring and gasket.

LABYRINTH SEALS
Standard Labyrinth Oil Seals prevent premature bearing failure caused by lubricant contamination and loss of lubricant.

HEAVY DUTY SHAFT
Designed for minimum deflection at maximum load. Dry shaft design–sealed by O-rings at sleeve/impeller hub and impeller bolt.

RENEWABLE SHAFT SLEEVE
Hook-type sleeve is positively driven by impeller key. Free to expand with temperature changes.



LUBRICATION FLEXIBILITY
Oil lubrication standard. Grease and oil mist optional.

REPLACEABLE STUFFING BOX BUSHING
Minimizes packing and sleeve maintenance.

FULLY OPEN IMPELLER
Designed for full range of services. Back pump-out vanes minimize stuffing box pressure, help prevent solids from entering seal chamber.

DUAL VOLUTE CASING
Provided on sizes as required to minimize radial unbalance for long packing, mechanical seal and bearing life.

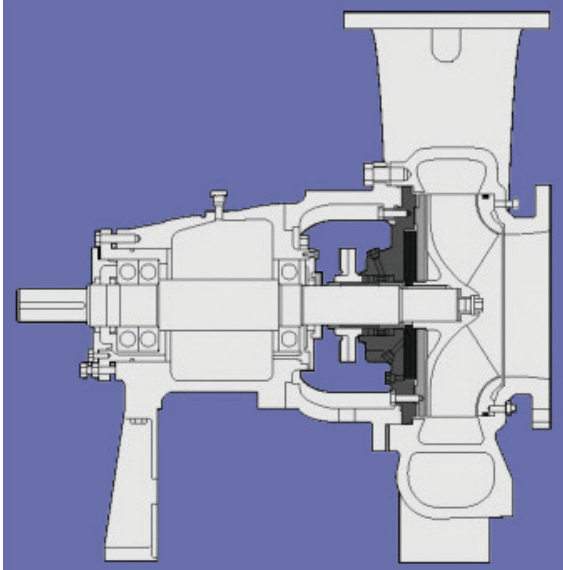
EXTRA THICK WALL SECTIONS
For extended wear life and reduced maintenance.

Maximum Sealing Flexibility

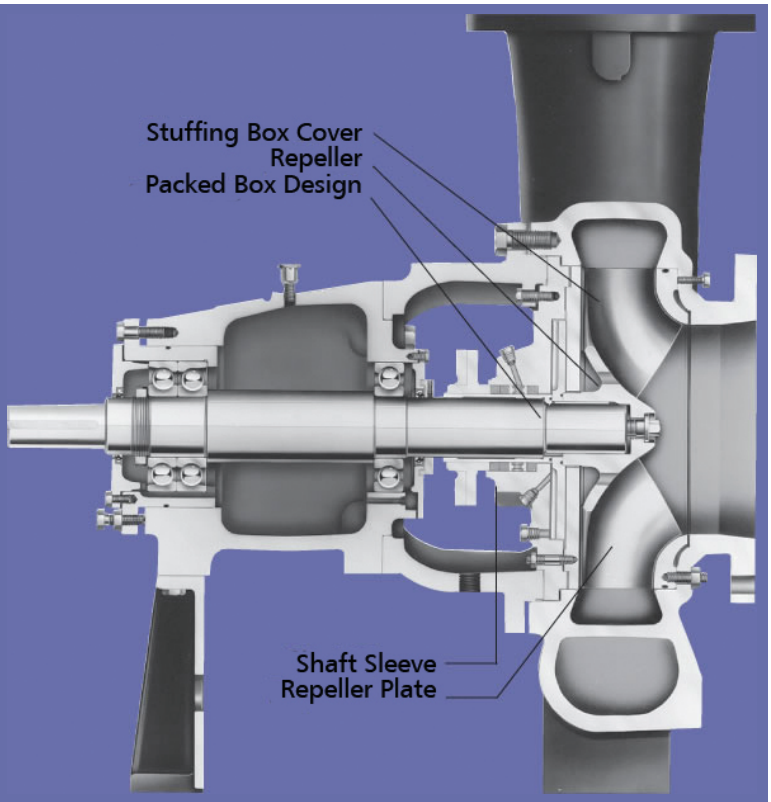
Dynamic Seal

For Elimination of Mechanical Seal Problems; Reduced Maintenance

Goulds Dynamic Seal pumps are designed to handle the tough applications where conventional mechanical seals or packing require outside flush and constant, costly attention. The major advantage is that external seal water is not required, thus eliminating leakage, pumpage contamination, product dilution and problems associated with piping from a remote source.



The 3175 is easily field converted to Dynamic Seal. Goulds retrofit kit includes repeller, stuffing box cover, repeller plate, shaft sleeve and choice of static sealing arrangement.

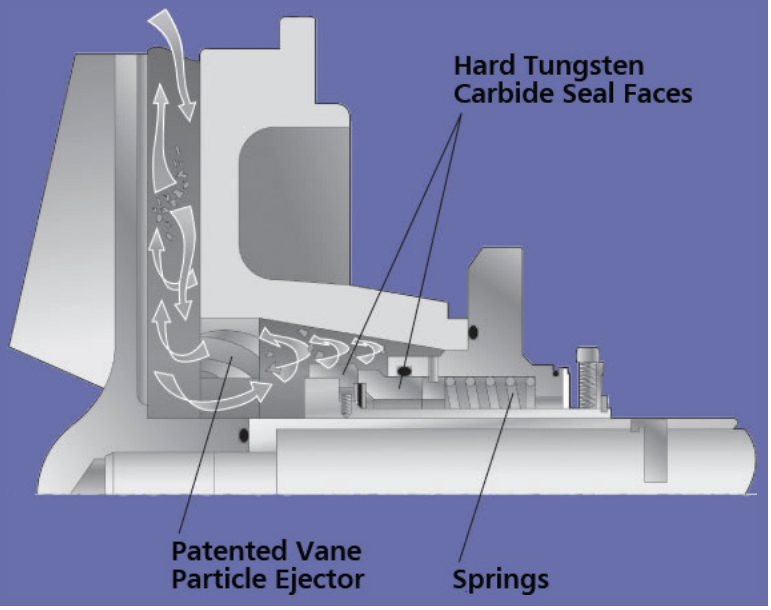


Standard Model 3175 pumps can be fitted with a repeller between the stuffing box and impeller. At startup, the repeller functions like an impeller and pumps liquid from the stuffing box. When the pump is shut down, a conventional static seal prevents pumpage from leaking.

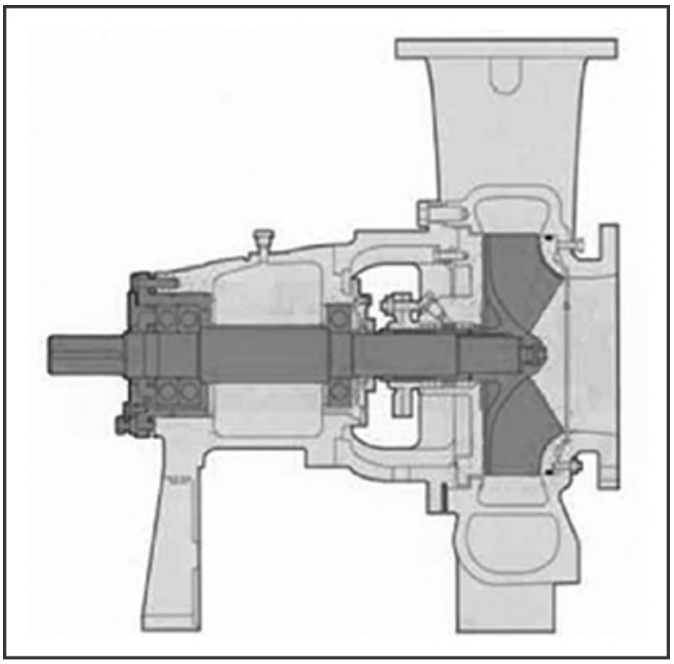
TaperBore™ Seal Chamber

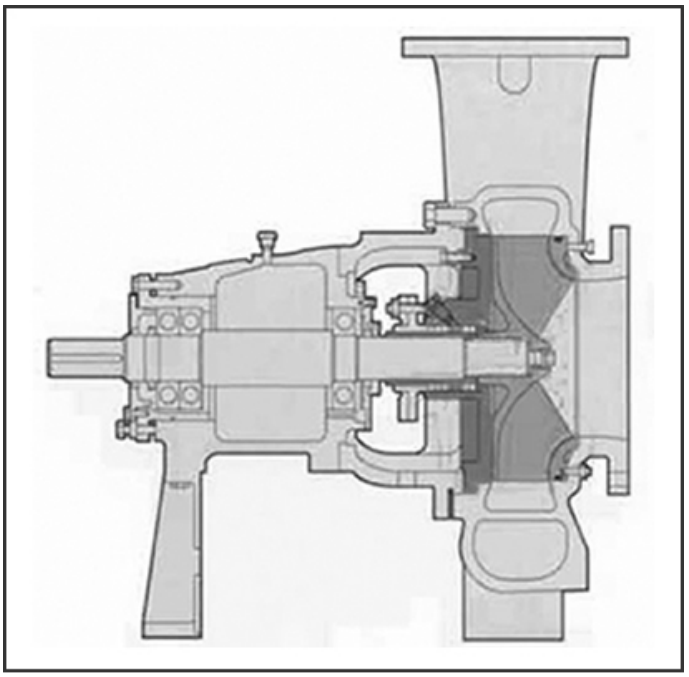
Goulds optional TaperBore™ seal chamber features an enlarged bore for improved lubrication and cooling of the mechanical seal. The design features a tapered throat and a vane particle ejector to keep solids away from seal faces and from building up in the seal chamber. Seal life is remarkably extended.

Goulds TaperBore™ seal chamber and cartridge mechanical seal. A full range of other seal types is available.



Long Life/Low Maintenance/Reliable Operation





External Impeller Adjustment

Impeller clearance can be easily reset by external adjust-ment to maintain hydraulic performance. Delivers long term energy savings, while downtime is kept to a minimum.

Renewable Wear Parts

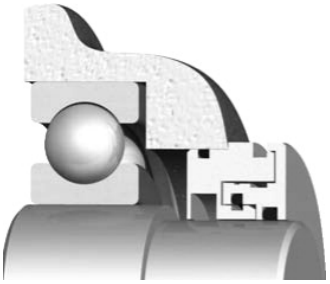
Low maintenance costs because all wear parts…suction sideplate, impeller, stuffing box cover, shaft sleeve and throat bushing…are easily replaced.

Heavy Duty Shaft

Designed for continuous service under most severe operating conditions—dry end broke, repulper, hydropulper, blowtank. Low deflection at maximum load for long seal and bearing life, extended MTBF.

Fully Open Impeller

Special warped vane, heavy duty open type for paper stock handling. Back pump-out vanes reduce stuffing box pressure, and help prevent solids from entering sealing chamber.



Standard Labyrinth Oil Seals

Prevent contamination of lubricant for extended bearing life.

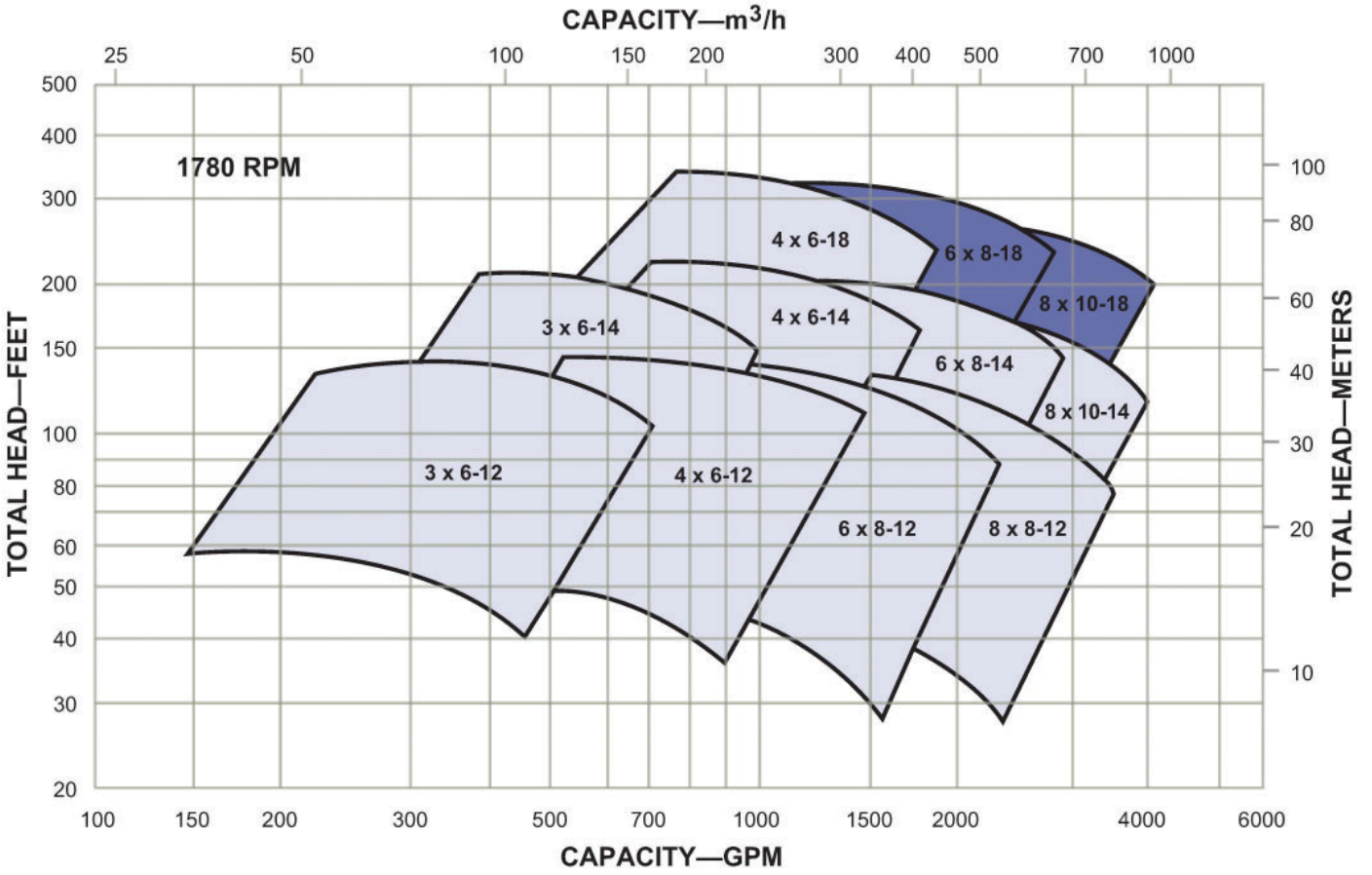
Optional TaperBore ™ Seal Chamber

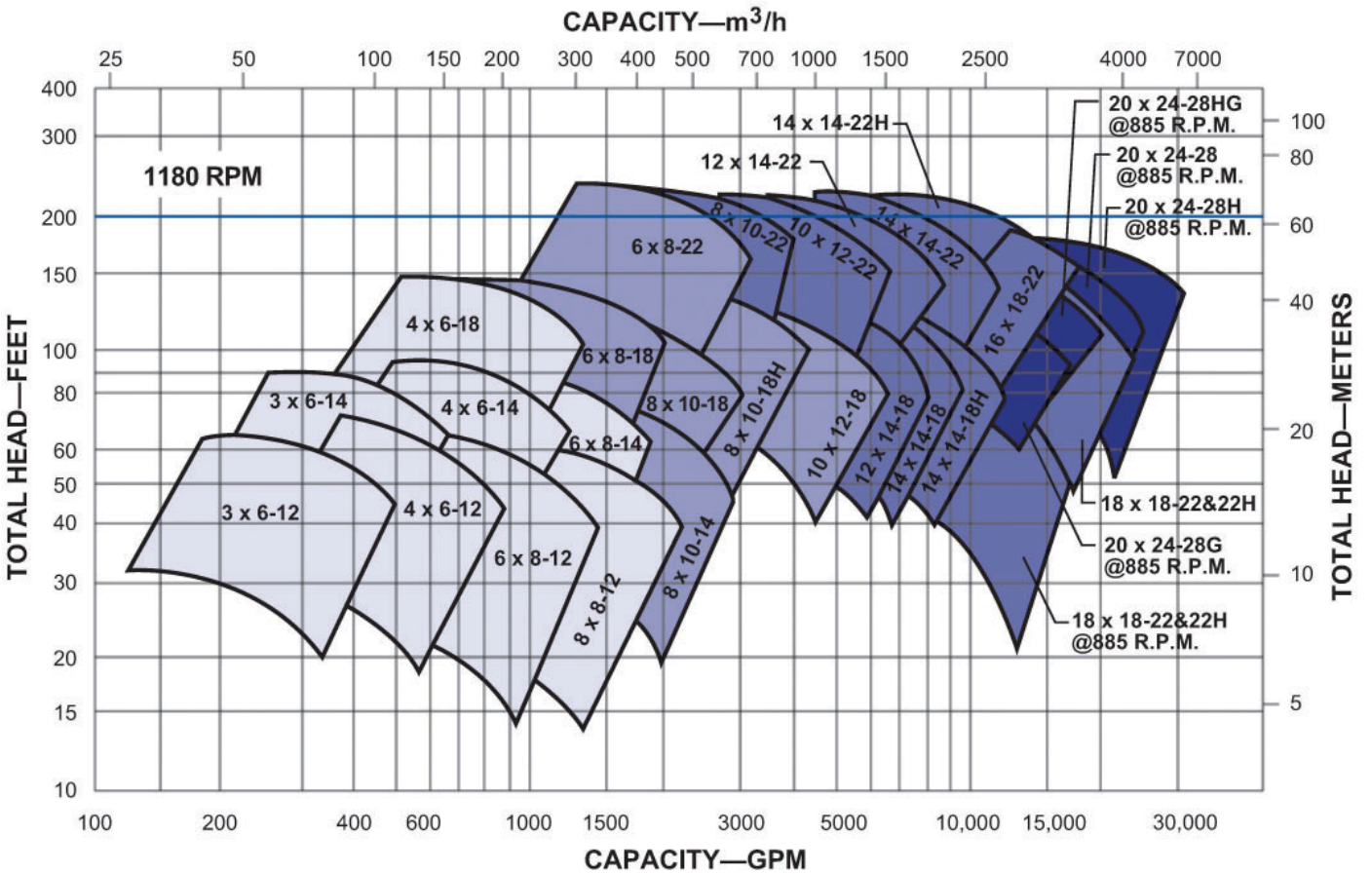
Features an enlarged bore for improved lubrication and cooling of the mechanical seal. The tapered throat keeps solids away from seal faces and from building up in the chamber. Seal life is remarkably extended.

Patented *i*-Alert Condition Monitor

Constantly measures vibration and temperature at the thrust bearing. Colored LED's indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

Hydraulic Coverage Model 3175





Parts List and Materials of Construction

Item Number	Part Name	Material			
		All Iron/316SS Trim	All 316SS	All 317SS	All CD4MCuN
100	Casing	Cast Iron	316SS	317SS	CD4MCuN
101	Impeller	316SS	316SS	317SS	CD4MCuN
105[1]	Lantern Ring	Glass-Filled Teflon*			
106	Stuffing Box Packing	Graphitized Non-Asbestos Fibers			
107	Gland, Packed Box	316SS	316SS	317SS	316SS
108	Frame Adapter	Cast Iron			
109A	Bearing End Cover—Coupling End	Cast Iron			
112A	Thrust Bearing	Duplex Angular Contact–Back-to-Back			
119A	Bearing End Cover—Inboard	Cast Iron			
122	Shaft	AISI 4140		316SS	AISI 4140
125	Stuffing Box Throat Bushing	Cast Iron	316SS	317SS	CD4MCuN
126[2]	Shaft Sleeve (Packed Box)	316SS Hard Metal Coated		317SS	316SS HMC
134A	Bearing Housing	Cast Iron			
136	Bearing Locknut and Lockwasher	Steel			
168A	Radial Bearing	Steel			
174	Suction Piece	Cast Iron	316SS	317SS	CD4MCuN
176	Suction Sideplate	Cast Iron	316SS	317SS	CD4MCuN
178	Impeller Key	AISI 303			
178J	Repeller Sleeve Key (Dynamic Seal)	AISI 303			
184	Stuffing Box Cover	Cast Iron	316SS	317SS	CD4MCuN
198	Impeller Screw	316SS		317SS	316SS
228	Bearing Frame	Cast Iron			
241	Frame Foot	Cast Iron			
262	Repeller (Dynamic Seal)	316SS	316SS	317SS	CD4MCuN
264	Gasket—Backplate to S.B. Cover (Dynamic Seal)	Aramid Fiber with EPDM Rubber Binder			
265	Stud/Nut—Repeller Plate to S.B. Cover (Dynamic Seal)	AISI 303/AISI 304			
332A	Labyrinth Oil Seal–Coupling End	Bronze			
333A	Labyrinth Oil Seal–Inboard	Bronze			
351	Gasket—S.B. Cover to Casing	Aramid Fiber with EPDM Rubber Binder			
353	Gland Stud/Nut	AISI 303/AISI 304			
356E	Stud/Nut—Suction Sideplate	AISI 303/AISI 304			
360	Gasket—Inboard Bearing End Cover	Vellumoid			
360A	Gasket—Outboard Bearing End Cover	Vellumoid			
360P	Gasket—Sideplate to Casing	Aramid Fiber with EPDM Rubber Binder			
412	O-ring—Shaft Sleeve	Teflon*			
412B	O-ring—Impeller Screw	Teflon*			
412C	O-ring—Suction Sideplate	Buna-N			
412U	O-ring—Repeller (Dynamic Seal)	Teflon*			
444	Backplate (Dynamic Seal)	316SS	316SS	317SS	CD4MCuN
494	Cooling Coil (Optional)		Copper/Steel		
496	O-ring—Bearing Housing	Buna-N			

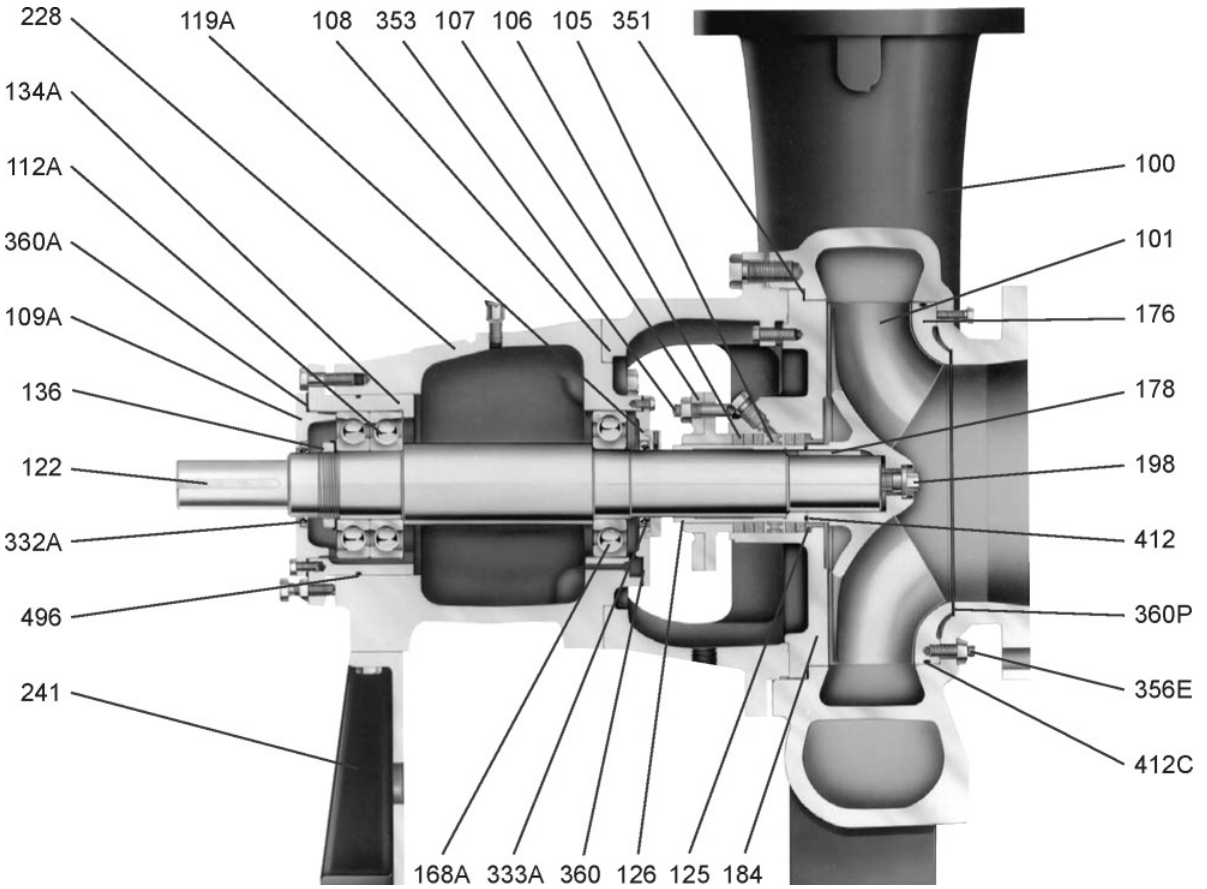
1 Group XL only: Cast Iron for AI/316SS trim, 316SS for All 316SS, 317SS for All 317SS, 316SS for All CD4MCuN.
2 Standard sleeve for 317SS pumps with packed box is 317SS and is not hard-coated. Standard sleeve for pumps with mechanical seal is 316SS (317SS on all 317SS).
*Registered trademark, E.I. DuPont.

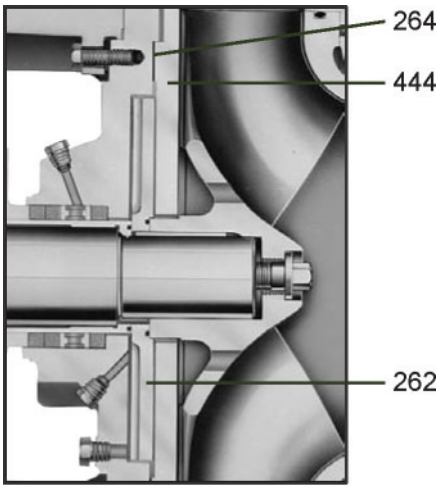
Materials of Construction

Cast Iron	Cast Iron—ASTM A48, Class 20, 25, 30
316SS	316 Stainless Steel— (Cast) ASTM A743 Gr CF-8M (Wrought) ASTM A276 Type 316

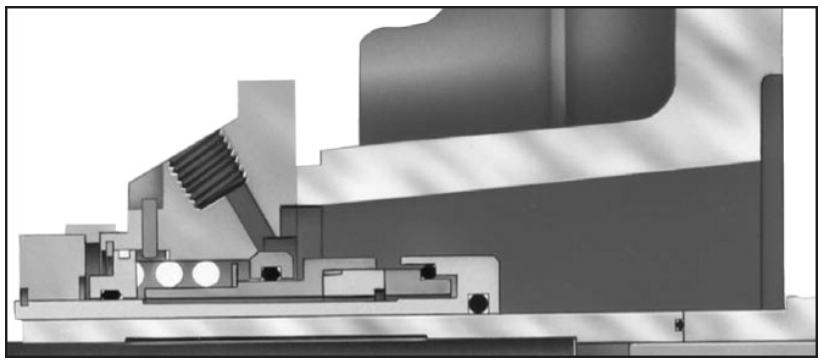
303SS	303 Stainless Steel—ASTM A582 Type 303
304SS	304 Stainless Steel—ASTM A276 Type 304
317SS	317 Stainless Steel—ASTM A743 Gr CG-8M
CD4MCuN	Iron-Chrome- Nickel Alloy—ASTM A743 Gr CD4MCuN
Steel	Carbon Steel—ASTM A322 Gr 4140

Sectional View Model 3175

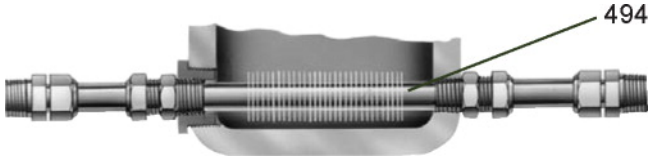




Dynamic Seal Option



TaperBore™ Seal Chamber and Mechanical Seal Option

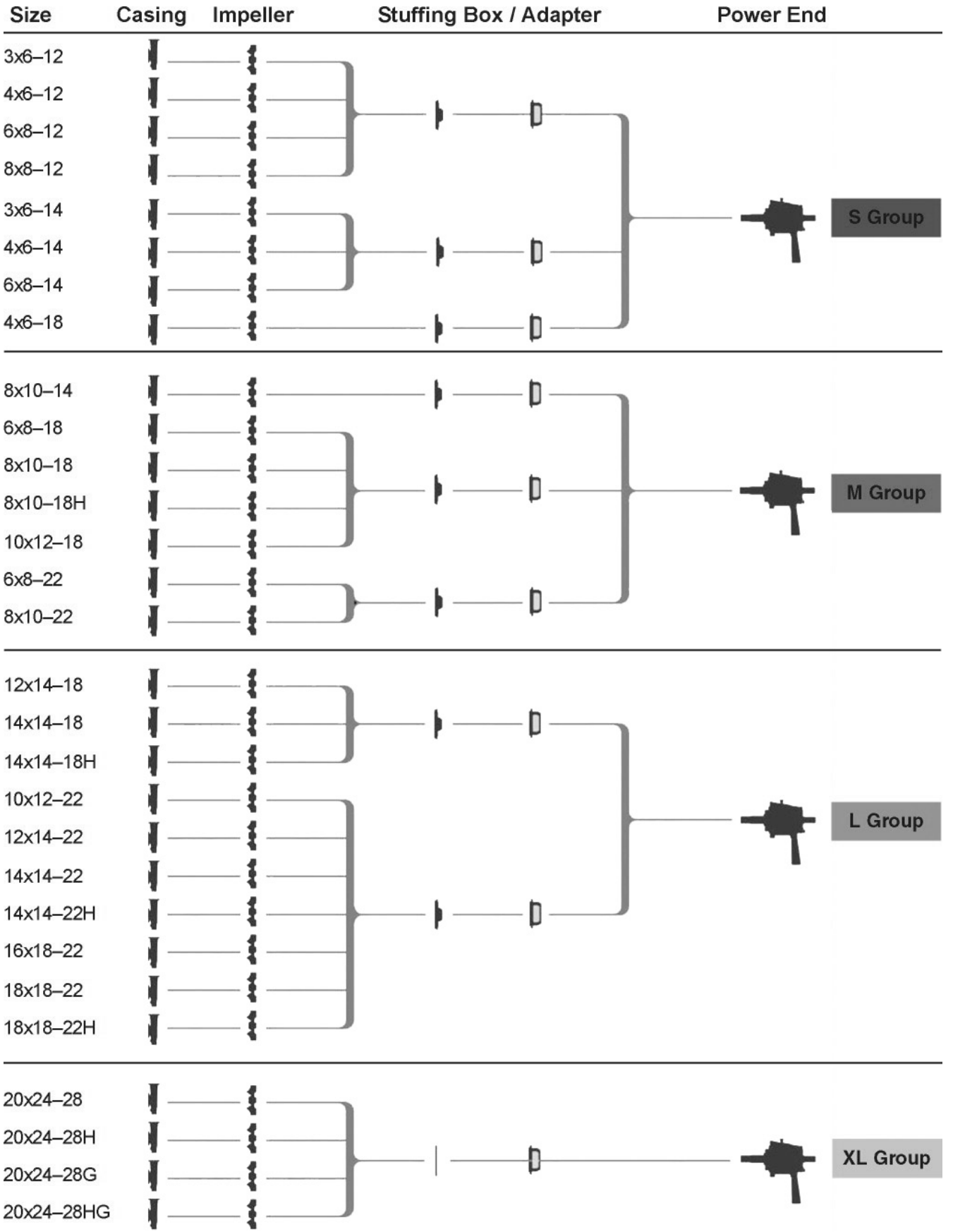


Optional High Efficiency Finned Cooler

Optional Suction Piece

Modular Interchangeability

Minimum Parts Requirements



Goulds Model 3175: A Proven Performer

Since its introduction in 1968, the 3175 has proved itself over and over again. Thousands of installations attest to its remarkable performance even under the severest conditions. And for ease of maintenance, it can't be beat. Customers know they can rely on the 3175 for minimum downtime, increased productivity.

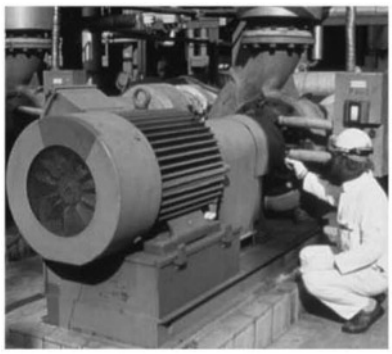
Model 3175 handling paper stock in a paper mill.

Black liquor circulation pump (3175 XL) on spring-loaded baseplate.

A 3175 installed in a major chemical plant.

Taking suction from a large stock tank... the 3175 is the preferred pump in the Pulp & Paper Industry.

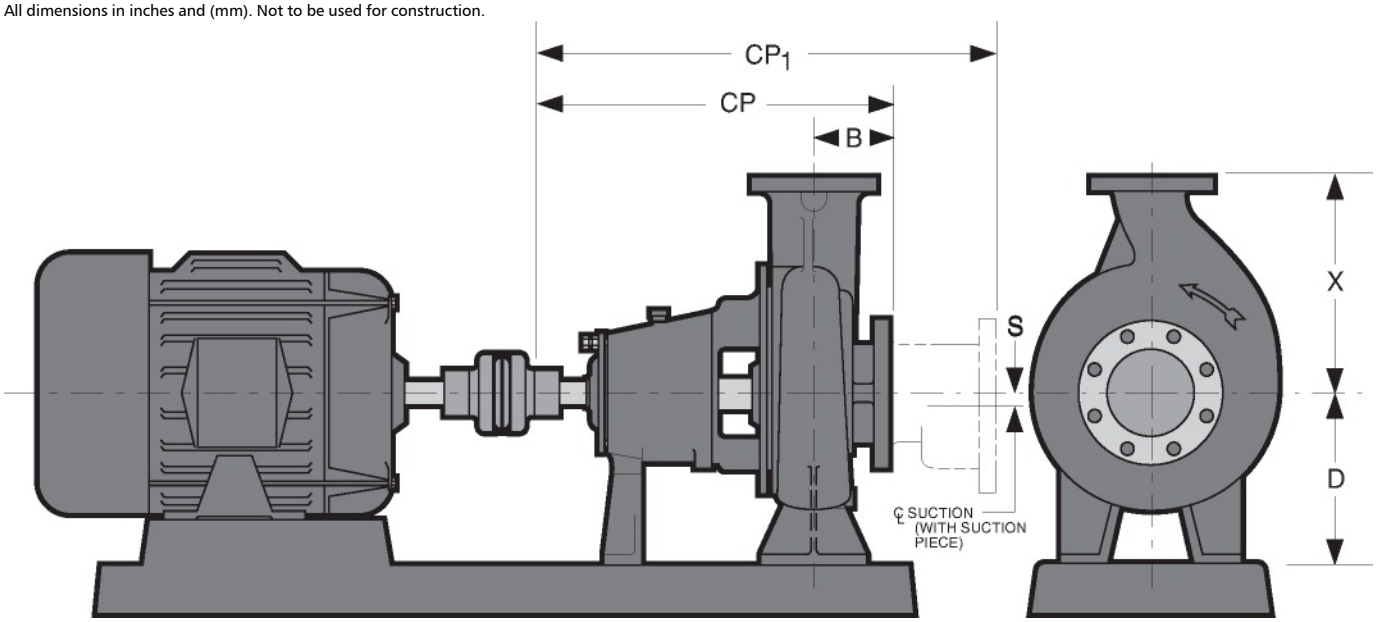
3175's on process services such as multieffect evaporators.



Preventive maintenance is fast and easy on a 3175.

Dimensions Model 3175

All dimensions in inches and (mm). Not to be used for construction.



DIMENSIONS												
Group	Pump Size	Disch Size.	Suct Size.	Suct.Size*	D	X	B	CP	CP_1	S	Shaft Diameter at Coupling	Bare Pump Weight* Lbs. (kg.)
S	3×6-12	3	6	8	12½ (318)	13 (330)	7¼ (184)	39¾ (1010)	51 (1295)	1 (25)	1.875 (47.63) 1.874 (47.60)	745 (338)
	4×6-12	4	6	10		14½ (368)				2 (51)		810 (367)
	6×8-12	6	8	–		16 (406)						975 (442)
	8×8-12	8	8	12	14½ (368)	19 (483)	8⅛ (206)	41⅛ (1045)	52⅜ (1330)			1205 (547)
	3×6-14	3	6	8	12½ (318)	13 (330)	7¼ (184)	39¾ (1010)	51 (1295)	1(25)	1.875 (47.63) 1.874 (47.60)	850 (386)
	4×6-14	4	6	10		14½ (368)				2 (51)		925 (420)
	4×6-18	4	6	10		16 (406)						1050 (476)
	6×8-14	6	8	12		16 (406)						1100 (499)
M	6×8-18	6	8	12	14½ (368)	18 (457)	7¼ (184)	39¾ (1010)	51 (1295)	2 (51)	2.375 (60.33) 2.374 (60.30)	1525 (692)
	6×8-22	6	8	12	17 (432)	21 (533)						1700 (771)
	8×10-14	8	10	14	14½ (368)	19 (483)	8⅛ (206)	41⅛ (1045)	53 (1346)			1550 (703)
	8×10-18	8	10	14	14½ (368)	21 (533)						1600 (726)
	8×10-18H	8	10	14	17 (432)	21 (533)						1725 (782)
	8×10-22	8	10	14	17 (432)	23 (584)						1800 (816)
	10×12-18	10	12	16	20 (508)	23 (584)						1900 (862)
L	10×12-22	10	12	16	20 (508)	25 (635)	8⅛ (206)	41⅛ (1045)	53 (1346)	2 (51)	3.375 (85.73) 3.374 (85.70)	2050 (930)
	12×14-18	12	14	18	20 (508)	25 (635)	8⅞ (225)	42½ (1080)	55 (1397)			2000 (907)
	12×14-22	12	14	18	20 (508)	27 (686)						2350 (1066)
	14×14-18 14×14-18H	14	14	20	20 (508)	27 (686)				3 (76)		2125 (964)
	14×14-22 14×14-22H	14	14	20	22 (559)	30 (762)						2800 (1270)
	16×18-22	16	18	–	28 (711)	32 (813)	12¾ (324)	$47^{7}/_{16}$ (1205)	–	–		3800 (1724)
	18×18-22	18	18	–	28 (711)	34 (864)	9⅞ (251)	43½ (1105)	–	–		4500 (2041)
	18×18-22H	18	18	–	28 (711)	34 (864)	16⅝ (422)	50¼ (1276)	–	–		4300 (less suction piece)
XL	20×24-28 20×24-28H 20×24-28G 20×24-28HG	20	24	–	30 (762)	40 (1016)	17½ (445)	66¾ (1695)	–	–	3.875 (98.43) 3.874 (98.40)	5300 (2404)

*With Suction Piece

Construction Details All dimensions in inches and (mm).

		S Group	M Group	L Group	XL Group
Temperature Limits	Maximum Liquid Temperature—Oil Lubrication Without Cooling	250°F (121°C)			
	Maximum Liquid Temperature—Oil Lubrication with Frame Cooling	350°F (177°C)-Cast Iron 450°F (232°C)-Steel			
	Maximum Liquid Temperature—Grease Lubrication	250°F (121°C)			
Power Limits	HP (kW) per 100 RPM—904L and Alloy 20 Construction	9.52 (7.10)	23.8 (17.8)	63.5 (47.4)	113.6 (84.7)
	HP (kW) per 100 RPM—Constructions other than Alloy 20	17.4 (13.0)	31.9 (23.8)	82.2 (61.3)	129.0 (96.2)
Shaft Diameter	At Impeller	1⅞ (48)	2 ¾ (70)	3⅜ (86)	3⅞ (98)
	Under Shaft Sleeve	2½ (64)	3 5/16 (84)	4 5/16 (109)	5 (127)
	At Coupling	1⅞ (48)	2⅜ (60)	3⅜ (86)	3⅞ (98)
	Between Bearings	3⅛ (79)	4 (102)	4⅞ (124)	6 (152)
Sleeve	O.D. through Stuffing Box	3 (76)	3¾ (95)	4¾ (121)	5½ (140)
Bearings	Thrust (Coupling End)	SKF 7313 BECBY	SKF 7317 BEGAM	SKF 7222 BECBM	SKF 7326 BCBM
	Radial (Inboard or Pump End)	SKF 6313	SKF 6317	SKF 6222	SKF 6326
	Bearing Span	12¼ (311)	11 11/16 (297)	11⅛ (283)	18 (457)
	Shaft Overhang	10 11/16 (271) to 11 27/32 (301)	11 13/32 (290) to 12 9/16 (319)	11⅞ (302) to 13 9/16 (344)	19 (483)
Stuffing Box	Bore	4 (102)	4¾ (121)	5¾ (146)	7½ (191)
	Depth—to Stuffing Box Bushing	3 11/16 (94)			6¾ (171)
	Packing Size	½ × ½ (13 × 13)			1 × 1(25 × 25)
	Distance from End of Stuffing Box to Nearest Obstruction	3⅛ (79)		3¼ (83)	3¾ (95)

World Class Service

Value-Added Capabilities

Goulds is much more than a manufacturer and marketer of pumps. Capabilities that extend from project consultation to on-site testing and start-up evaluation are available to every customer. Many specialized services from Goulds are only evident after the sale and installation of the product: parts, repair, training and more.

Research and Development

Goulds continually tests and evaluates every product. The R&D team constantly seeks innovative designs, new materials and system improvements.

Fabrication and Casting

The most advanced foundry and fabrication concepts are utilized to improve quality. Our own advanced foundries produce metals from cast iron to Hastelloy including the new generation of high alloys. Because we're not dependent on outside suppliers, we have total control over metallurgical quality.

Repair and Overhaul

Goulds PRO (Pump Repair and Overhaul) Services ® Centers repair all types of rotating equipment. Each facility also has special diagnostic equipment to facilitate preventive maintenance. Let the nearest PRO Services ® Center demonstrate repair as an economical alternative to replacement.

Field Service

A staff of highly specialized installation, training and commissioning engineers is available to insure each projects' successful completion and start-up.

Training

Goulds offers the most advanced training program of its kind in the industry including product training, maintenance schools, and PRIME™ seminars. Each seminar is structured as an ongoing educational experience for customers around the world.

Parts Availability

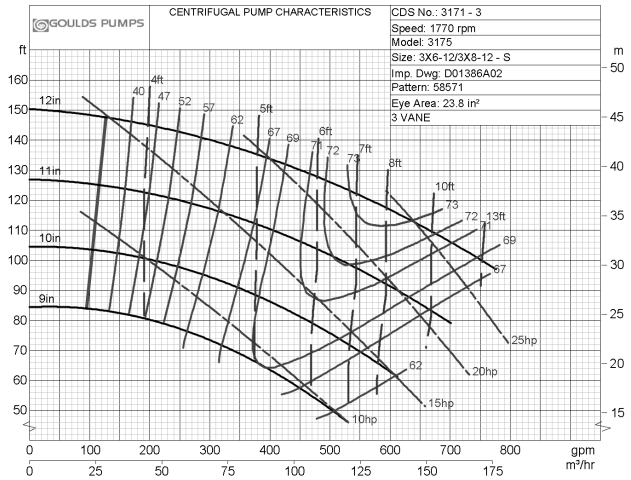
Goulds Distribution Centers are strategically located worldwide, and are committed to the ready availability of repair parts.

Service and Support

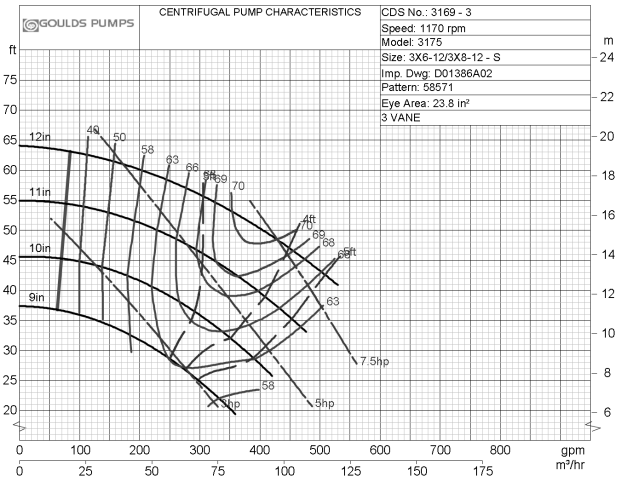
In addition to direct sales offices around the world, over 200 authorized Goulds representatives and distributors are totally committed to meeting customers' requirements.

NOTES

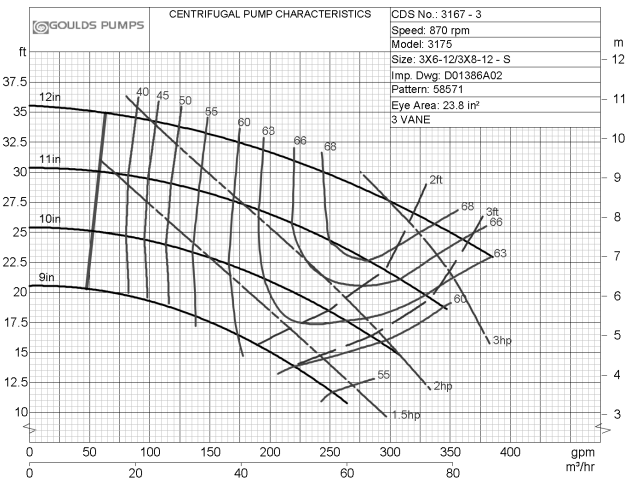
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



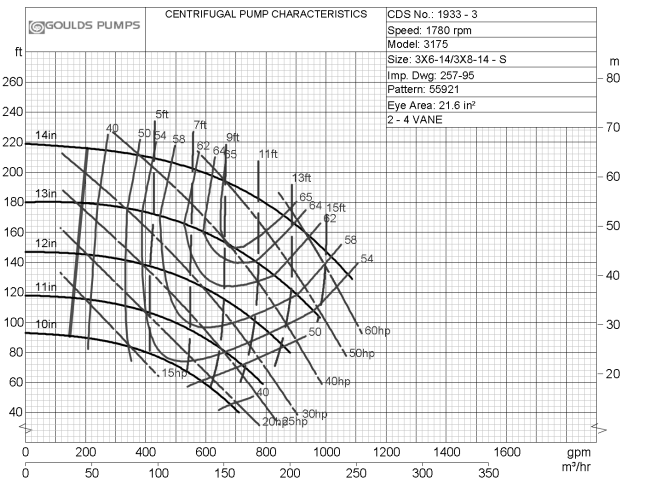
3X6-12/3X8-12 **1770rpm**



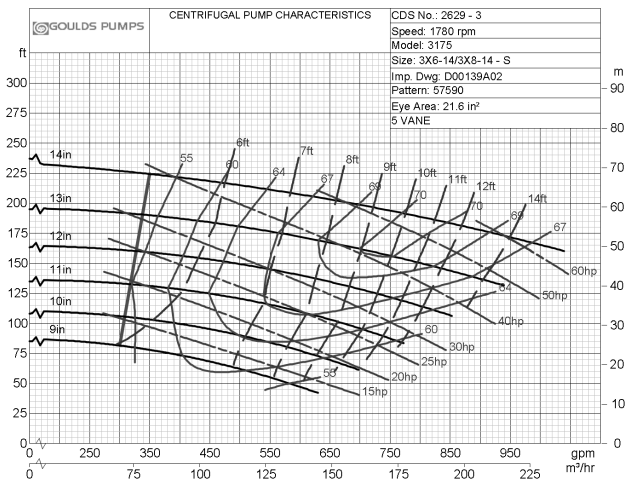
3X6-12/3X8-12 **1170rpm**



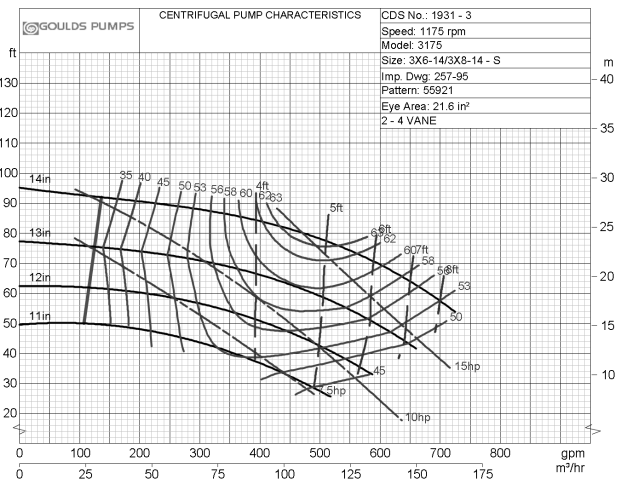
3X6-12/3X8-12 **870rpm**



3X6-14/3X8-14 **1780rpm**



3X6-14/3X8-14 **1780rpm**



3X6-14/3X8-14 **1175rpm**

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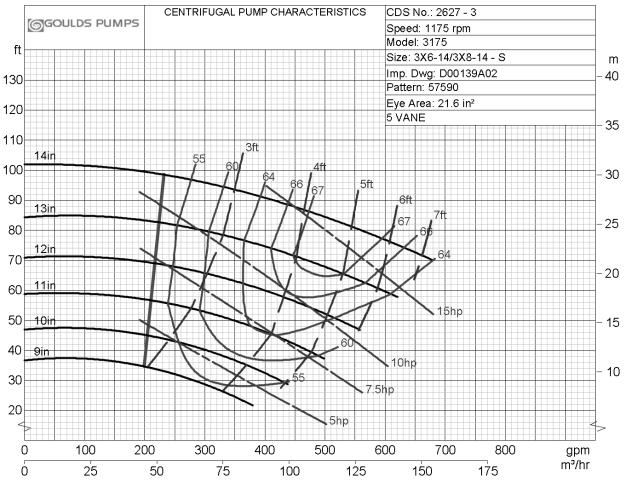
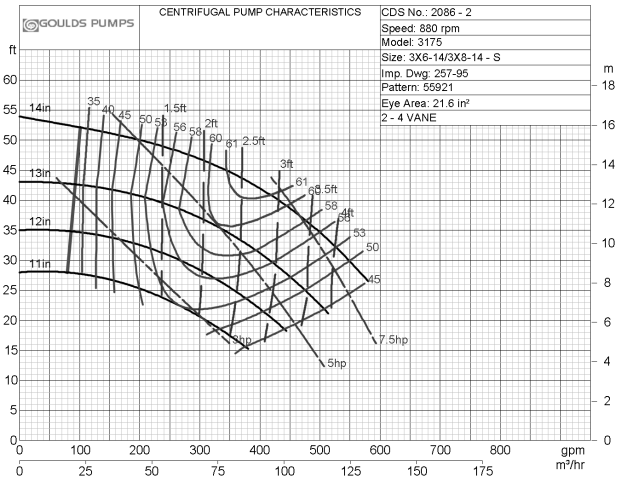
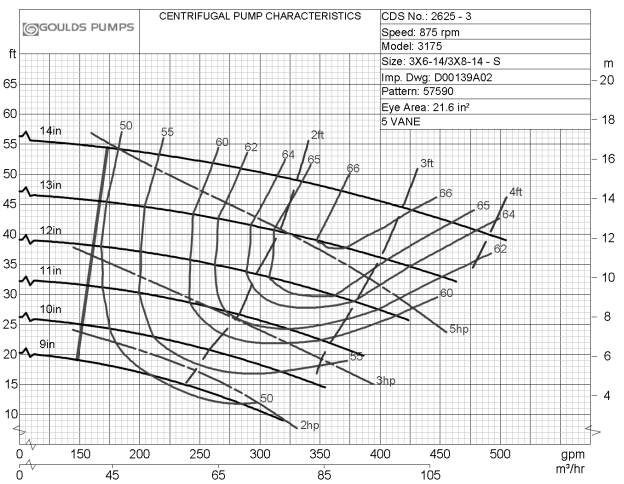


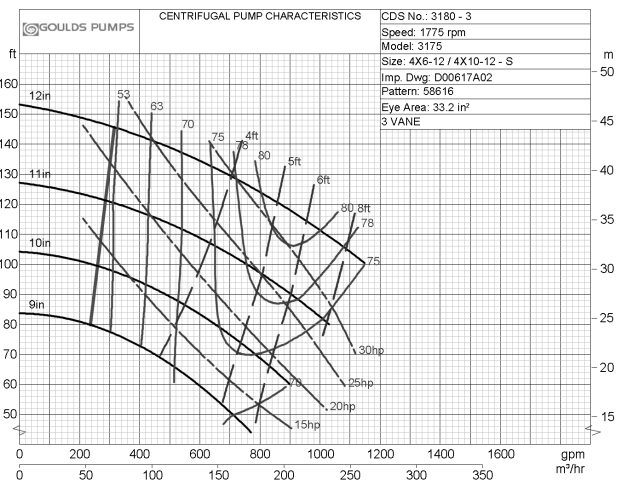
3X6-14/3X8-14 **1175rpm**



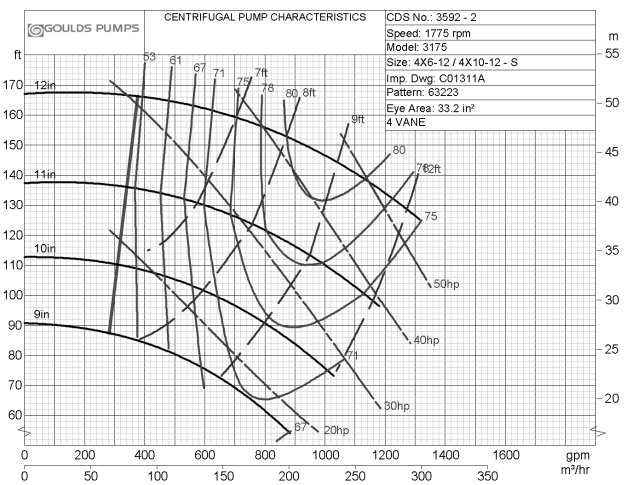
3X6-14/3X8-14 **880rpm**



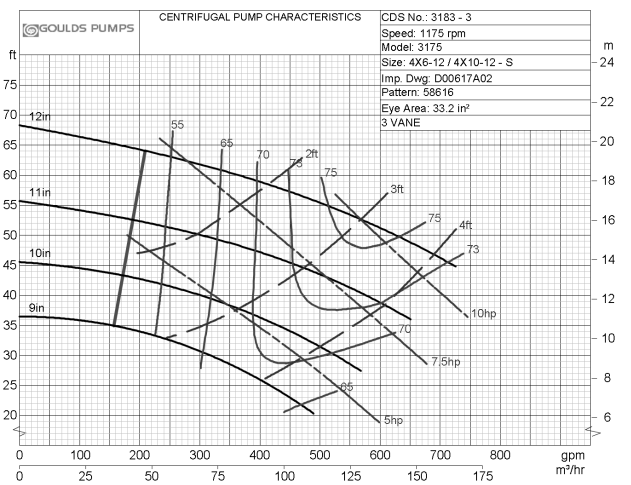
3X6-14/3X8-14 **875rpm**



4X6-12 / 4X10-12 **1775rpm**



4X6-12 / 4X10-12 **1775rpm**



4X6-12 / 4X10-12 **1175rpm**

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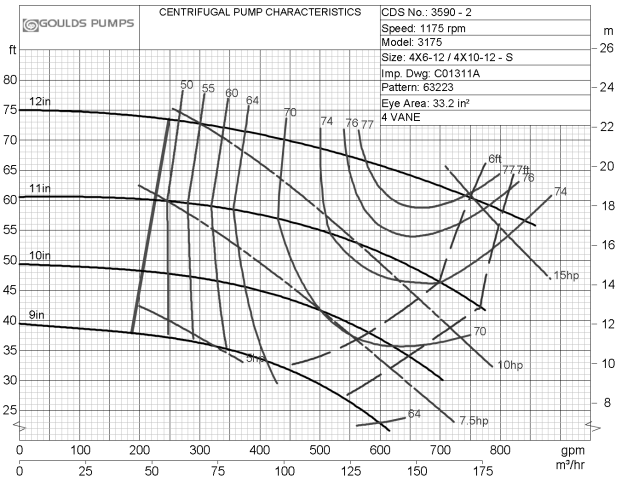
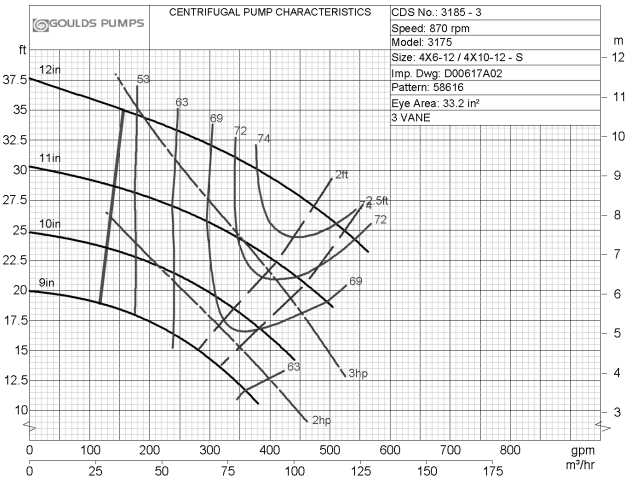
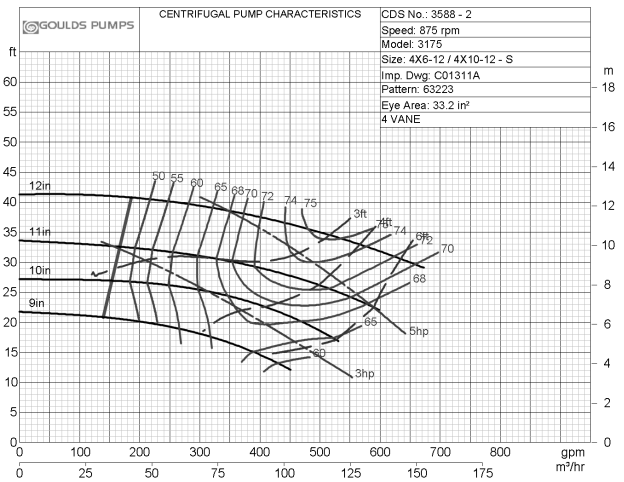


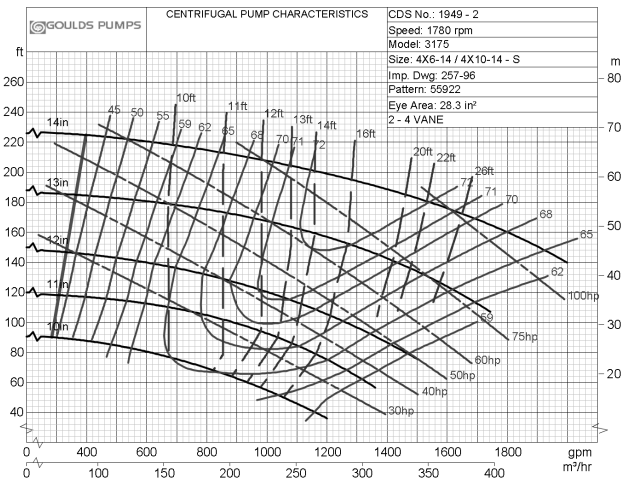
4X6-12 / 4X10-12 1175rpm



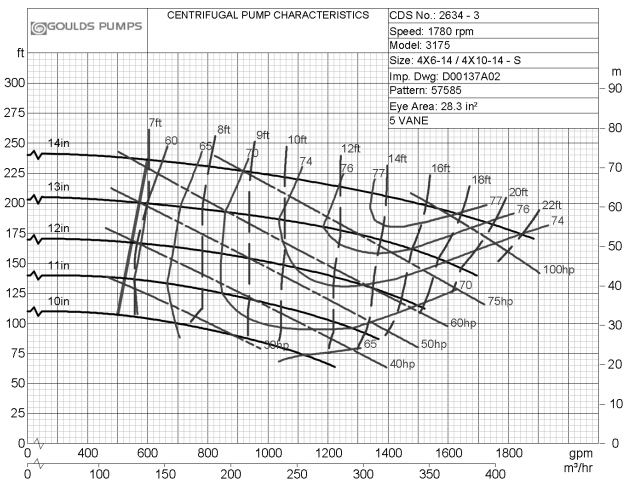
4X6-12 / 4X10-12 870rpm



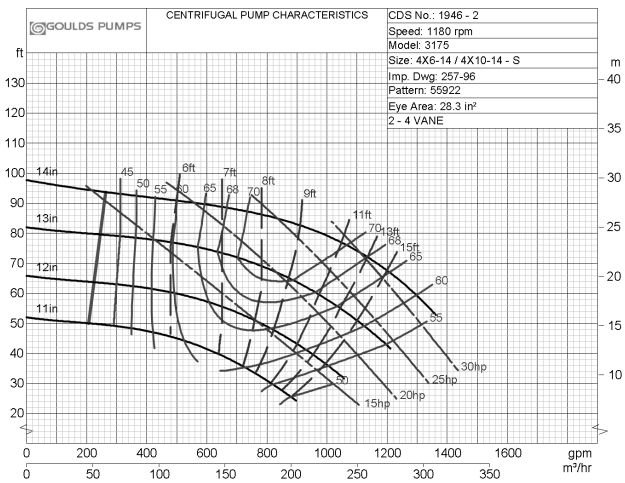
4X6-12 / 4X10-12 875rpm



4X6-14 / 4X10-14 1780rpm

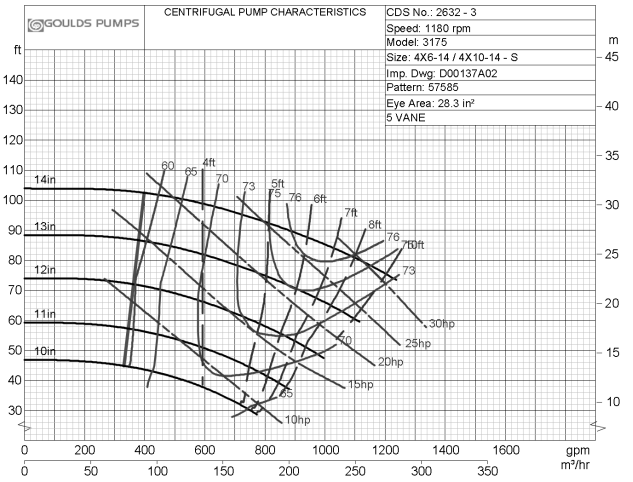


4X6-14 / 4X10-14 1780rpm

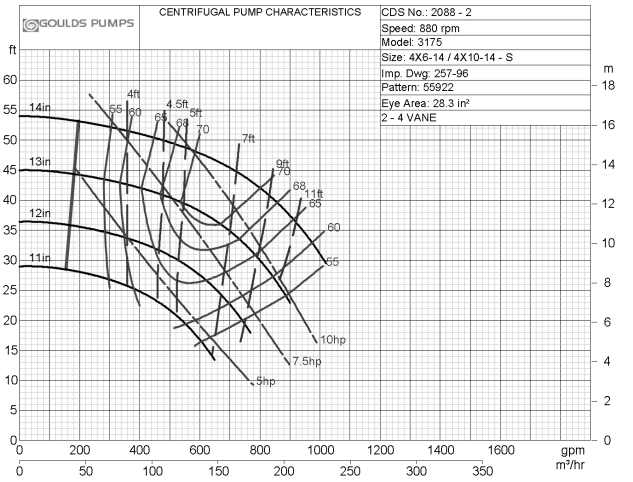


4X6-14 / 4X10-14 1180rpm

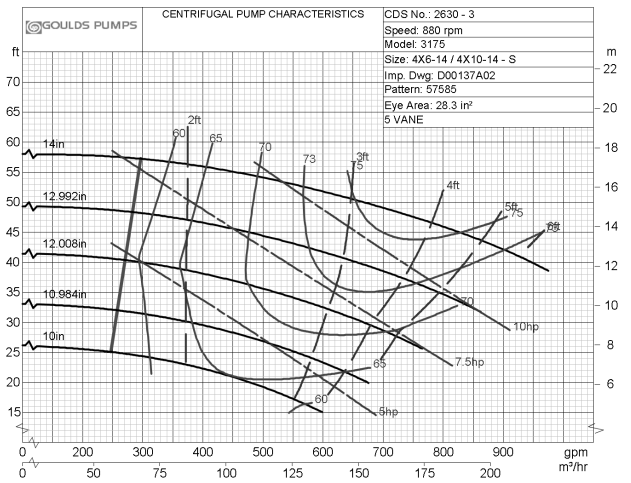
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



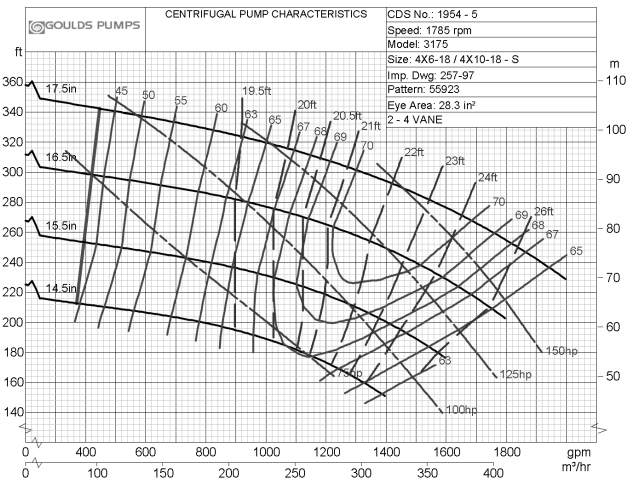
4X6-14 / 4X10-14 **1180rpm**



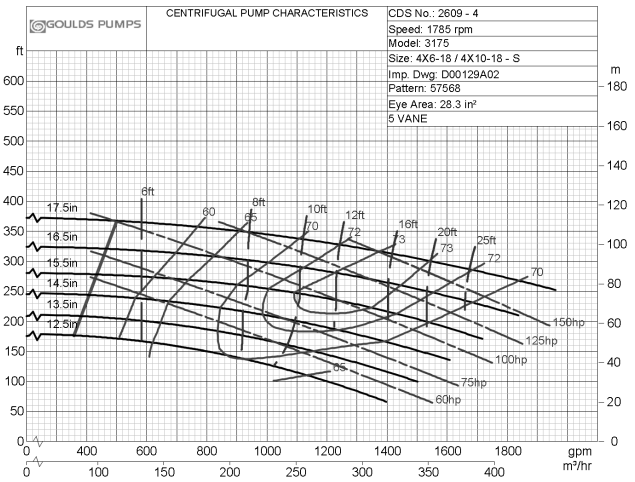
4X6-14 / 4X10-14 **880rpm**



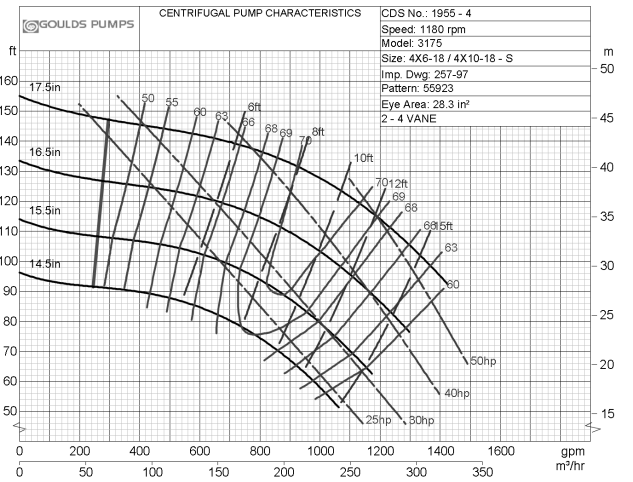
4X6-14 / 4X10-14 **880rpm**



4X6-18 / 4X10-18 **1785rpm**

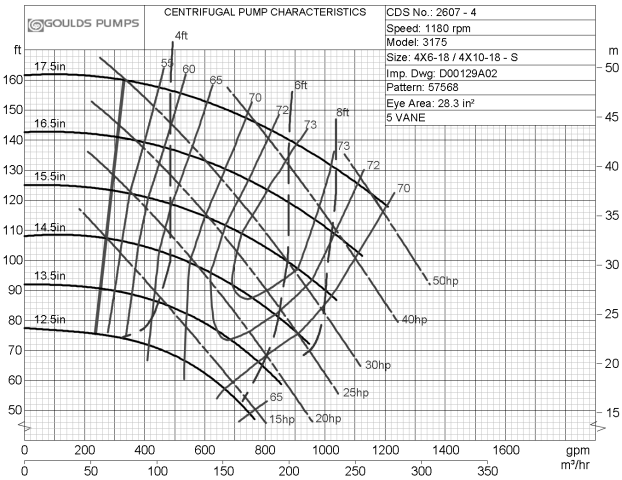


4X6-18 / 4X10-18 **1785rpm**

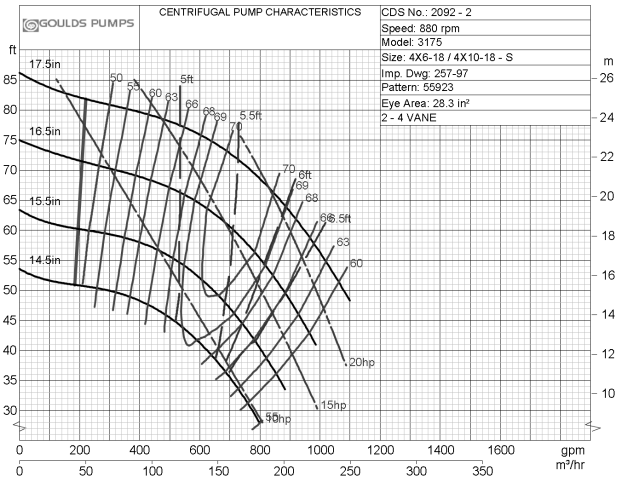


4X6-18 / 4X10-18 **1180rpm**

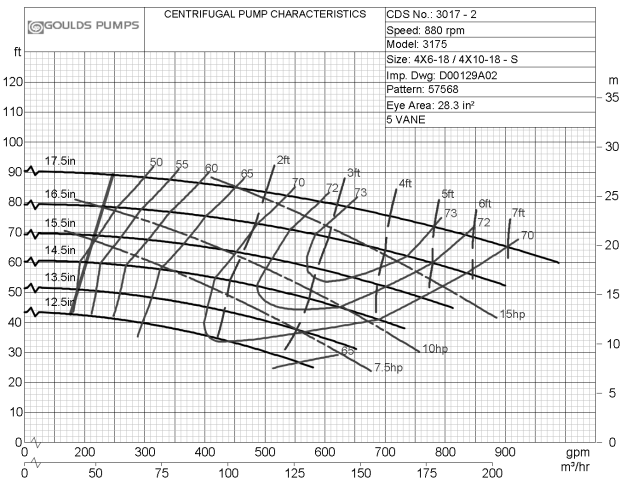
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



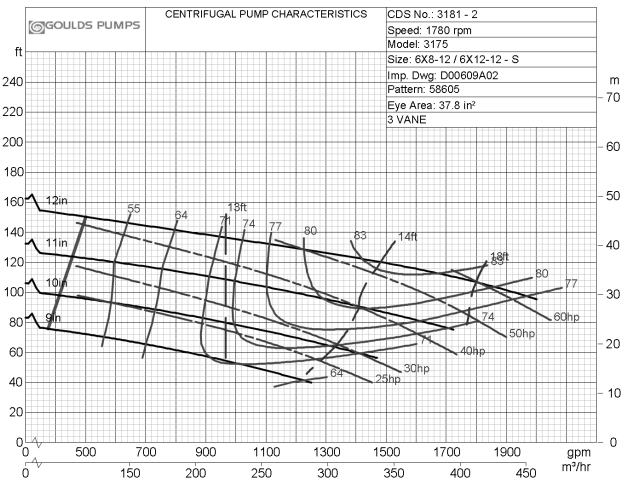
4X6-18 / 4X10-18 **1180rpm**



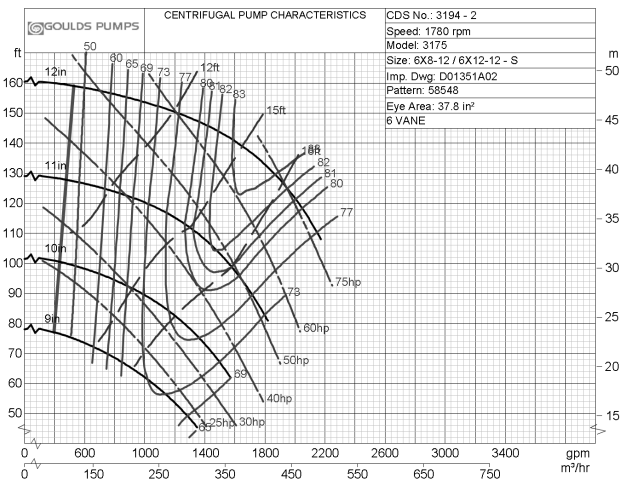
4X6-18 / 4X10-18 **880rpm**



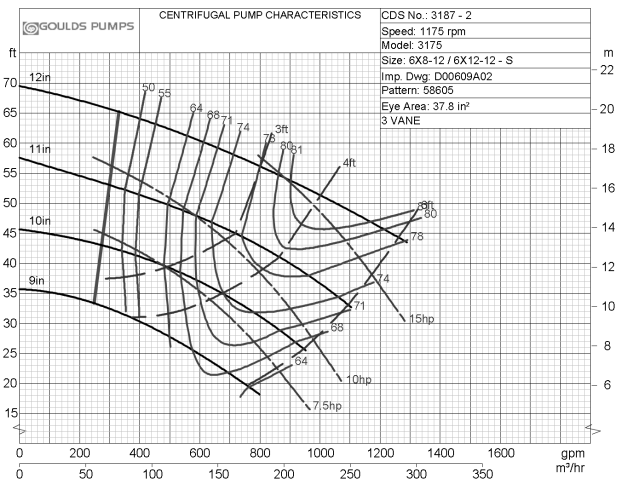
4X6-18 / 4X10-18 **880rpm**



6X8-12 / 6X12-12 **1780rpm**



6X8-12 / 6X12-12 **1780rpm**

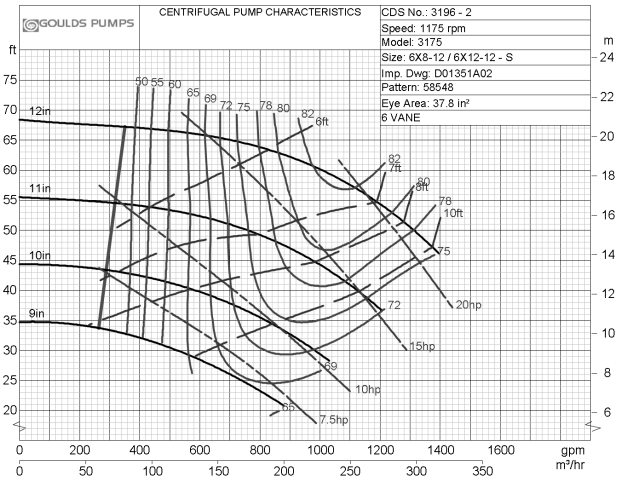


6X8-12 / 6X12-12 **1175rpm**

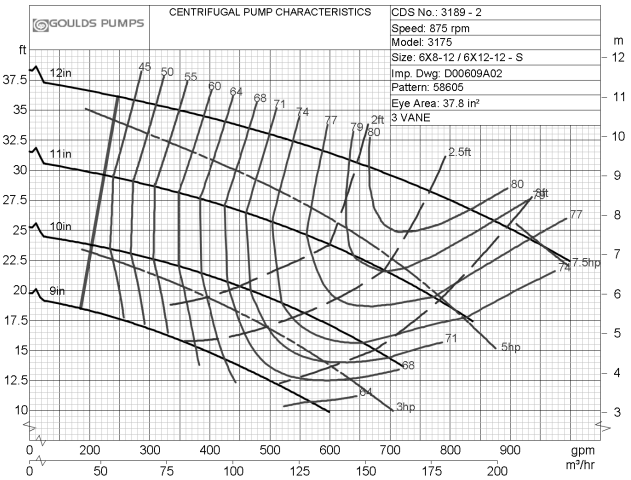
60Hz Curves

Model 3175

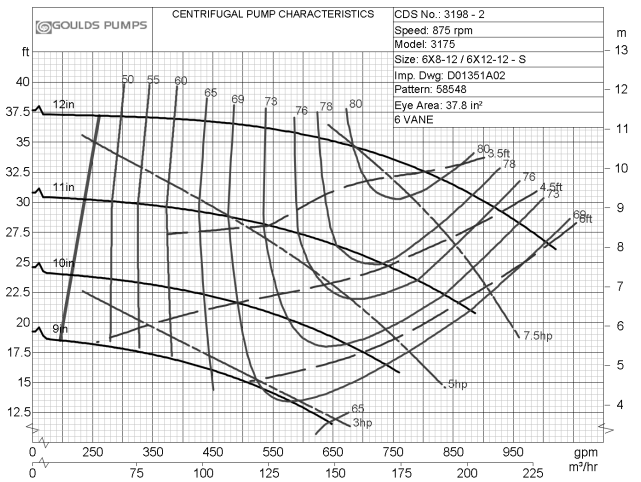
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



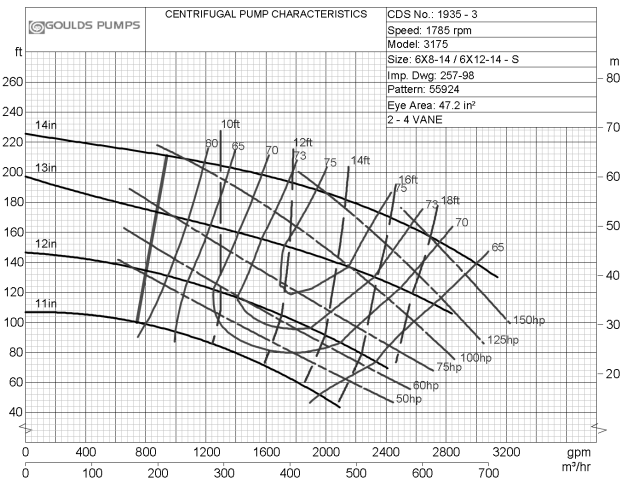
6X8-12 / 6X12-12 **1175rpm**



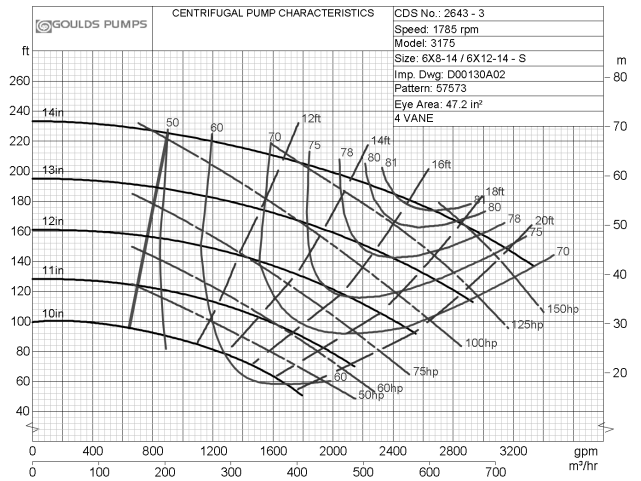
6X8-12 / 6X12-12 **875rpm**



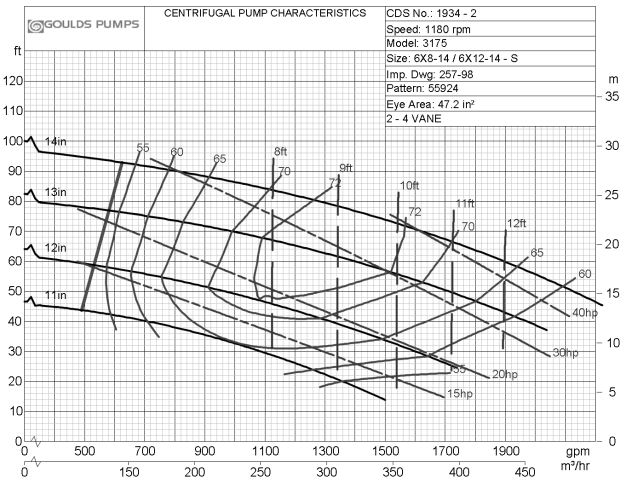
6X8-12 / 6X12-12 **875rpm**



6X8-14 / 6X12-14 **1785rpm**

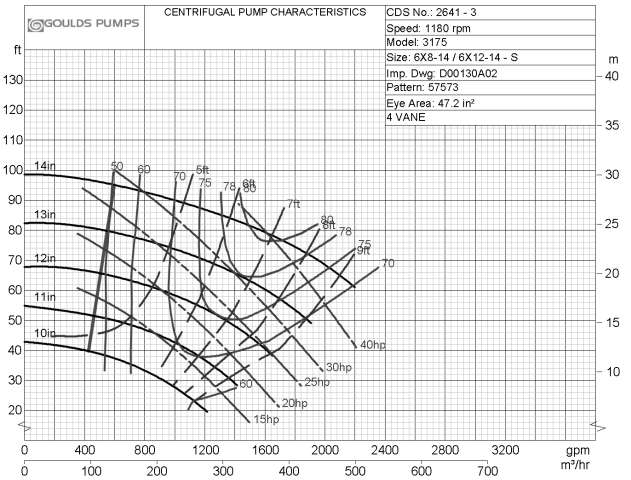


6X8-14 / 6X12-14 **1785rpm**

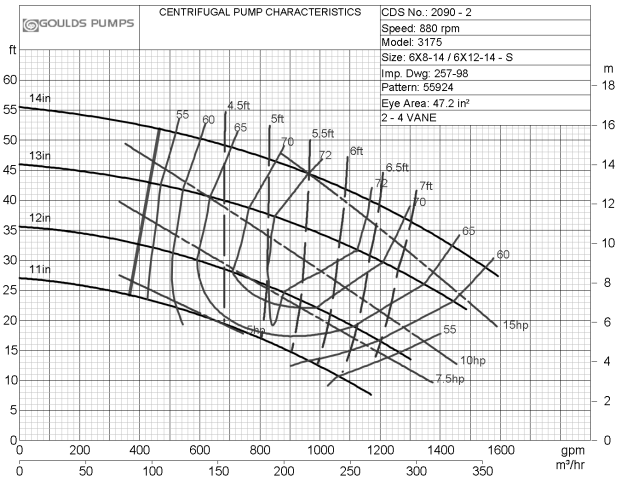


6X8-14 / 6X12-14 **1180rpm**

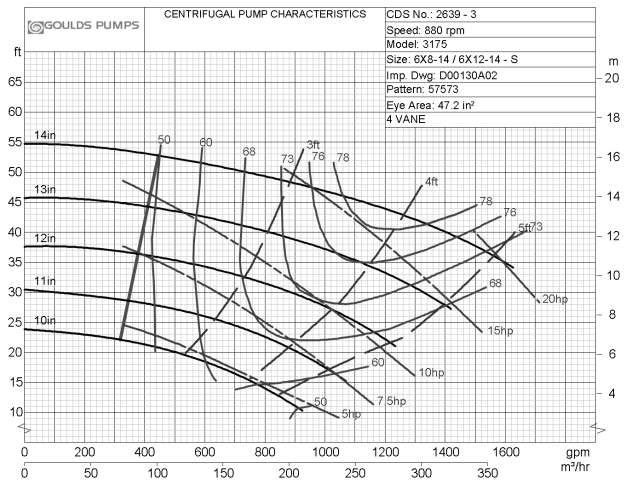
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



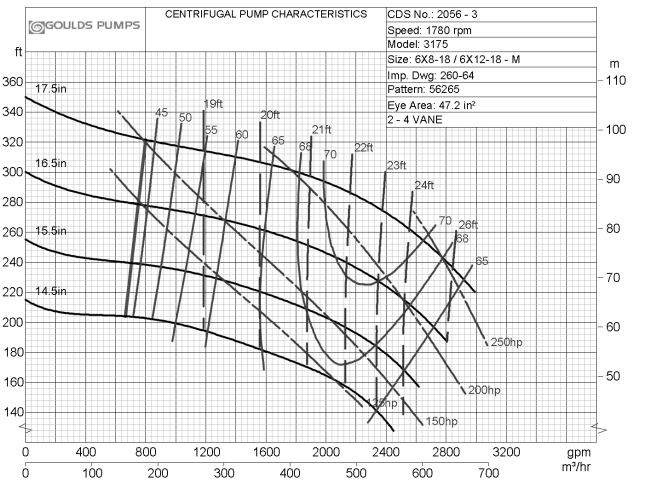
6X8-14 / 6X12-14 **1180rpm**



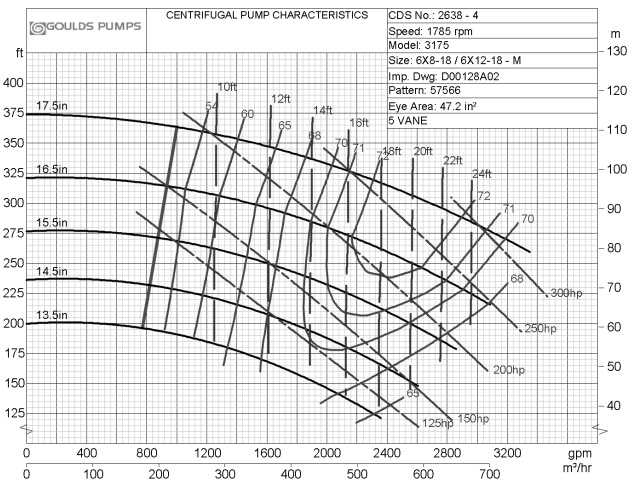
6X8-14 / 6X12-14 **880rpm**



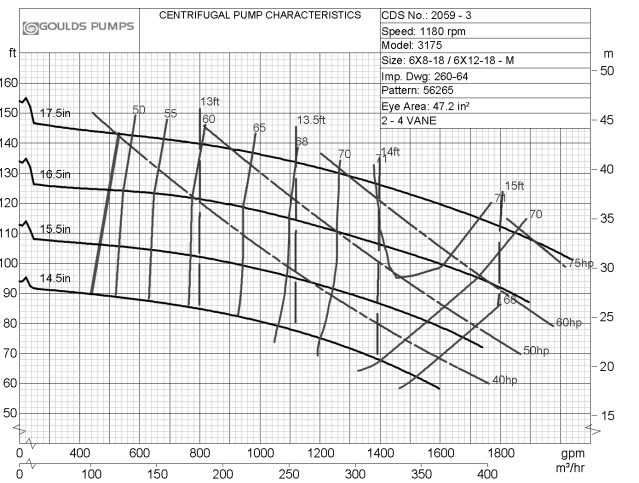
6X8-14 / 6X12-14 **880rpm**



6X8-18 / 6X12-18 **1780rpm**



6X8-18 / 6X12-18 **1785rpm**

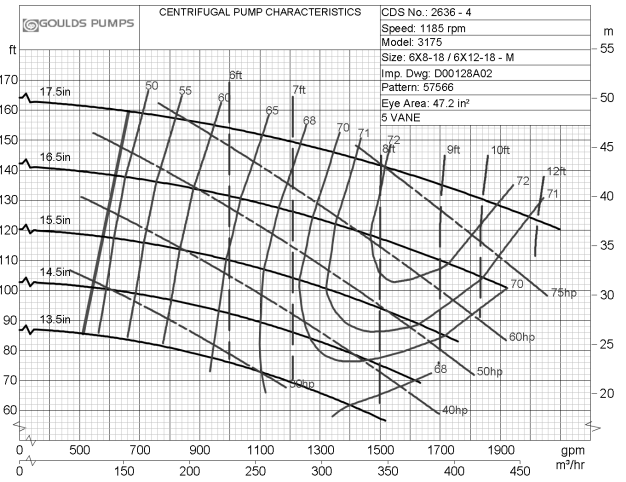


6X8-18 / 6X12-18 **1180rpm**

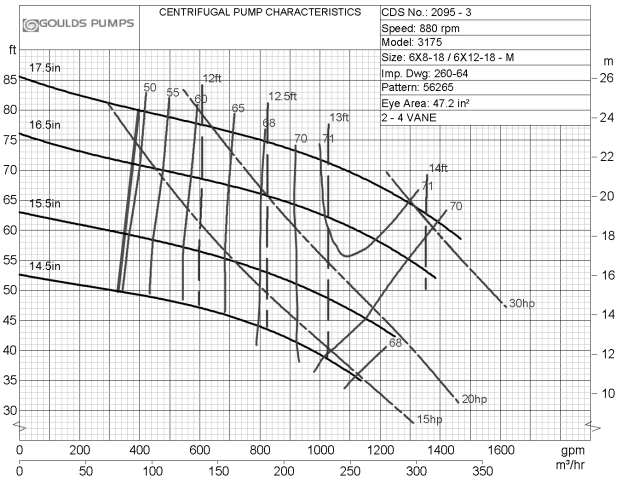
60Hz Curves

Model 3175

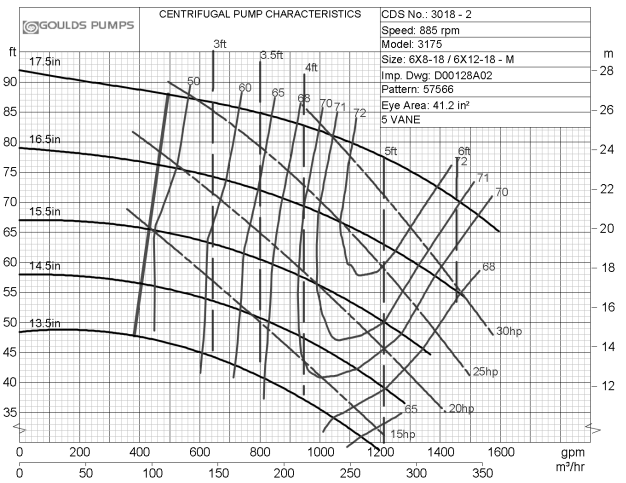
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



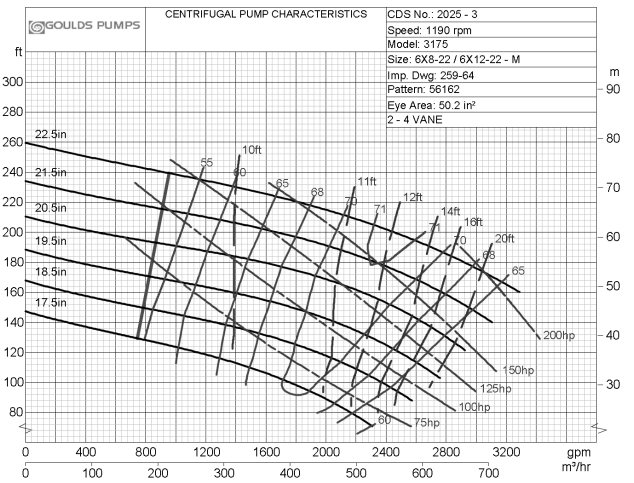
6X8-18 / 6X12-18 **1185rpm**



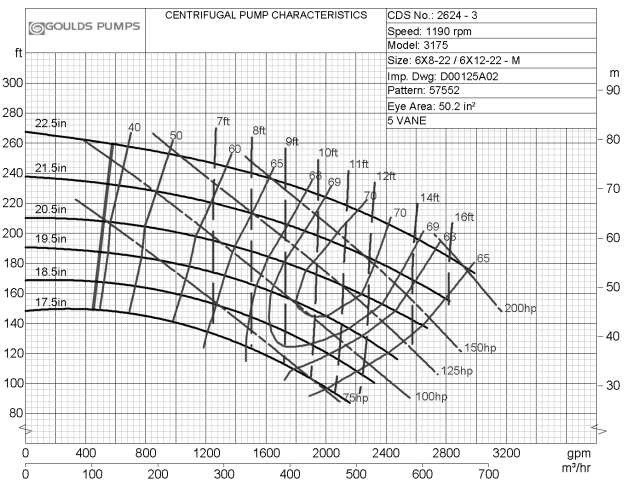
6X8-18 / 6X12-18 **880rpm**



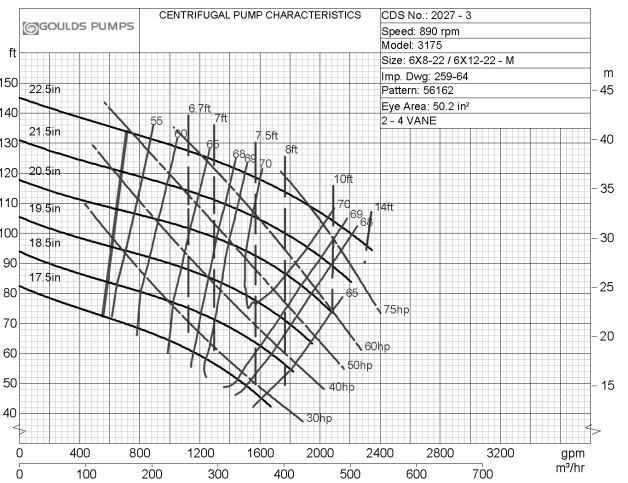
6X8-18 / 6X12-18 **885rpm**



6X8-22 / 6X12-22 **1190rpm**

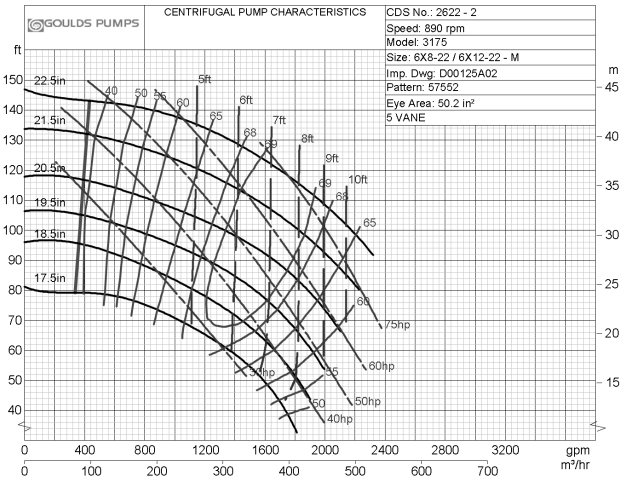


6X8-22 / 6X12-22 **1190rpm**

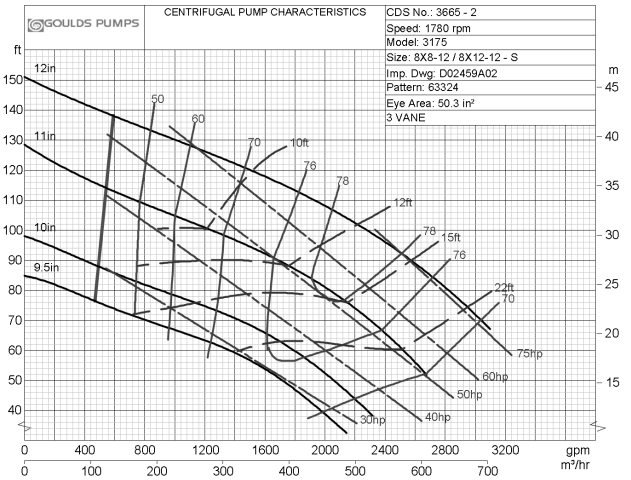


6X8-22 / 6X12-22 **890rpm**

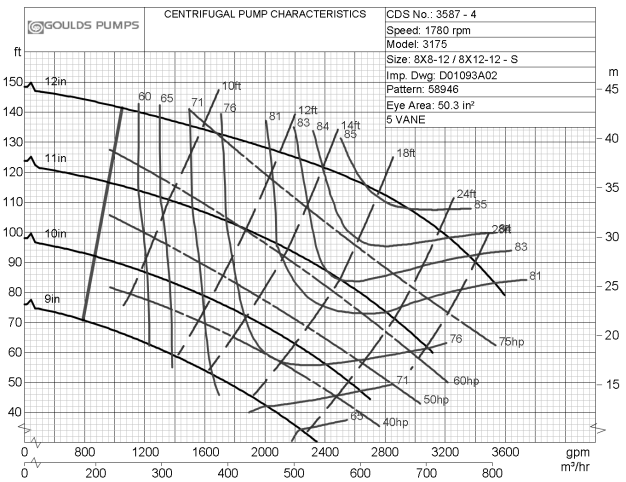
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



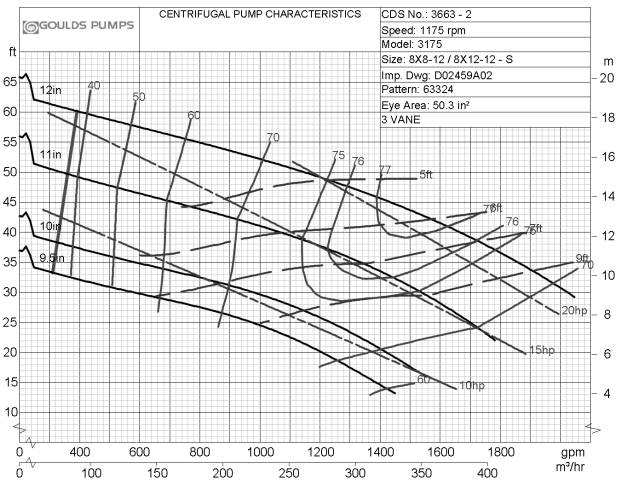
6X8-22 / 6X12-22 **890rpm**



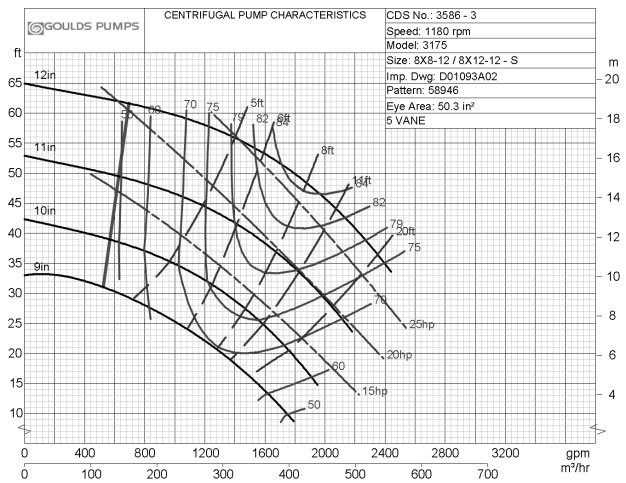
8X8-12 / 8X12-12 **1780rpm**



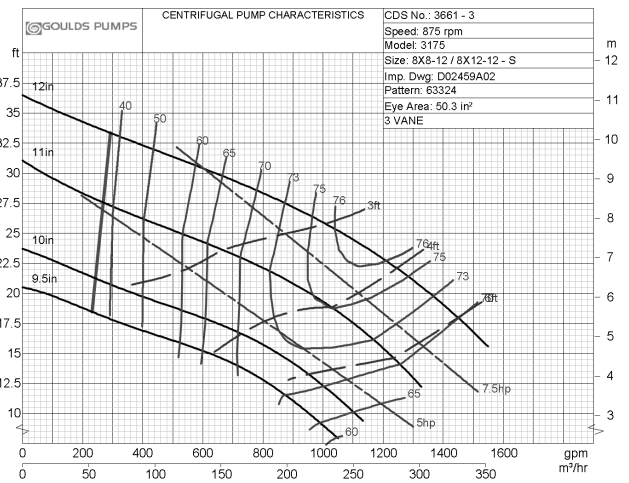
8X8-12 / 8X12-12 **1780rpm**



8X8-12 / 8X12-12 **1175rpm**



8X8-12 / 8X12-12 **1180rpm**



8X8-12 / 8X12-12 **875rpm**

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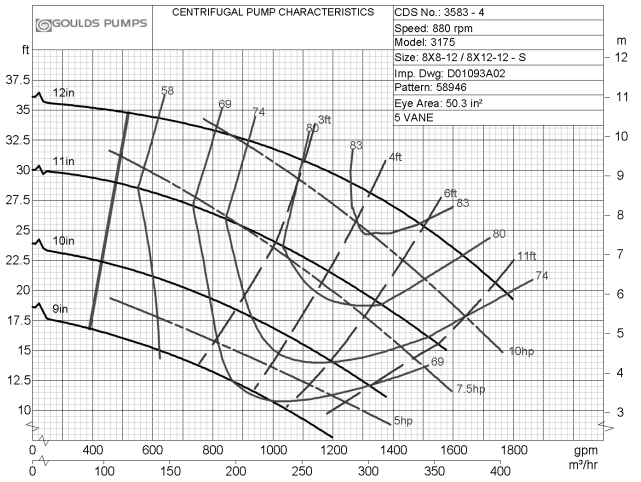
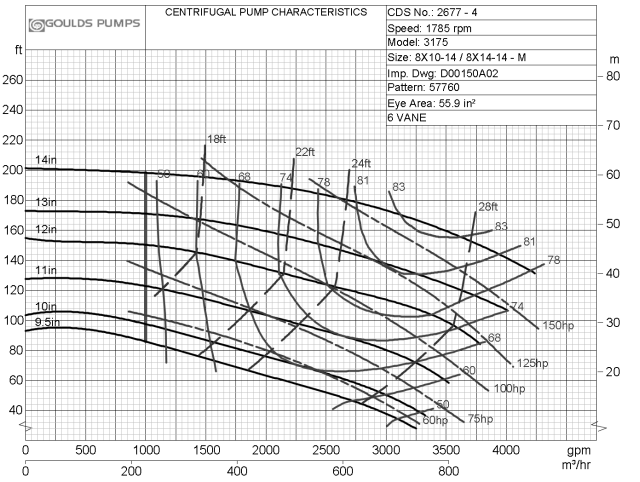
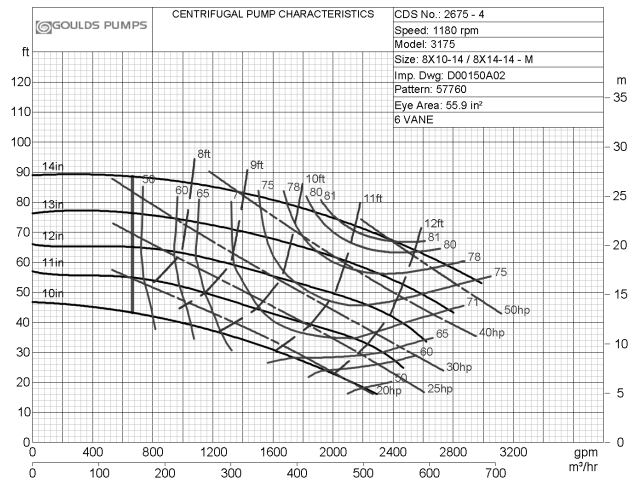


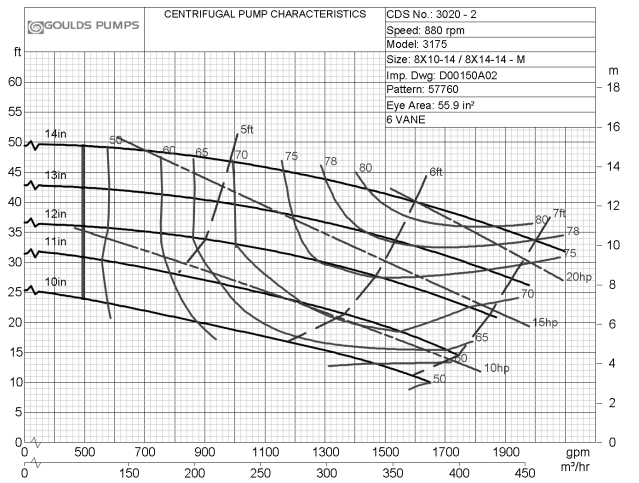
8X8-12 / 8X12-12 **880rpm**



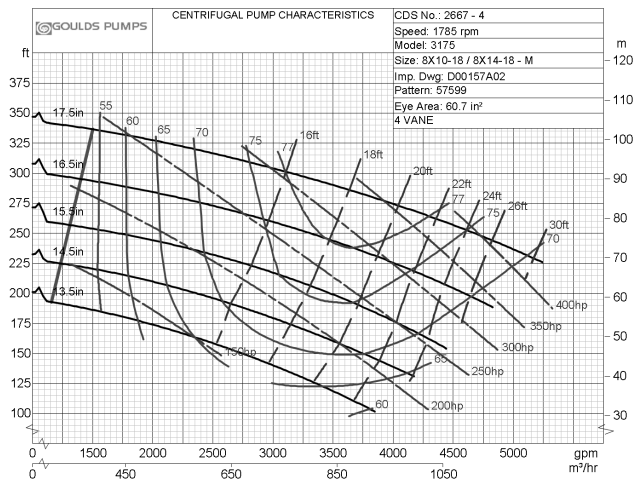
8X10-14 / 8X14-14 **1785rpm**



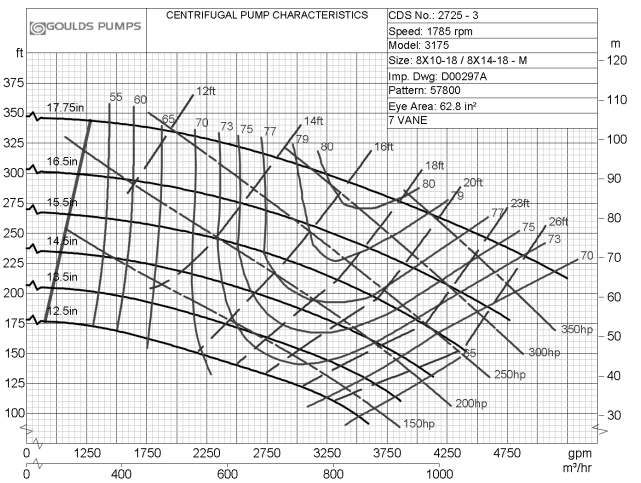
8X10-14 / 8X14-14 **1180rpm**



8X10-14 / 8X14-14 **880rpm**



8X10-18 / 8X14-18 **1785rpm**



8X10-18 / 8X14-18 **1785rpm**

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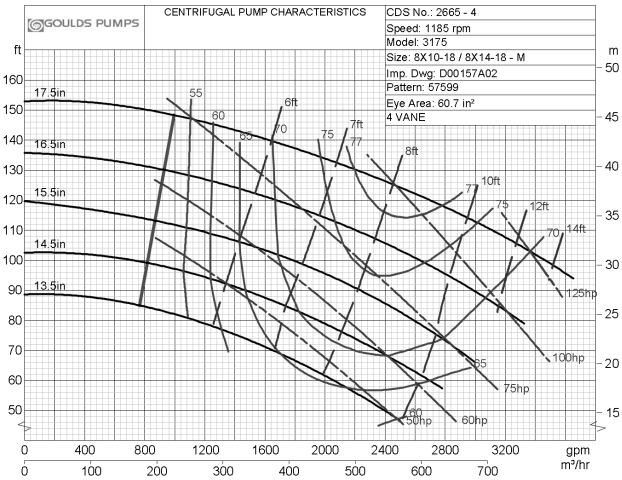
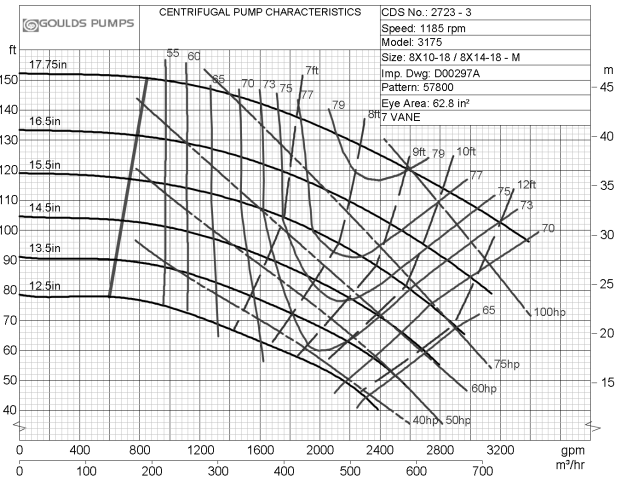
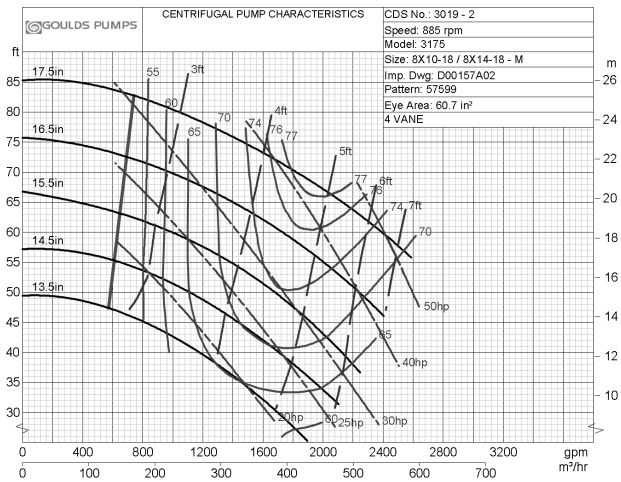


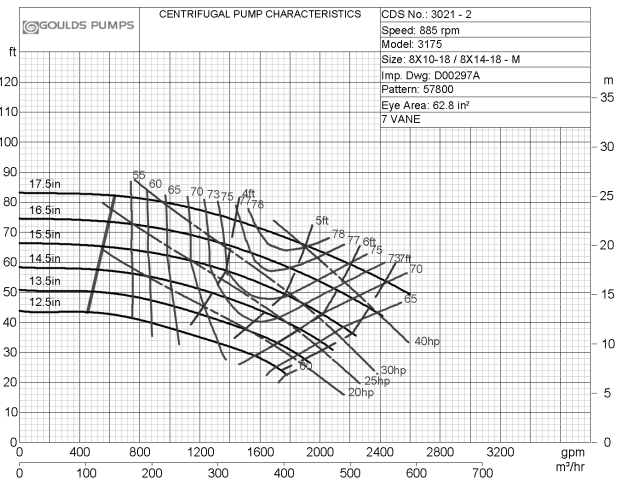
8X10-18 / 8X14-18 **1185rpm**



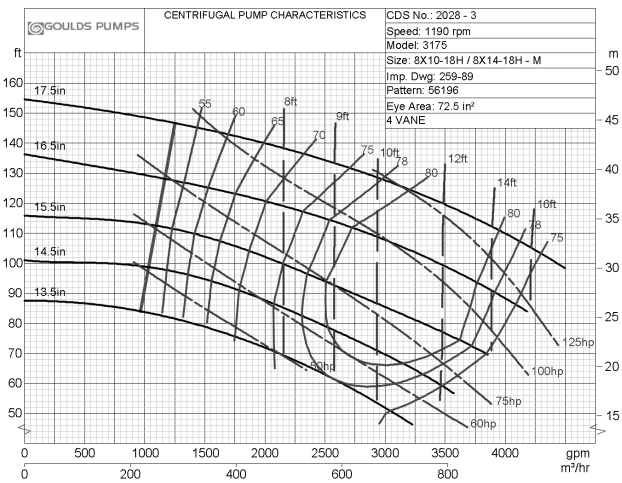
8X10-18 / 8X14-18 **1185rpm**



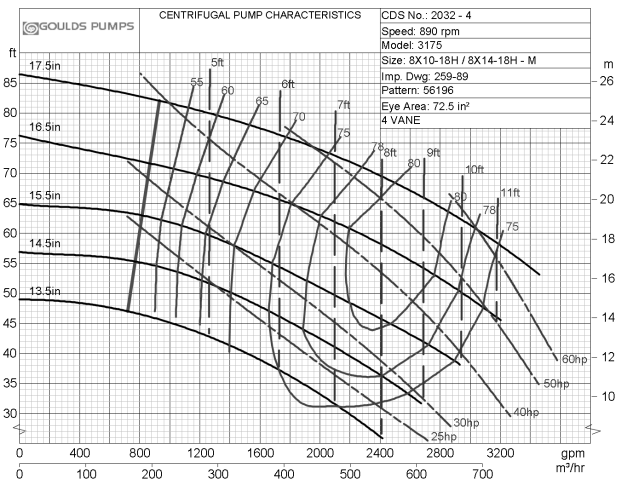
8X10-18 / 8X14-18 **885rpm**



8X10-18 / 8X14-18 **885rpm**



8X10-18H / 8X14-18H **1190rpm**

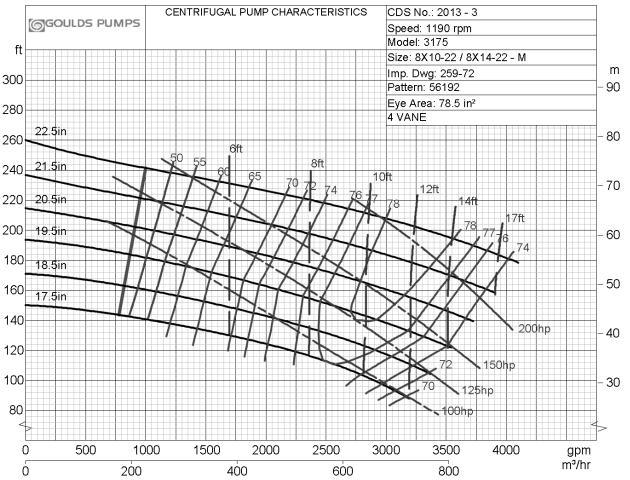


8X10-18H / 8X14-18H **890rpm**

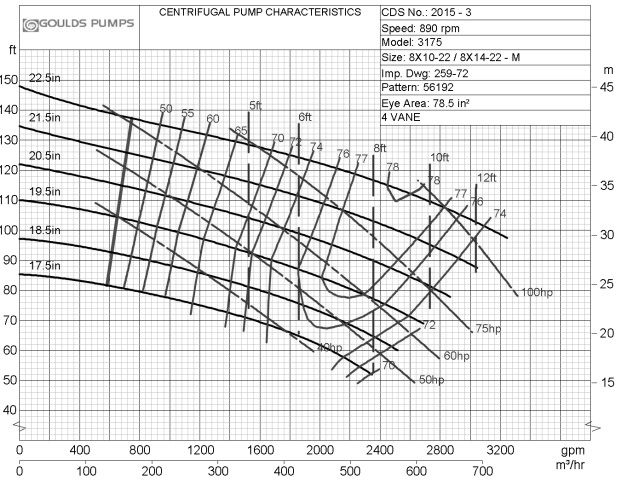
60Hz Curves

Model 3175

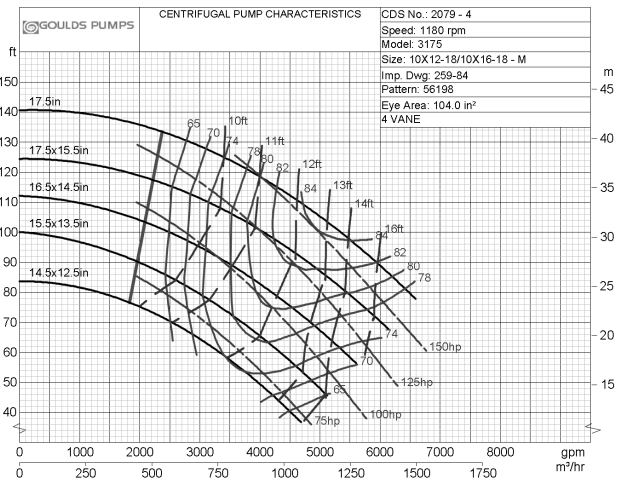
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



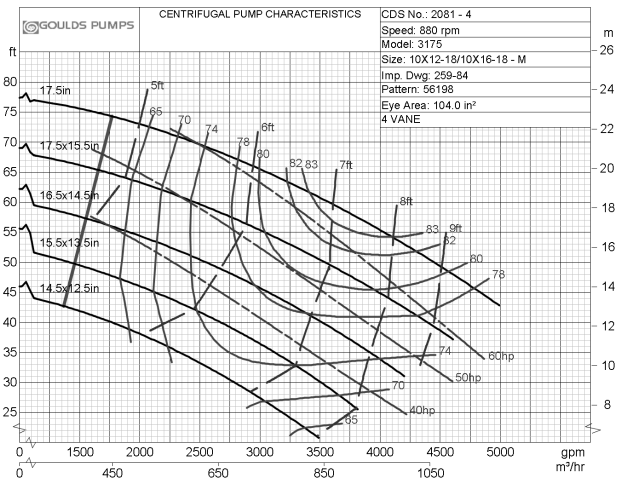
8X10-22 / 8X14-22 **1190rpm**



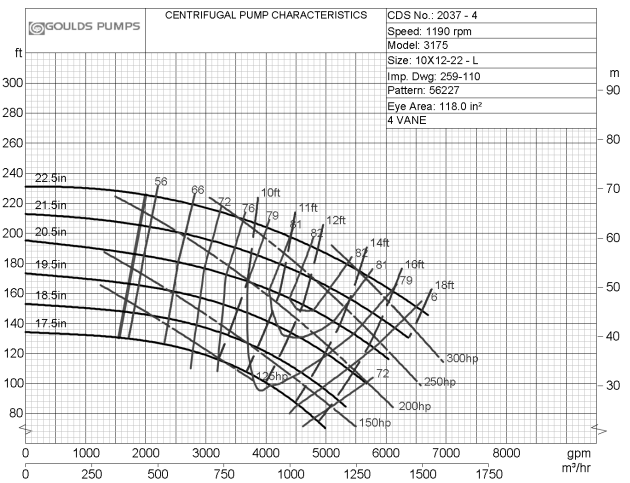
8X10-22 / 8X14-22 **890rpm**



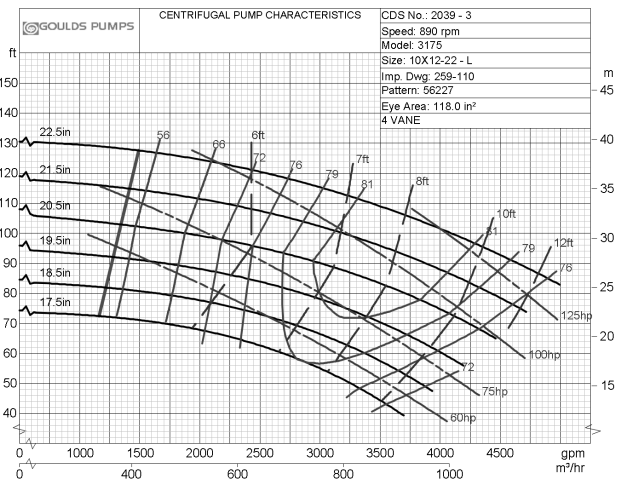
10X12-18/10X16-18 **1180rpm**



10X12-18/10X16-18 **880rpm**

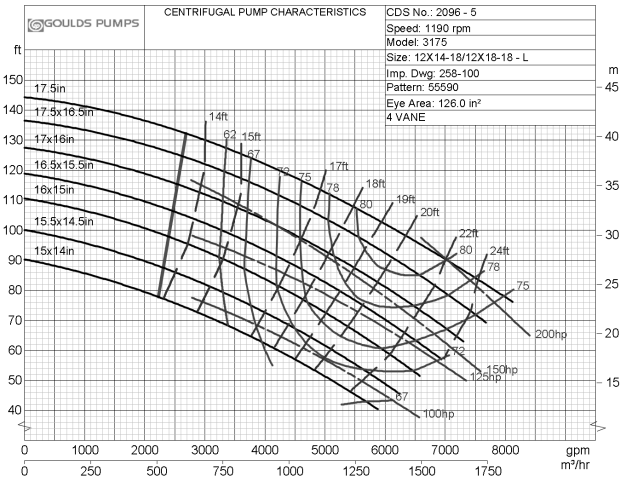


10X12-22 **1190rpm**

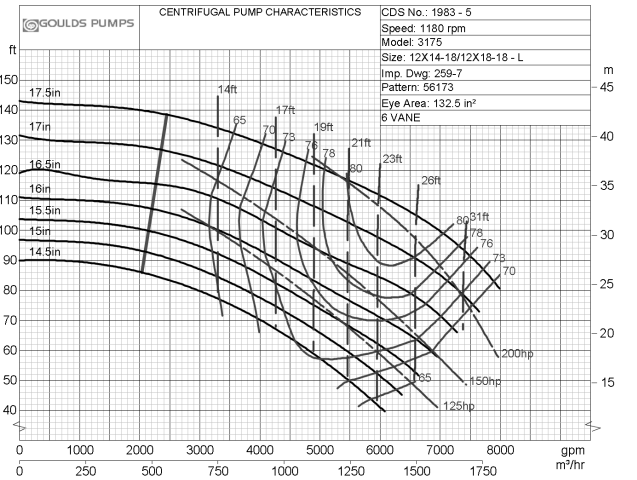


10X12-22 **890rpm**

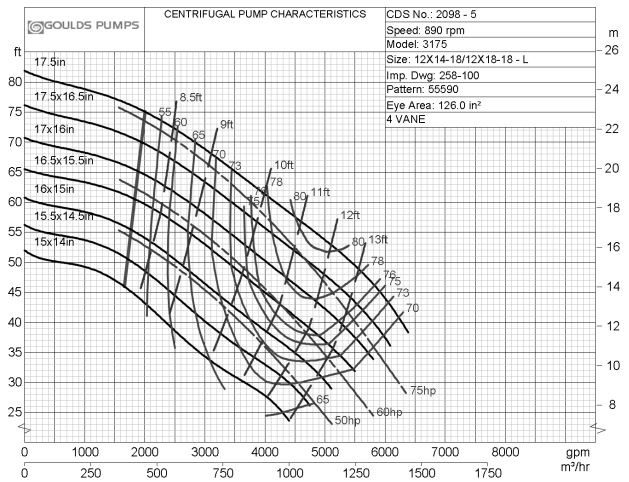
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



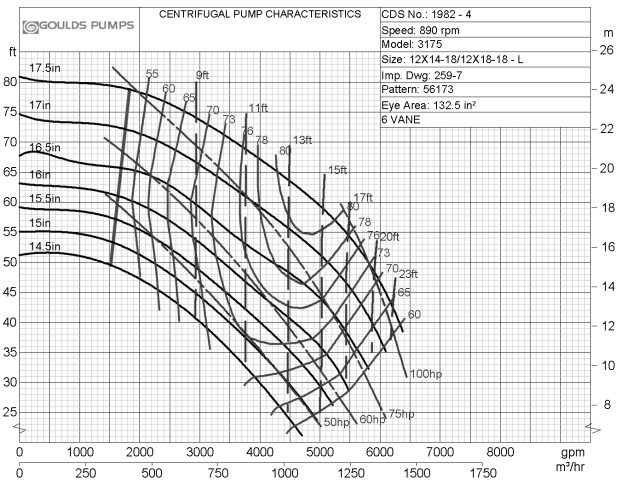
12X14-18/12X18-18 **1190rpm**



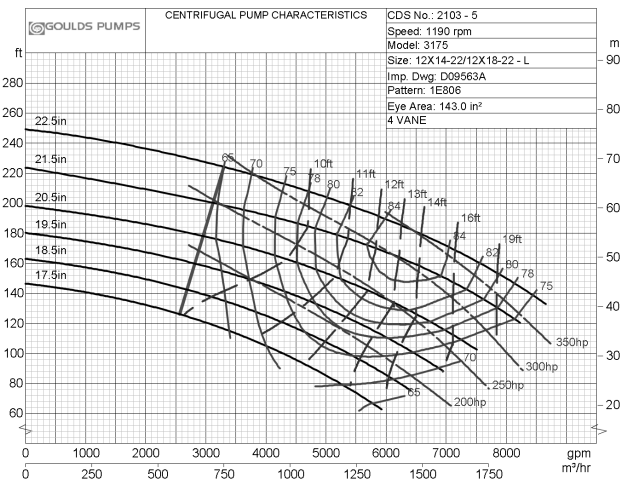
12X14-18/12X18-18 **1180rpm**



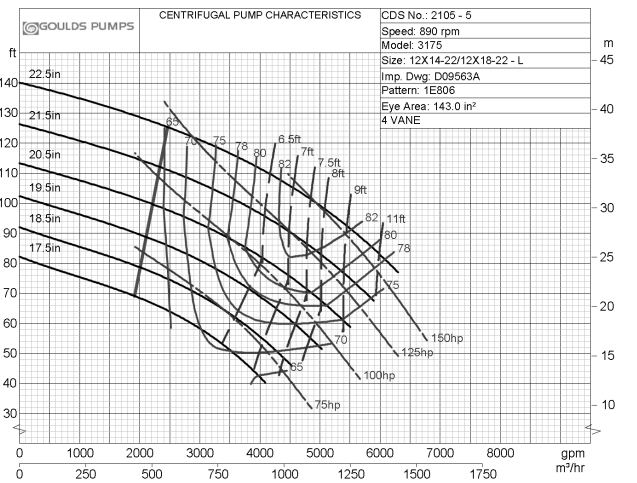
12X14-18/12X18-18 **890rpm**



12X14-18/12X18-18 **890rpm**



12X14-22/12X18-22 **1190rpm**

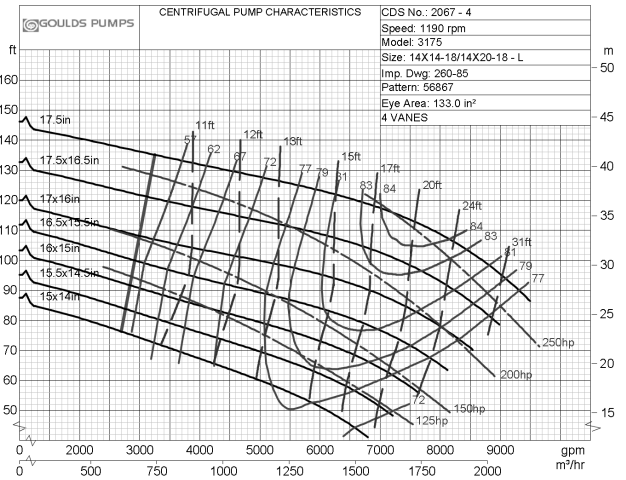


12X14-22/12X18-22 **890rpm**

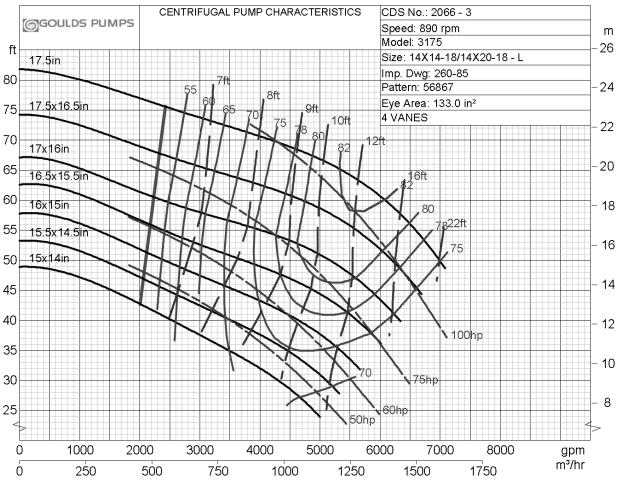
60Hz Curves

Model 3175

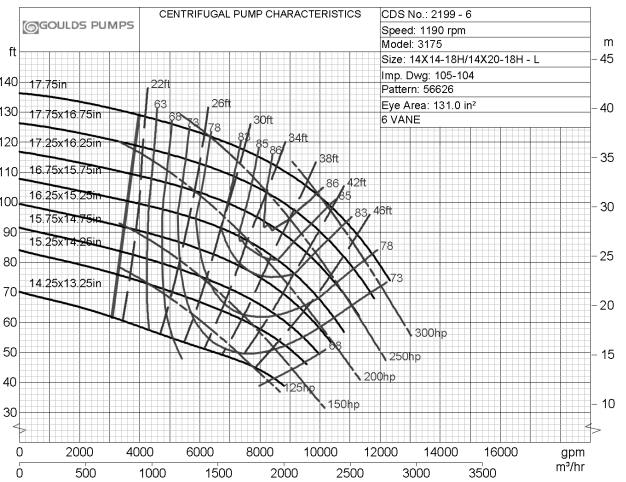
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



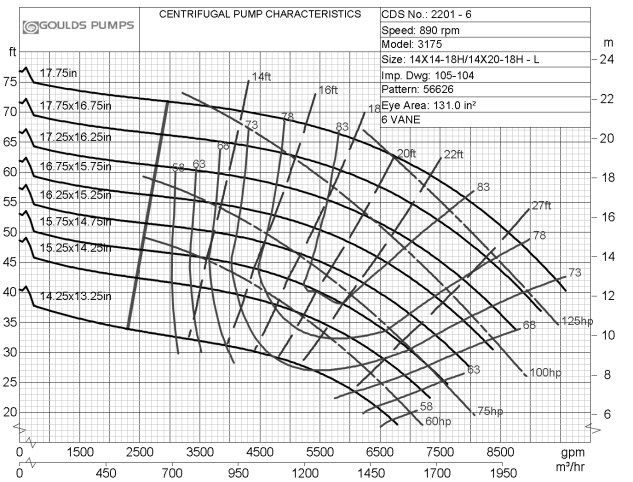
14X14-18/14X20-18 **1190rpm**



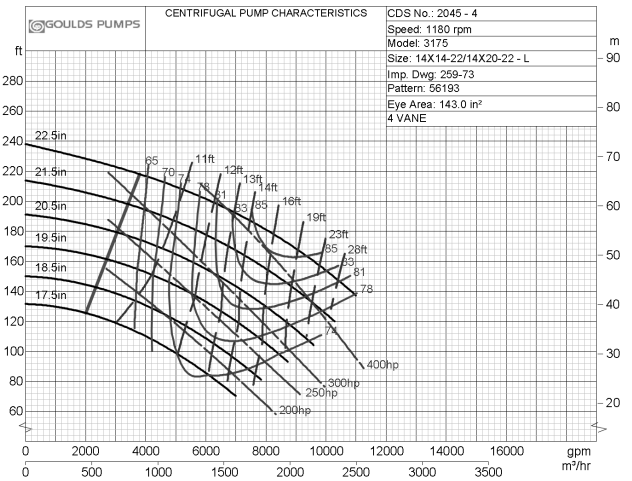
14X14-18/14X20-18 **890rpm**



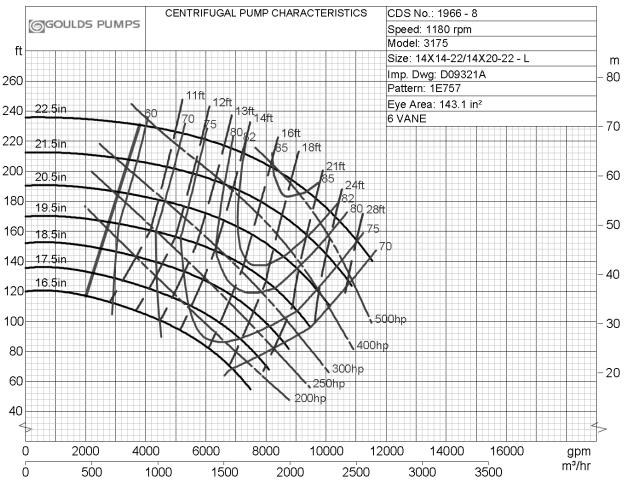
14X14-18H/14X20-18H **1190rpm**



14X14-18H/14X20-18H **890rpm**

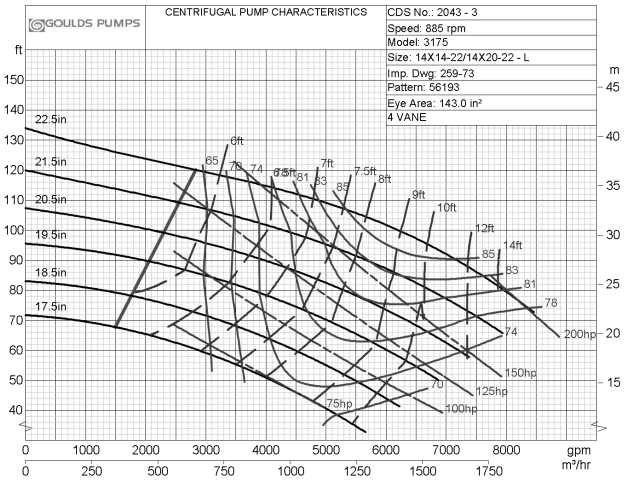


14X14-22/14X20-22 **1180rpm**

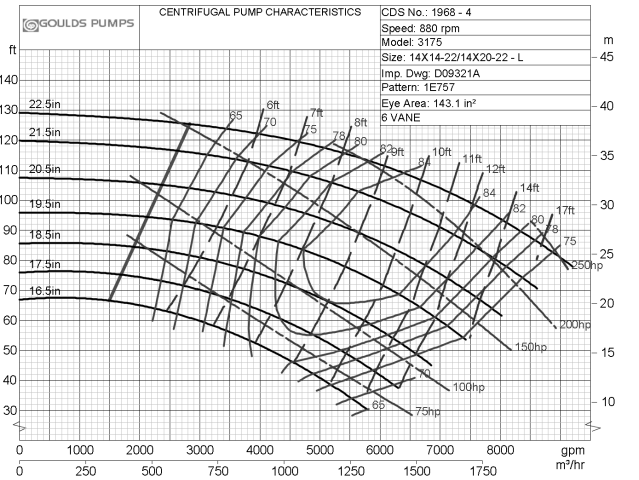


14X14-22/14X20-22 **1180rpm**

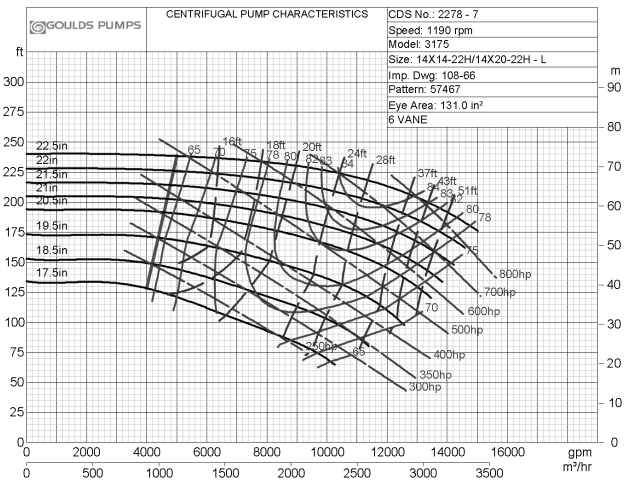
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



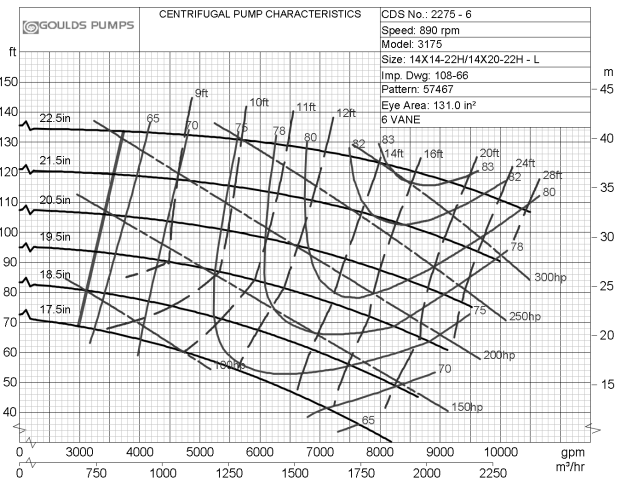
14X14-22/14X20-22 **885rpm**



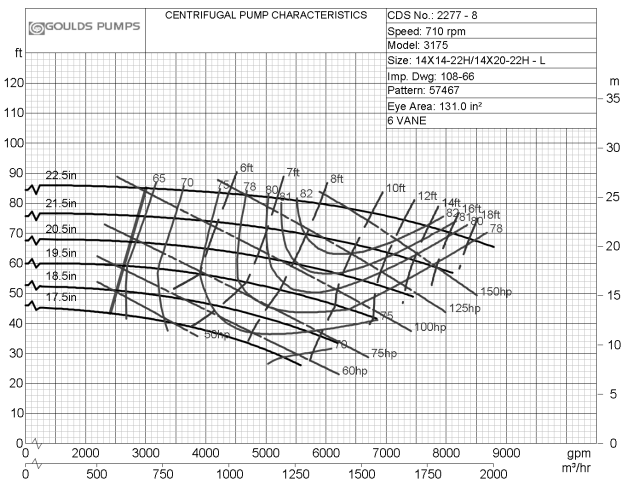
14X14-22/14X20-22 **880rpm**



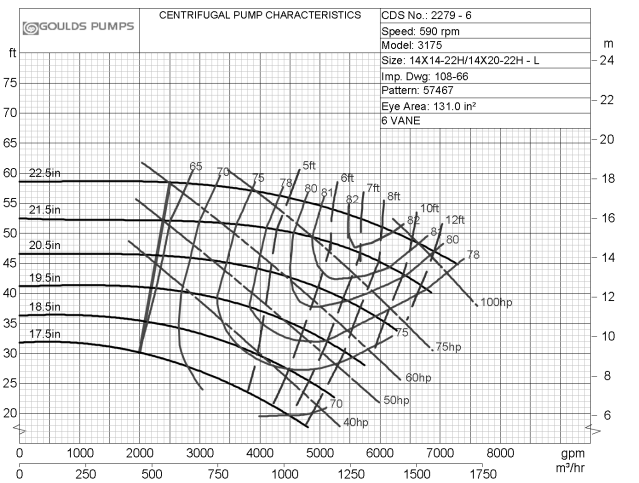
14X14-22H/14X20-22H **1190rpm**



14X14-22H/14X20-22H **890rpm**



14X14-22H/14X20-22H **710rpm**

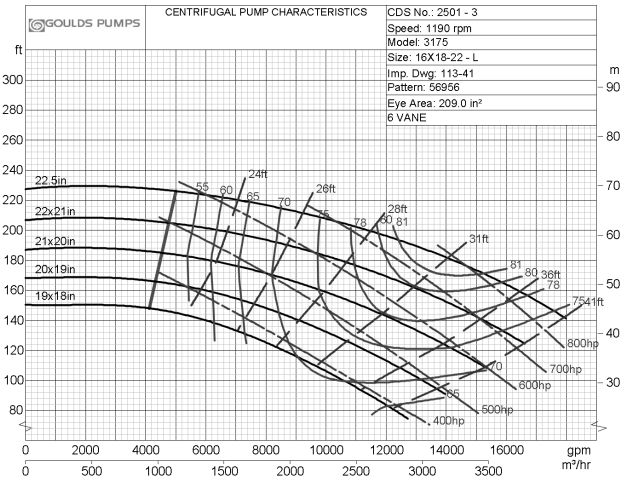


14X14-22H/14X20-22H **590rpm**

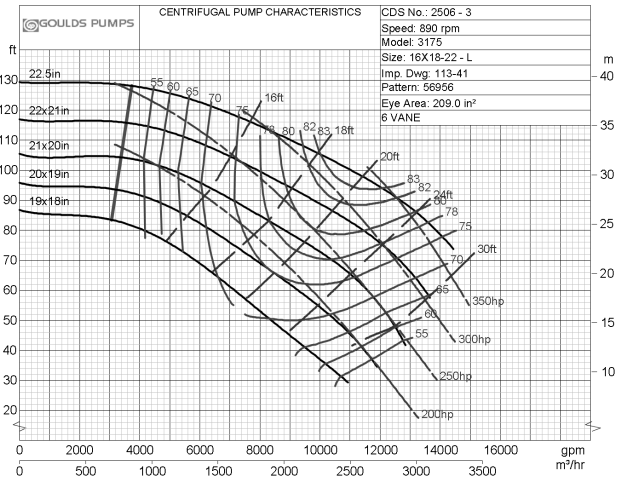
60Hz Curves

Model 3175

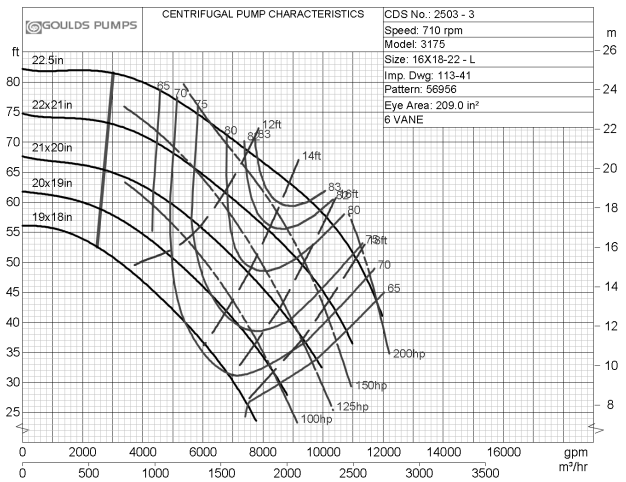
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



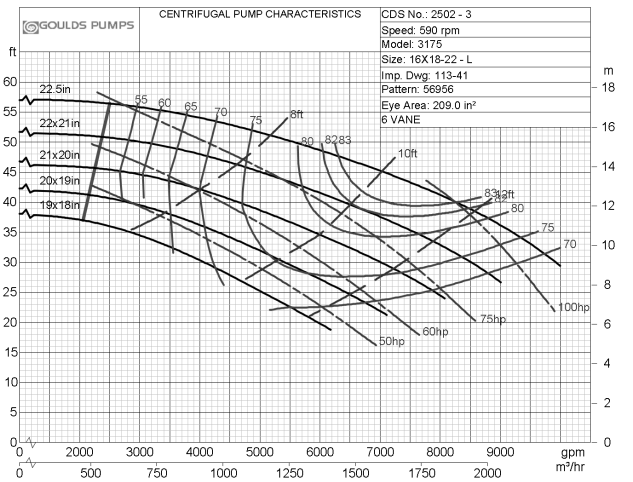
16X18-22 **1190rpm**



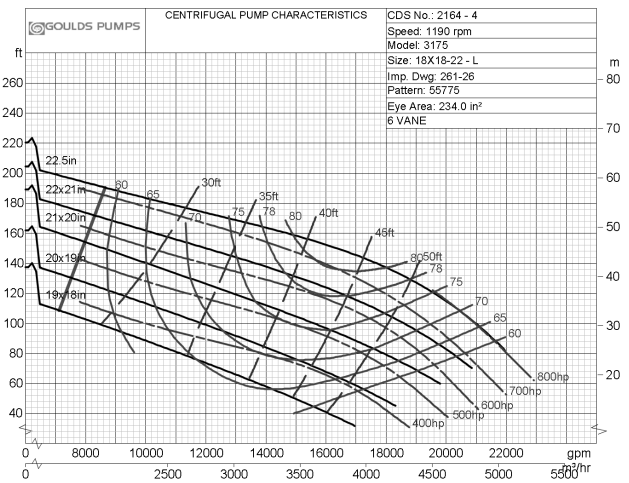
16X18-22 **890rpm**



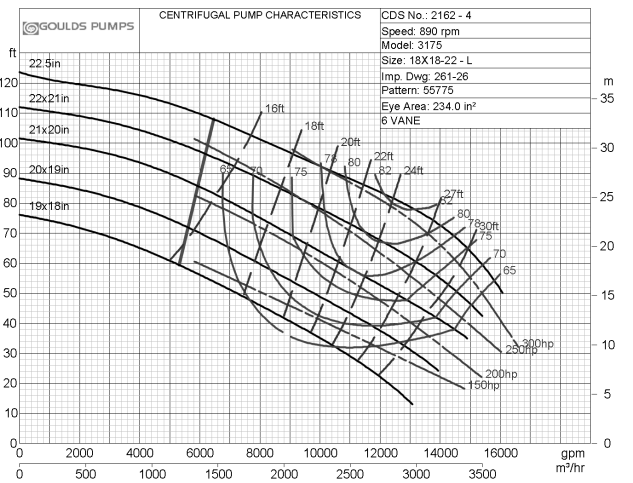
16X18-22 **710rpm**



16X18-22 **590rpm**

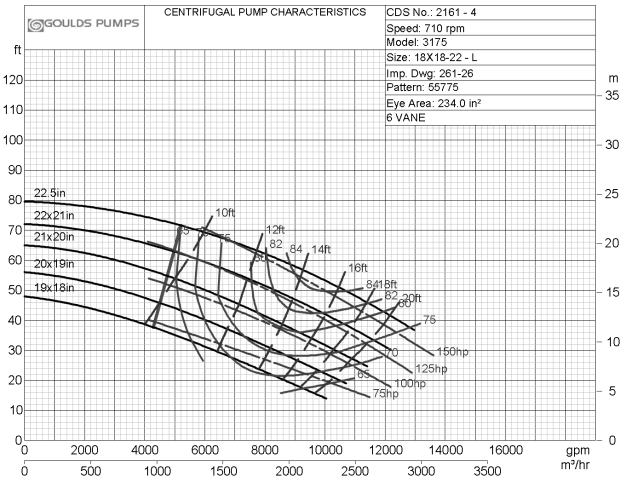


18X18-22 **1190rpm**

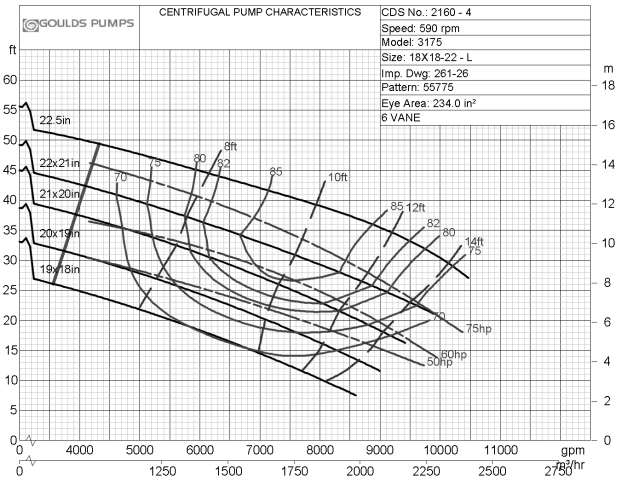


18X18-22 **890rpm**

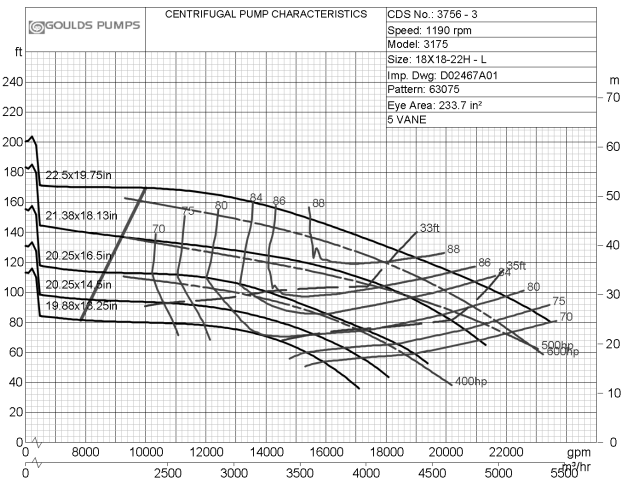
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



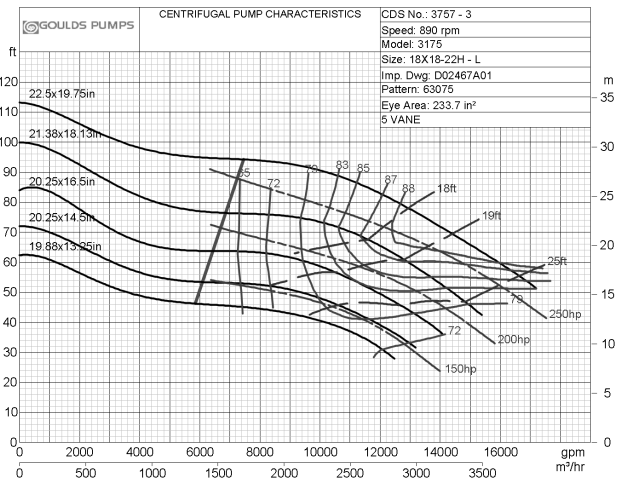
18X18-22 **710rpm**



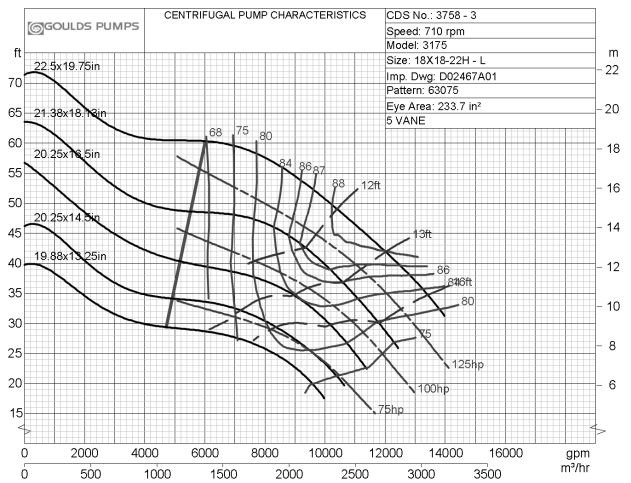
18X18-22 **590rpm**



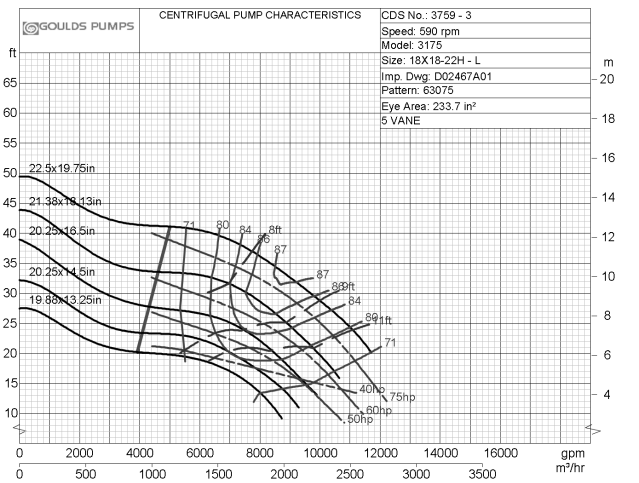
18X18-22H **1190rpm**



18X18-22H **890rpm**



18X18-22H **710rpm**

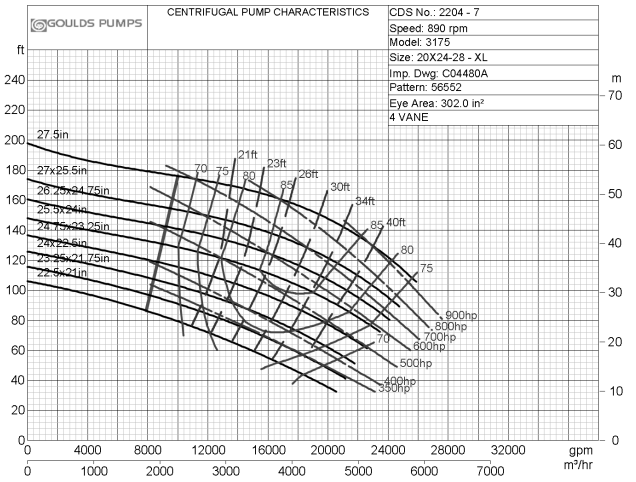


18X18-22H **590rpm**

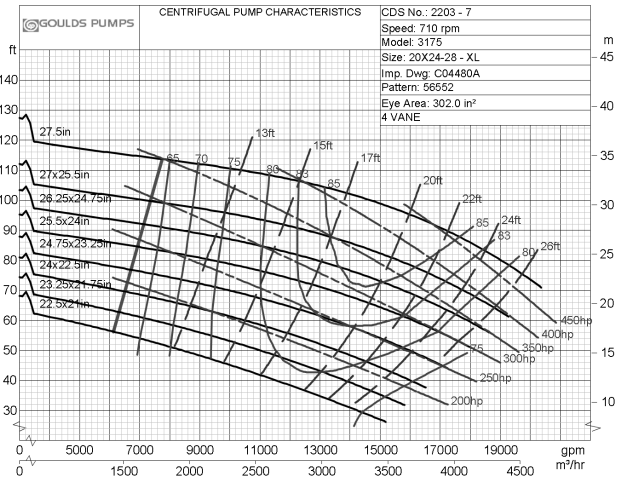
60Hz Curves

Model 3175

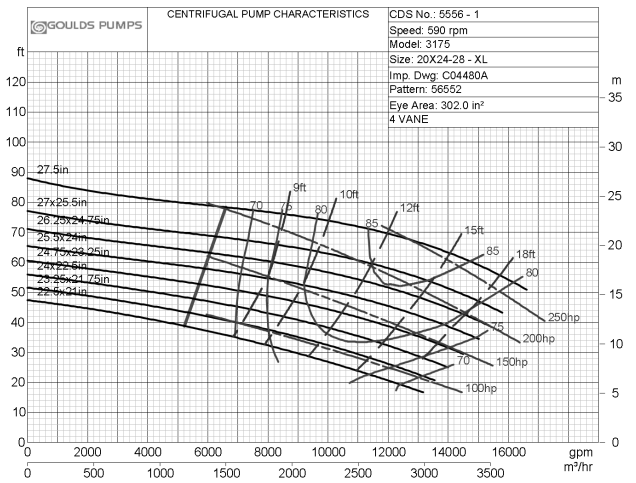
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



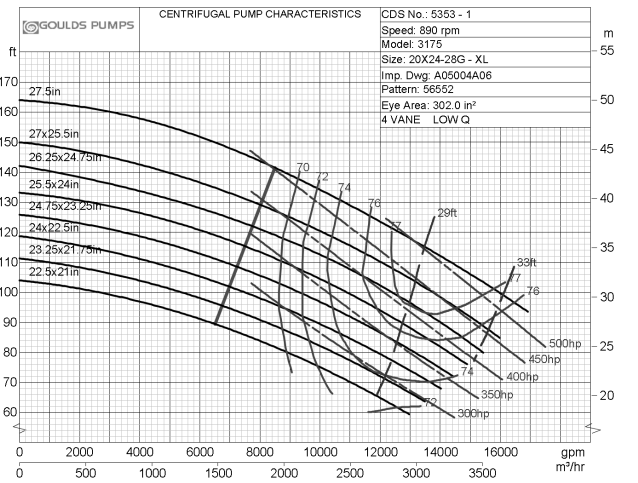
20X24-28 **890rpm**



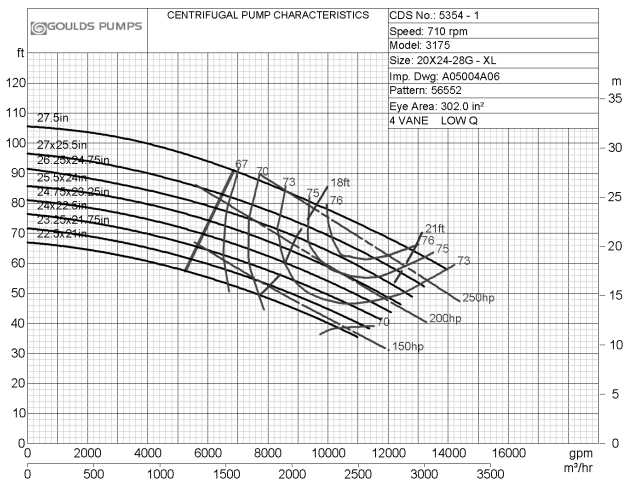
20X24-28 **710rpm**



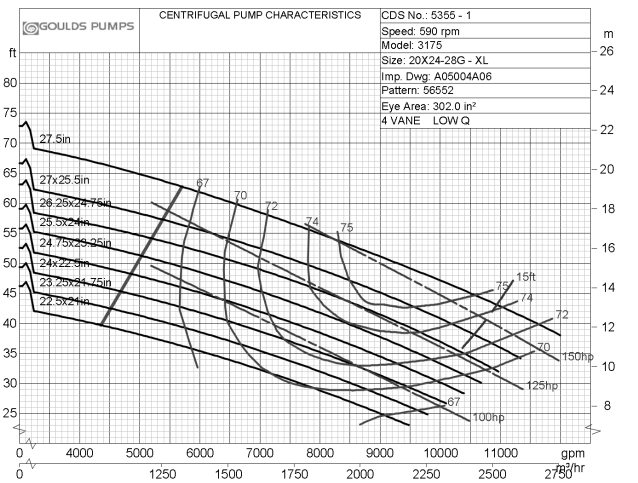
20X24-28 **590rpm**



20X24-28G **890rpm**

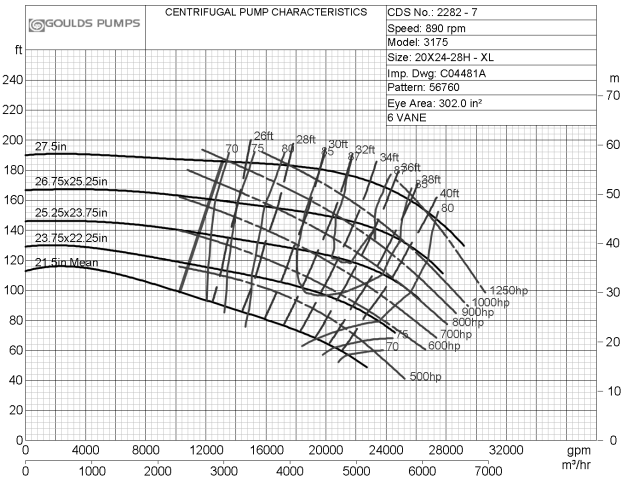


20X24-28G **710rpm**

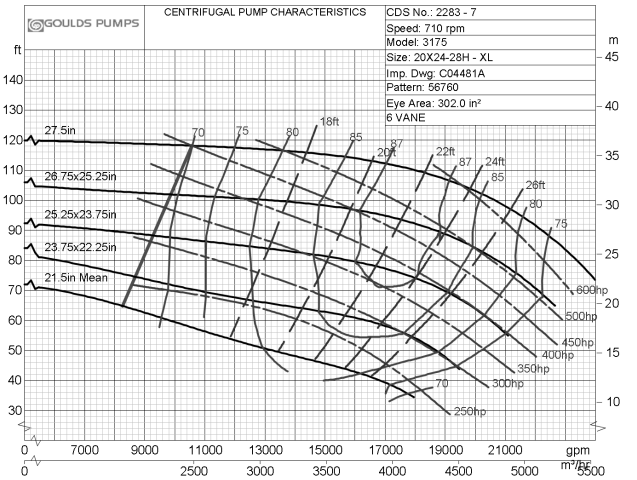


20X24-28G **590rpm**

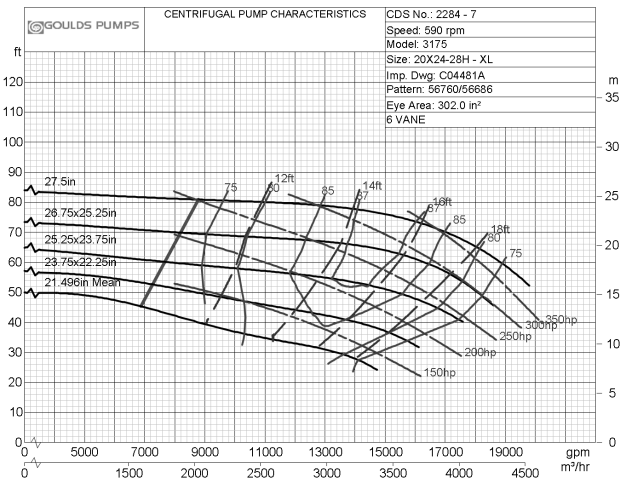
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



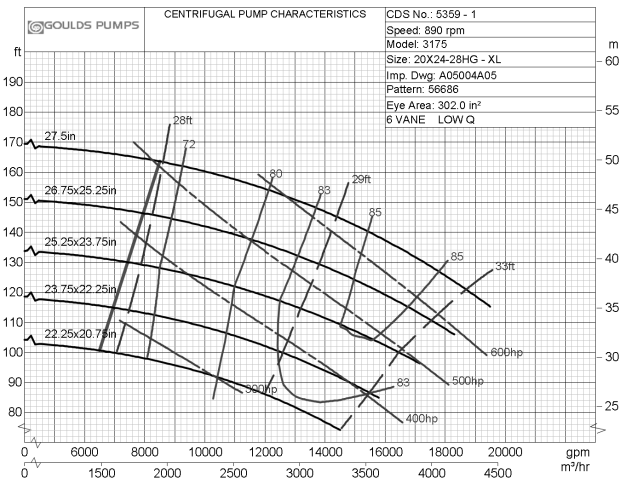
20X24-28H **890rpm**



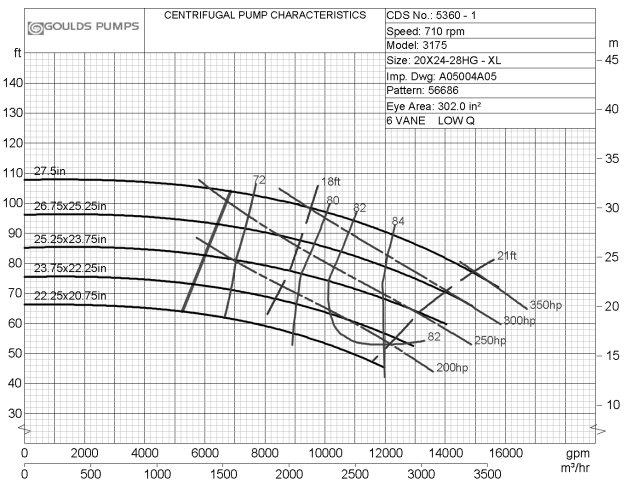
20X24-28H **710rpm**



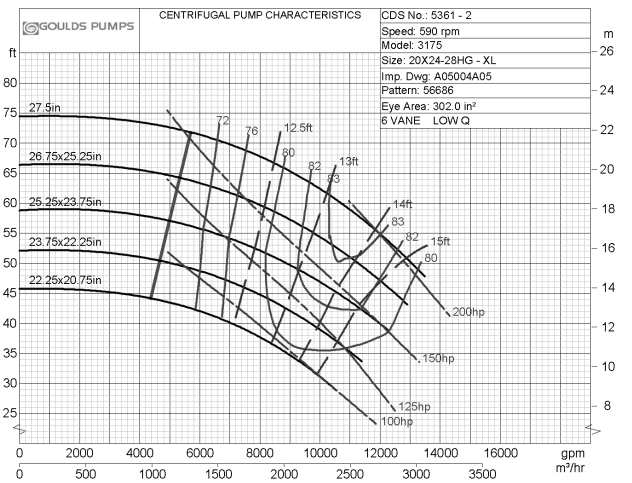
20X24-28H **590rpm**



20X24-28HG **890rpm**

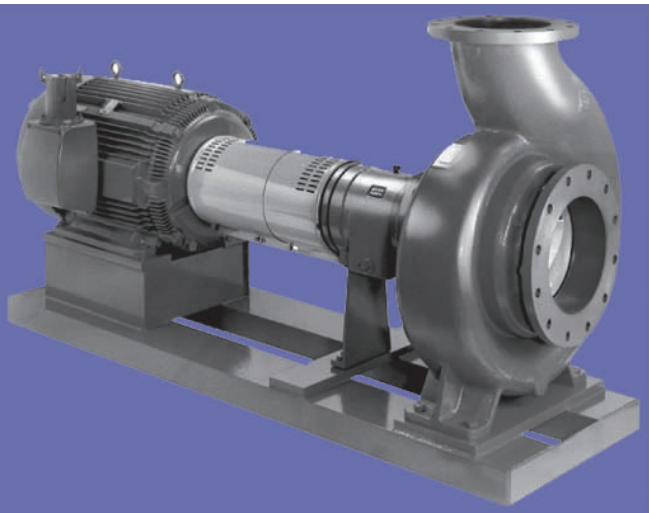


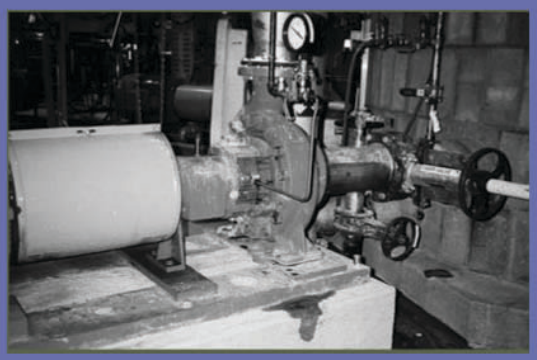
20X24-28HG **710rpm**

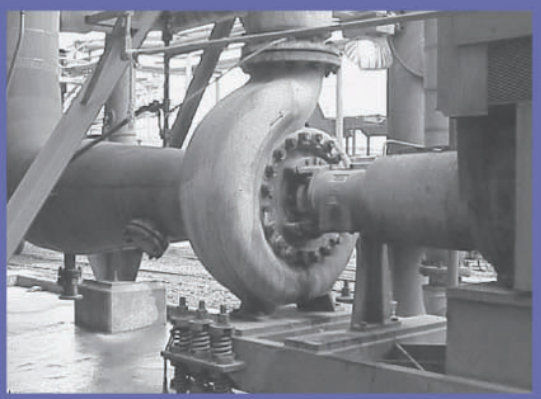


20X24-28HG **590rpm**

NOTES







Models 3180/3185

Heavy-Duty Process Pumps

3180

- Capacities to 45,000 GPM (10,220 m^3/h)
- Heads to 410 feet (125 m)
- Temperatures to 446° F (230° C)
- Pressures to 232 PSIG (16 bar)

3185

- Capacities to 26,000 GPM (6,000 m^3/h)
- Heads to 125 m (410 feet)
- Temperatures to 230°C (446°F)
- Pressures to 16 bar (232 PSIG)

Worldwide Experience in Process Pumping Services

When Goulds Pumps developed the 3180/3185, we utilized 160+ years of pump design experience to ensure unmatched mechanical reliability. Today, installations around the world attest to its remarkable performance. The 3180/3185 is the heavy-duty process pump designed to handle all of your tough process pumping applications.

World-Class Pump Line

Model 3180 is built to ANSI standards.

- ANSI class 125/150 lb. flange drilling
- Inch-dimensional O.D. of mechanical seal sleeve
- Inch-dimensional bearing locknut
- Inch-dimensional shaft and keyway at coupling

Model 3185 is built to Metric standards.

- Built to Metric standards
- ISO or JIS 16 bar flange drilling
- mm-dimensioned O.D. of mechanical seal sleeve
- mm-dimensioned bearing locknut
- mm-dimensioned coupling extension

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Models 3180/3185 Paper Stock/Process Pumps

Heavy Duty Design Features for Handling the Toughest Services

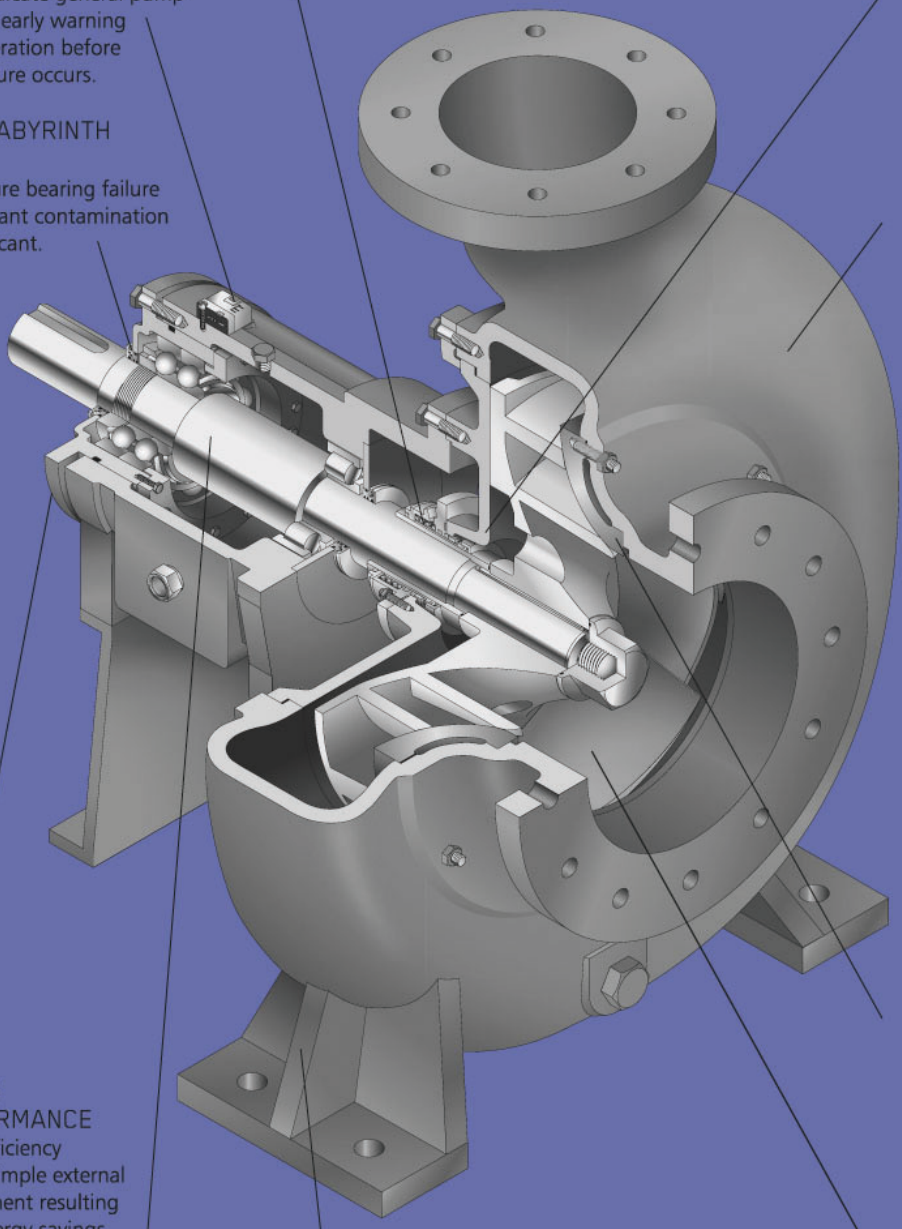
PATENTED *i-ALERT*™ CONDITION MONITOR
Constantly measures vibration and temperature at the thrust bearing. Colored LEDs indicate general pump health. Provides early warning of improper operation before catastrophic failure occurs.

STANDARD LABYRINTH OIL SEALS
Prevent premature bearing failure caused by lubricant contamination and loss of lubricant.

SEALING FLEXIBILITY
Choice of mechanical seal (illustrated), packed box or dynamic seal.

TAPERBORE™ PLUS SEAL CHAMBER
Wide range of sealing arrangements available to meet service conditions. Seal chambers improve lubrication and heat removal (cooling) of seal faces for extended seal life and pump uptime.

CASING
Top centerline discharge for air handling and self-venting. Special volute design reduces radial loads. Back pull-out design. Foot-mounted.



RENEWABLE SUCTION SIDEPLATE
With open impeller design minimizes maintenance costs. Positively sealed with O-ring and gasket.

OPEN IMPELLER
Full back shroud and thick impeller vanes for handling slurries and stringy fibers. Large balance holes and back pump-out vanes minimize stuffing box pressure and axial thrust. Optional enclosed impeller available. Shearpeller™ design available for difficult recycle services.

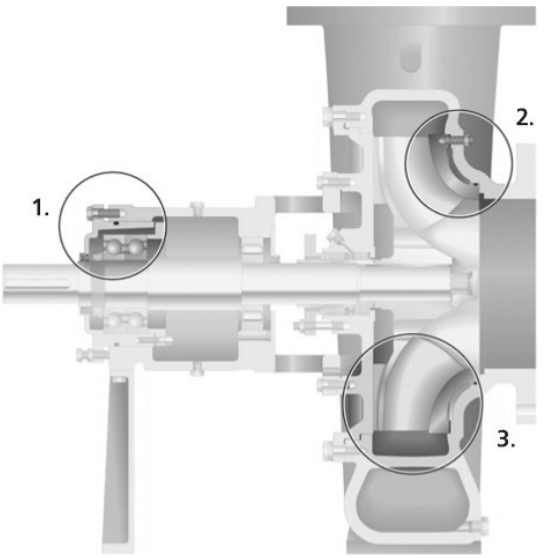
CONTINUOUS HIGH-PERFORMANCE
Original high efficiency maintained by simple external impeller adjustment resulting in long-term energy savings.

HEAVY-DUTY SHAFT
Designed for minimum deflection at maximum load. Dry shaft achieved by sealing from pumpage by O-rings at sleeve and impeller nut.

RIGID FEET
Large casing and bearing frame feet maintain driver alignment with high pipe loads; absorb system vibration.

Engineered Impeller and Sideplate

Acknowledged best design for industrial process services

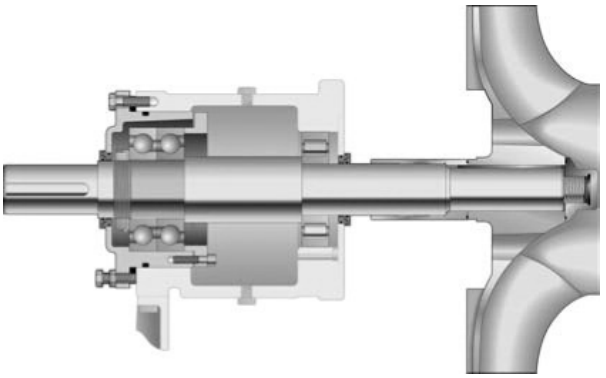


It offers:

- Ease of adjustment to maintain optimum performance
- Clamped sideplate for maximum reliability and zero leakage
- Minimum hydraulic loads for maximum mechanical reliability

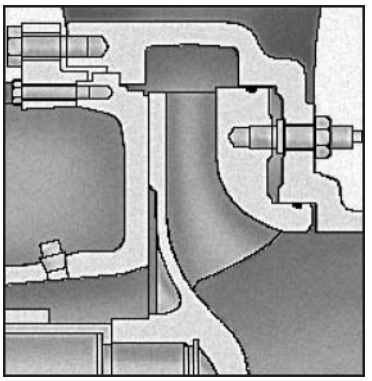
1. Renewable High Performance

Easy and reliable

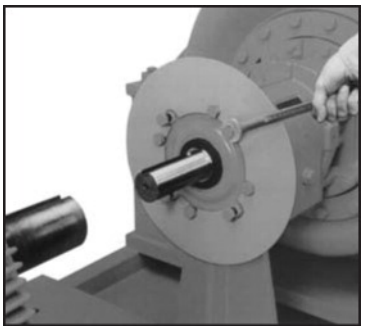


With any impeller adjustment, two metal components must move relative to each other. Goulds Pumps puts this precision fit in the sealed and lubricated environment of the power end.

VS.



Less reliable pumps utilizing adjustable sideplates are difficult to adjust and are not precise in clearances. The adjustment must take place in the corroded casing interior, leading to leakage. Improper adjustments lead to broken studs and catastrophic failure.



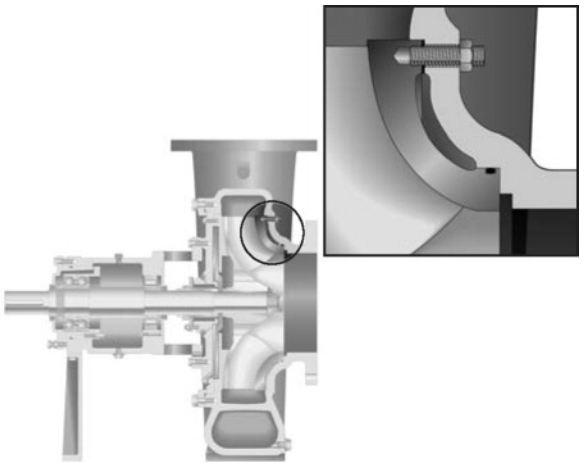
The Goulds adjustment bolts are very accessible and can be adjusted with one tool.

VS.

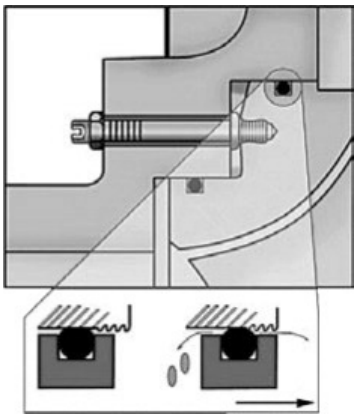
The adjustable sideplate method requires two tools. Additionally, the pump suction flange limits accessibility to the adjusting screws.

2. Clamped Sideplate

For maximum reliability and zero leakage



VS.



CLAMPED

The sideplate is clamped securely and sealed positively to prevent breakage or leakage.

FLOATING

The "floating" sideplate design must scrape over a casing surface that will be corroded and fouled.

This commonly leads to a leakage path through the sideplate studs.

3. Minimum Hydraulic Loads

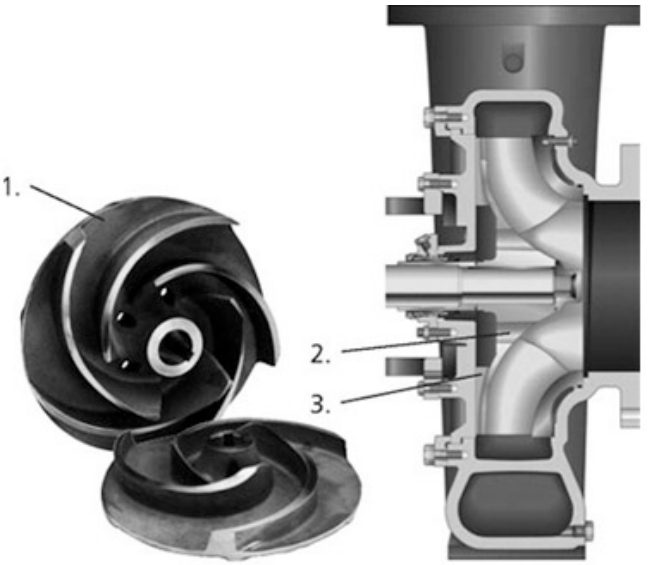
Maximum mechanical reliability

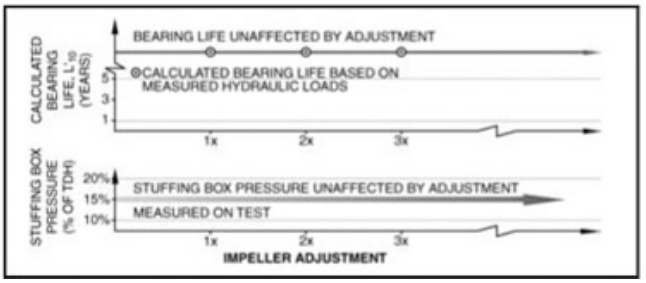
Goulds Pumps' open-impeller design was engineered to assure minimum radial and axial thrust loads, maximizing seal and bearing life.

1. Full back shroud — maximizes mechanical integrity
2. Balance holes — Low axial thrust
3. Engineered back vanes — Extended seal and bearing life

ENGINEERED FOR LONG LIFE

Back vane height/angle and shroud design are engineered to minimize hydraulic loads throughout the life of the pump. Bearing life is guaranteed.





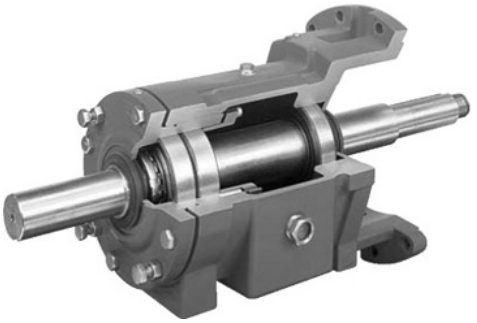
As the open impeller is adjusted and performance renewed, back pumpout vanes control axial thrust.

Bearing and seal life are maintained — unaffected by adjustment.

Power Ends Designed for Maximum Reliability

Power end reliability is vital with regard to pump *mean time between failure* (MTBF). To ensure maximum bearing life, the design of the 3180 accounts for three key bearing design factors:

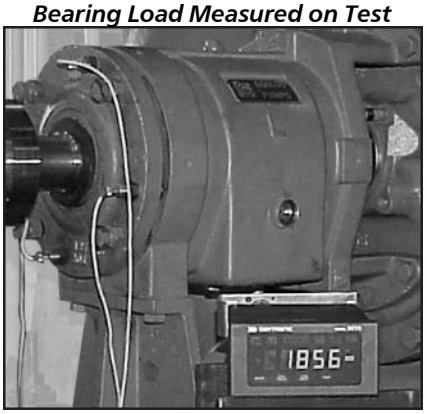
1 Bearing Design Life
2 Bearing Temperature
3 Bearing Environment

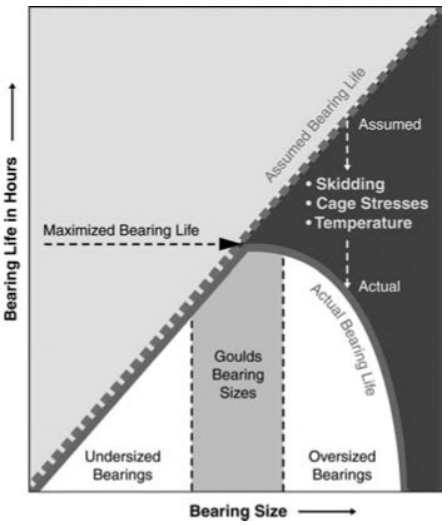


1. Bearing Design Life

Bearing manufacturers state that skidding, cage stresses and oil temperatures can greatly reduce the bearing life of oversized bearings. Correct bearing size is vital to overall bearing life.

Bearing Load Measured on Test



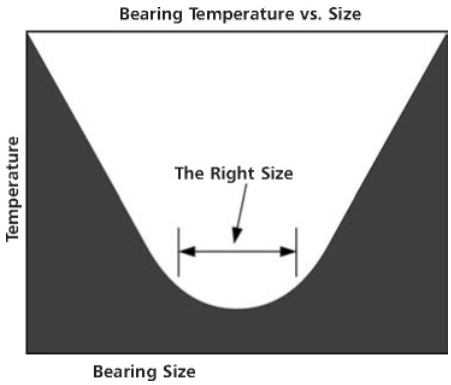


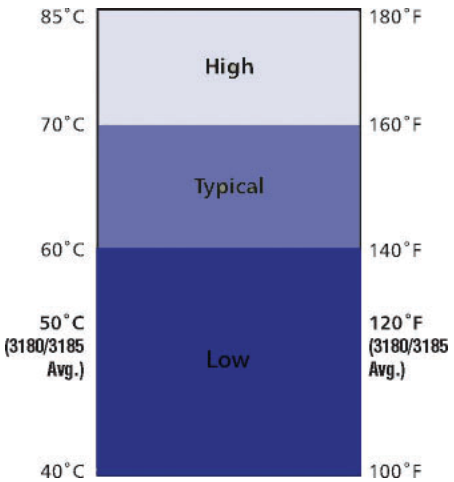
Bigger is not always better.

Bearings are often oversized because pump designers often estimate bearing loads. Goulds measured their loads on test and chose bearing designs that would enable bearing life of 100,000 hours.

2. Bearing Temperature

Keeping the pump loads minimized and selecting the right bearing help keep bearing temperature under control.



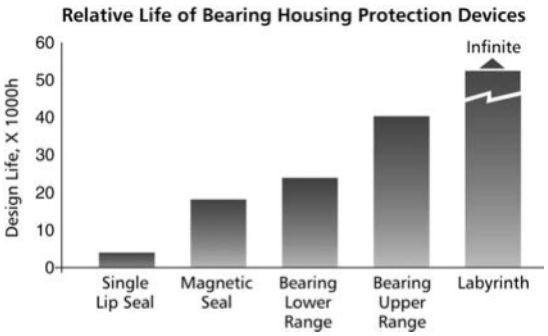


Typical bearing operating temperatures of competitors' process pumps are between 140 and 160°F. Goulds Model 3180/3185 bearing temperatures average only 120°F(50°C)!

3. Bearing Environment

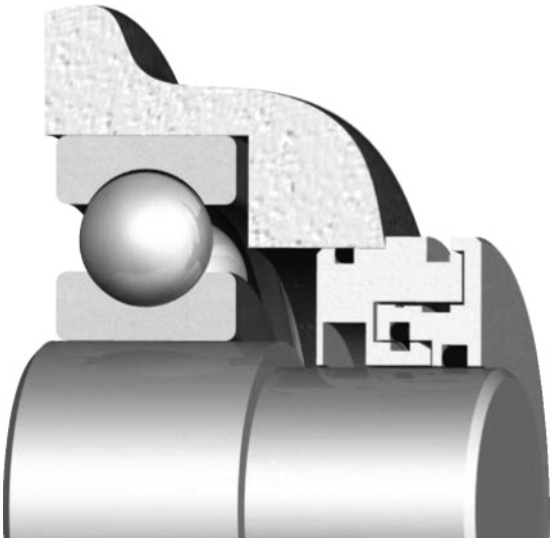
Labyrinth oil seals standard

As the second-leading cause of bearing failure, contamination requires special attention. Common lip seals were not considered due to their 2,000 hour design life. After wearing out, they leave a passageway open for contamination. For this reason, the 3180 is supplied with Labyrinth oil seals as standard. The Labyrinth is the industry's leading bearing isolator and provides the best operating environment



STANDARD LABYRINTH OIL SEALS

Prevent contamination of lubricant for extended bearing life.



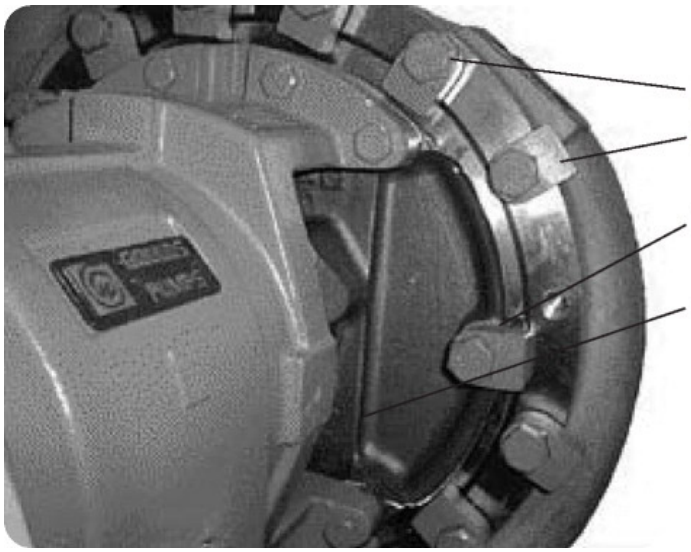
RIGID FRAME FOOT

Heavy duty foot reduces effects of pipeloads/ thermal expansion on bearing life. Bearings continue to run cool.

LARGE OIL SIGHT GLASS

The standard oil sight glass assures oil level is properly set and maintained. Condition of oil is also easily monitored.

Ease of Maintenance



- High strength casing lugs to secure cover to casing.
- Lugs swing away without removal during disassembly. Prevents lost or misplaced lugs and casing bolts.
- Lug can be used as jacking bolt to assist in pump disassembly.
- Large opening on each side of adapter for easy access to seal and gland.

Monitoring sites

- Monitoring sites for vibration and temperature are provided as standard for accurate and repeatable readings.
- Bull's eye sight gauge for accurately monitoring oil level. Also provides visual inspection of oil quality.

Power End Reliability

Designed-in and guaranteed

Bearing Design Life	>100,000 hours
Bearing Temperature	120°F (50°C) average
Bearing Environment	Superior Oil Seal design
i-*ALERT*™	Condition Monitoring
Guarantee	Reliability Guarantee

Our Guarantee

Goulds Pumps backs the 3180 power ends with an unconditional guarantee against defects in workmanship and material for 3 years from date of manufacture.

Patented i-*Alert*™ Condition Monitoring

The i-*Alert*™ condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your pumps so that your plant profitability is maximized.

Impeller Designs to Optimize Performance

The right design for the service results in optimum efficiency and up-time, especially when handling difficult media such as recycle fibers with contaminants.

1 Open Impeller

Suitable design for most services and resists wear and corrosion. Provides for easily renewable clearances. Designed for optimum efficiency.

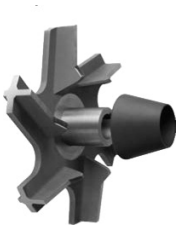
2 Enclosed Impeller

Available for services where efficiency is a consideration and an enclosed design is suitable for service conditions. Efficiency can be renewed with axial adjustment and/or wear ring replacement.

Also beneficial for high temperature services, as it allows the suction sideplate to be eliminated.

Goulds clog-free pumping solution patented design (# 6,609,890)

Pumping applications in recycle mills present unique challenges with the presence of plastic and tape along with other contaminants that can readily clog the pump impeller.

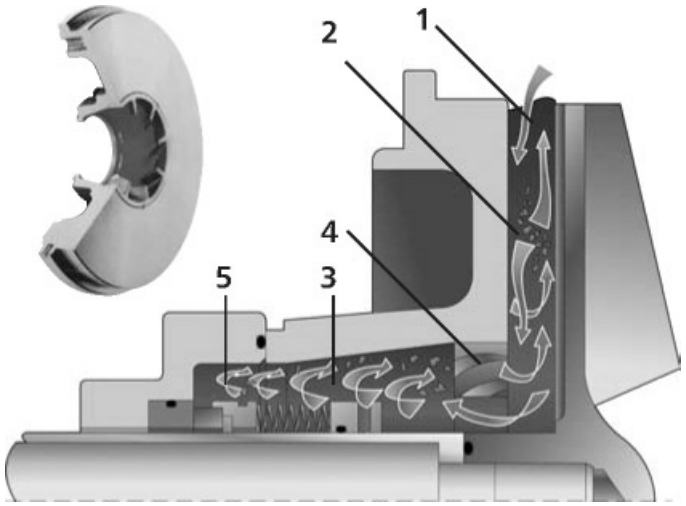


3 The Goulds Shearpeller™ Solves This Problem:

- Generous front clearance with vortex-type design prevents binding and plugging.
- Patented tapered inlet sleeve prevents contaminants from plugging inlet area. The sleeve is loose to rotate independently from impeller. The slower rotation prevents contaminants from collecting at the impeller eye and prevents erosion of the hub.
- Proven in tough services such as repulper dump service in OCC recycle mills. In one service, the pump went from a daily outage to clear impeller to uninterrupted, continuous service.
- Component changes involve only the impeller and sleeve. Uses same casing, sideplate, shaft and impeller nut as 3180.

Seal Configuration Optimized for Service and Environment

For services with solids and vapor Goulds TaperBore™ PLUS



The unique flow path created by the Vane Particle Ejector directs solids away from the mechanical seal, not towards the seal as with other tapered bore designs. The amount of solids entering the bore is minimized. Air and vapors are also efficiently removed. On services with or without solids, and air or vapors, the TaperBore™ PLUS is the effective solution for extended seal and pump life and lower maintenance costs.

1 Solids/liquid mixture flows toward mechanical seal/seal chamber.

2 Turbulent zone. Some solids continue to flow toward shaft. Other solids are forced back out by centrifugal force (generated by back pump-out vanes).

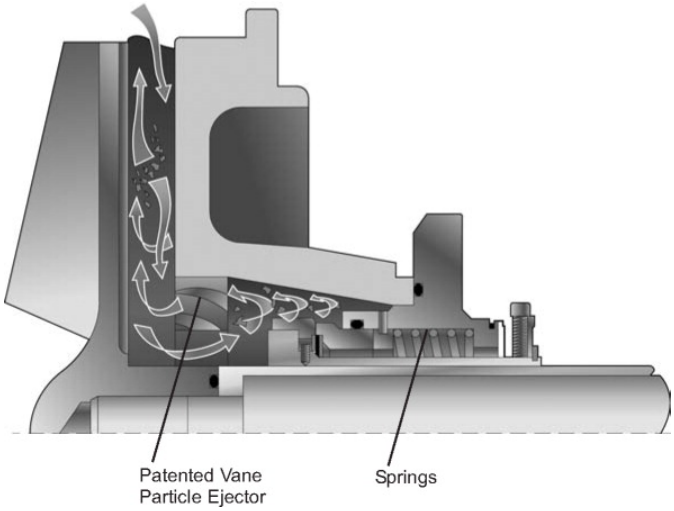
3 Clear liquid continues to move toward mechanical seal faces. Solids, air, vapors flow away from seal.

4 Low pressure zone created by Vane Particle Ejector. Solids, air, vapor liquid mixture exit seal chamber bore.

5 Flow in TaperBore™ PLUS seal chamber assures efficient heat removal (cooling) and lubrication. Seal face heat is dissipated. Seal faces are continuously flushed with clean liquid.

Zero Flush Water (Mechanical seals)

Hard Tungsten Carbide Seal Faces



The 3180 has a revolutionary seal chamber design guaranteed to operate on 6% paper stock without flush water!

Aside from the high cost of flushing mechanical seals and the possible dilution of the product, contaminants in the flush water can also cause seal failures. Disruption of flush water caused by plugging, freezing or inadvertently closing a valve can also cause failures.

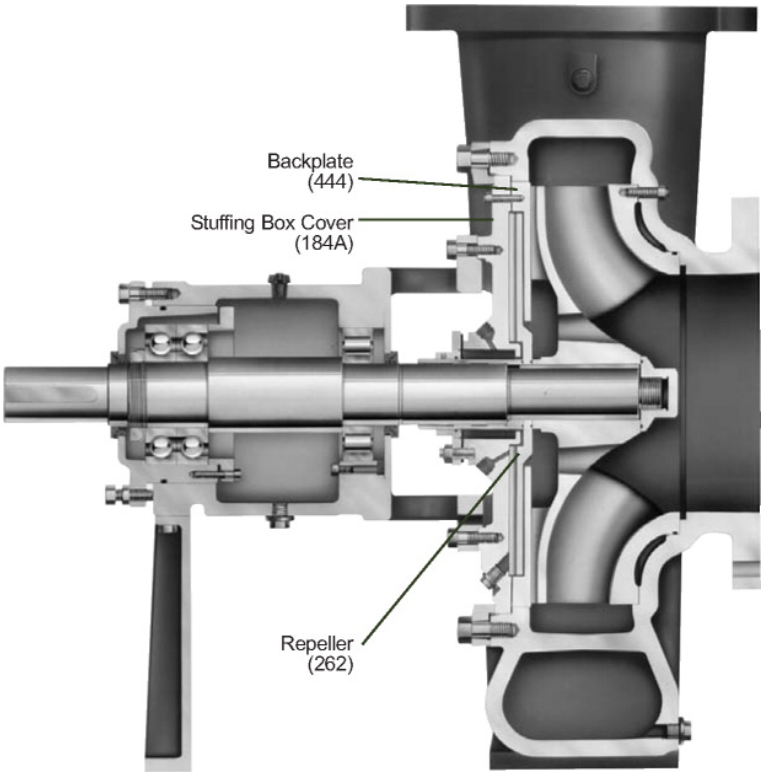
The answer to those problems is solved with the Goulds TaperBore™ PLUS.

Dynamic Seal

Eliminates Mechanical Seal Problems, Reduces Maintenance

The 3180/3185 is easily field converted to Dynamic Seal with retrofit parts–backplate, stuffing box cover, repeller, sleeve.

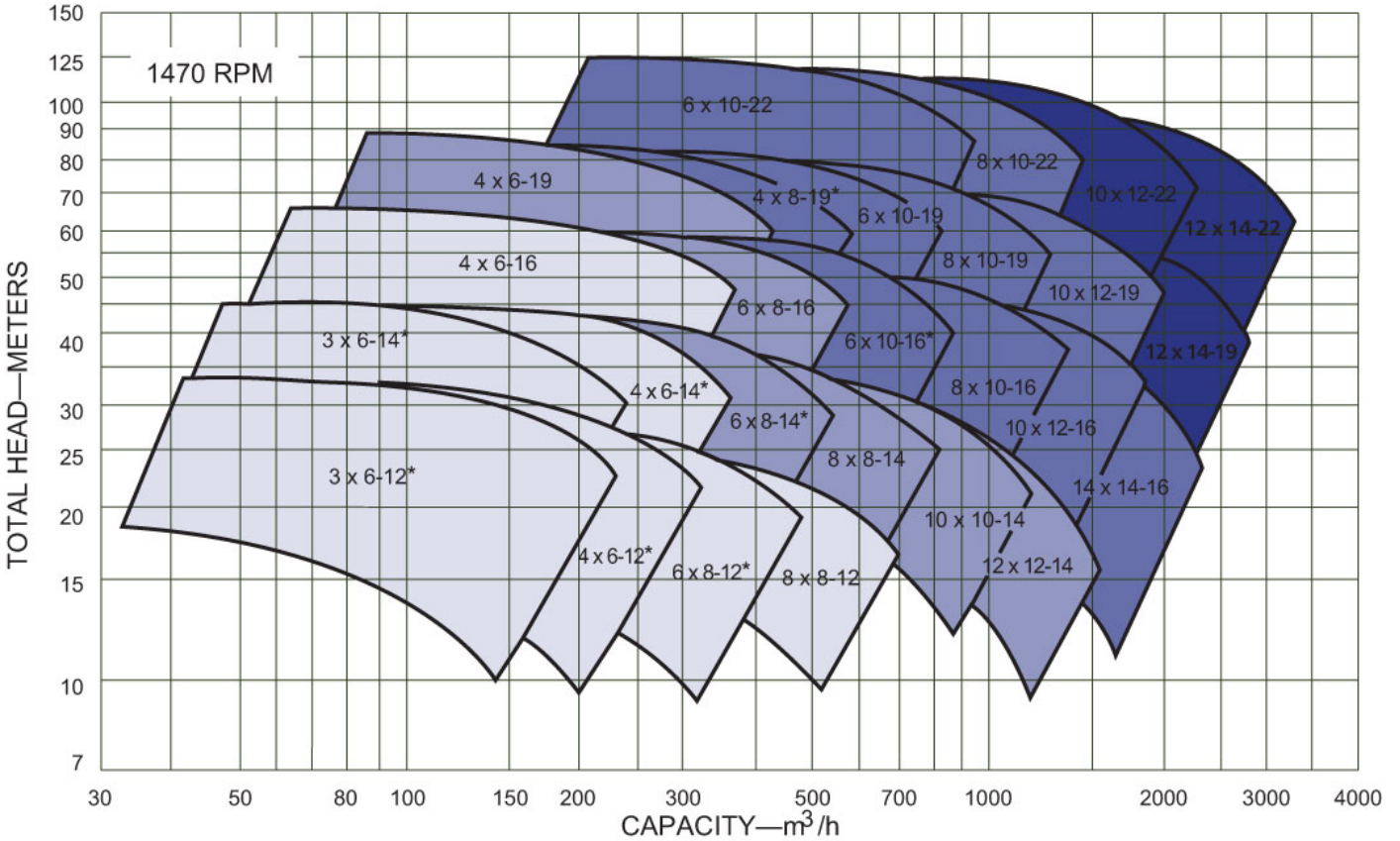
Goulds *Dynamic Seal* option is ideally suited to handle the tough applications where conventional mechanical seals or packing require outside flush and/or constant, costly attention. This option allows pumping slurries *without* external flush. A *repeller* between the stuffing box cover and impeller pumps liquid from the stuffing box while the pump is running. A diaphragm seal prevents leakage when the pump is not operating.

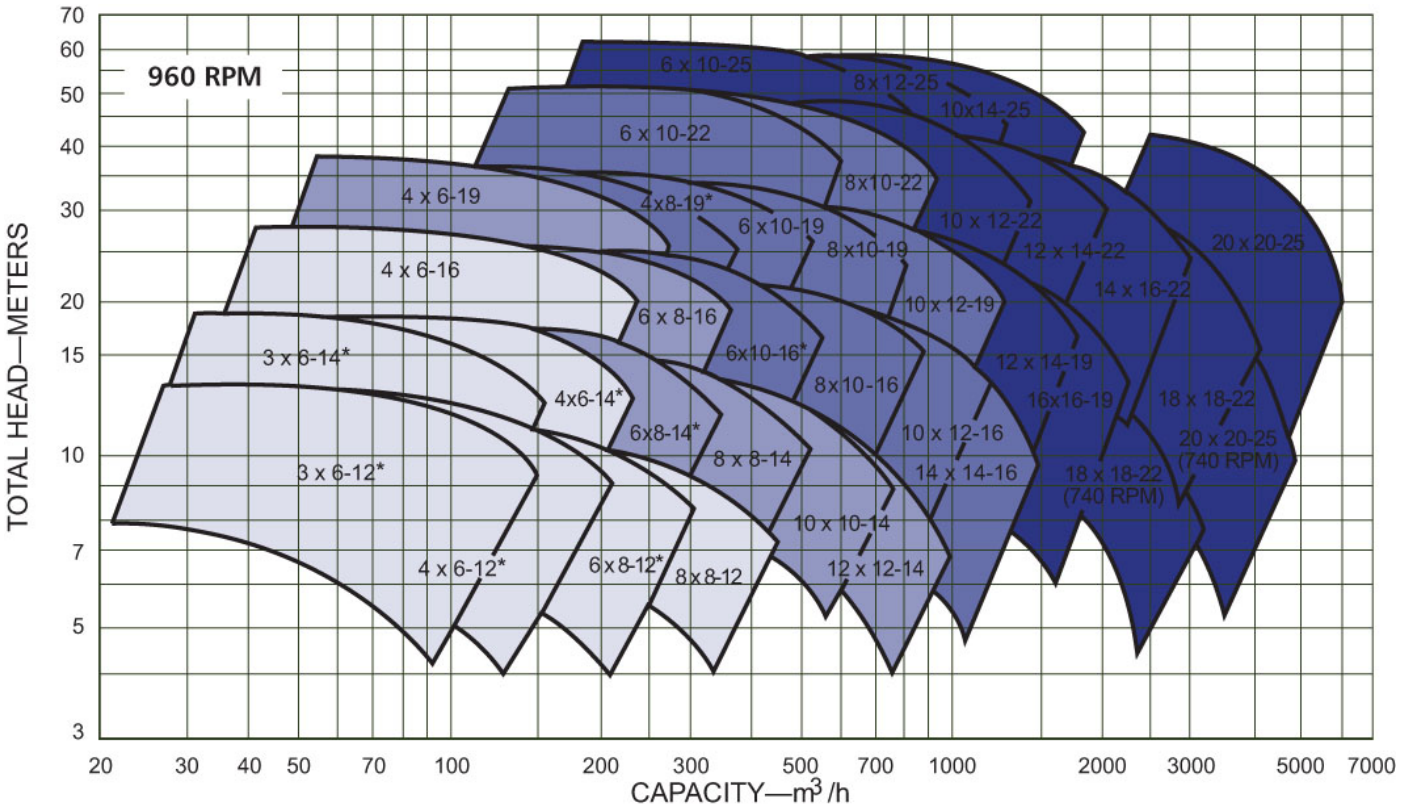


Benefits of Goulds Dynamic Seal:

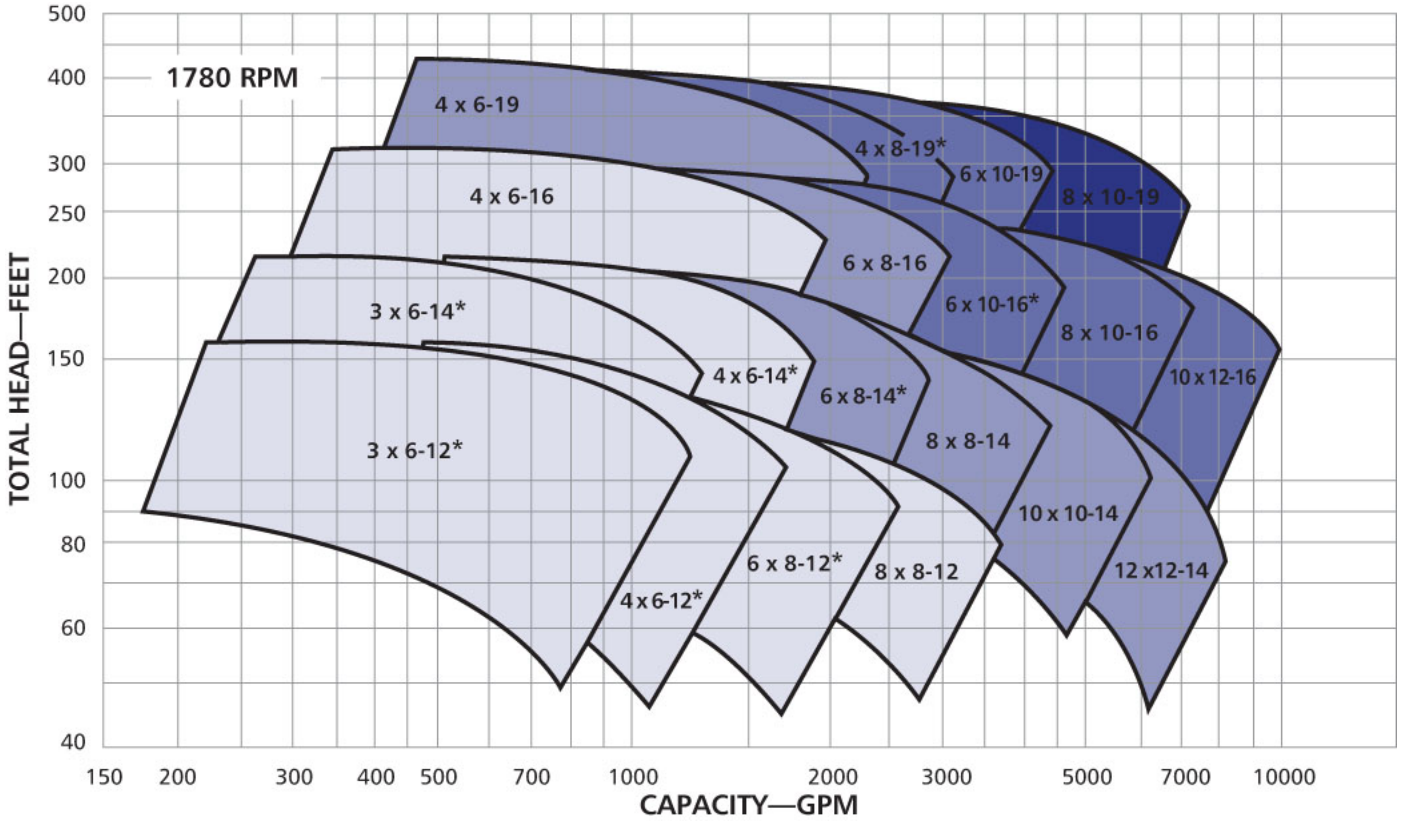
- External seal water not required.
- Eliminates problems and costs associated with piping from a remote source.

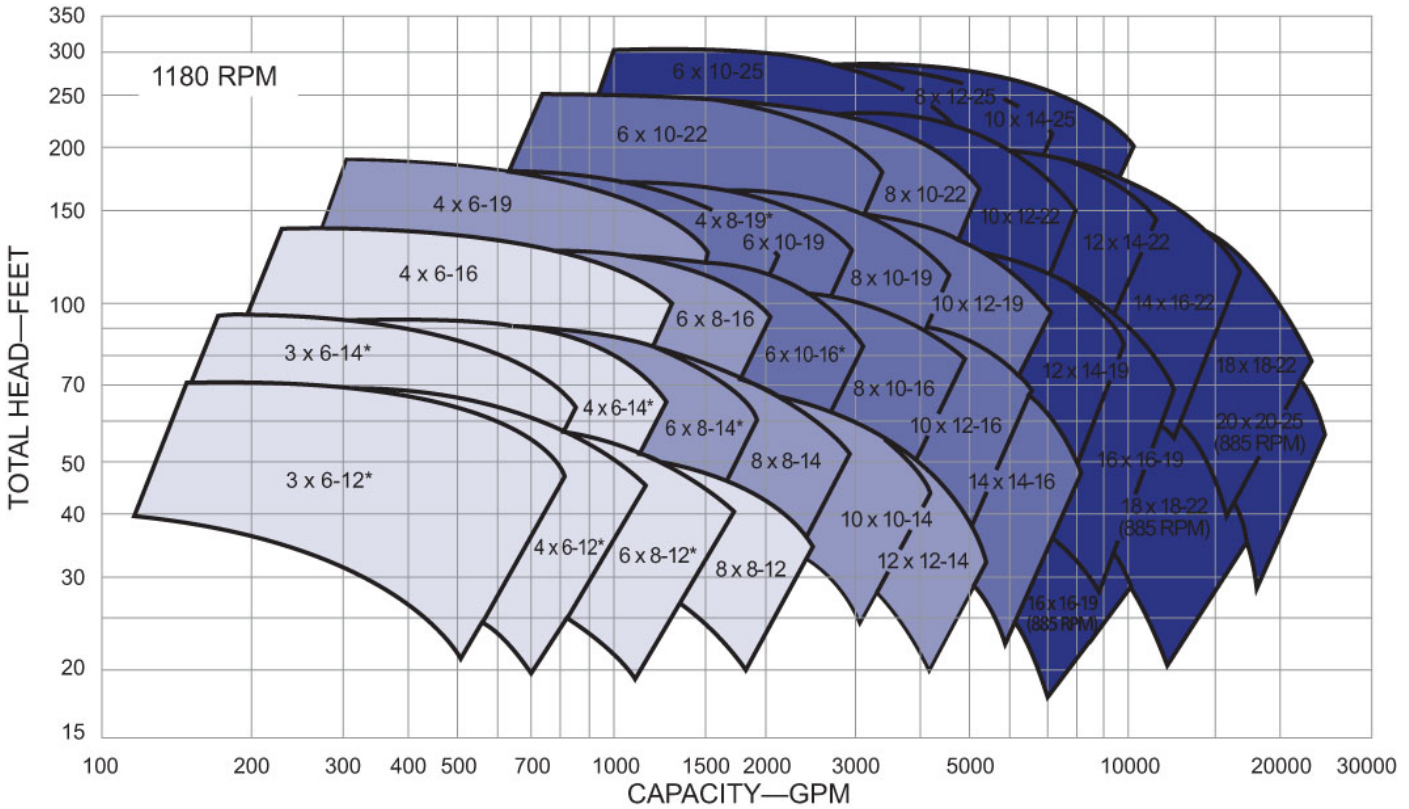
Hydraulic Coverage Model 3180 50 Hz



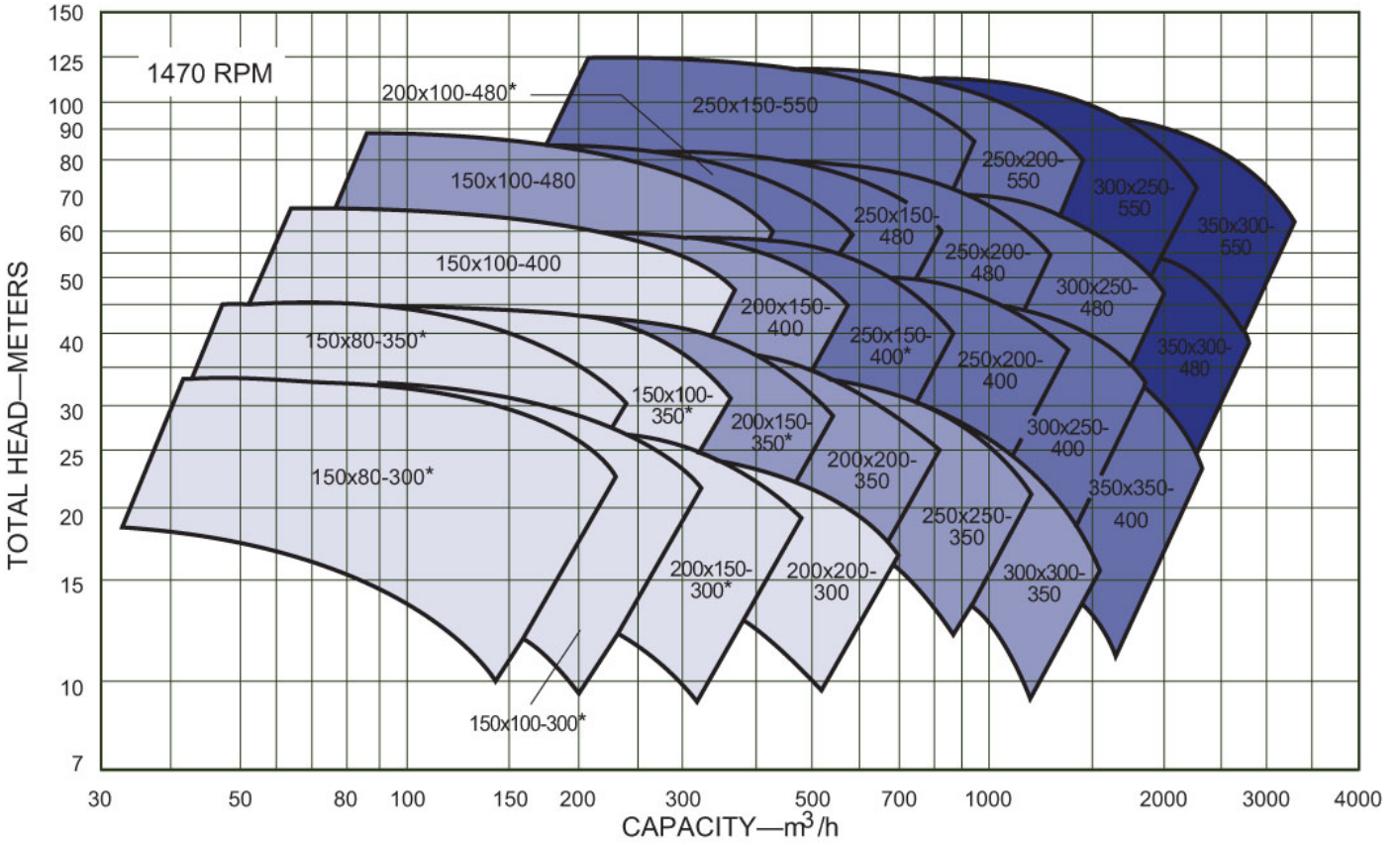


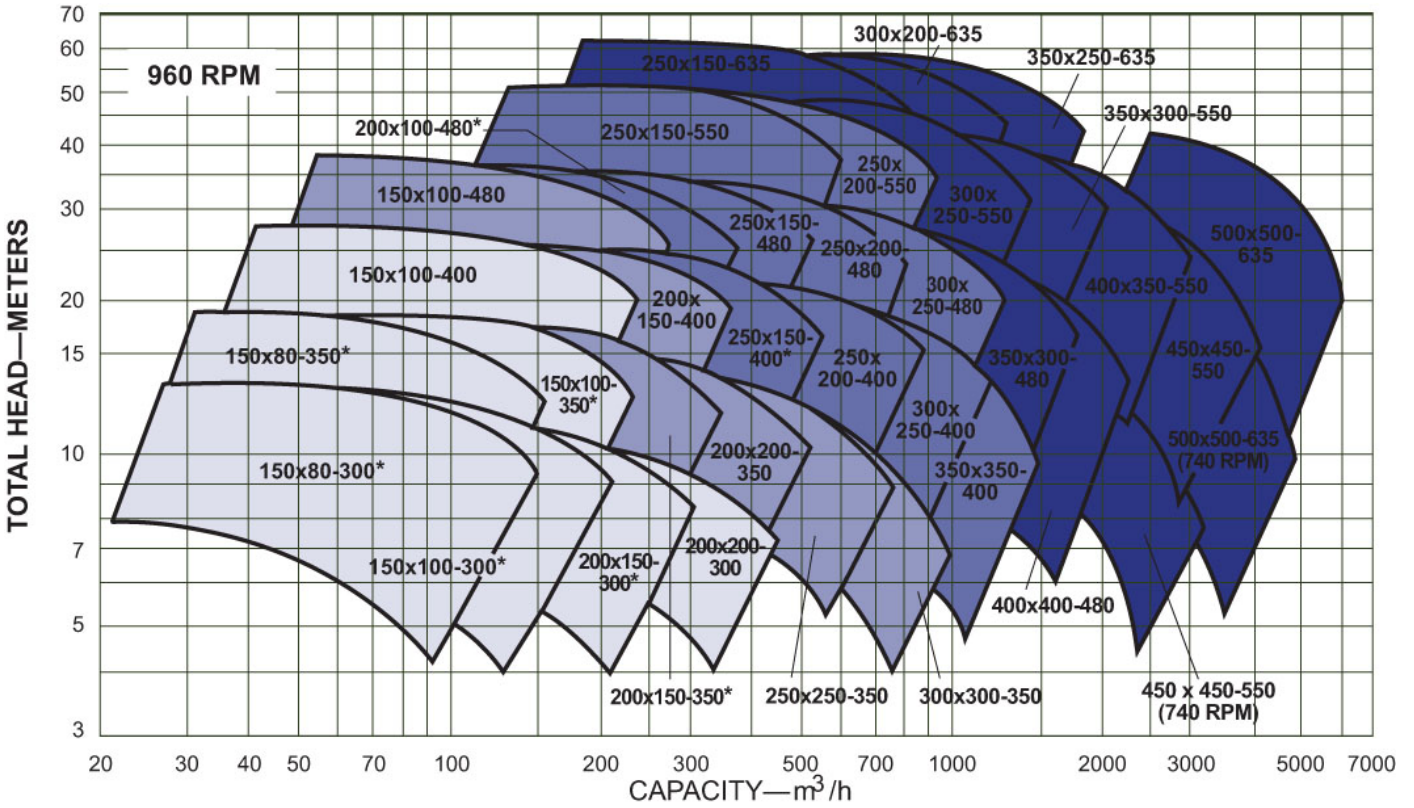
Hydraulic Coverage Model 3180 60 Hz



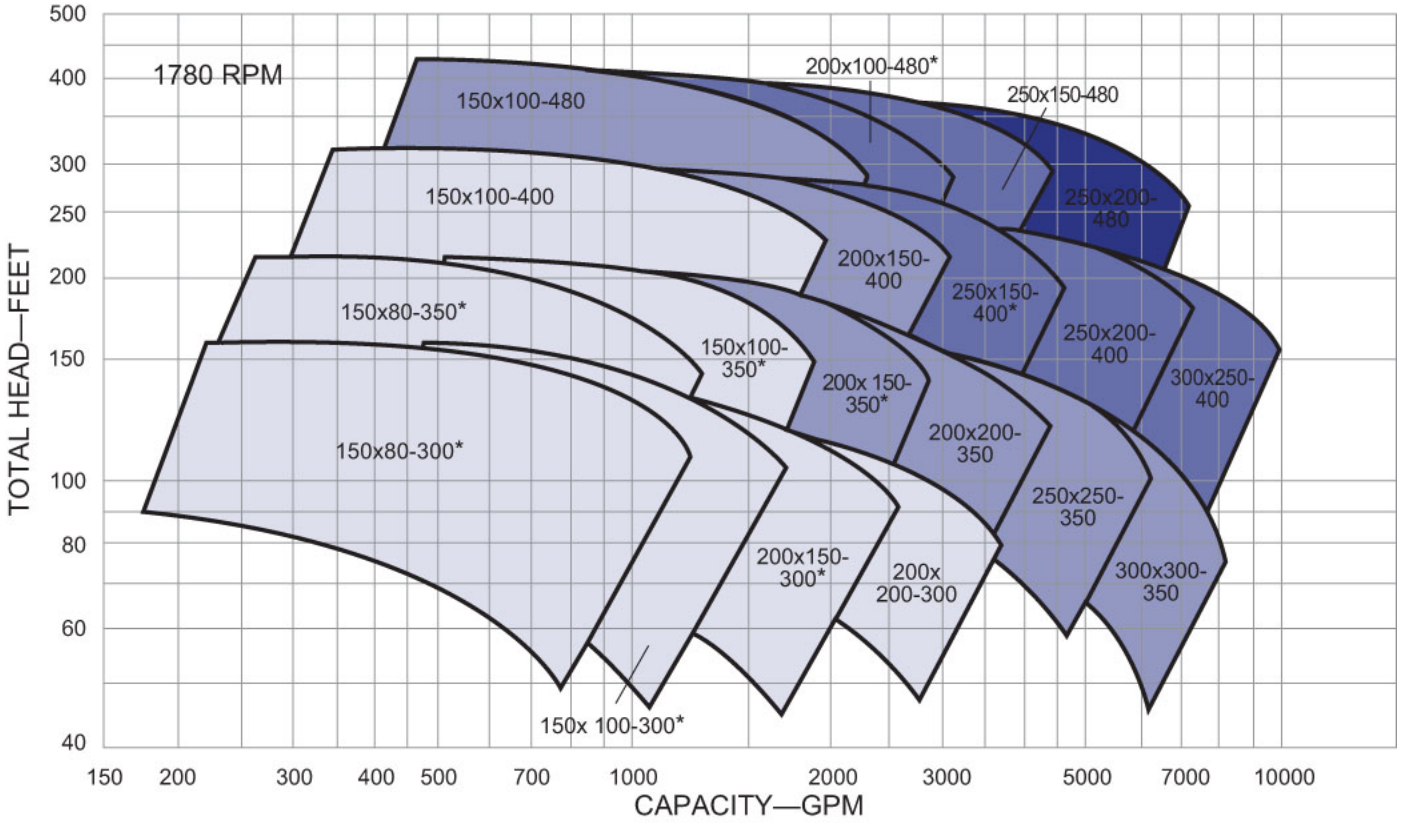


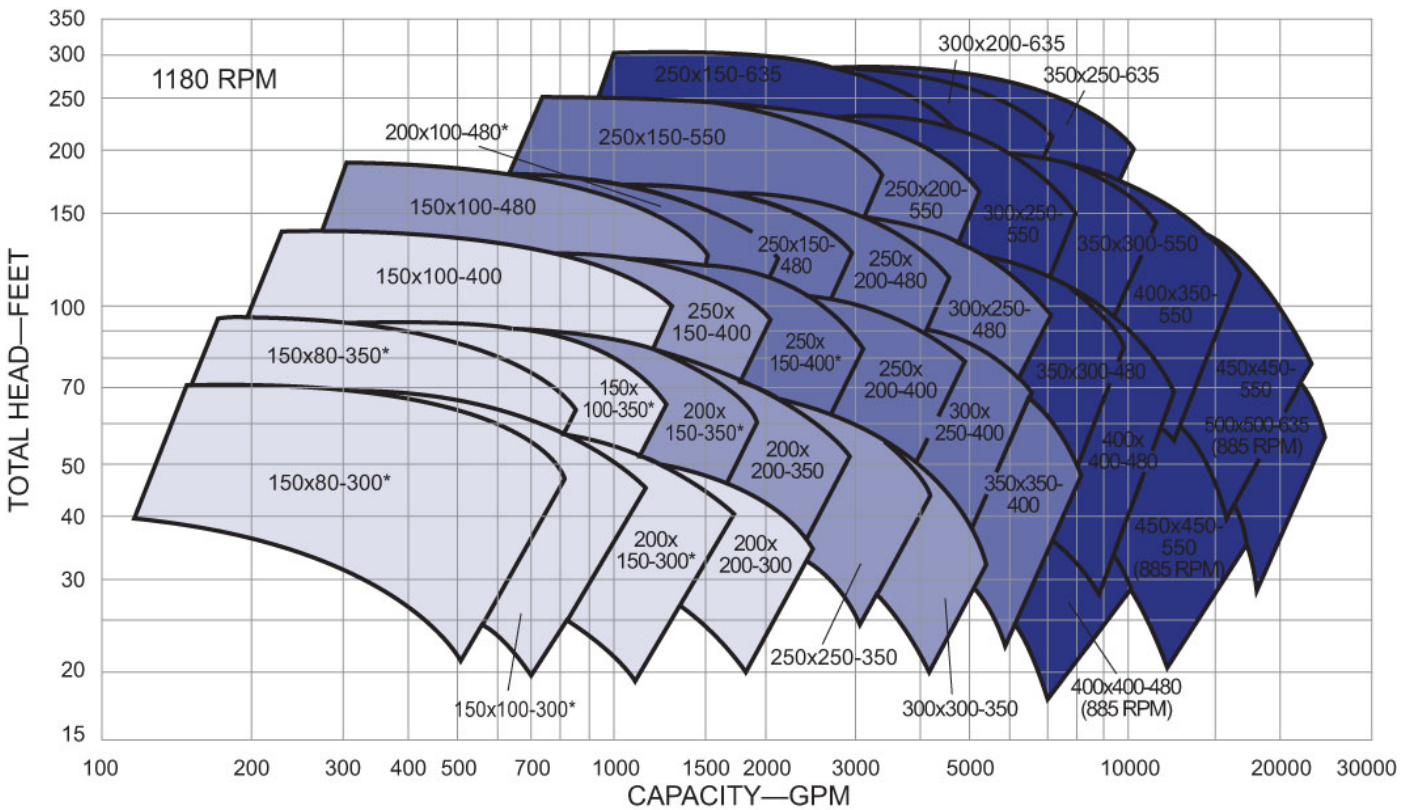
Hydraulic Coverage Model 3185 50 Hz





Hydraulic Coverage Model 3185 60 Hz





PP-1B

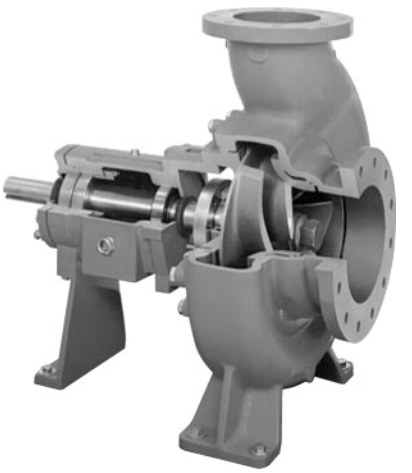
Parts List and Materials of Construction

		Material				
Item Number	Part Name	All Iron/SS Impeller	All Iron/SS Impeller, SS Sideplate	All 316SS	All CD4MCuN	All 317SS
100	Casing	Cast Iron	Cast Iron	316SS	CD4MCuN	317SS
101	Impeller (Note 1)	316SS	316SS	316SS	CD4MCuN	317SS
105	Lantern Ring	Teflon®				
106	Packing	Teflon® Impregnated Fibers				
107	Gland	316SS				
112	Thrust Bearing	Duplex Angular Contact				
122	Shaft	Carbon Steel (4340)				
126	Shaft Sleeve	316SS	316SS	316SS	316SS	317SS
126A	Shearpeller™ Sleeve	N/A	Carbon-filled Teflon			N/A
134A	Bearing Housing	Cast Iron				
136	Bearing Locknut and Lockwasher	Steel				
159	Seal Chamber (Mechanical Seal)	Cast Iron	Cast Iron	316SS	CD4MCuN	317SS
164	Case Wear Ring (Enclosed Impeller)	316SS	316SS	316SS	CD4MCuN	317SS
176	Suction Sideplate (Open Impeller)	Cast Iron	316SS	316SS	CD4MCuN	317SS
178	Impeller Key	AISI 303				
184	Stuffing Box Cover (Packed Box)	Cast Iron	Cast Iron	316SS	CD4MCuN	317SS
184A	Stuffing Box Cover (Dynamic Seal Option)	316SS	316SS	316SS	CD4MCuN	317SS
202	Impeller Wear Ring (Enclosed Impeller)	316SS	316SS	316SS	CD4MCuN	317SS
228	Bearing Frame	Cast Iron				
262	Repeller (Dynamic Seal Option)	316SS	316SS	316SS	CD4MCuN	317SS
304	Impeller Nut	316SS	316SS	316SS	CD4MCuN	317SS
332A	Labyrinth Seal, Outboard	Bronze				
333A	Labyrinth Seal, Inboard	Bronze				
351	Casing Gasket	Aramid Fiber with EPDM Rubber				
353	Mechanical Seal	As Required				
358	Casing Drain Plug	Carbon Steel	Carbon Steel	316SS	Alloy 20	317SS
360P	Sideplate-to-Casing Gasket	Aramid Fiber with EPDM Rubber				
409	Radial Bearing	Cylindrical Roller				
412A	O-ring, Impeller	Teflon®				
412C	O-ring, Sideplate-to-Casing	Viton®				
412F	O-ring, Sleeve	Teflon®				
444	Backplate (Dynamic Seal Option)	316SS	316SS	316SS	CD4MCuN	317SS
496	O-ring, Bearing Housing	Buna				
748	Casing Lug	Ductile Iron				

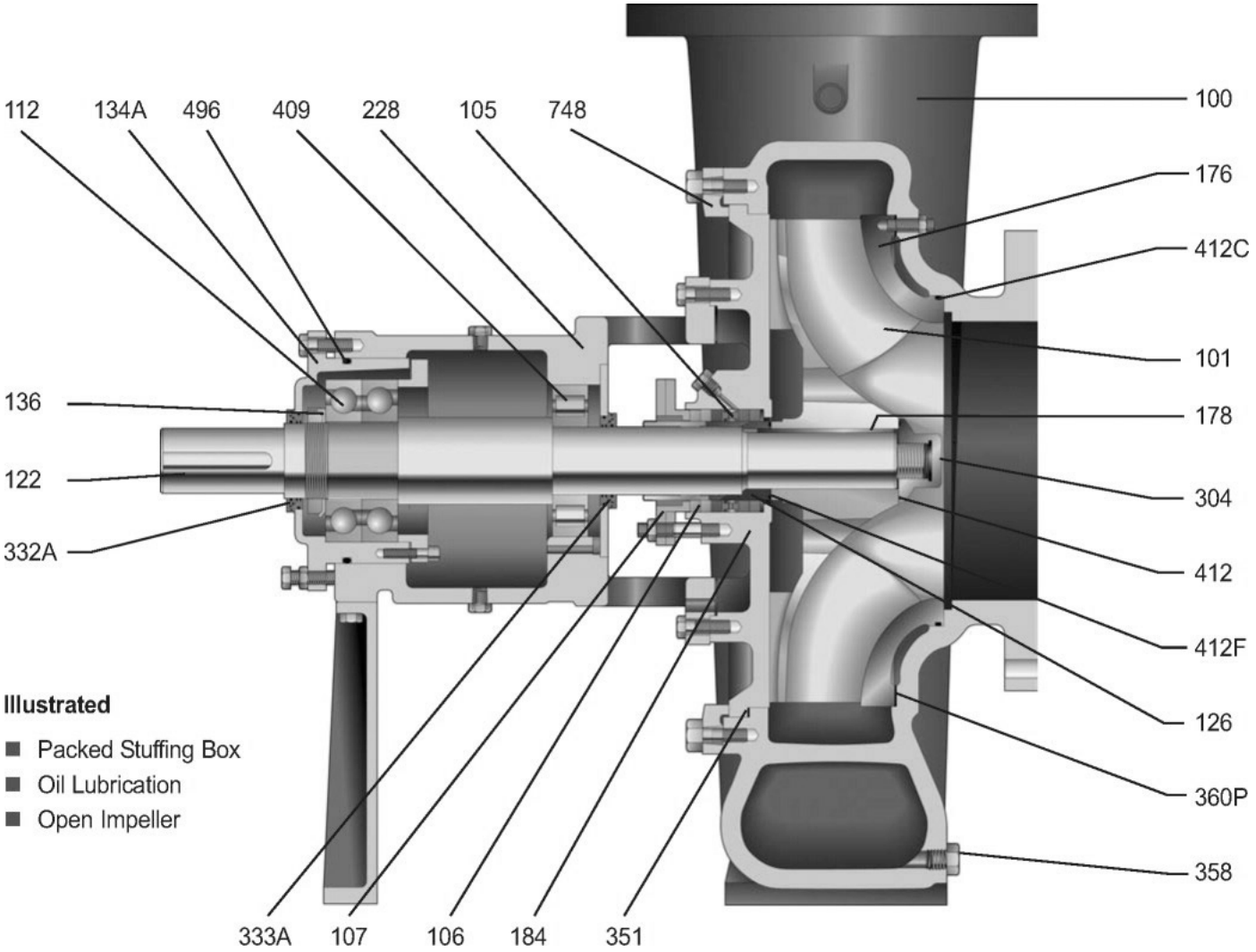
Note 1: Shearpeller™ available only in Duplex 2205.

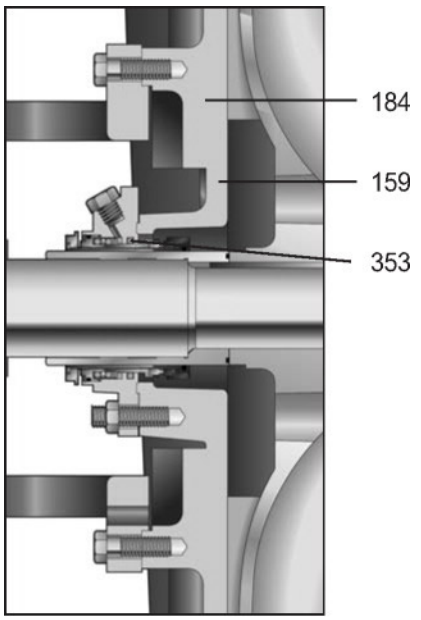
Materials of Construction

		Approximate Equivalent Standards		
Material	ASTM	DIN	JIS	ISO
Ductile Iron	A536 Gr 60-40-18	0.7043	G5502 FCD40	R1083/400-12
Cast Iron	A48 Class 30B	0.6020	G5501 FC20	DR185/Gr200
316SS	A743 CF-8M	1.4408	G5121 SCS14	
317SS	A743 CG-8M	1.4448		
CD4MCuN	A890 GR1B CD4MCuN	1.4517		
Alloy 20	A743 CN-7M	1.4536		
Duplex 2205	A240	1.4462		

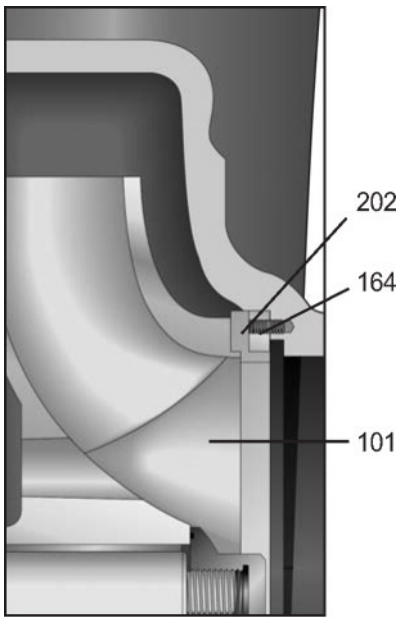


Sectional View

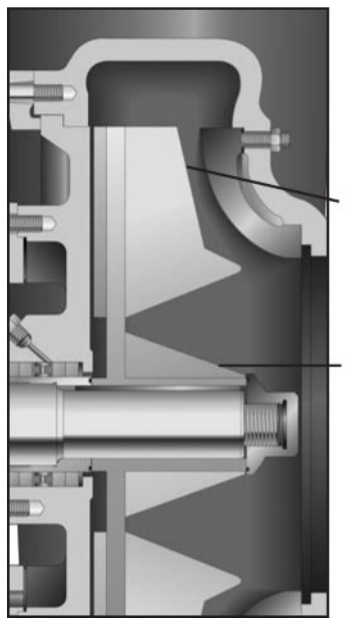




Mechanical Seal Option



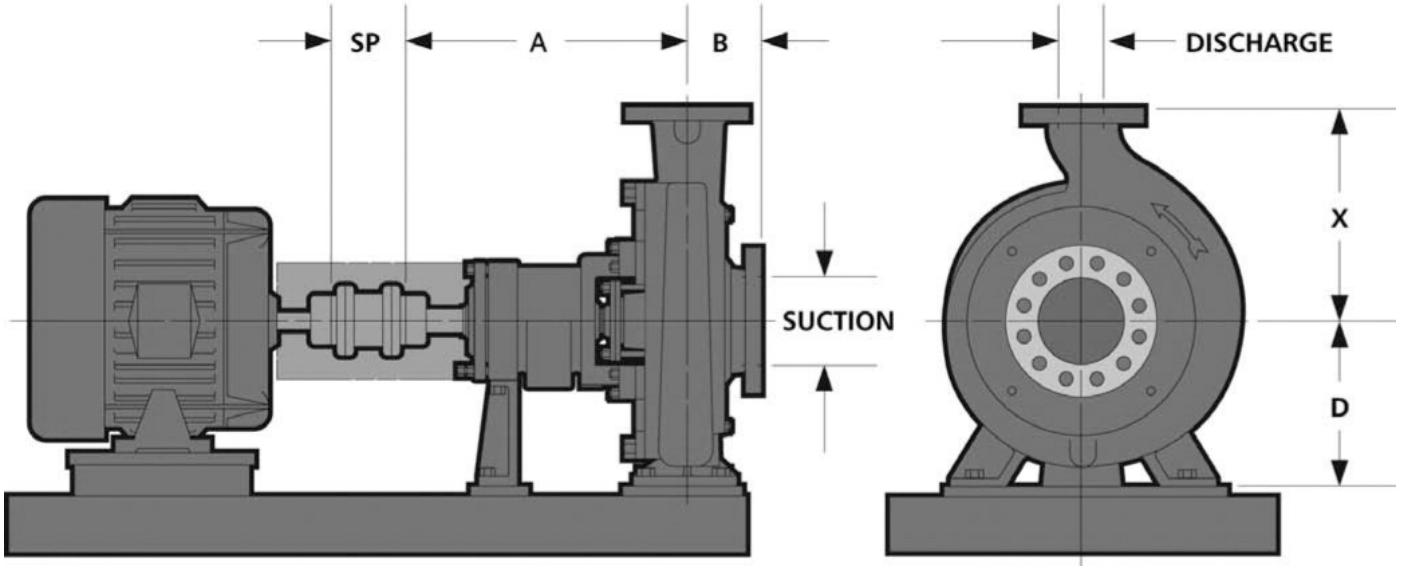
Enclosed Impeller Option



Shearpeller™

Dimensions Model 3180

All dimensions in inches. Not to be used for construction.

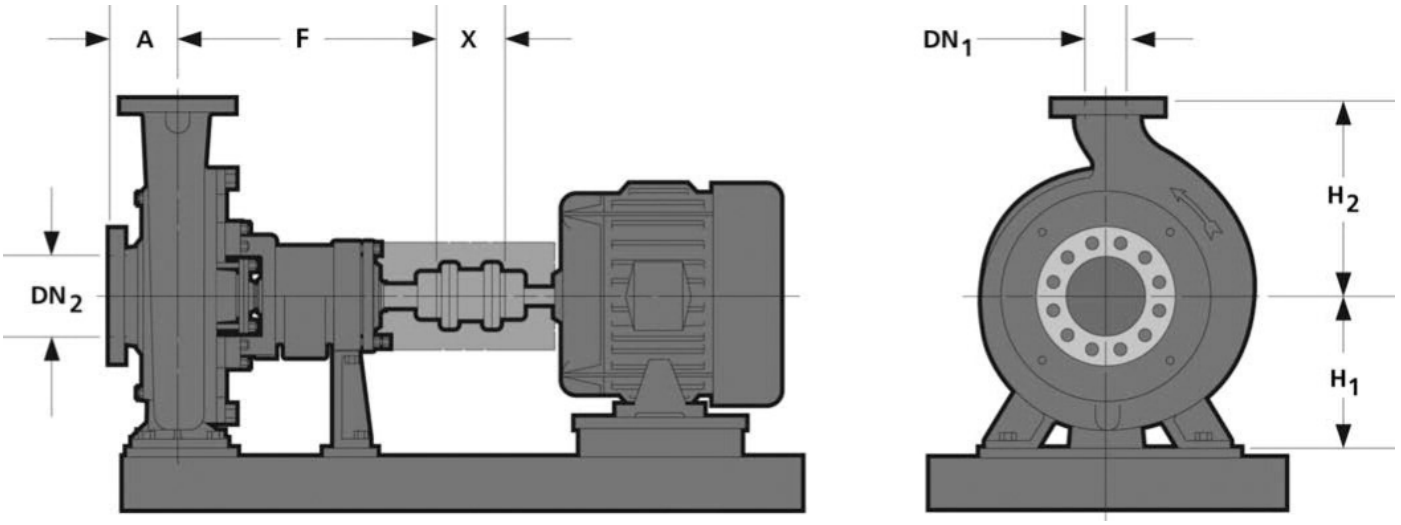


DIMENSIONS–ENGLISH (INCHES)

Group	Size	Discharge	Suction	D	X	B	A	SP (minimum)	Pump Weight–Pounds
S	3×6–12	3	6	9.84	12.40	4.92	20.87	5.51	368
	4×6–12	4	6	9.84	13.98	5.51	20.87	5.51	389
	6×8–12	6	8	11.02	14.76	6.30	20.87	5.51	520
	8×8–12	8	8	12.40	16.73	7.87	20.87	5.51	650
	3×6–14	3	6	9.84	12.40	4.94	20.87	5.51	468
	4×6–14	4	6	11.02	13.98	5.51	20.87	5.51	503
	4×6–16	4	6	12.40	15.75	5.51	20.87	5.51	566
M	6×8–14	6	8	12.40	15.75	6.30	26.38	7.09	545
	8×8–14	8	8	12.40	17.72	7.09	26.38	7.09	620
	10×10–14	10	10	13.98	18.70	8.86	26.38	7.09	773
	12×12–14	12	12	16.73	22.05	9.84	26.38	7.09	922
	6×8–16	6	8	12.40	17.72	6.30	26.38	7.09	626
	4×6–19	4	6	12.40	16.73	6.30	26.38	7.09	672
L	6×10–16	6	10	13.98	19.69	7.09	29.53	7.09	821
	8×10–16	8	10	16.73	19.69	8.86	29.53	7.09	913
	10×12–16	10	12	16.73	23.62	10.43	29.53	7.09	1077
	14×14–16	14	14	19.69	26.38	11.04	29.53	7.09	1336
	4×8–19	4	8	13.98	17.72	6.30	29.53	7.09	700
	6×10–19	6	10	13.98	19.69	7.09	29.53	7.09	926
	8×10–19	8	10	16.73	22.05	7.87	29.53	7.09	994
	10×12–19	10	12	16.73	23.62	9.84	29.53	7.09	1133
	6×10–22	6	10	16.73	22.05	7.09	29.53	7.09	1087
	8×10–22	8	10	16.73	23.62	8.86	29.53	7.09	1198
XL	12×14–19	12	14	19.69	26.38	11.02	32.68	9.84	1538
	16×16–19	16	16	22.05	29.53	11.81	33.46	9.84	1846
	10×12–22	10	12	19.69	26.38	8.86	32.68	9.84	1451
	12×14–22	12	14	22.05	26.38	10.43	32.68	9.84	1682
	14×16–22	14	16	24.80	29.53	13.19	32.68	9.84	2018
	18×18–22	18	18	24.80	33.46	13.98	33.46	9.84	2321
	6×10–25	6	10	16.73	22.05	7.87	32.68	9.84	1389
	8×12–25	8	12	19.69	24.80	8.86	32.68	9.84	1515
	10×14–25	10	14	22.05	29.53	9.84	32.68	9.84	1688
	20×20–25	20	20	29.53	39.37	15.75	33.46	9.84	2681

Dimensions Model 3185

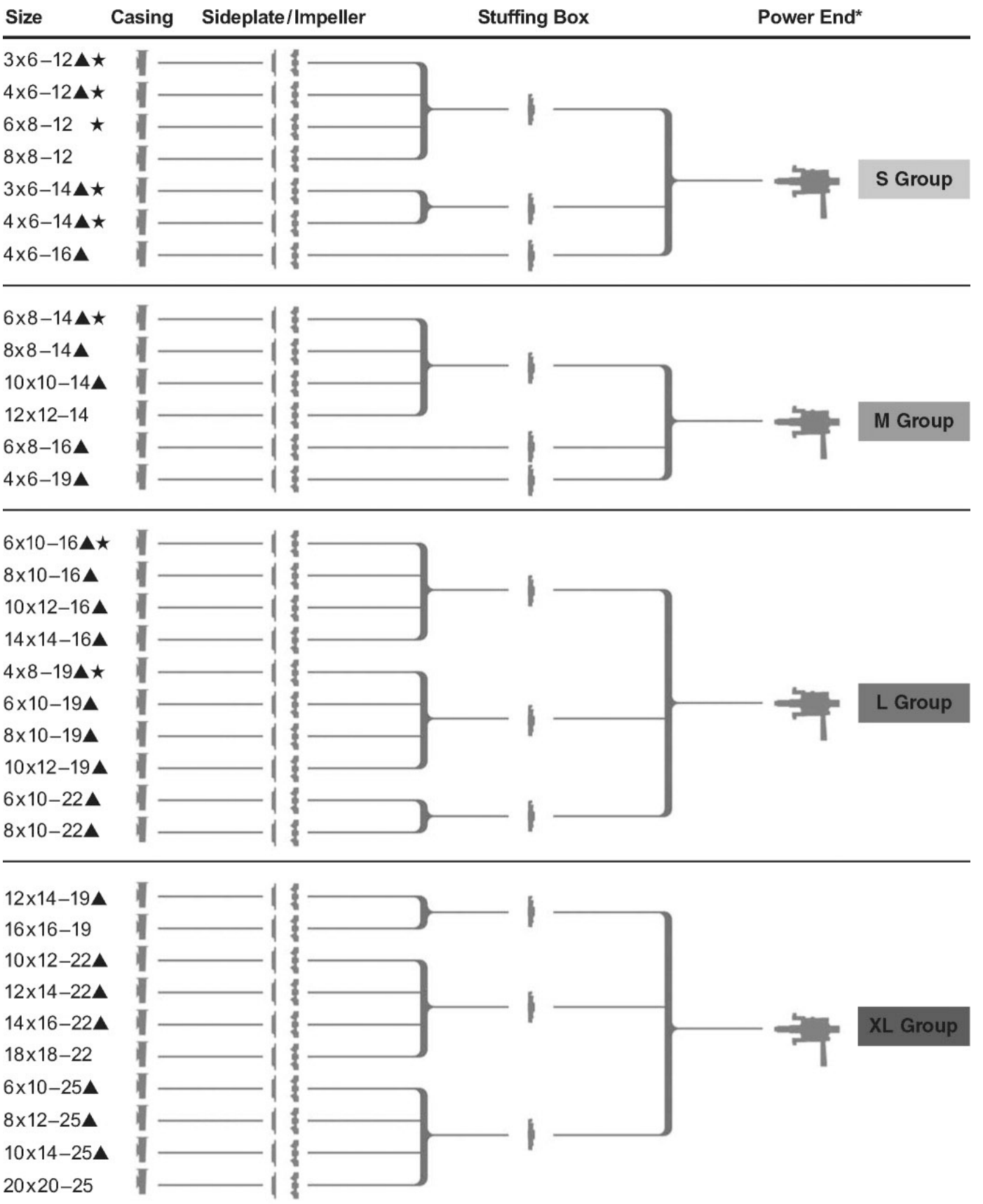
All dimensions in mm. Not to be used for construction.



DIMENSIONS–METRIC (mm)

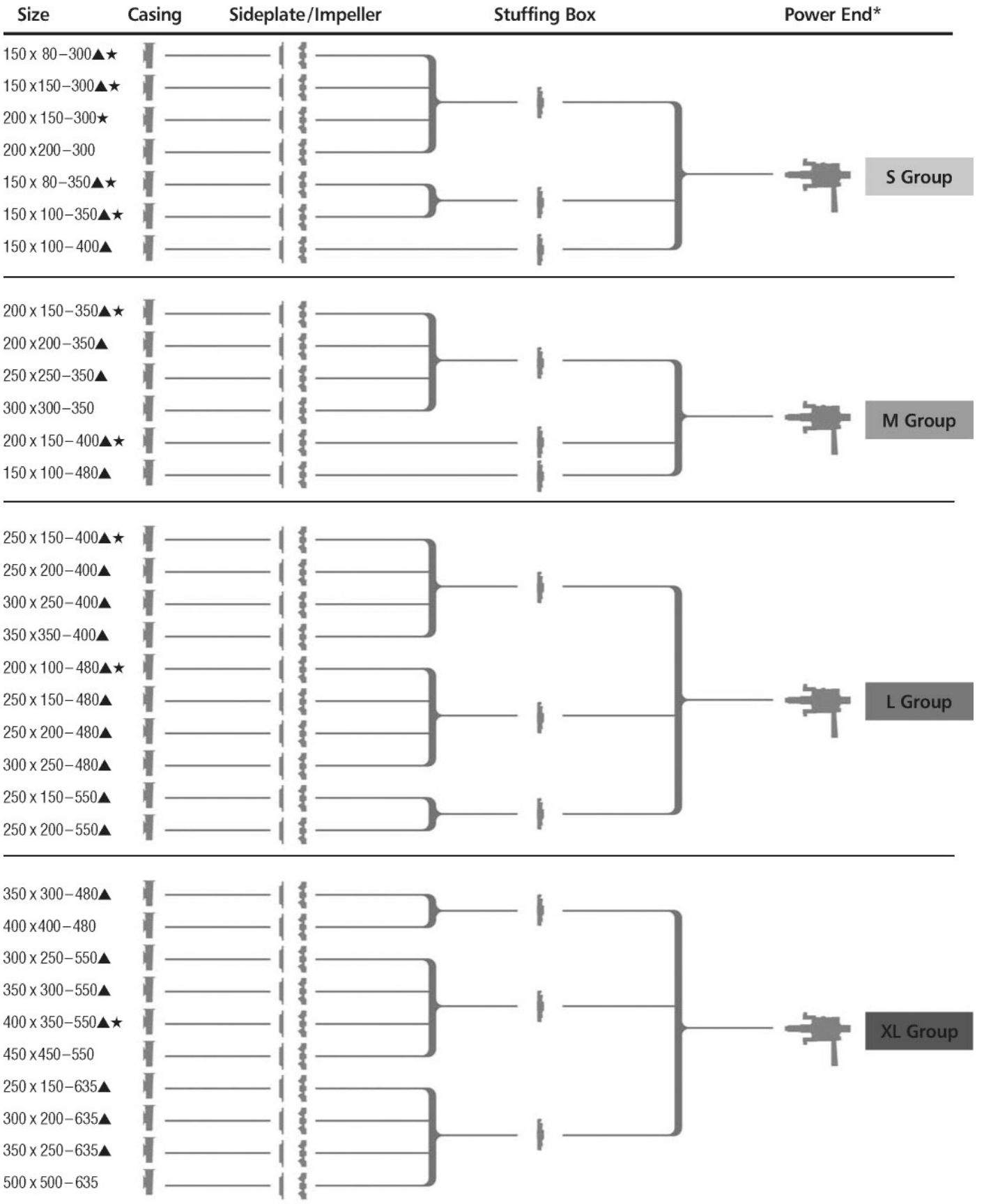
Group	Size	Discharge DN_1		H_1	H_2	A	F	X (minimum)	Pump Weight–kg
S	150×80-300	80	150	250	315	125	530	140	167
	150×100-300	100	150	250	355	140	530	140	176
	200×150-300	150	200	280	375	160	530	140	236
	200×200-300	200	200	315	425	200	530	140	295
	150×80-350	80	150	250	315	125	530	140	212
	150×100-350	100	150	280	355	140	530	140	228
	150×100-400	100	150	315	400	140	530	140	257
M	200×150-350	150	200	315	400	160	670	180	247
	200×200-350	200	200	315	450	180	670	180	281
	250×250-350	250	250	355	475	225	670	180	351
	300×300-350	300	300	425	560	250	670	180	418
	200×150-400	150	200	315	450	160	670	180	284
	150×100-480	100	150	315	425	160	670	180	305
L	250×150-400	150	250	355	500	180	750	180	372
	250×200-400	200	250	425	500	225	750	180	414
	300×250-400	250	300	425	600	265	750	180	489
	350×350-400	350	350	500	670	180	750	180	606
	200×100-480	100	200	355	450	160	750	180	318
	250×150-480	150	250	355	500	180	750	180	420
	250×200-480	200	250	425	560	200	750	180	451
	300×250-480	250	300	425	600	250	750	180	514
	250×150-550	150	250	425	560	180	750	180	493
	250×200-550	200	250	425	600	225	750	180	543
XL	350×300-480	300	350	500	670	280	830	250	698
	400×400-480	400	400	560	750	300	850	250	837
	300×250-550	250	300	500	670	225	830	250	658
	350×300-550	300	350	560	670	265	830	250	763
	400×350-550	350	400	630	750	335	830	250	915
	450×450-550	450	450	630	850	355	850	250	1053
	250×150-635	150	250	425	560	200	830	250	630
	300×200-635	200	300	500	630	225	830	250	687
	350×250-635	250	300	560	750	250	830	250	766
	500×500-635	500	500	750	1000	400	850	250	1216

Modular Interchangeability Model 3180



*Shafts for Models 3180 and 3185 are not interchangeable.
Sleeves for mechanical seals on the 3180 and 3185 are not interchangeable.
▲ Available with enclosed impeller.
★ Available with Shearpeller™.

Modular Interchangeability Model 3185



* Shafts for Models 3180 and 3185 are not interchangeable.
Sleeves for mechanical seals on the 3180 and 3185 are not interchangeable.
▲ Available with enclosed impeller.
★ Available with Shearpeller™.

Contruction Details

		S Group	M Group	L Group	XL Group
Temperature Limits	Grease Lube	355° F	355° F	355° F	355° F
	Oil Lube w/o Cooling	355° F	355° F	355° F	355° F
	Oil lube w/Cooling	445° F	445° F	445° F	445° F
Shaft Diameters (inches)	At Impeller	1.51	1.77	2.20	2.60
	Under Shaft Sleeve	1.97	2.28	2.68	3.15
	At Coupling	1.625	1.875	2.375	2.875
	Between Bearings	2.63	2.88	3.39	4.06
Packed Stuffing Box (inches)	Bore	3.35	3.74	4.13	4.72
	Depth	3.35	3.35	3.54	3.54
	Packing Size	1/2	1/2	1/2	1/2
	# of Packing Rings	5	5	5	5
	Width of Lantern Ring	5/8	5/8	3/4	3/4
	Distance to 1st Obstruction	2.26	3.14	2.76	3.24
	Sleeve Diameter	2.362	2.756	3.150	3.738
Mechanical Seal Chamber (inches)	Bore	3.37	3.88	4.49	5
	Depth to VPE ring	1.81	2.40	2.15	2.15
	Distance to 1st Obstruction	2.89	3.64	3.46	3.98
	Sleeve Diameter	2.375	2.75	3.25	3.75
Coupling Spacing	Min. req'd for back pull-out	5.5 inch	7.09 inch	7.09 inch	9.84 inch

NOTES

NOTES

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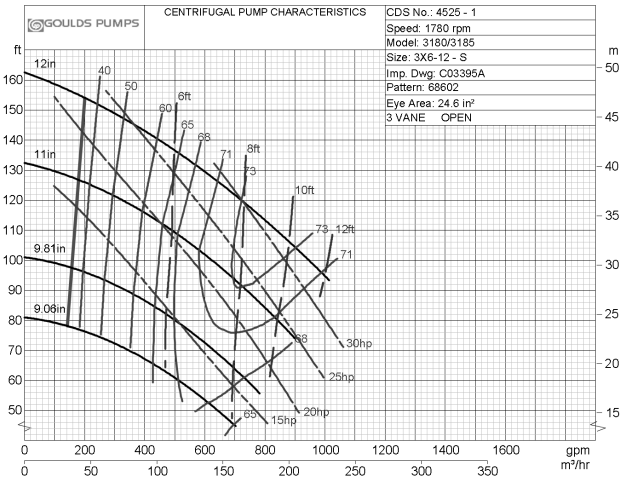
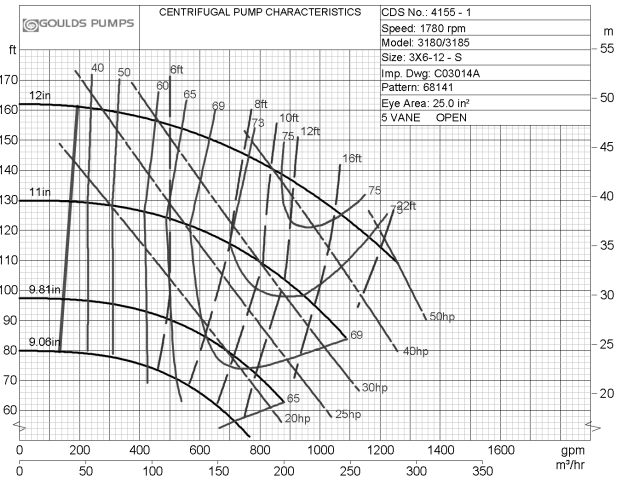
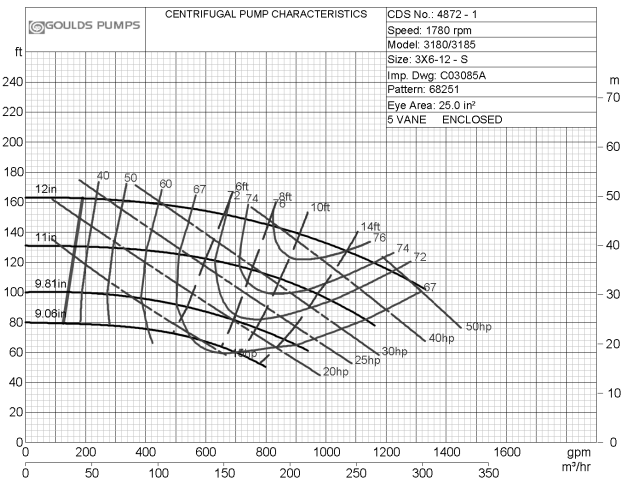


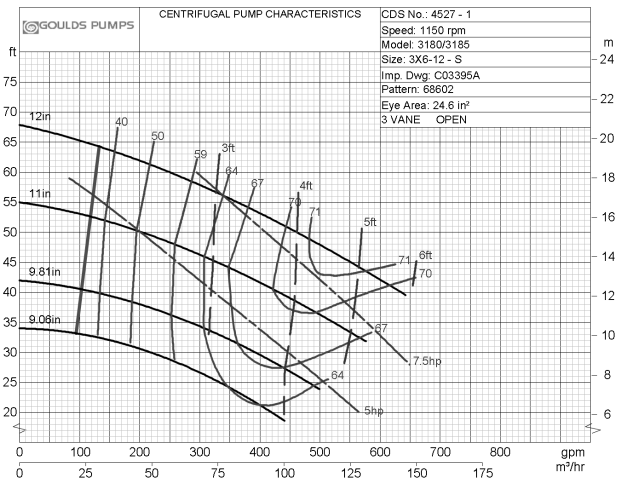
3X6-12 **1780rpm**



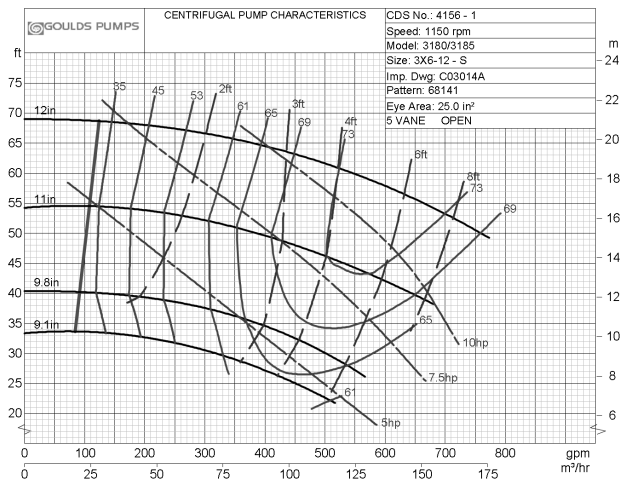
3X6-12 **1780rpm**



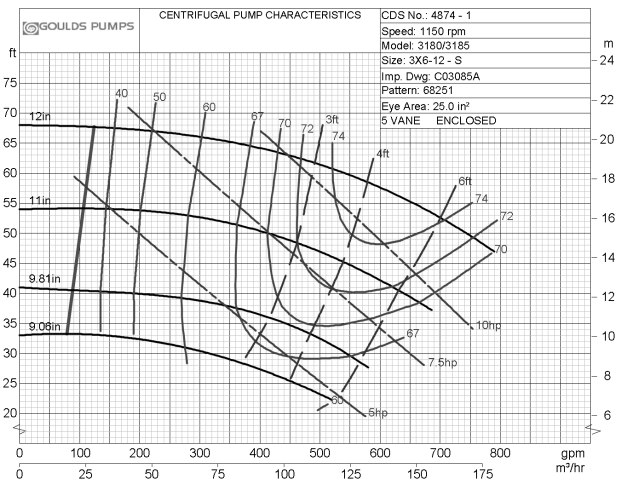
3X6-12 **1780rpm**



3X6-12 **1150rpm**



3X6-12 **1150rpm**



3X6-12 **1150rpm**

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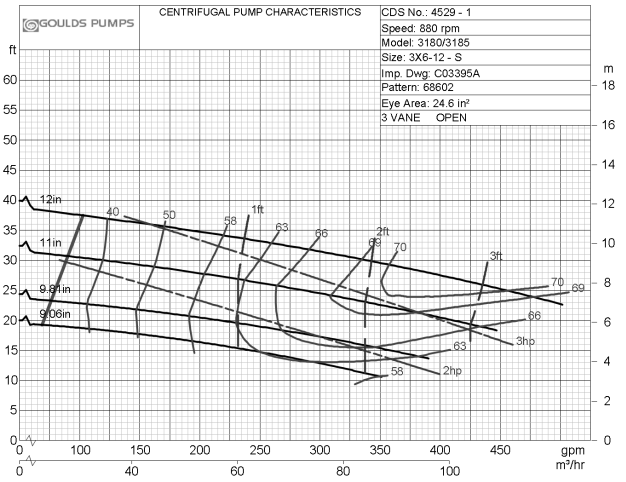
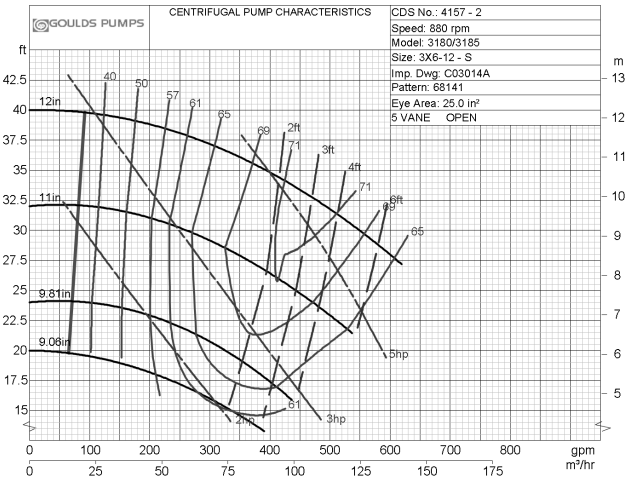
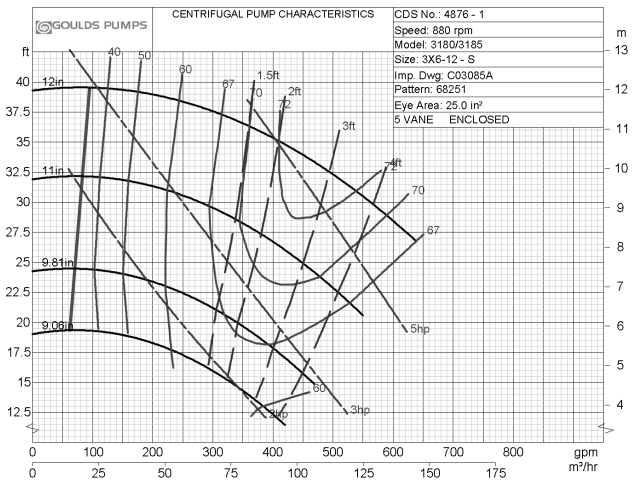


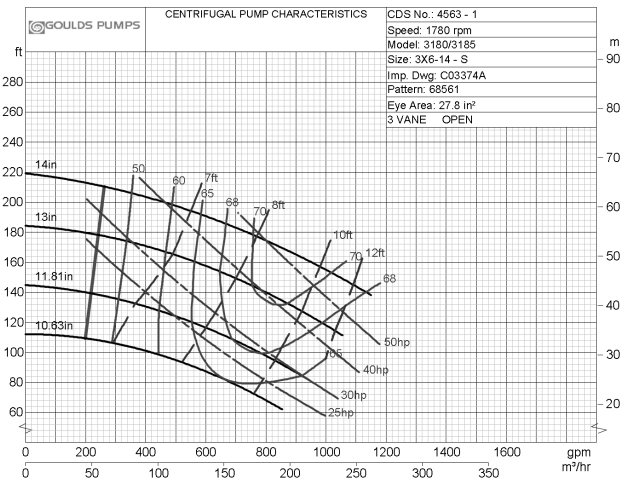
3X6-12 **880rpm**



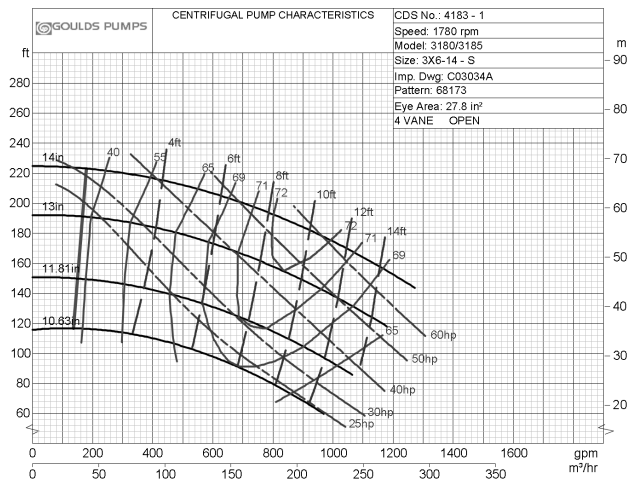
3X6-12 **880rpm**



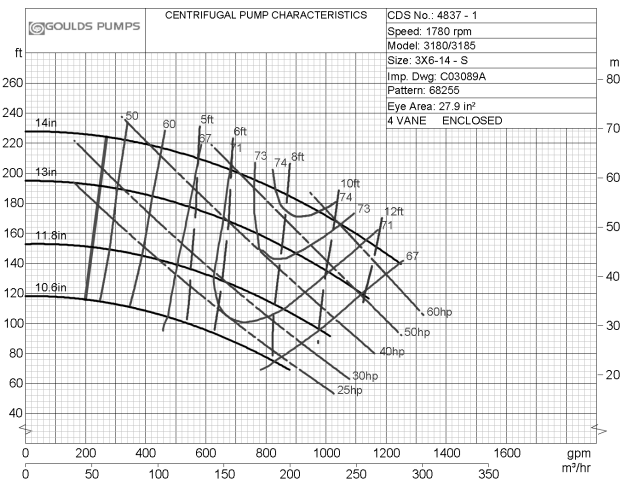
3X6-12 **880rpm**



3X6-14 **1780rpm**



3X6-14 **1780rpm**



3X6-14 **1780rpm**

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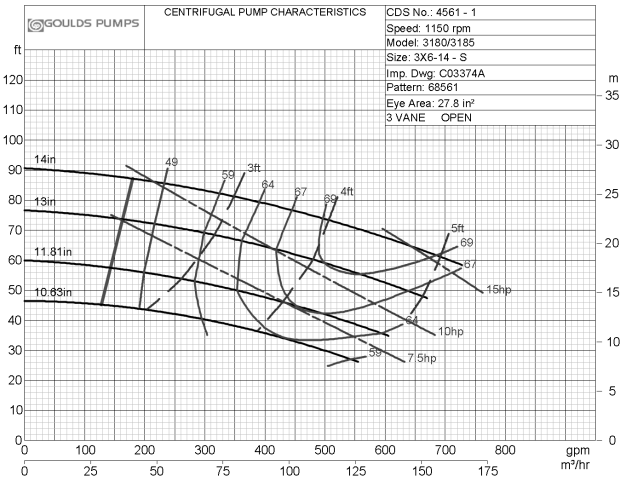
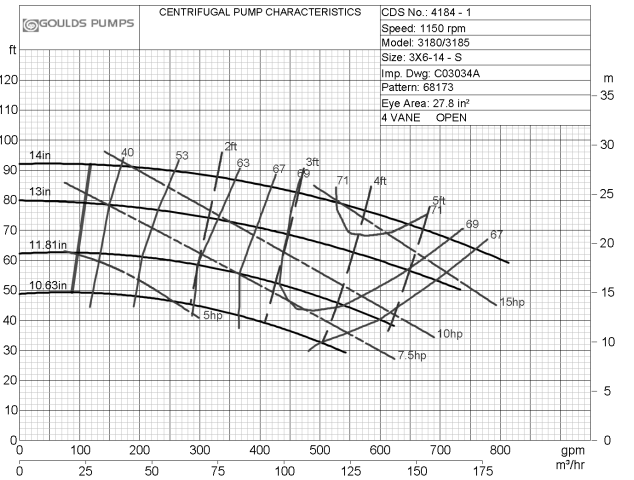
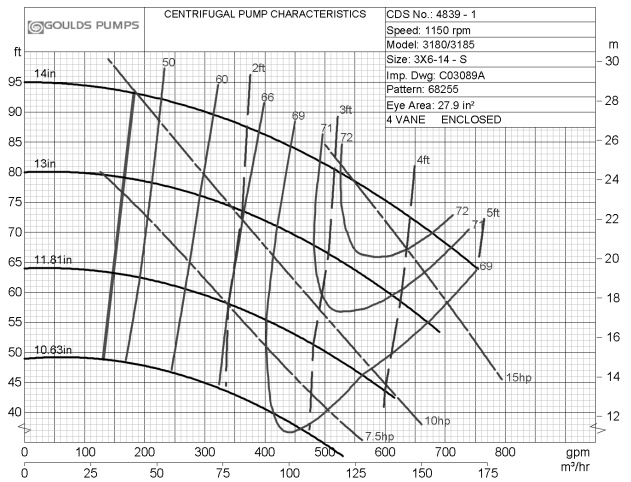


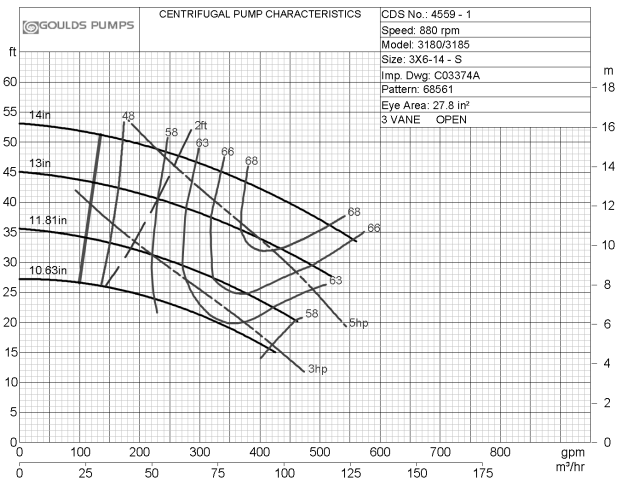
3X6-14 **1150rpm**



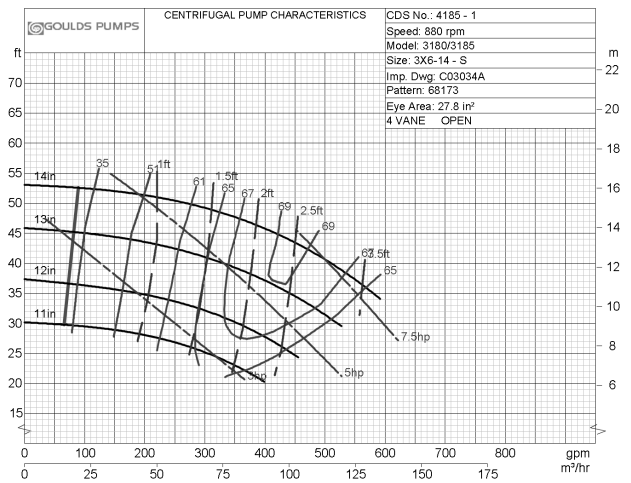
3X6-14 **1150rpm**



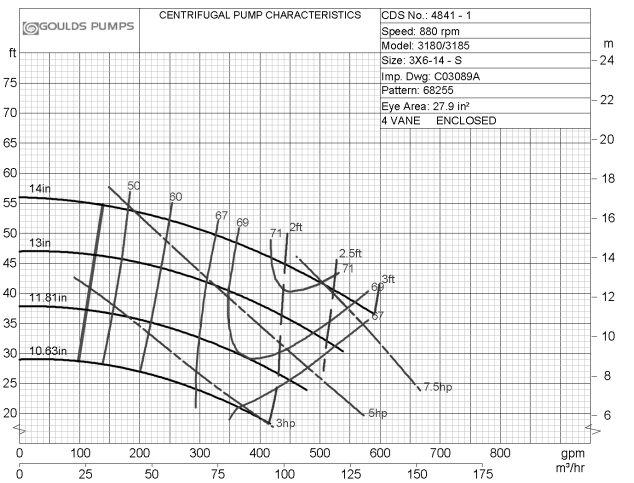
3X6-14 **1150rpm**



3X6-14 **880rpm**



3X6-14 **880rpm**



3X6-14 **880rpm**

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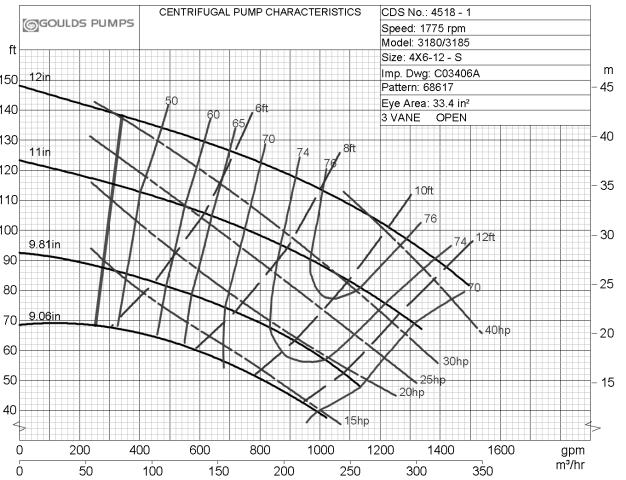
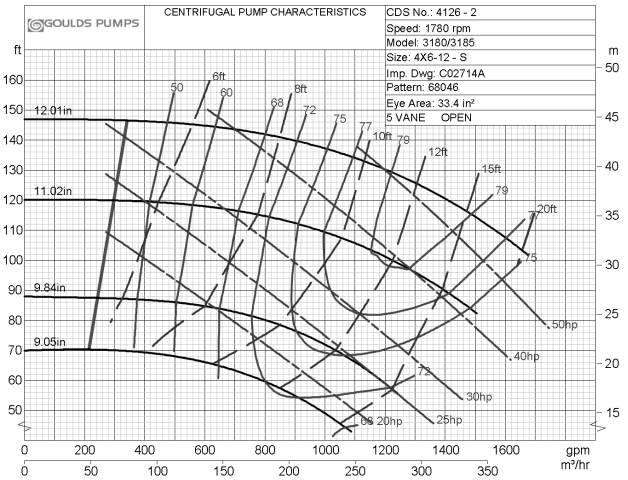
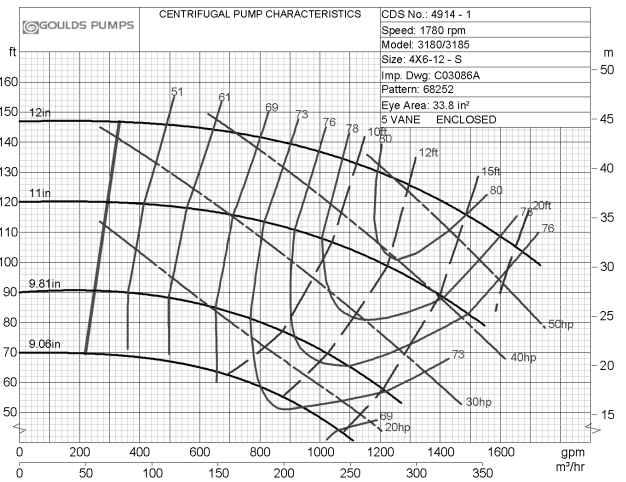


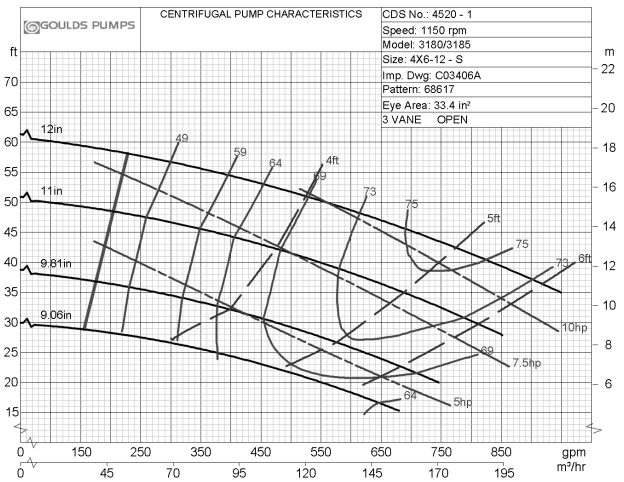
4X6-12 **1775rpm**



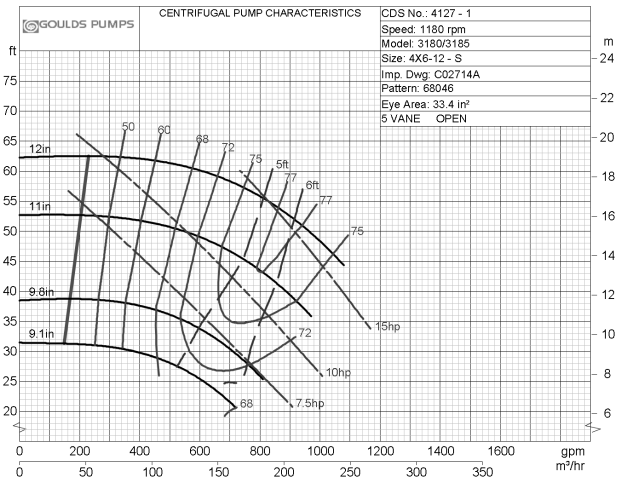
4X6-12 **1780rpm**



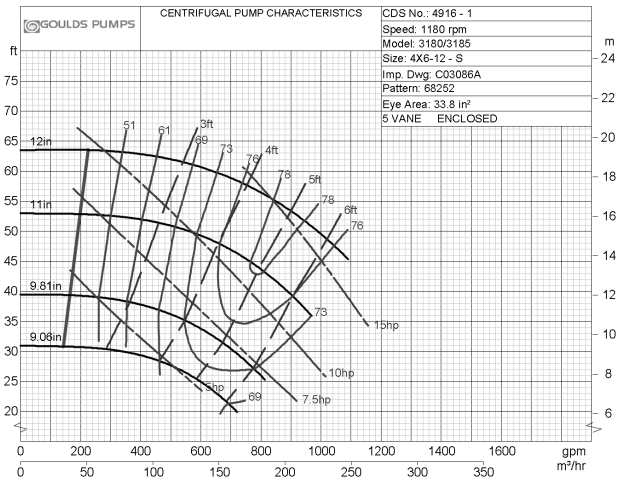
4X6-12 **1780rpm**



4X6-12 **1150rpm**



4X6-12 **1180rpm**



4X6-12 **1180rpm**

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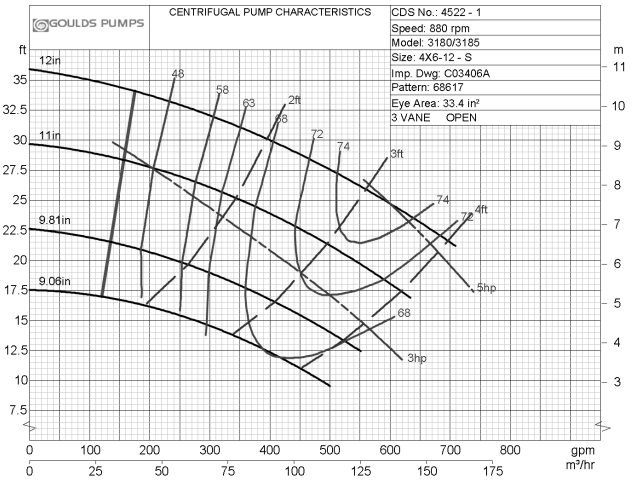
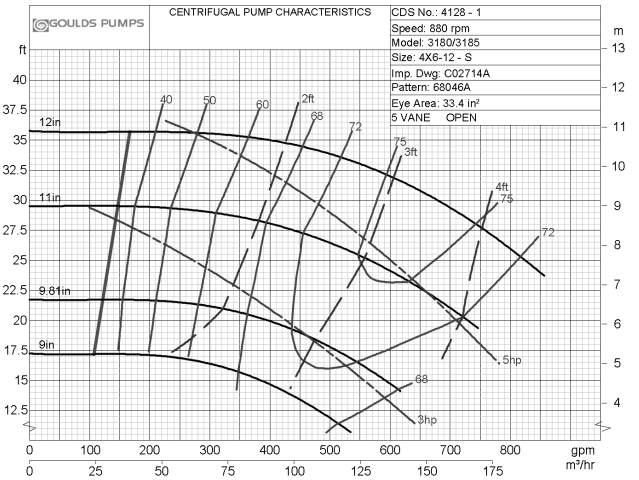
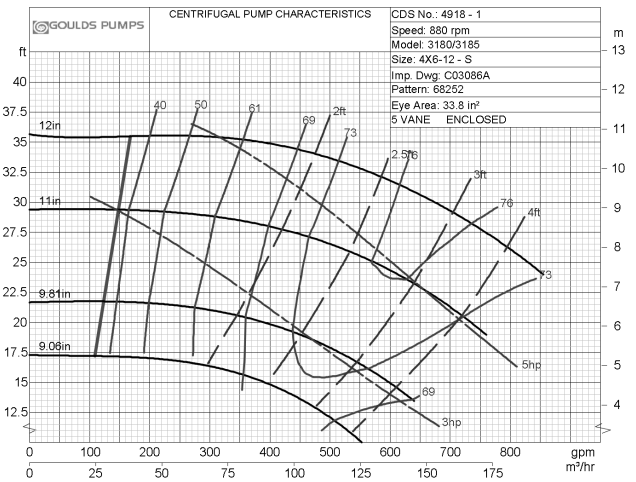


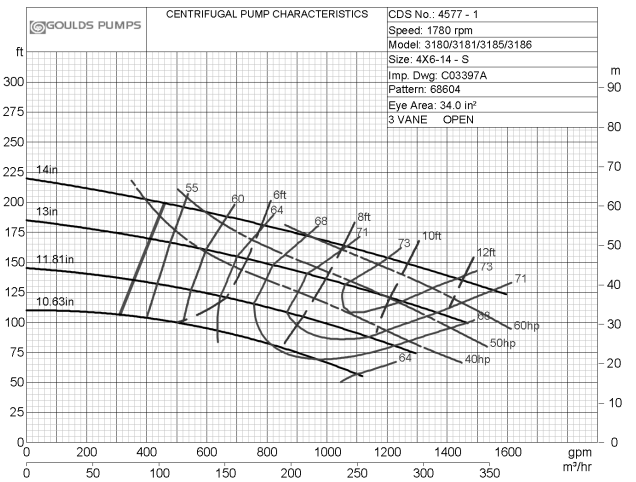
4X6-12 **880rpm**



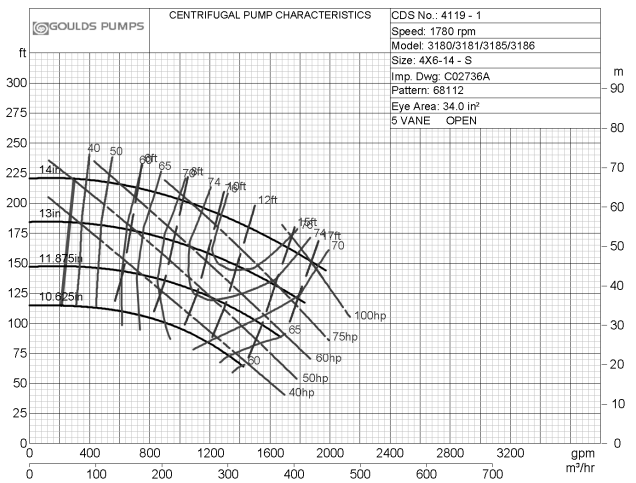
4X6-12 **880rpm**



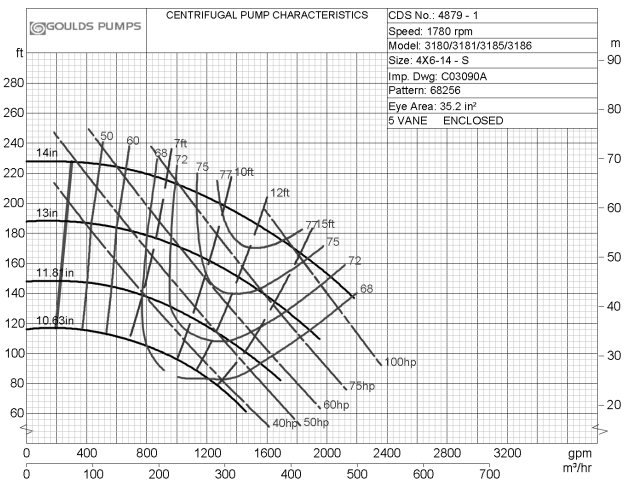
4X6-12 **880rpm**



4X6-14 **1780rpm**



4X6-14 **1780rpm**



4X6-14 **1780rpm**

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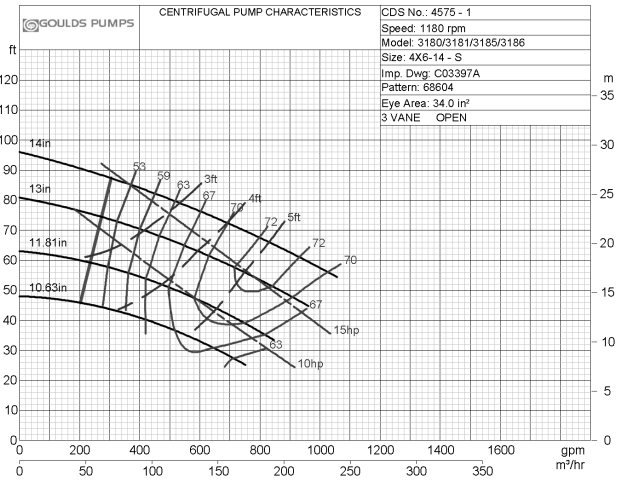
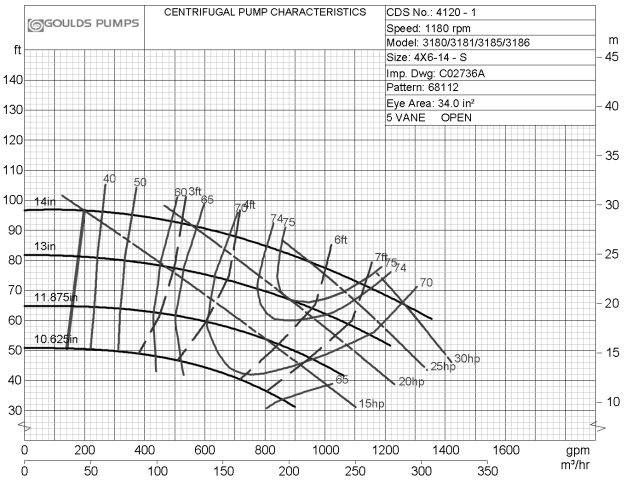
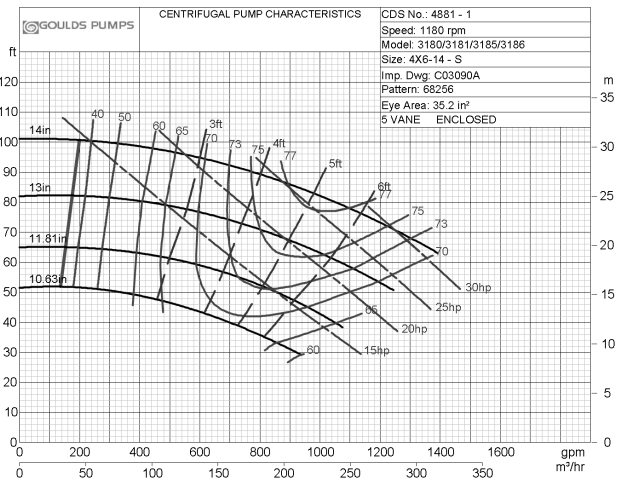


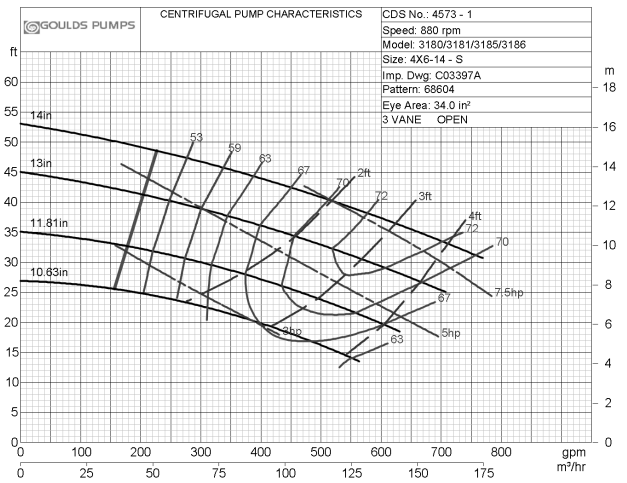
4X6-14 **1180rpm**



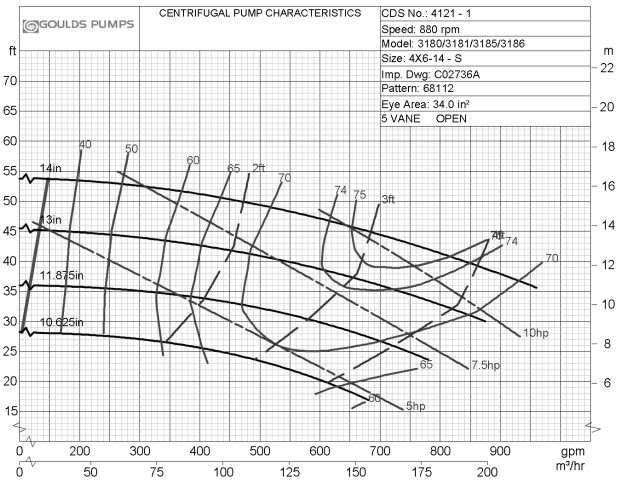
4X6-14 **1180rpm**



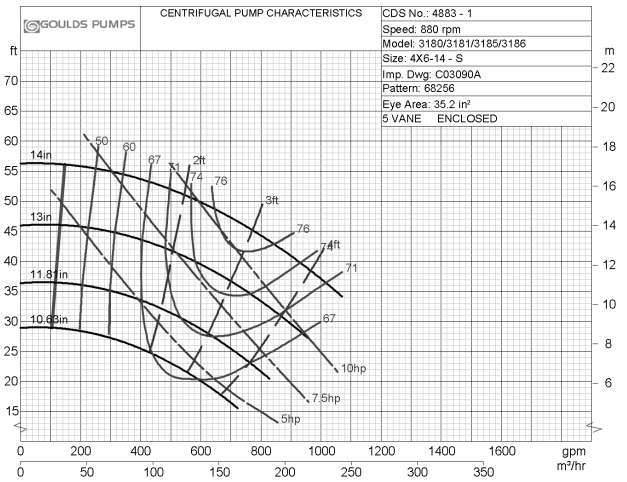
4X6-14 **1180rpm**



4X6-14 **880rpm**



4X6-14 **880rpm**



4X6-14 **880rpm**

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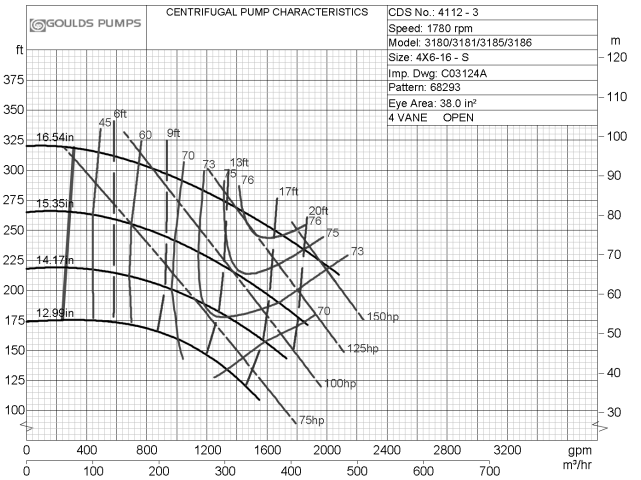
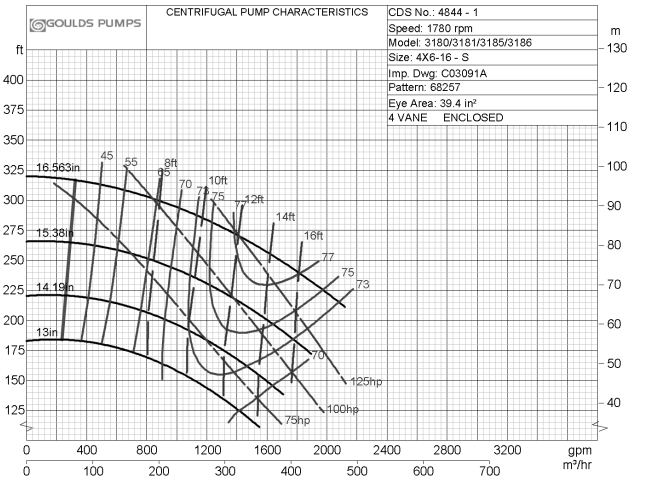
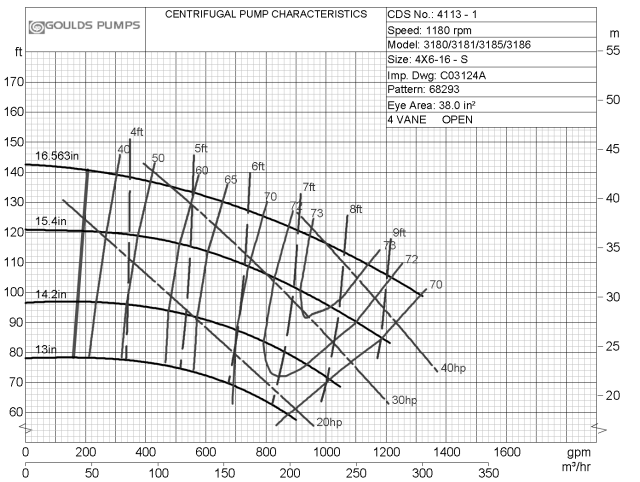


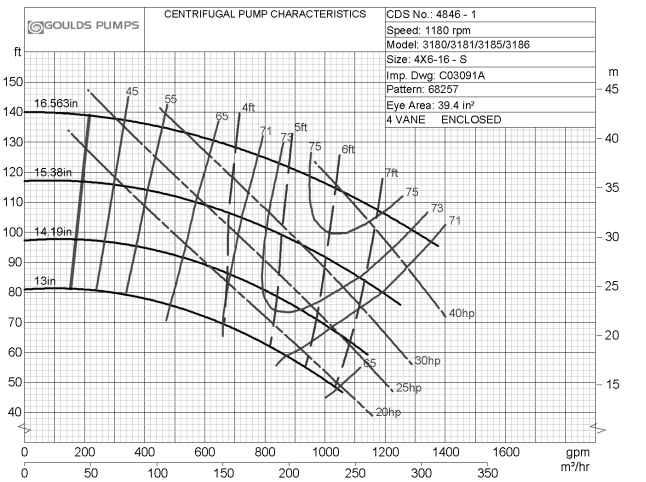
4X6-16 **1780rpm**



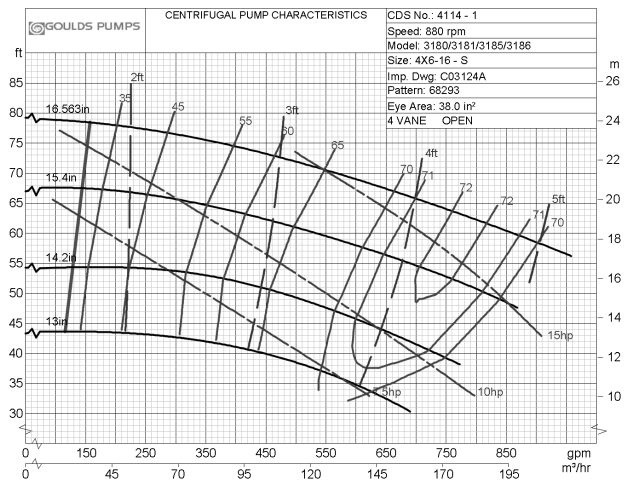
4X6-16 **1780rpm**



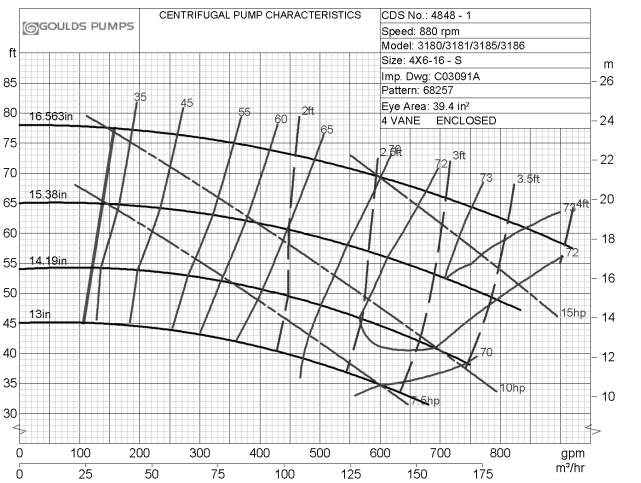
4X6-16 **1180rpm**



4X6-16 **1180rpm**



4X6-16 **880rpm**

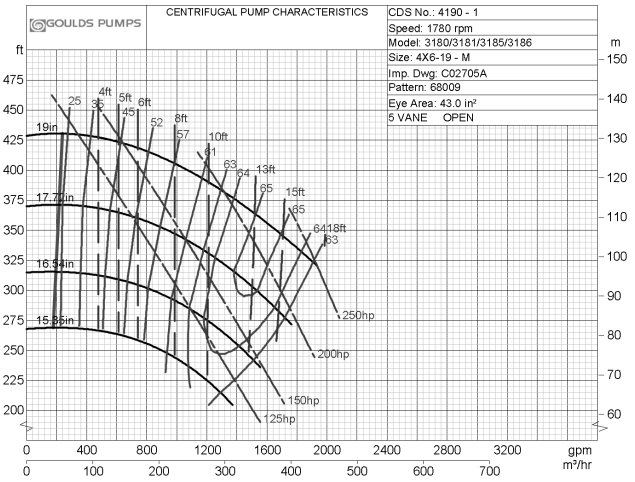


4X6-16 **880rpm**

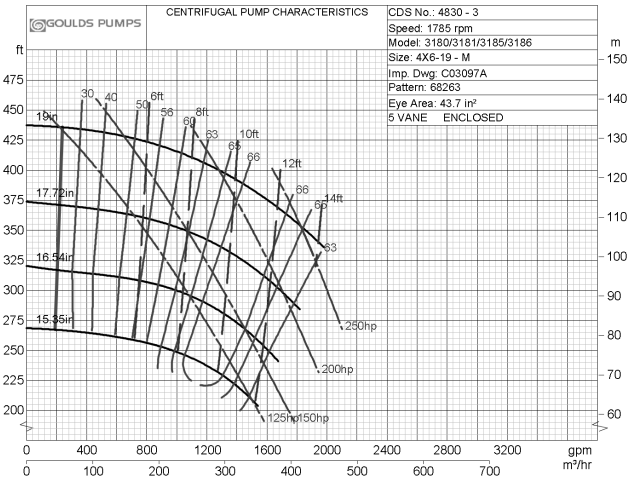
60Hz Curves

Model 3180/3185

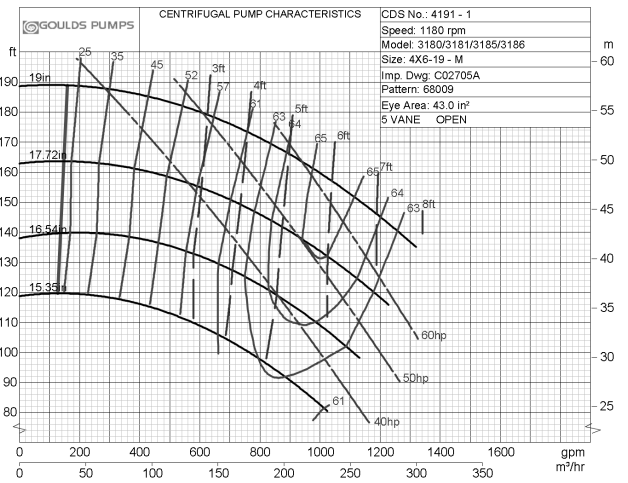
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



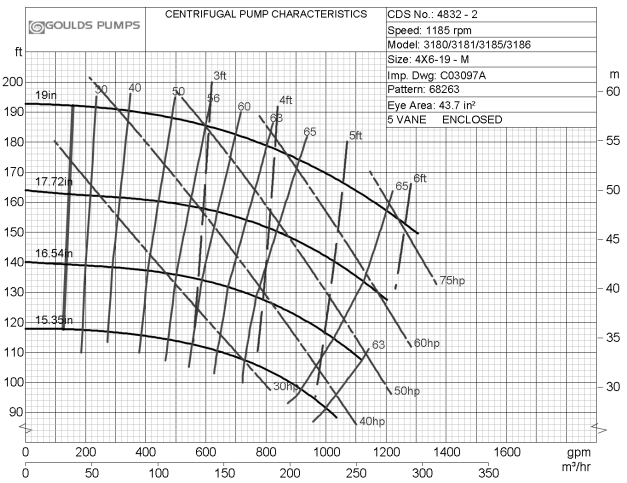
4X6-19 **1780rpm**



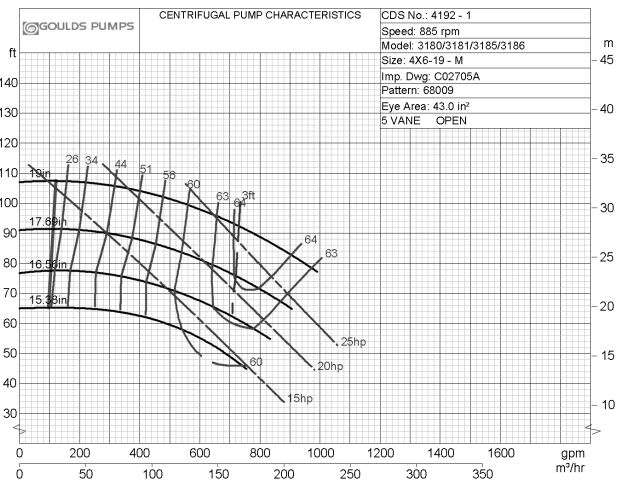
4X6-19 **1785rpm**



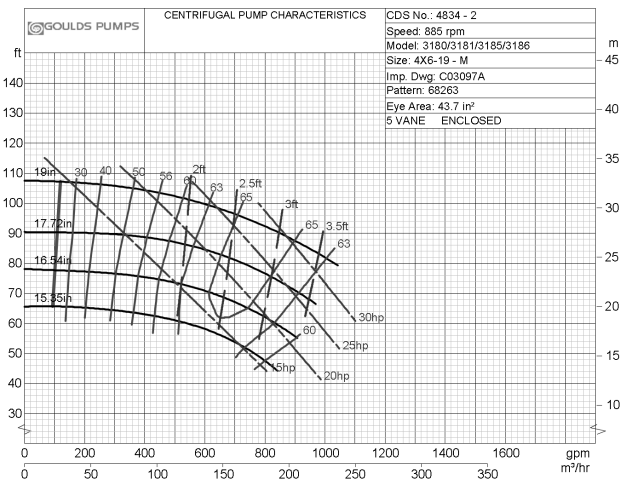
4X6-19 **1180rpm**



4X6-19 **1185rpm**



4X6-19 **885rpm**



4X6-19 **885rpm**

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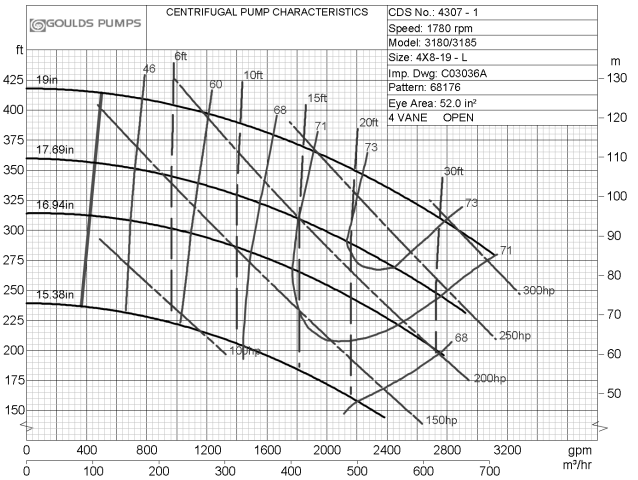
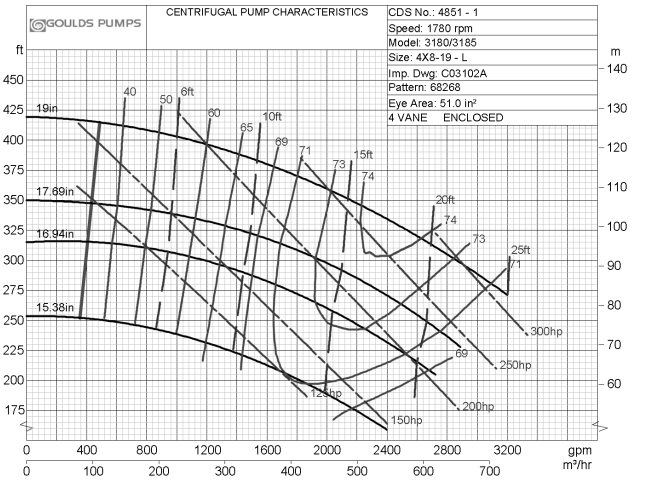
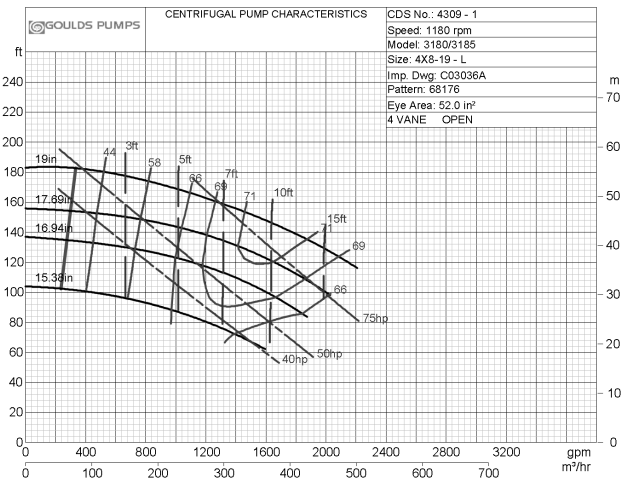


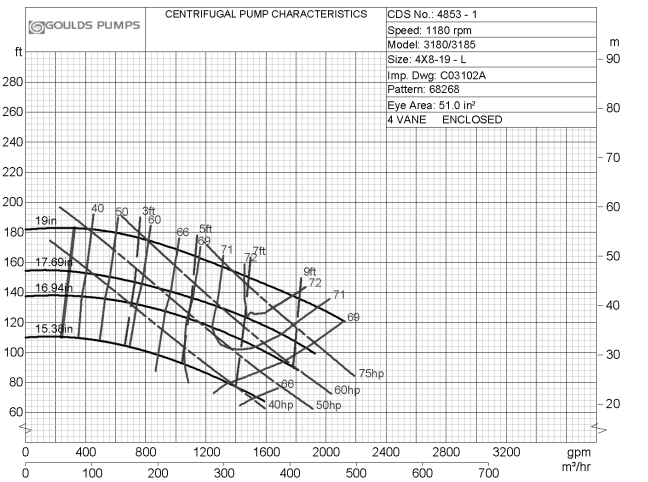
4X8-19 **1780rpm**



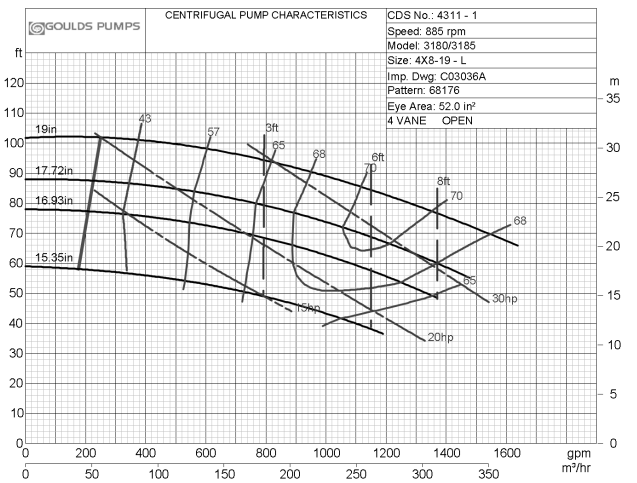
4X8-19 **1780rpm**



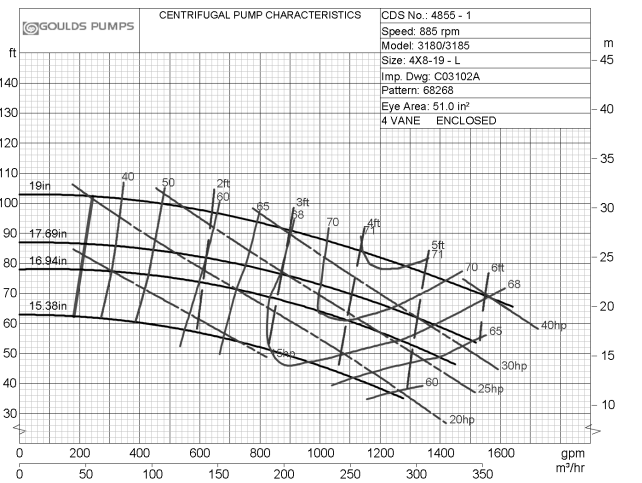
4X8-19 **1180rpm**



4X8-19 **1180rpm**



4X8-19 **885rpm**



4X8-19 **885rpm**

60Hz Curves

Model 3180/3185

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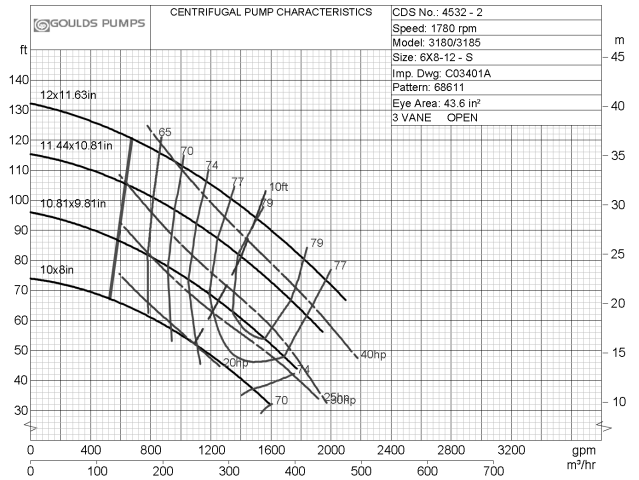
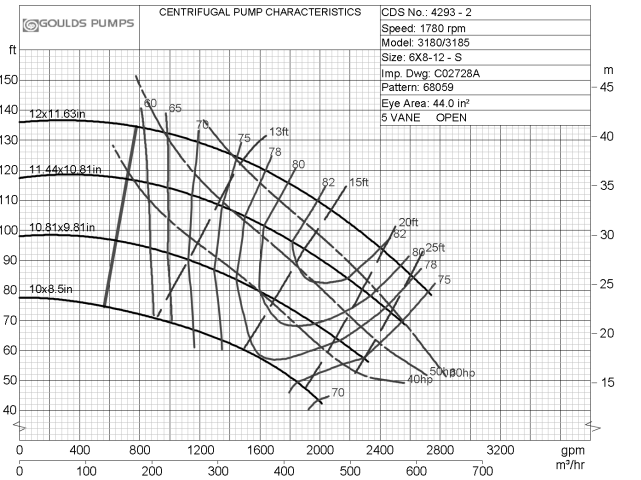
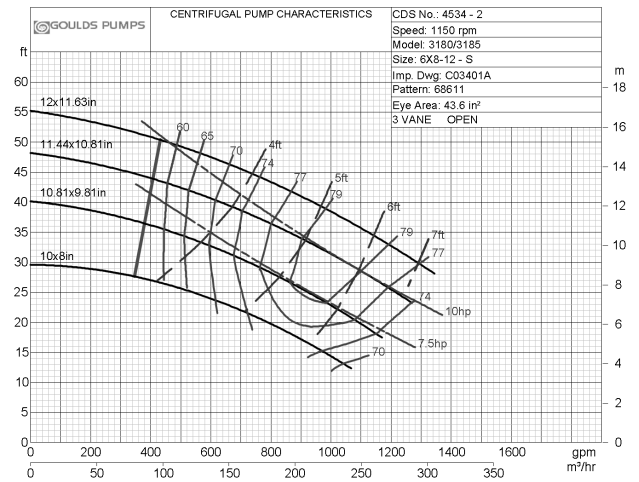


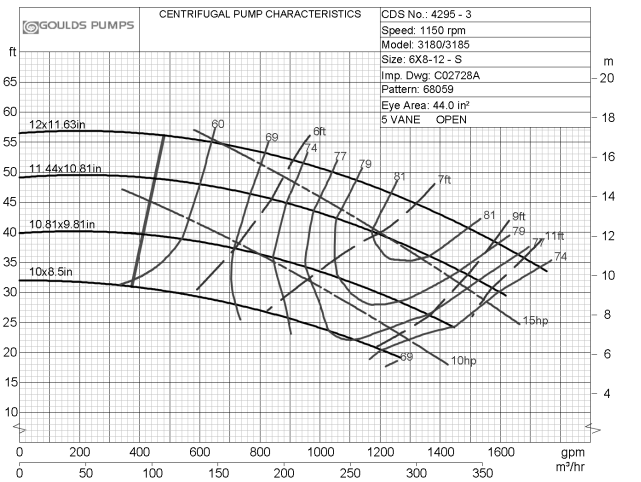
6X8-12 **1780rpm**



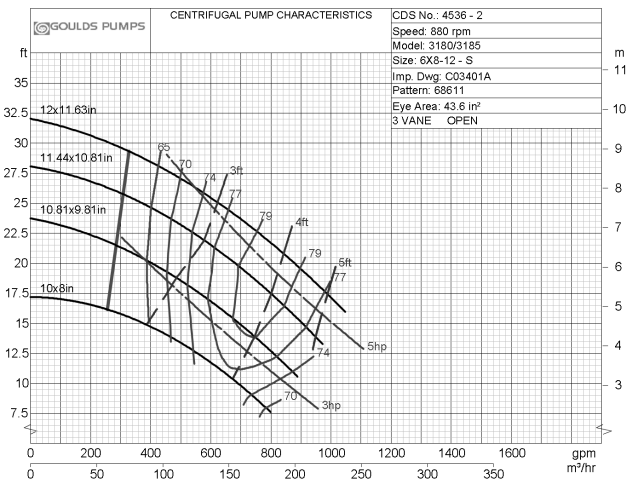
6X8-12 **1780rpm**



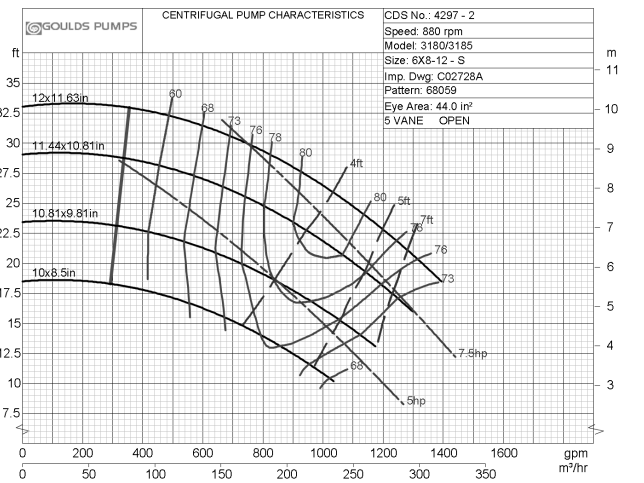
6X8-12 **1150rpm**



6X8-12 **1150rpm**



6X8-12 **880rpm**



6X8-12 **880rpm**

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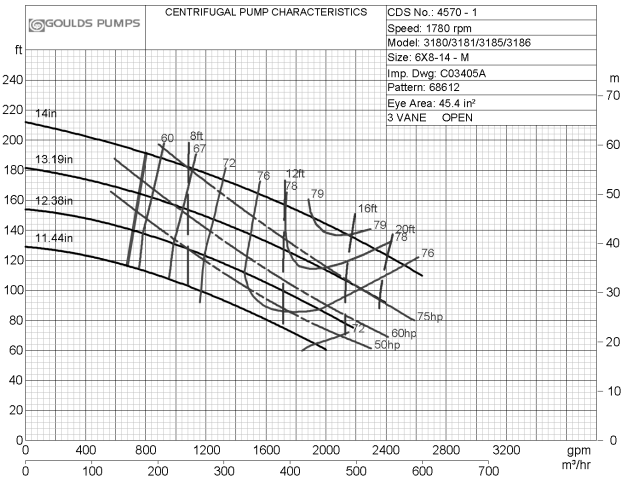
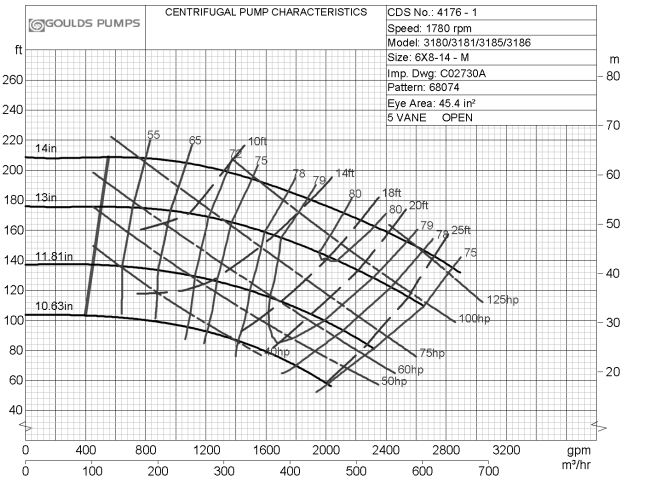
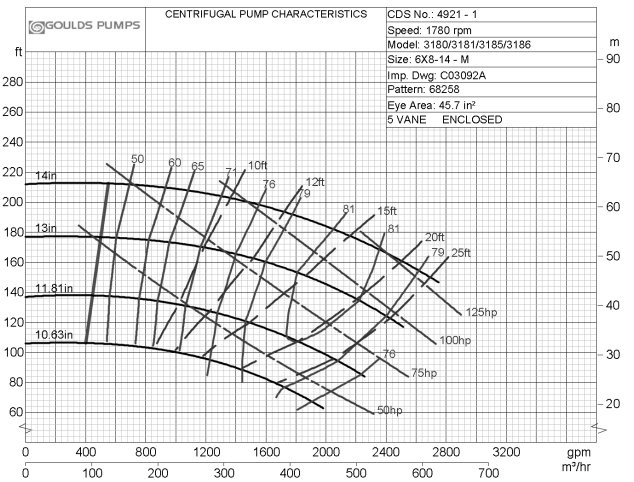


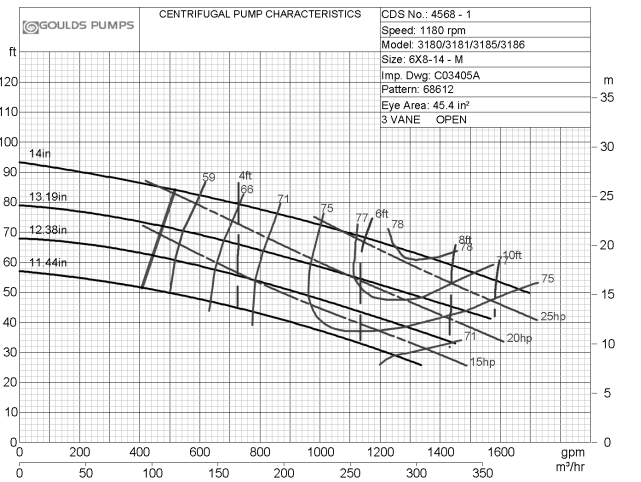
6X8-14 **1780rpm**



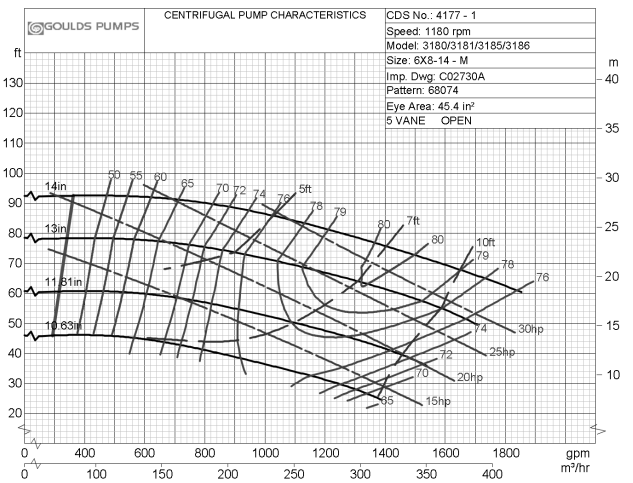
6X8-14 **1780rpm**



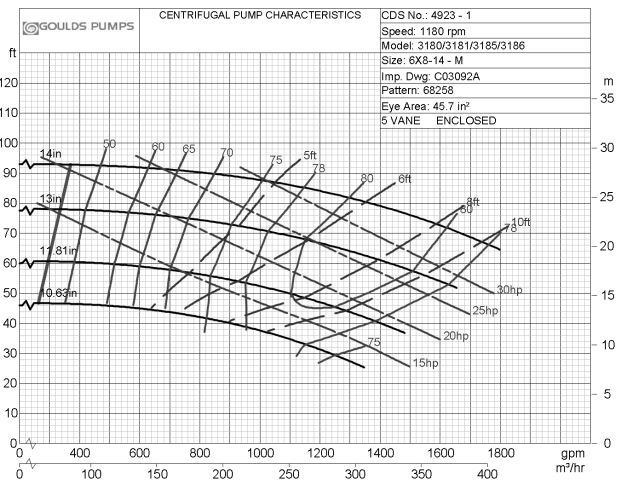
6X8-14 **1780rpm**



6X8-14 **1180rpm**



6X8-14 **1180rpm**



6X8-14 **1180rpm**

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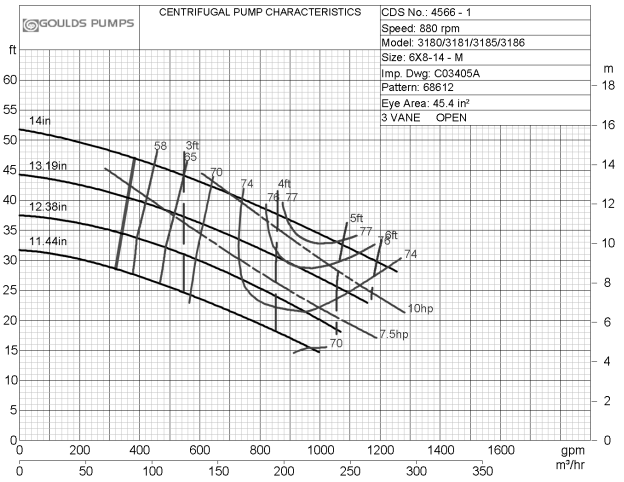
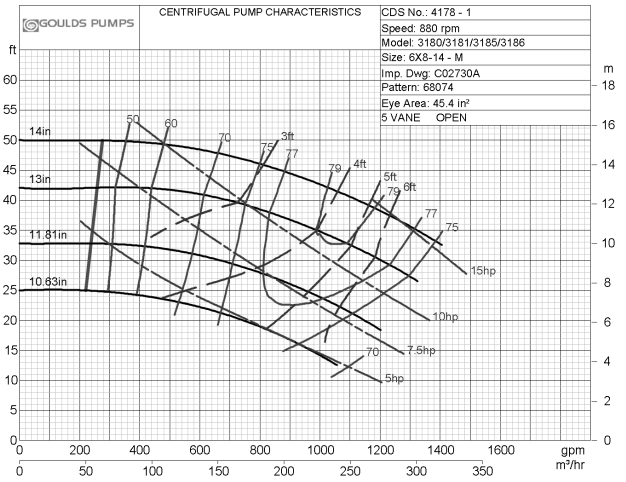
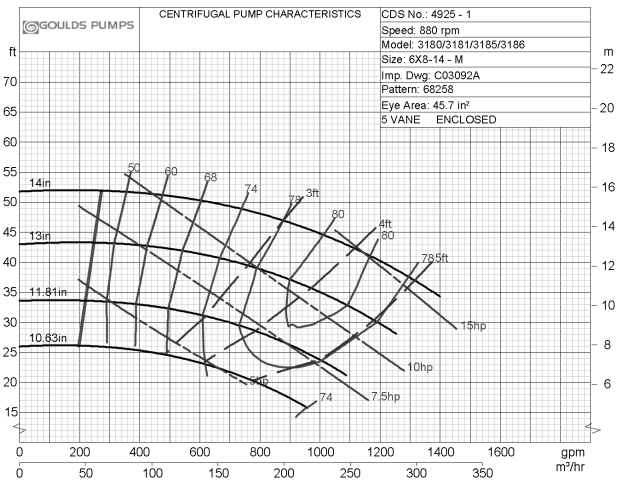


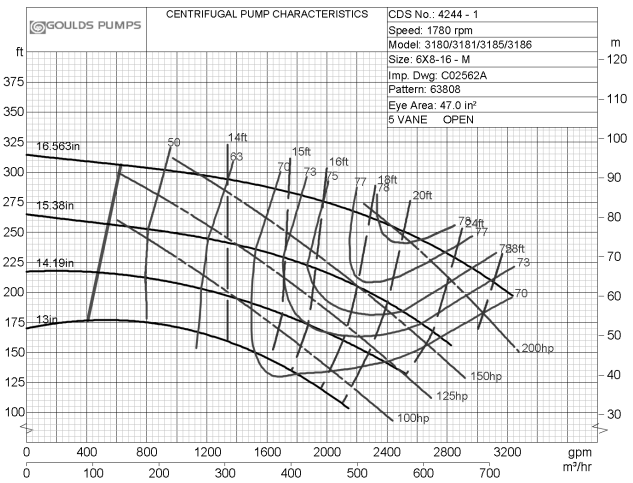
6X8-14 **880rpm**



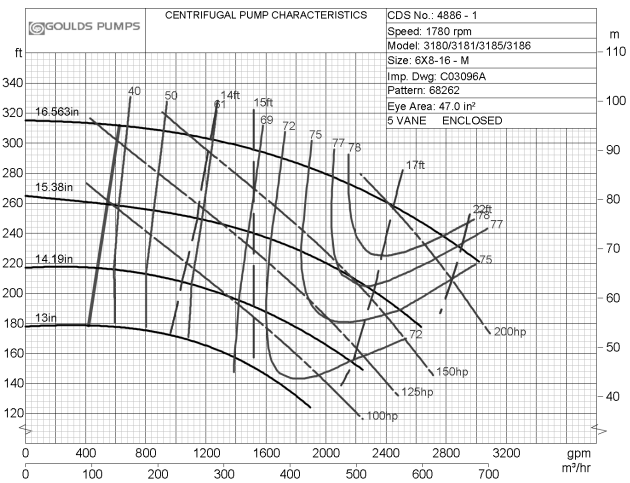
6X8-14 **880rpm**



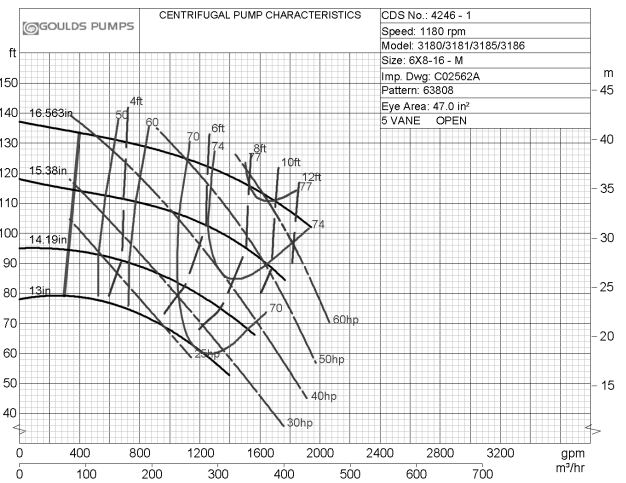
6X8-14 **880rpm**



6X8-16 **1780rpm**



6X8-16 **1780rpm**



6X8-16 **1180rpm**

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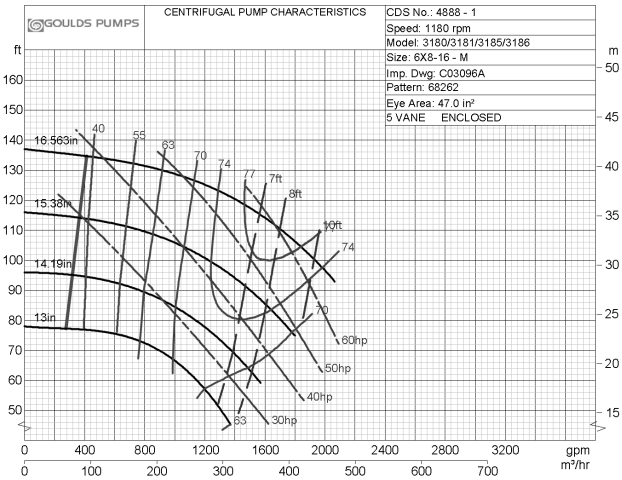
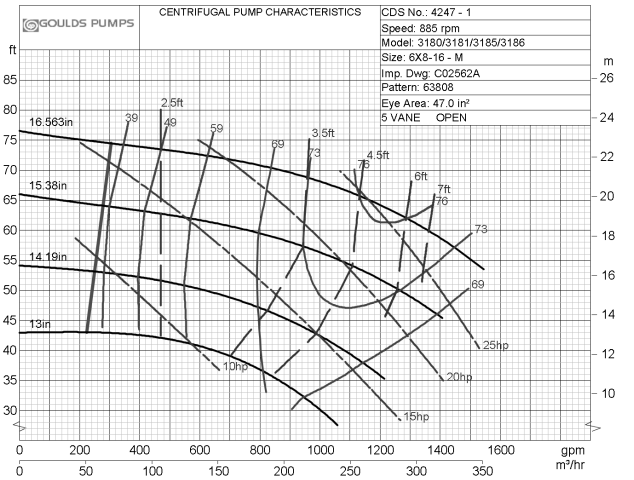
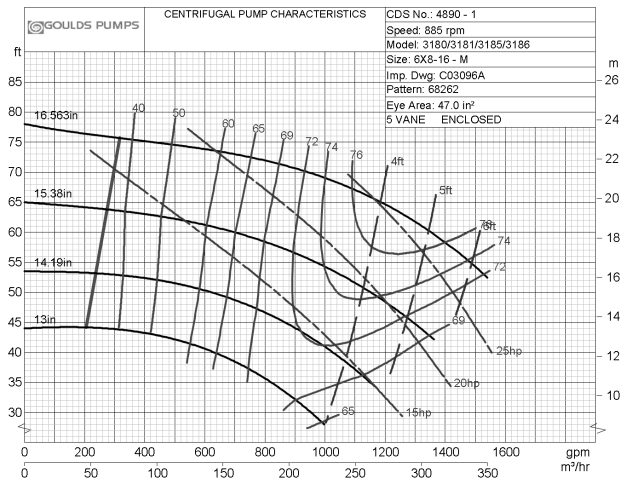


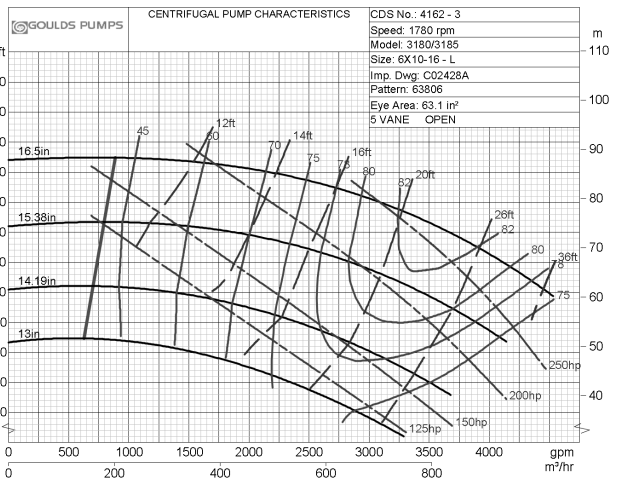
6X8-16 **1180rpm**



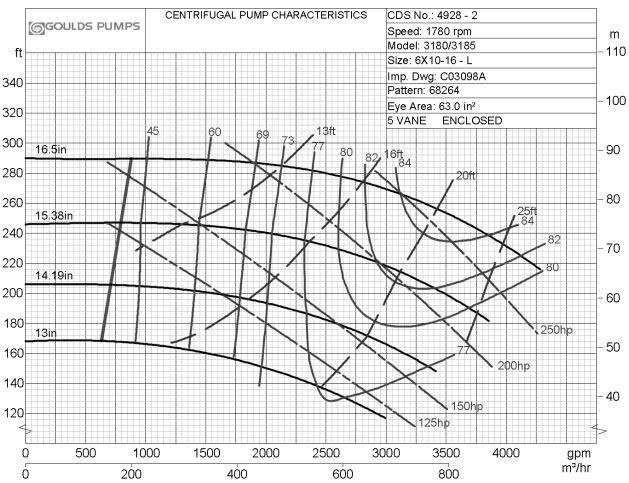
6X8-16 **885rpm**



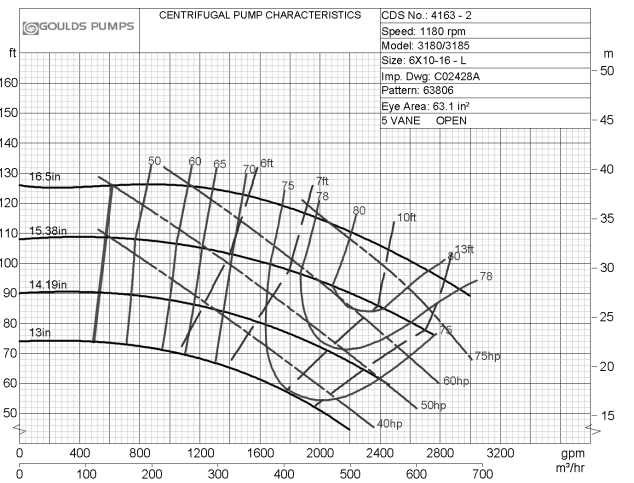
6X8-16 **885rpm**



6X10-16 **1780rpm**



6X10-16 **1780rpm**

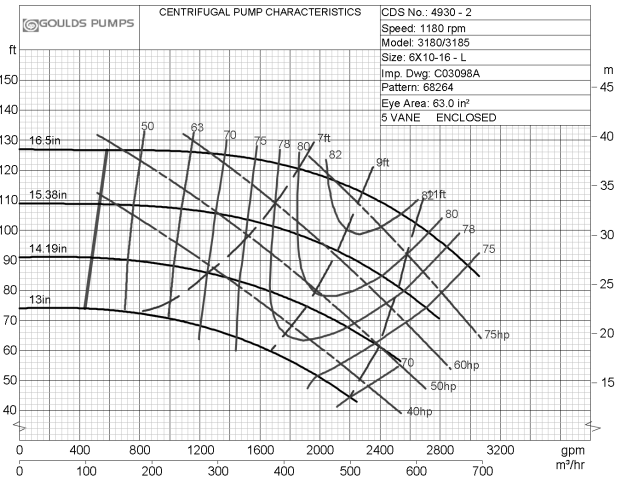


6X10-16 **1180rpm**

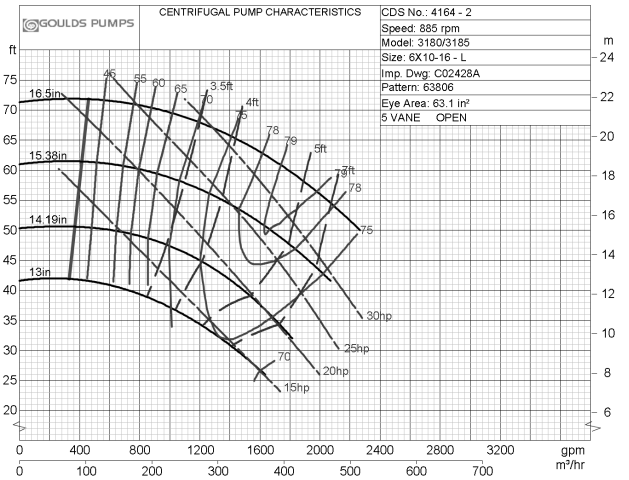
60Hz Curves

Model 3180/3185

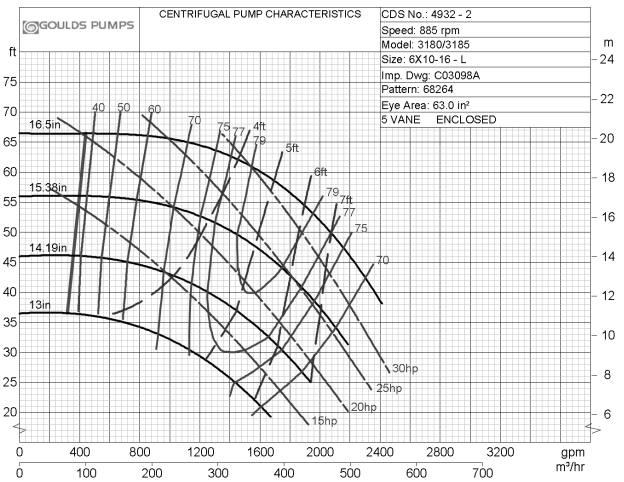
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



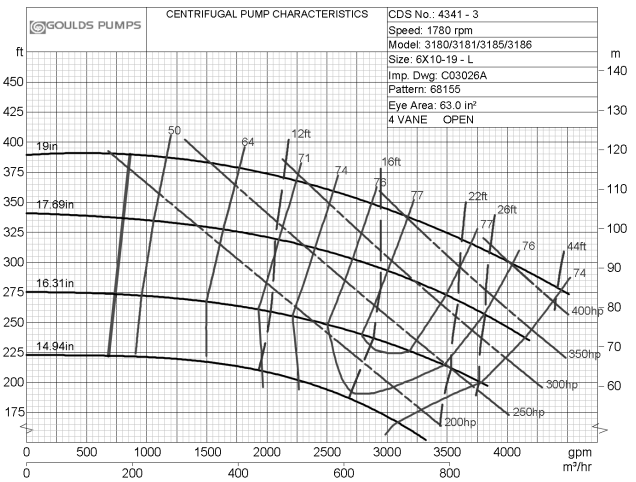
6X10-16 **1180rpm**



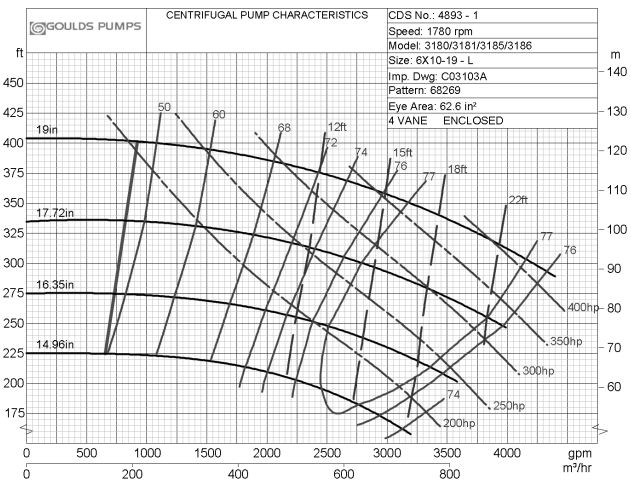
6X10-16 **885rpm**



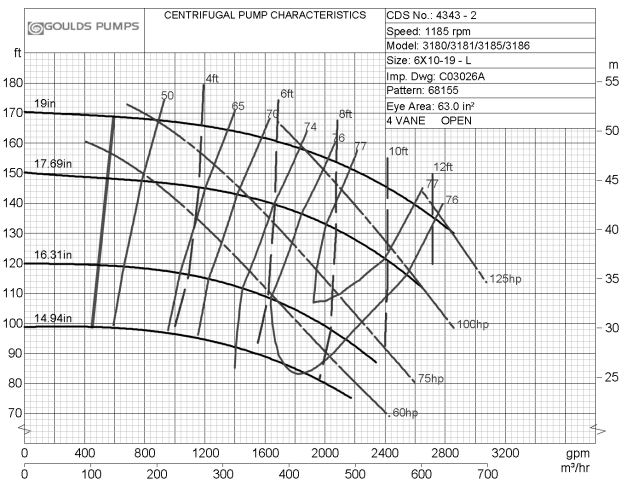
6X10-16 **885rpm**



6X10-19 **1780rpm**

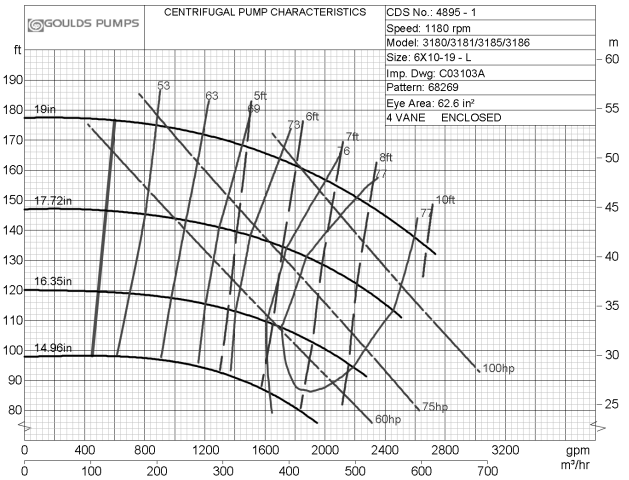


6X10-19 **1780rpm**

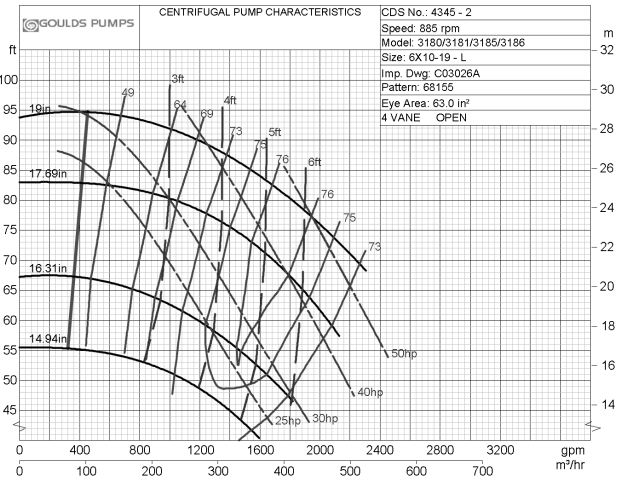


6X10-19 **1185rpm**

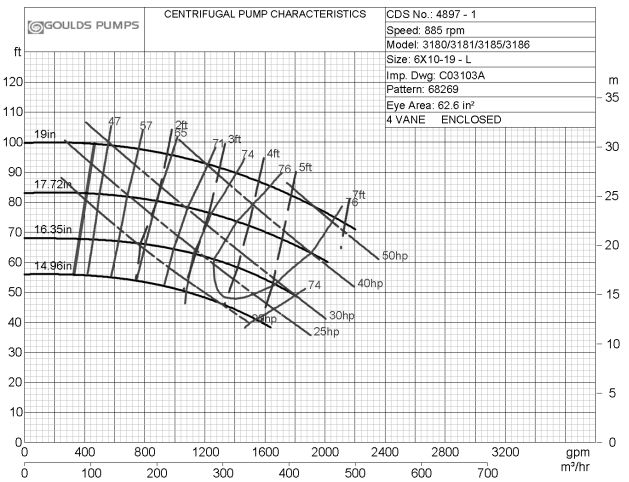
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



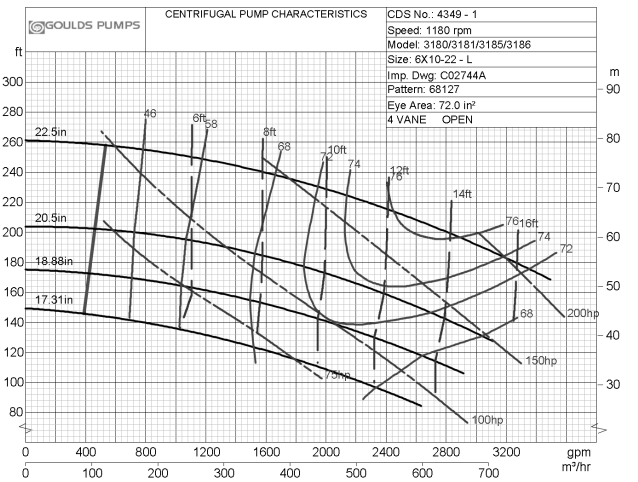
6X10-19 **1180rpm**



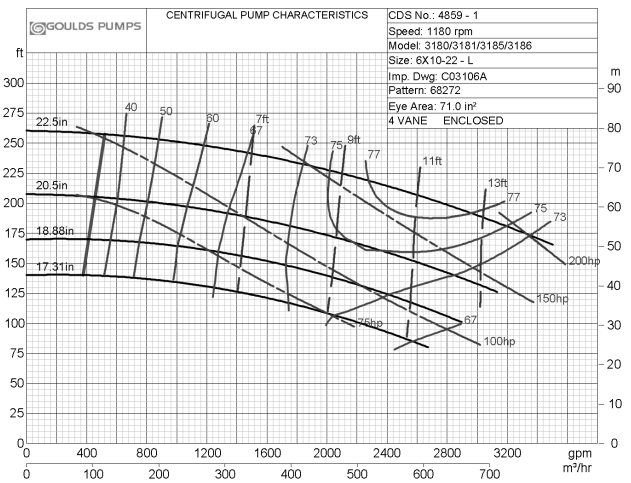
6X10-19 **885rpm**



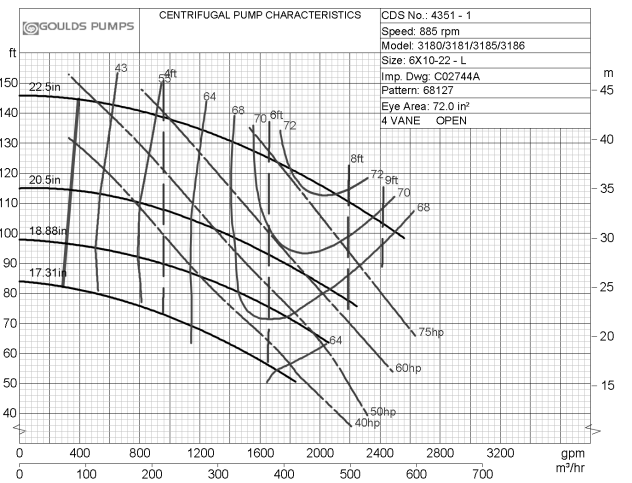
6X10-19 **885rpm**



6X10-22 **1180rpm**

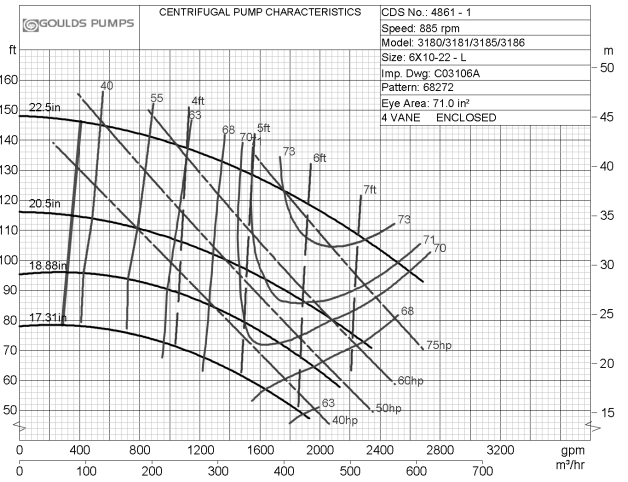


6X10-22 **1180rpm**

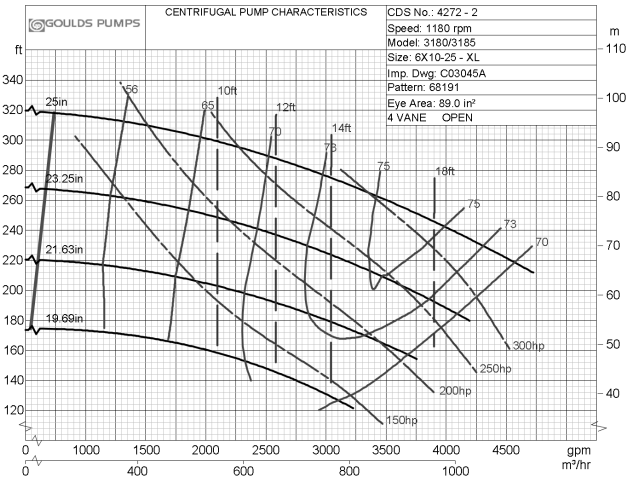


6X10-22 **885rpm**

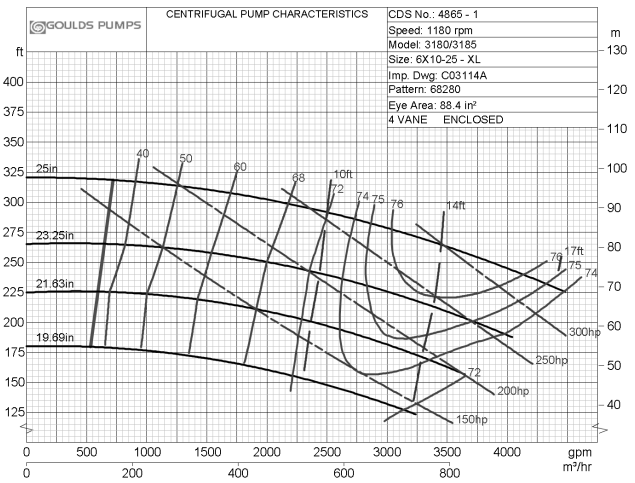
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



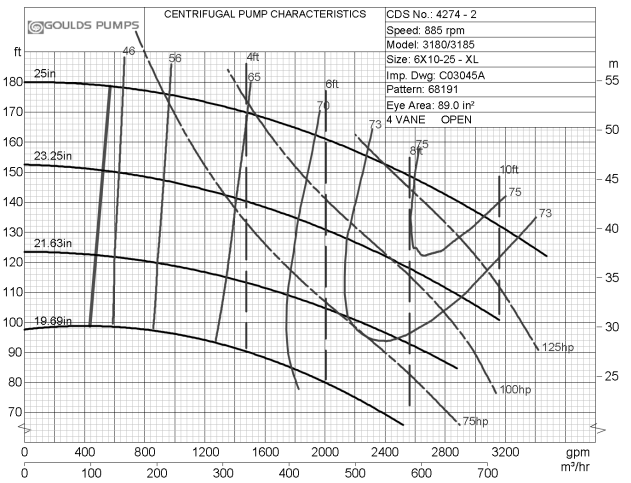
6X10-22 **885rpm**



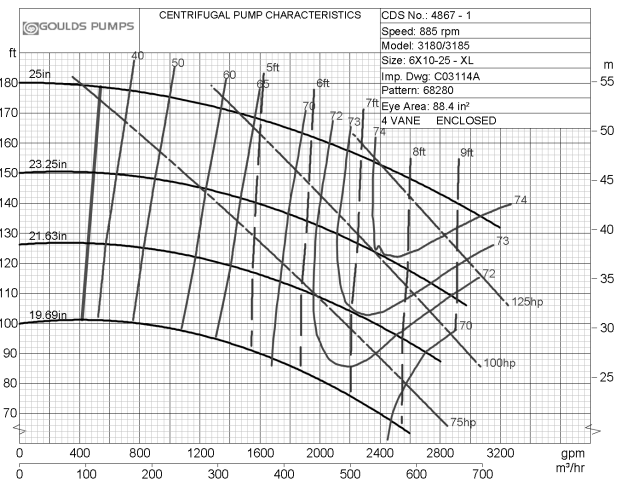
6X10-25 **1180rpm**



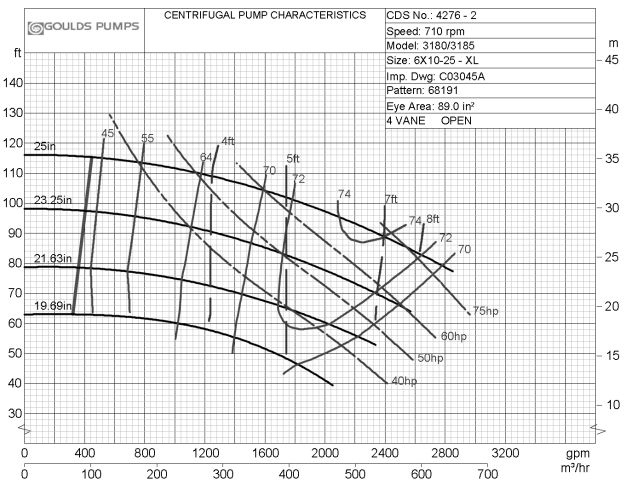
6X10-25 **1180rpm**



6X10-25 **885rpm**

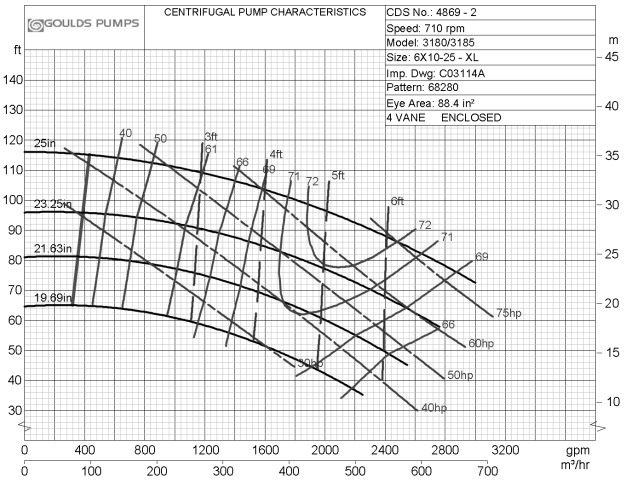


6X10-25 **885rpm**

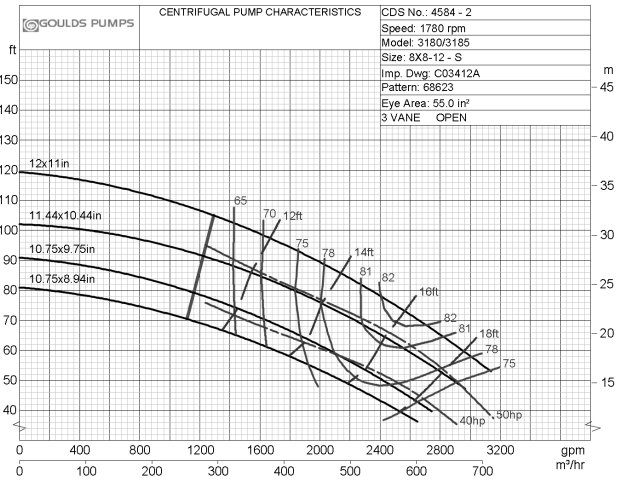


6X10-25 **710rpm**

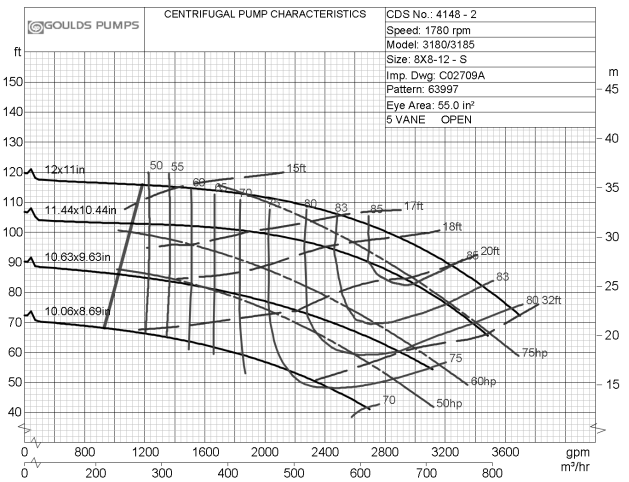
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



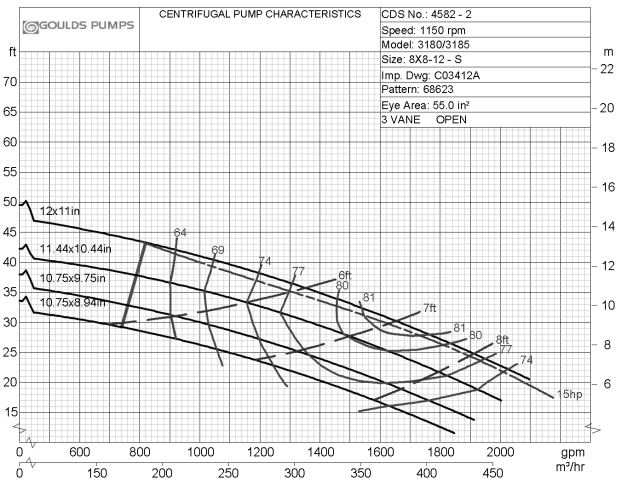
6X10-25 **710rpm**



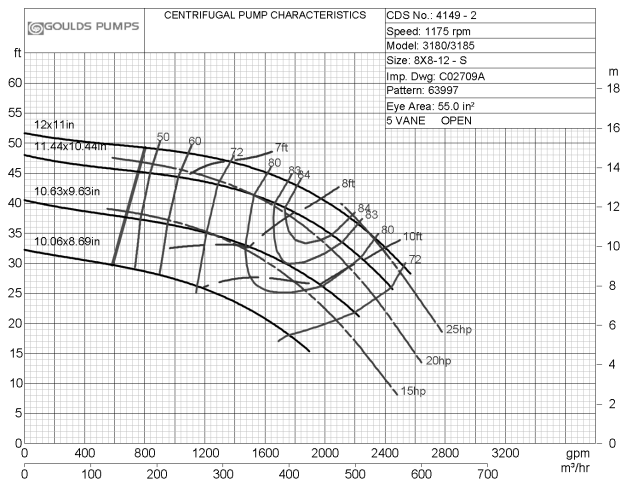
8X8-12 **1780rpm**



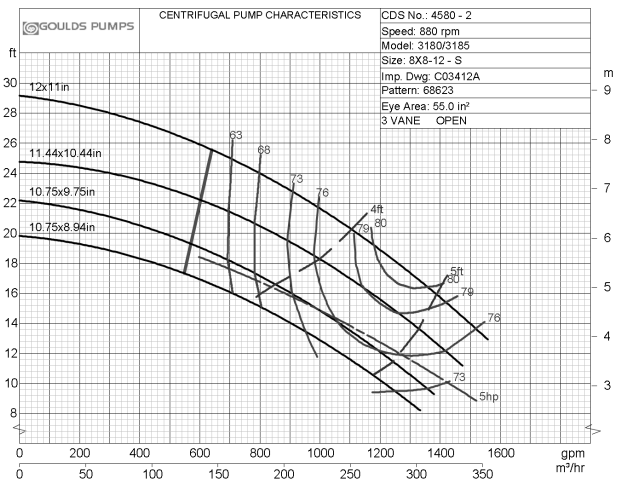
8X8-12 **1780rpm**



8X8-12 **1150rpm**

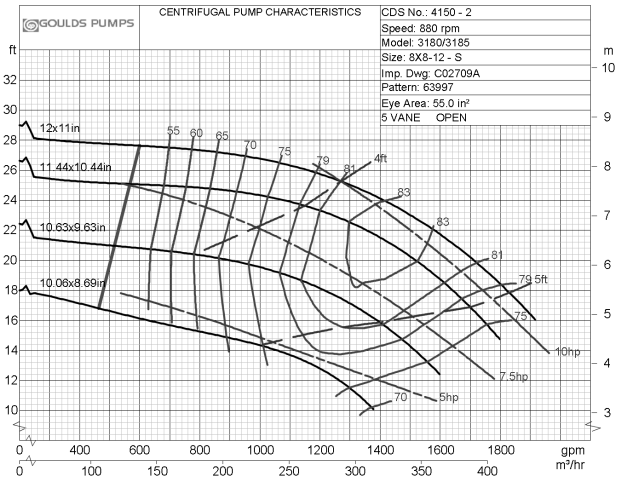


8X8-12 **1175rpm**

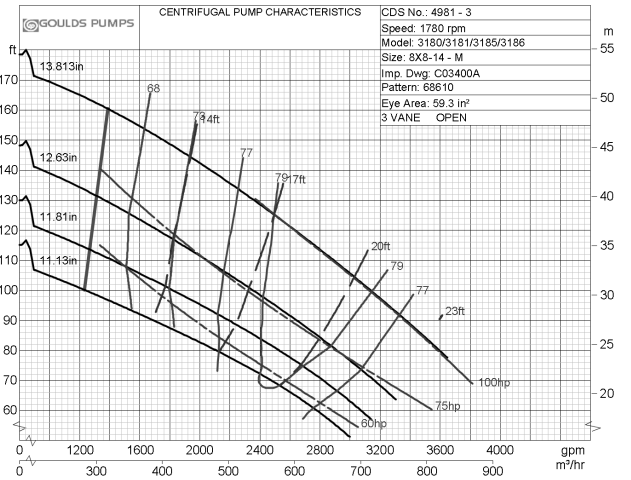


8X8-12 **880rpm**

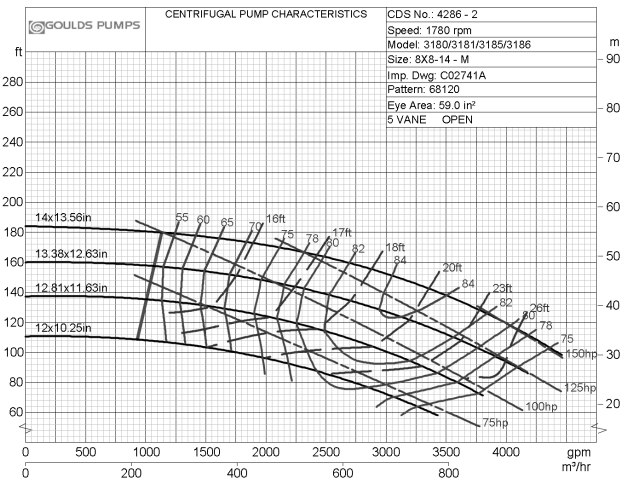
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



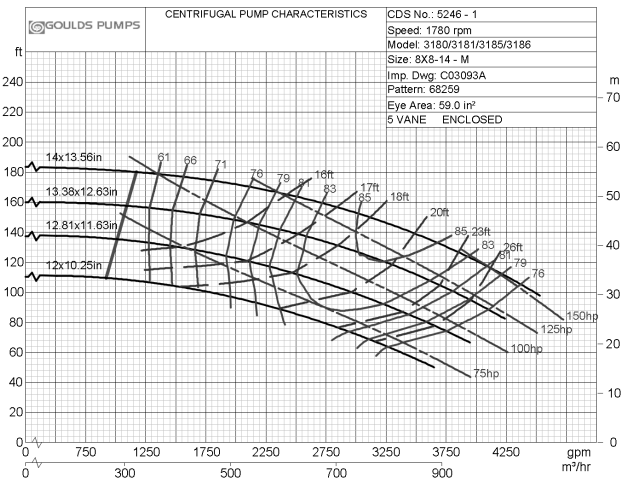
8X8-12 **880rpm**



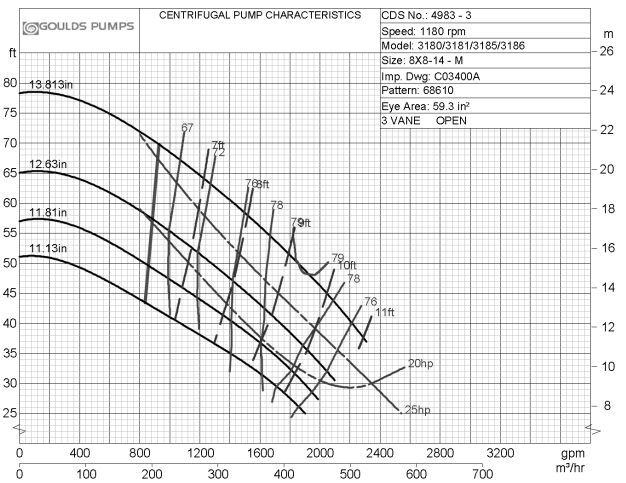
8X8-14 **1780rpm**



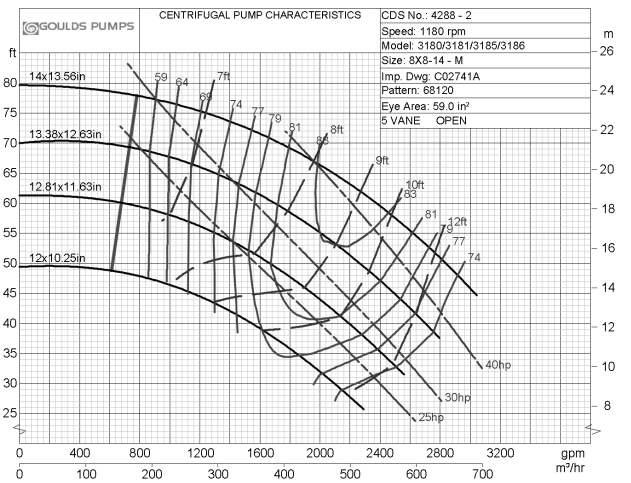
8X8-14 **1780rpm**



8X8-14 **1780rpm**



8X8-14 **1180rpm**



8X8-14 **1180rpm**

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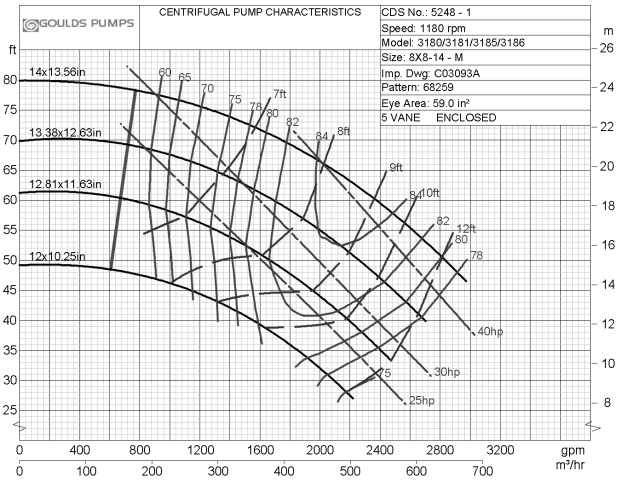
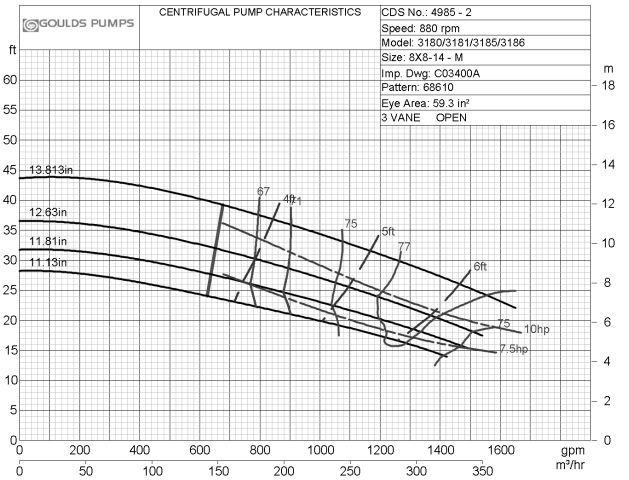
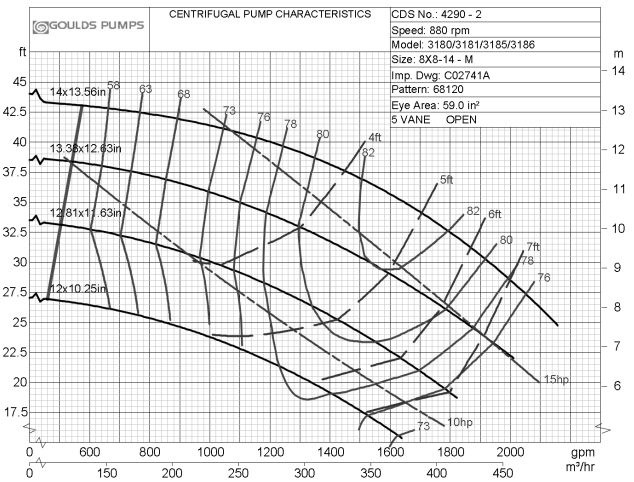


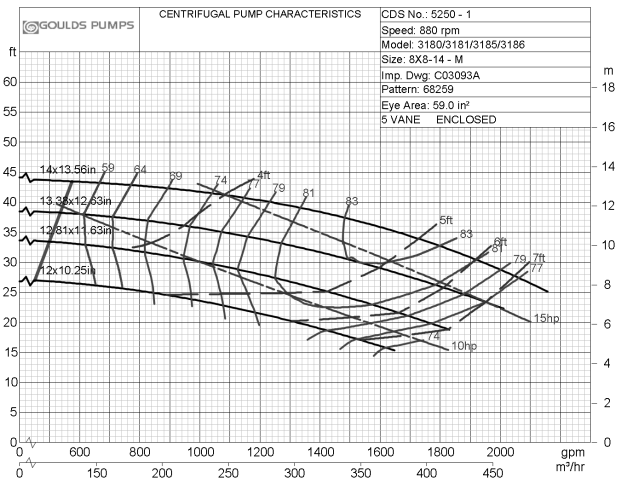
8X8-14 **1180rpm**



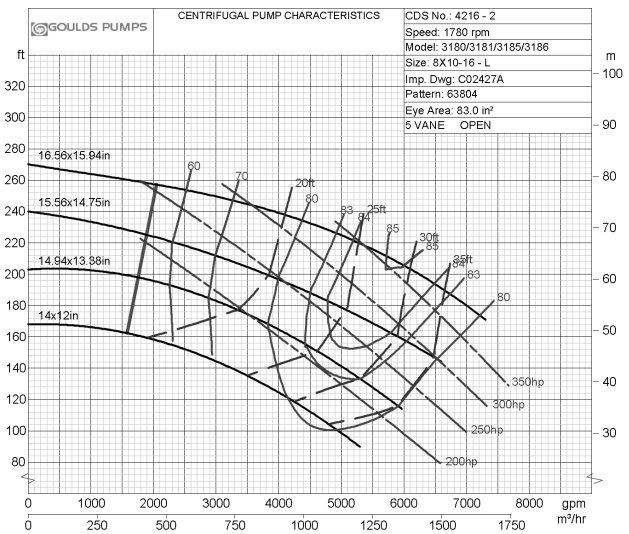
8X8-14 **880rpm**



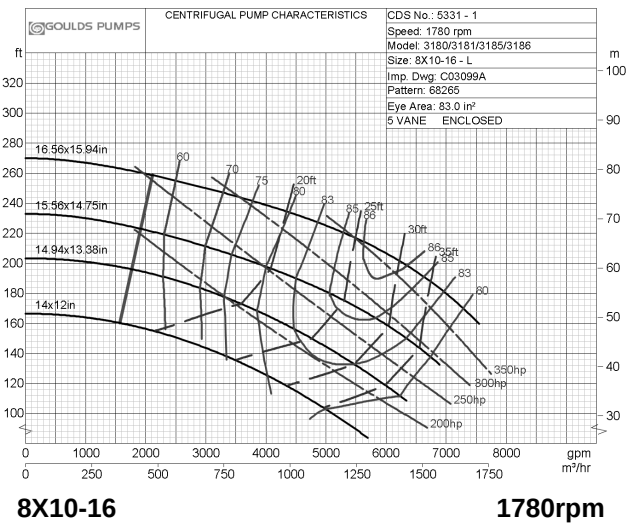
8X8-14 **880rpm**



8X8-14 **880rpm**



8X10-16 **1780rpm**

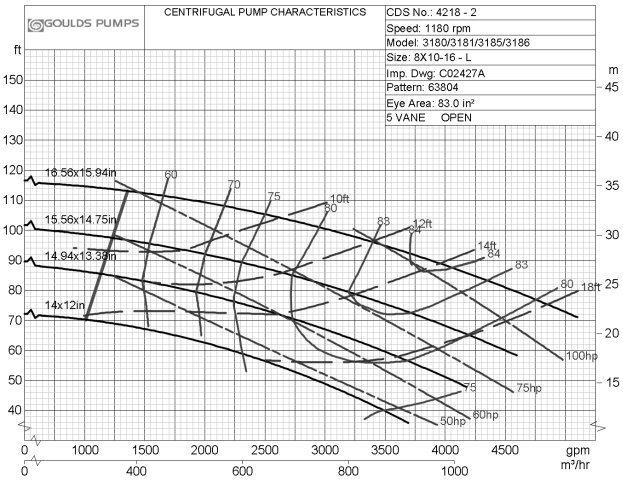


8X10-16 **1780rpm**

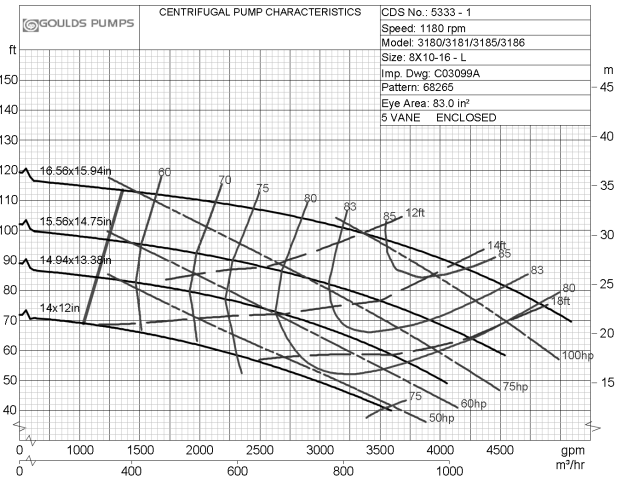
60Hz Curves

Model 3180/3185

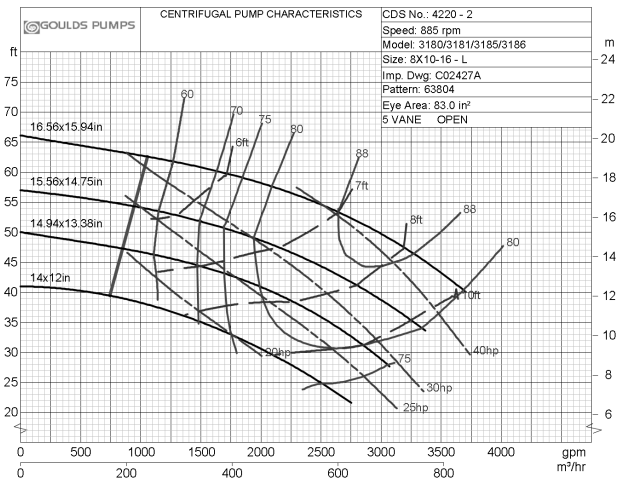
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



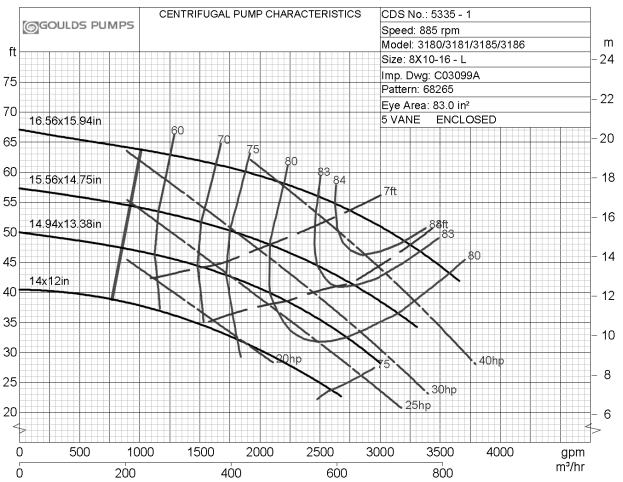
8X10-16 **1180rpm**



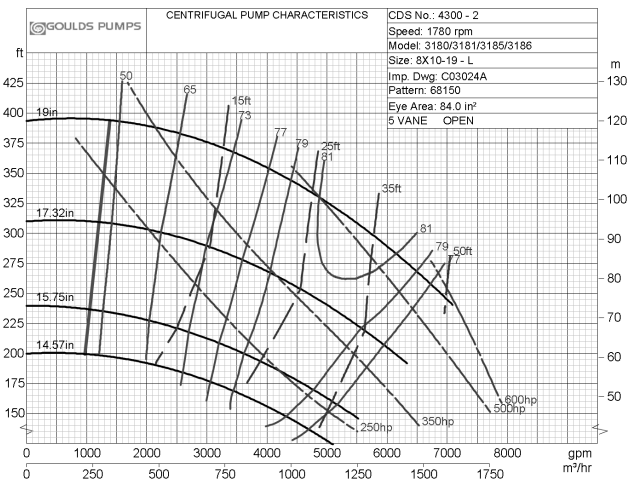
8X10-16 **1180rpm**



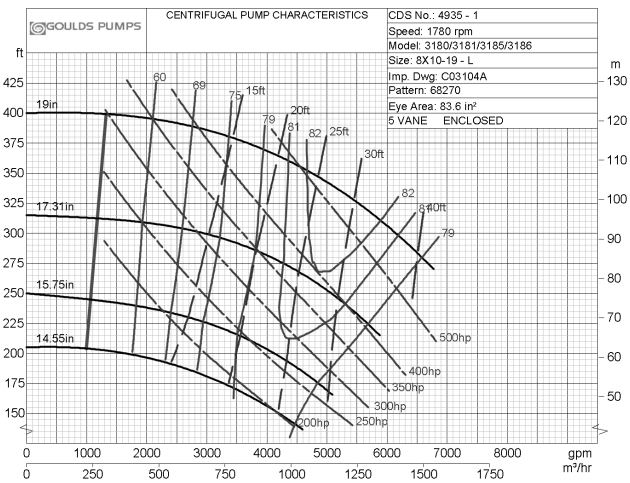
8X10-16 **885rpm**



8X10-16 **885rpm**



8X10-19 **1780rpm**



8X10-19 **1780rpm**

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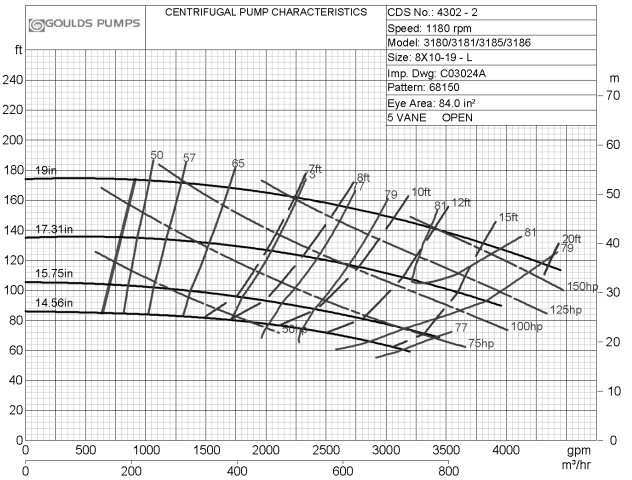
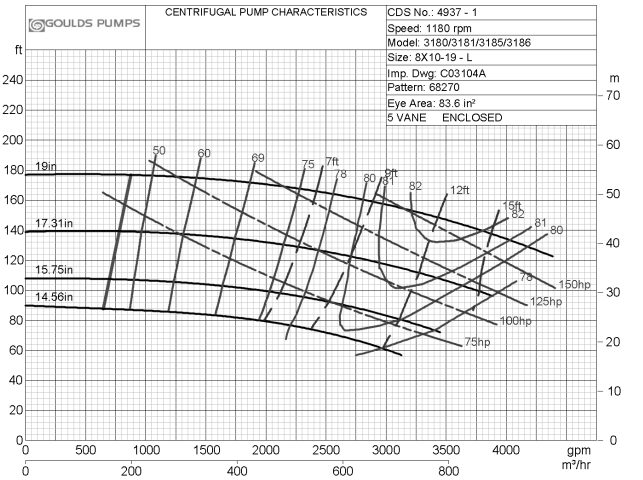
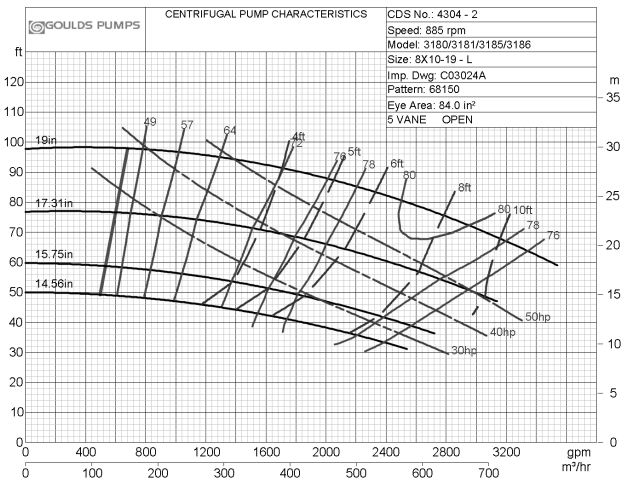


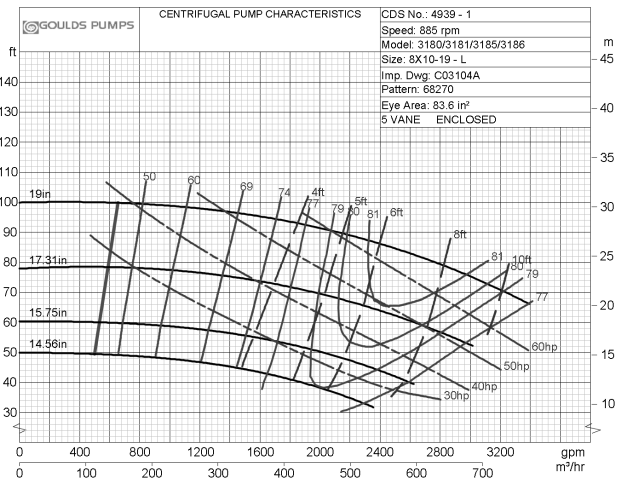
8X10-19 **1180rpm**



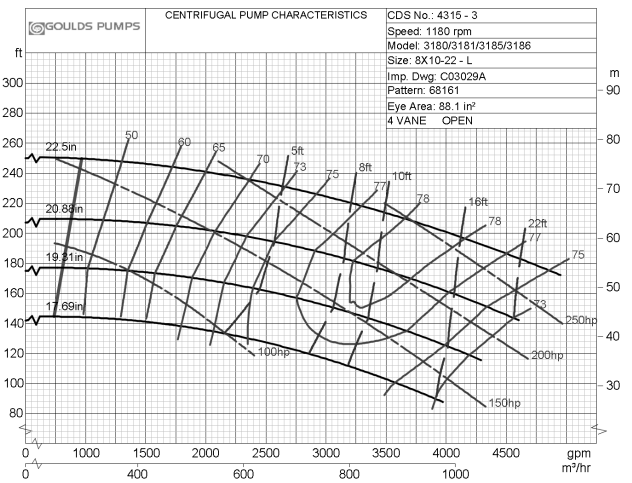
8X10-19 **1180rpm**



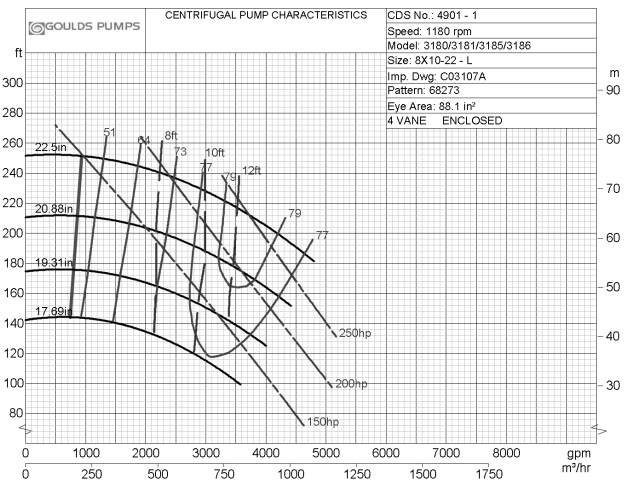
8X10-19 **885rpm**



8X10-19 **885rpm**



8X10-22 **1180rpm**



8X10-22 **1180rpm**

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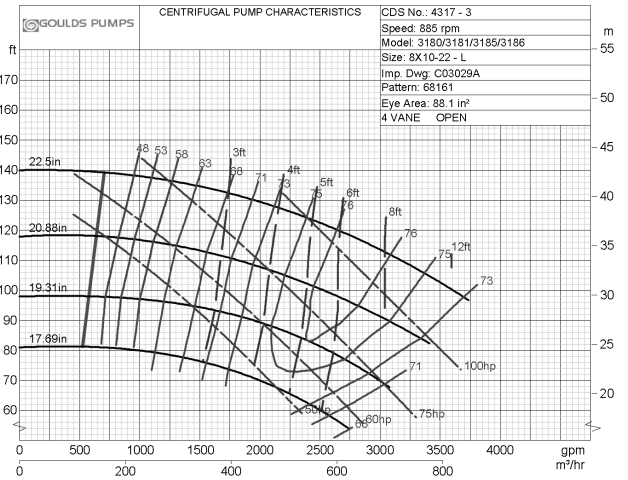
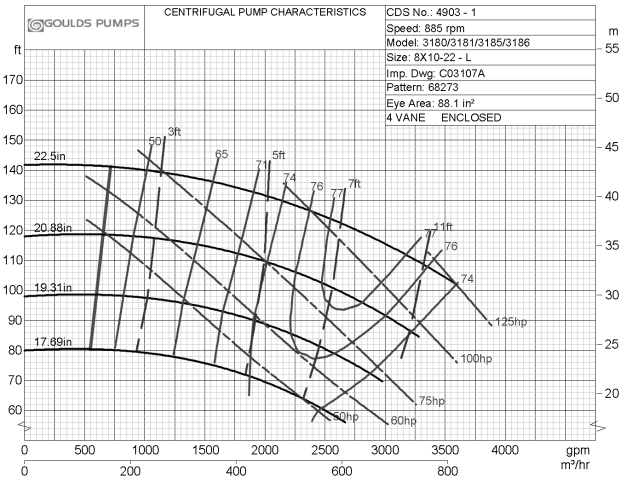
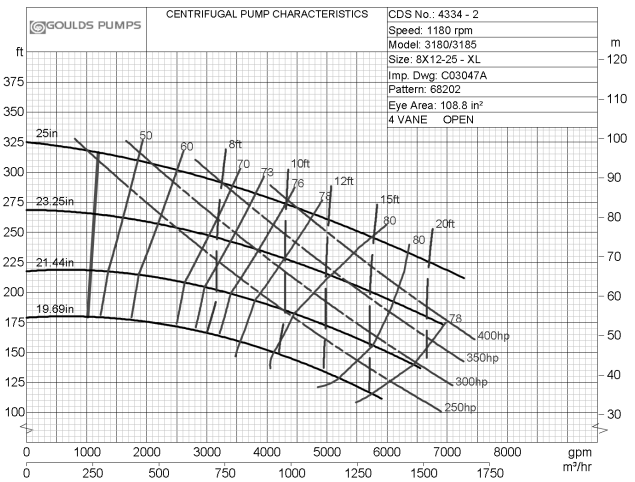


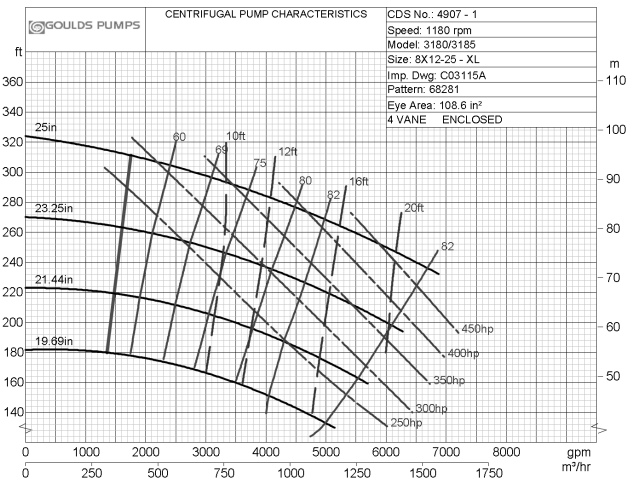
8X10-22 **885rpm**



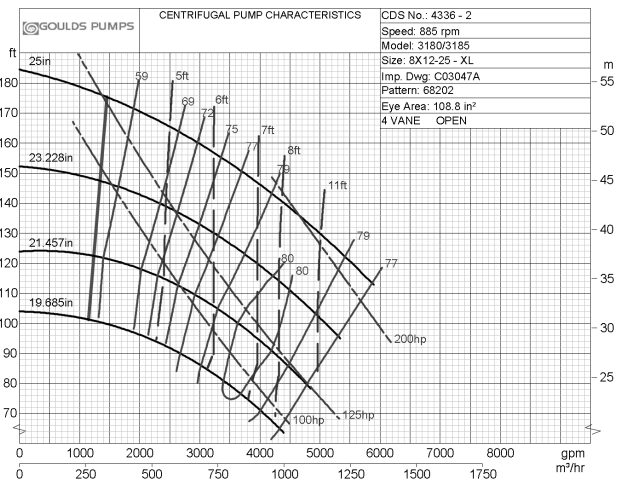
8X10-22 **885rpm**



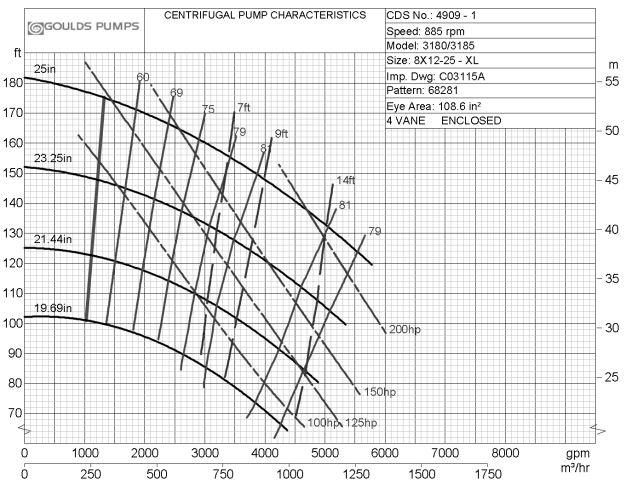
8X12-25 **1180rpm**



8X12-25 **1180rpm**



8X12-25 **885rpm**



8X12-25 **885rpm**

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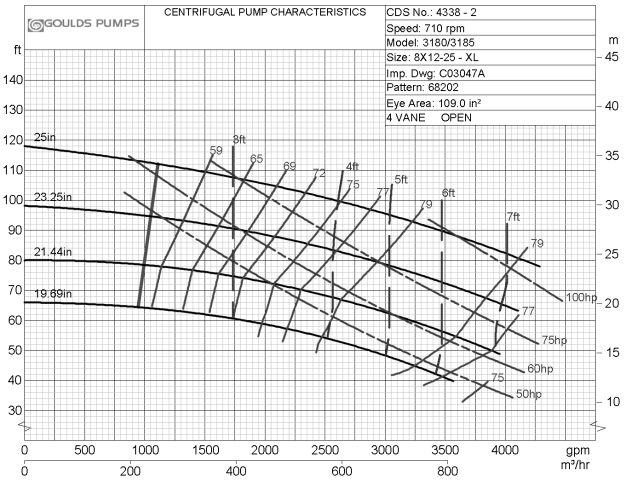
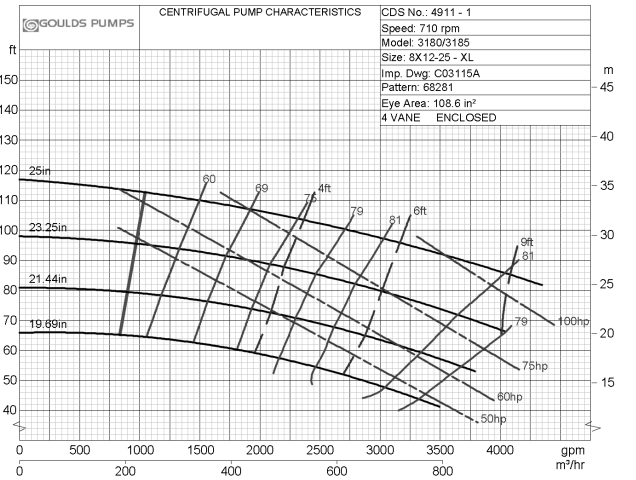
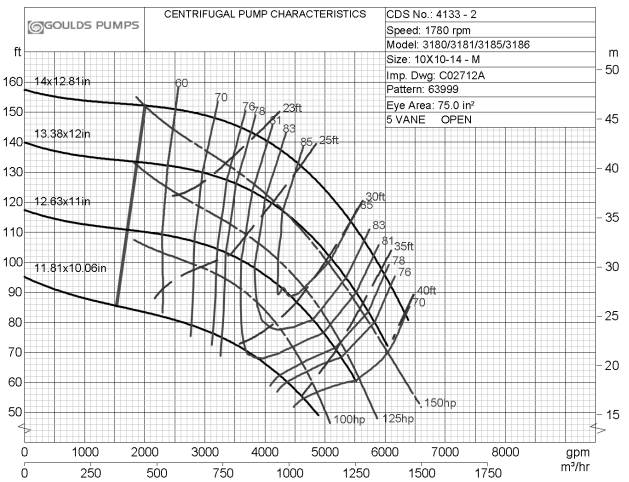


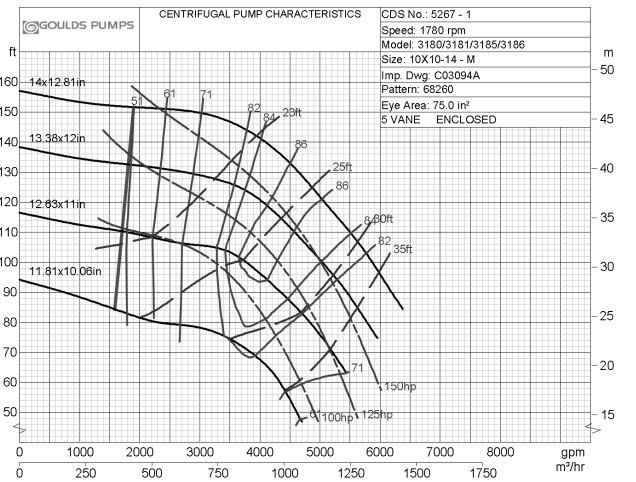
8X12-25 **710rpm**



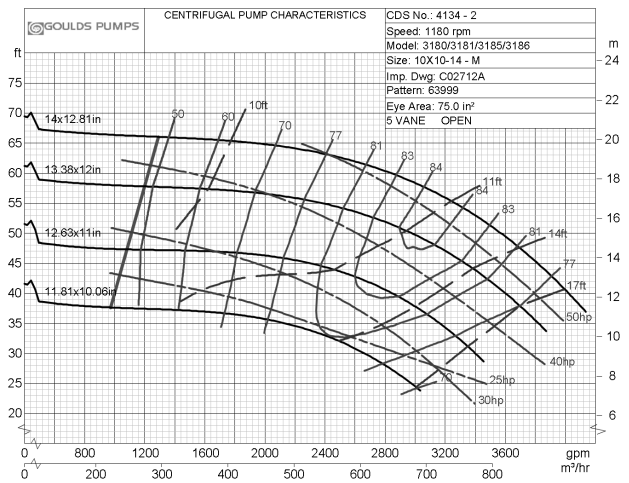
8X12-25 **710rpm**



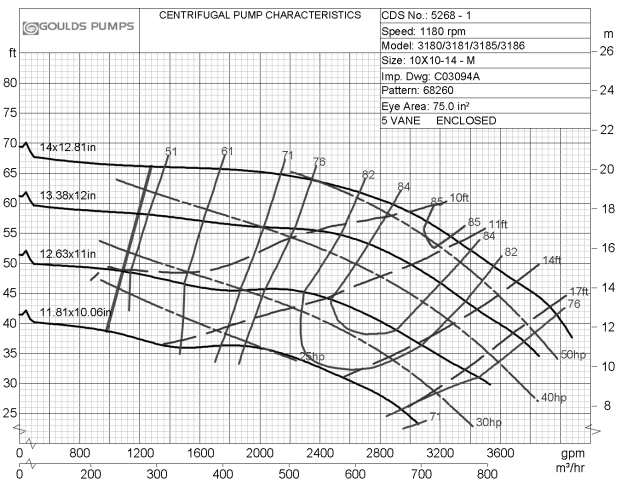
10X10-14 **1780rpm**



10X10-14 **1780rpm**



10X10-14 **1180rpm**



10X10-14 **1180rpm**

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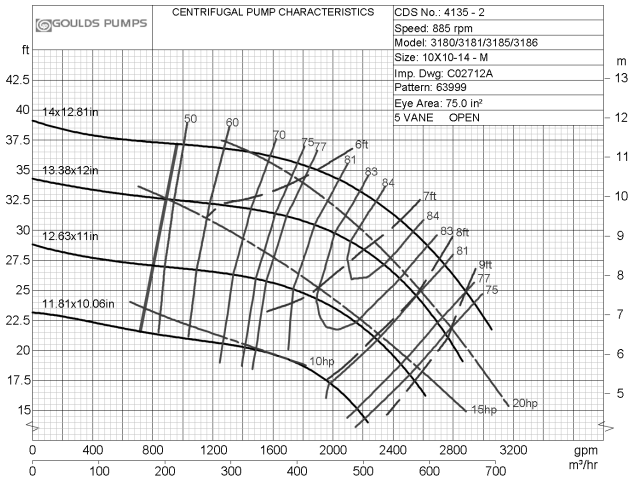
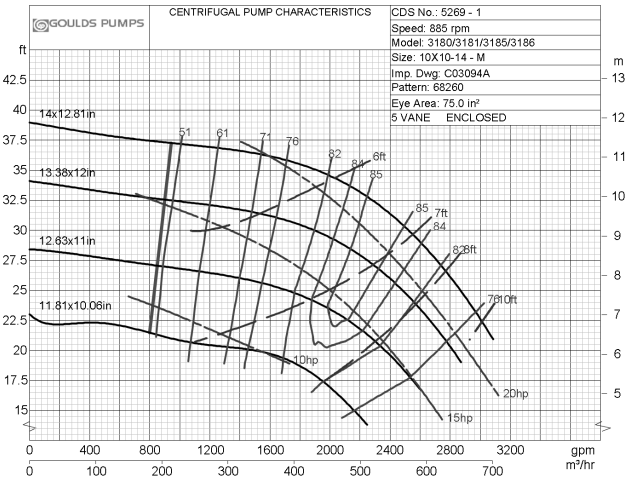
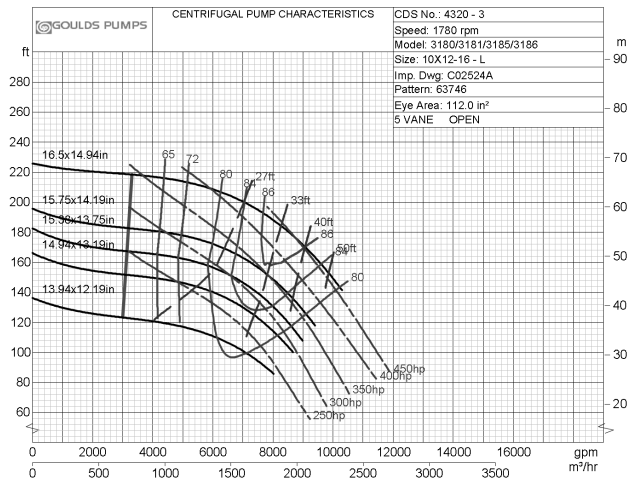


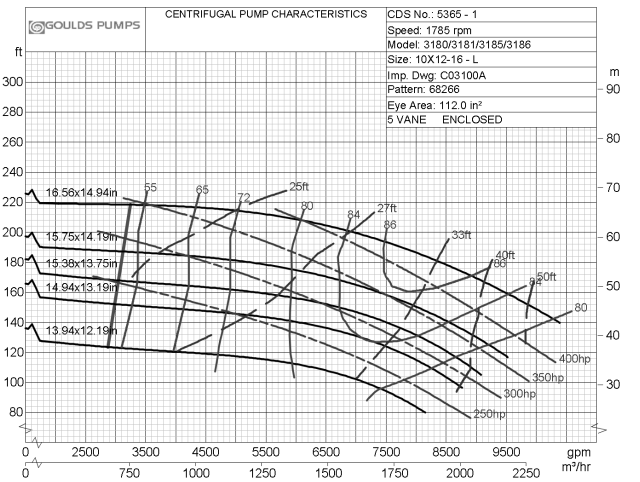
10X10-14 **885rpm**



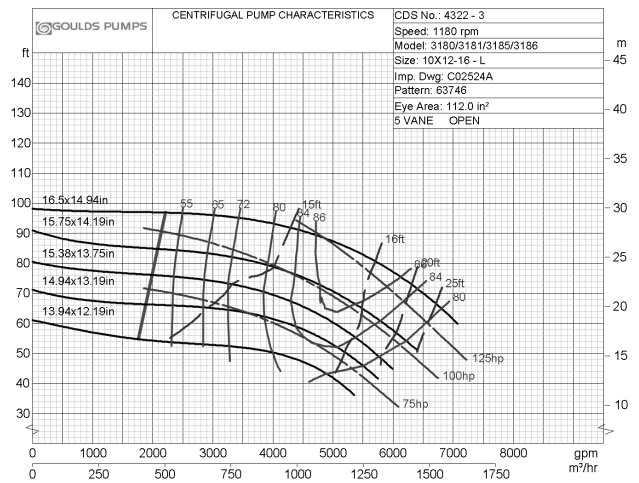
10X10-14 **885rpm**



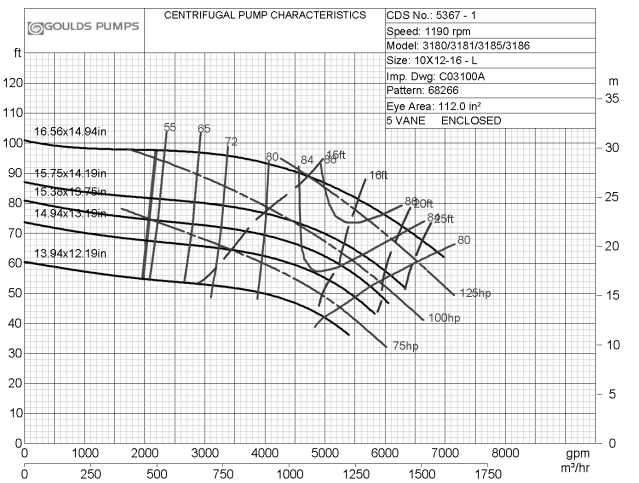
10X12-16 **1780rpm**



10X12-16 **1785rpm**

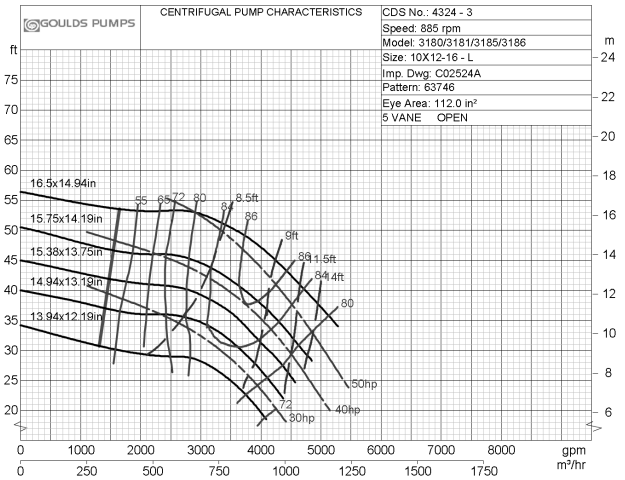


10X12-16 **1180rpm**

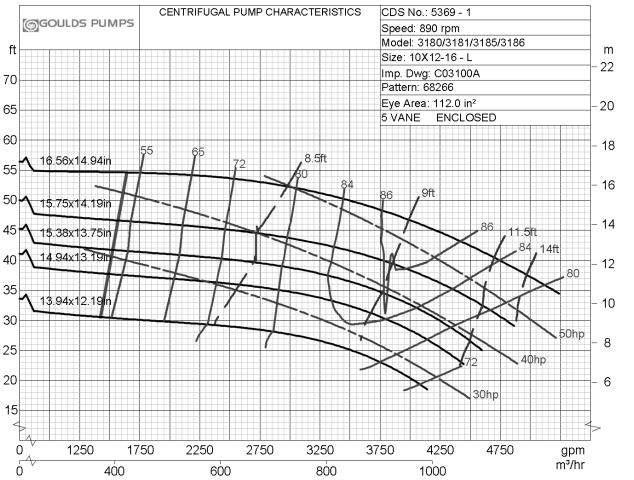


10X12-16 **1190rpm**

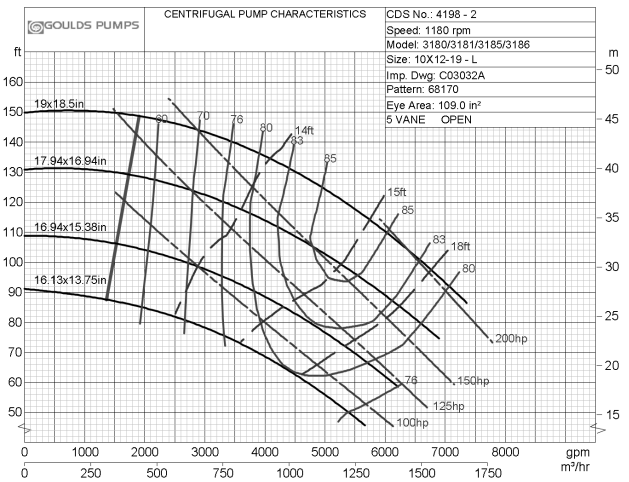
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



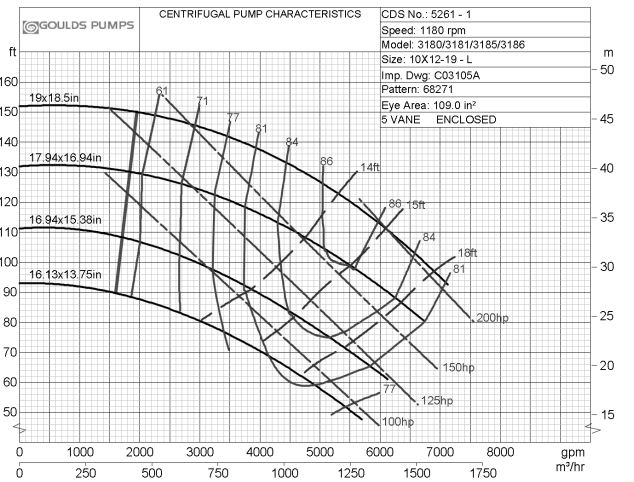
10X12-16 **885rpm**



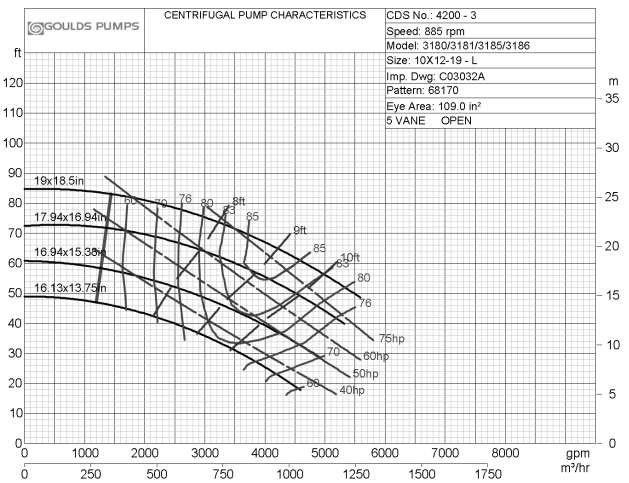
10X12-16 **890rpm**



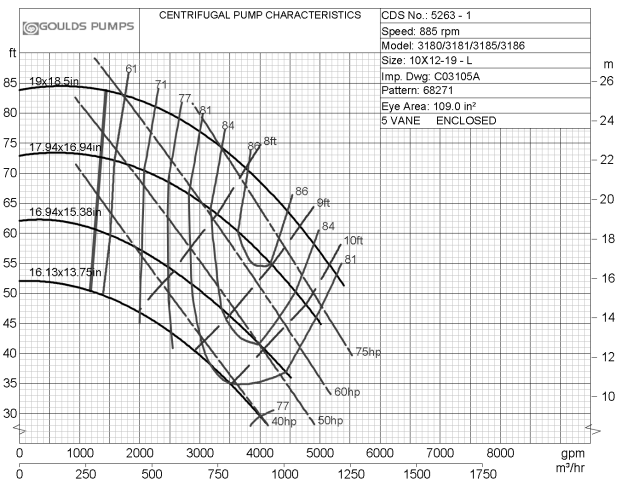
10X12-19 **1180rpm**



10X12-19 **1180rpm**



10X12-19 **885rpm**

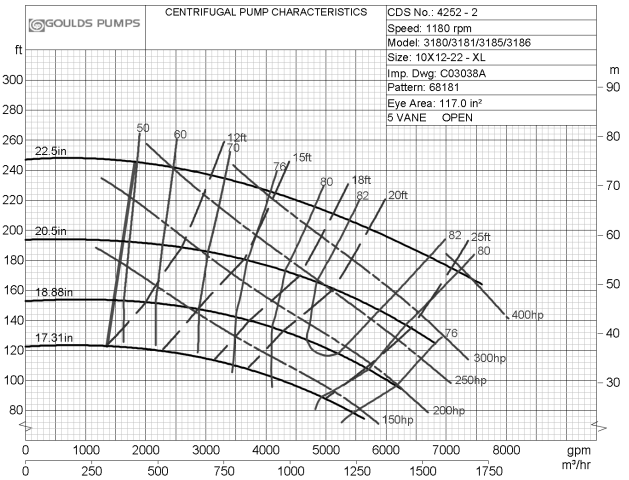


10X12-19 **885rpm**

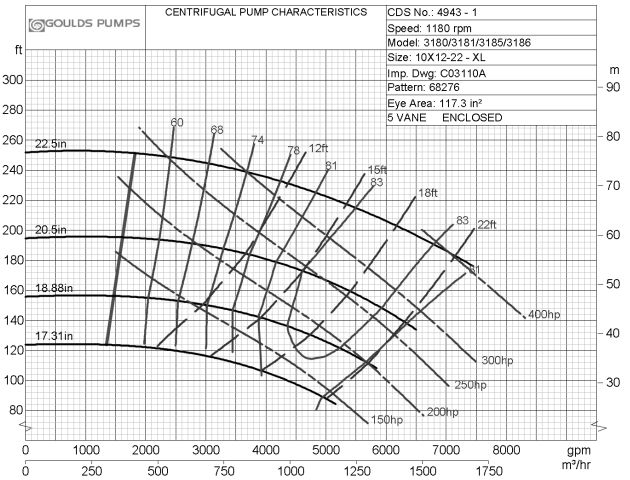
60Hz Curves

Model 3180/3185

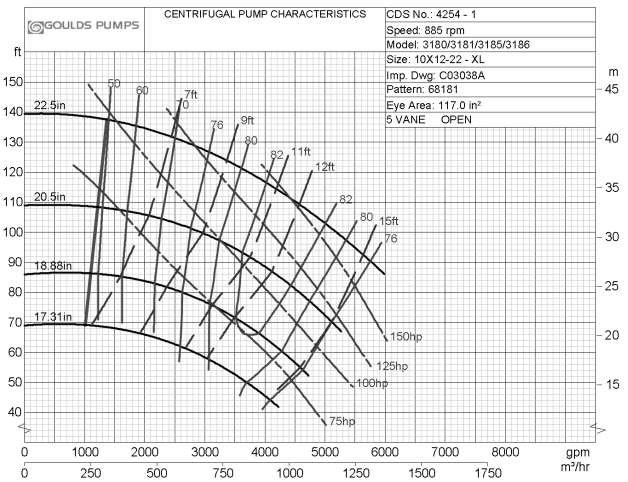
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



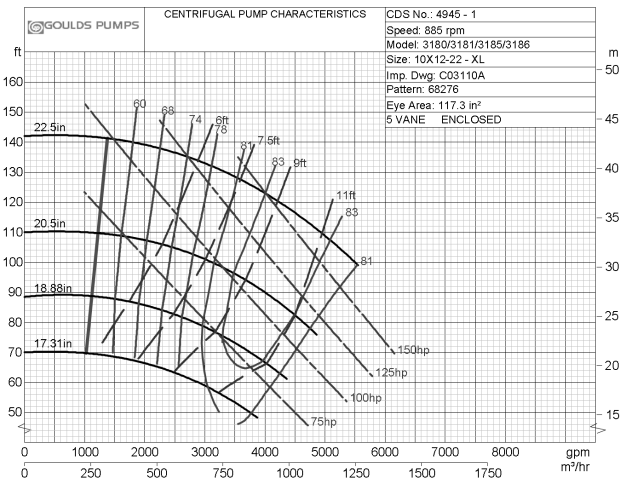
10X12-22 **1180rpm**



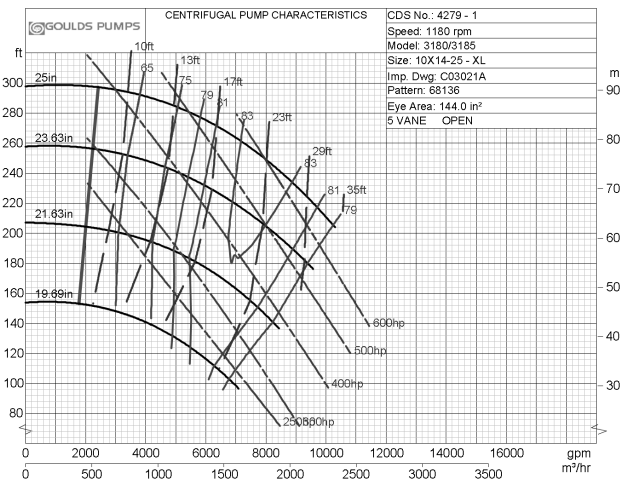
10X12-22 **1180rpm**



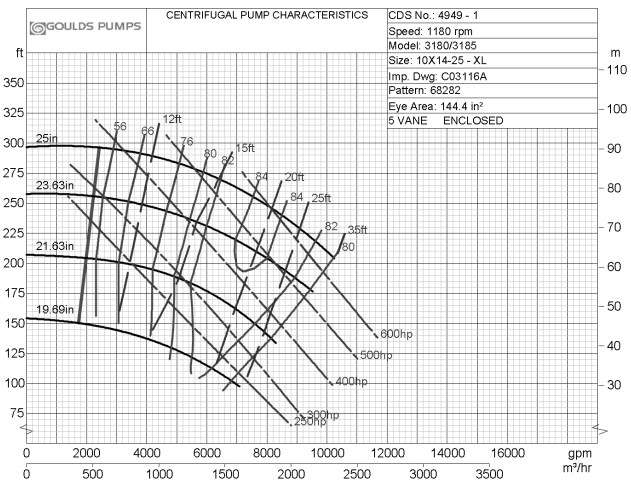
10X12-22 **885rpm**



10X12-22 **885rpm**



10X14-25 **1180rpm**



10X14-25 **1180rpm**

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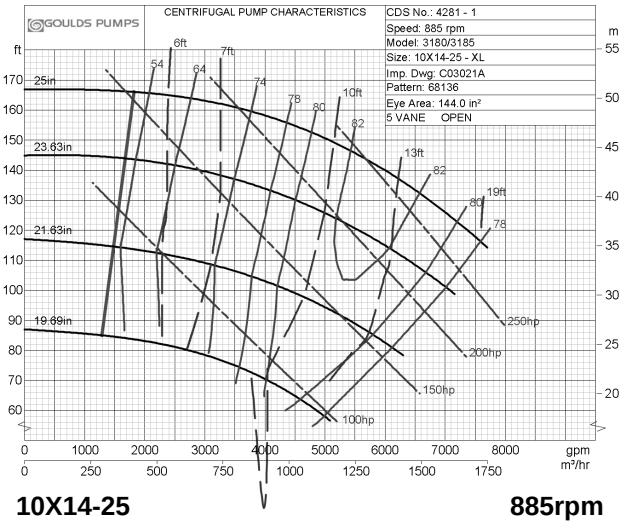
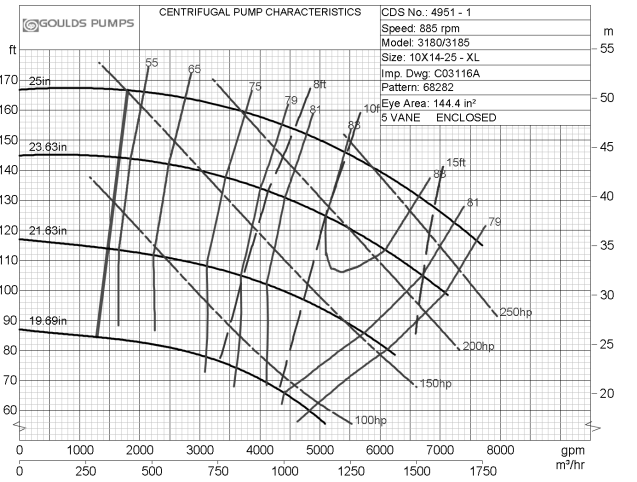
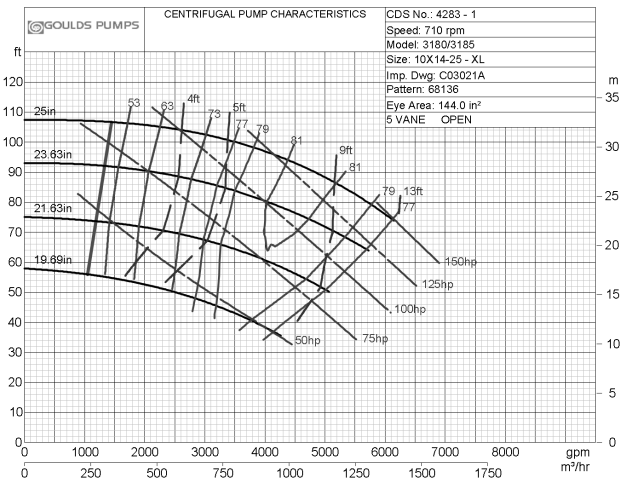


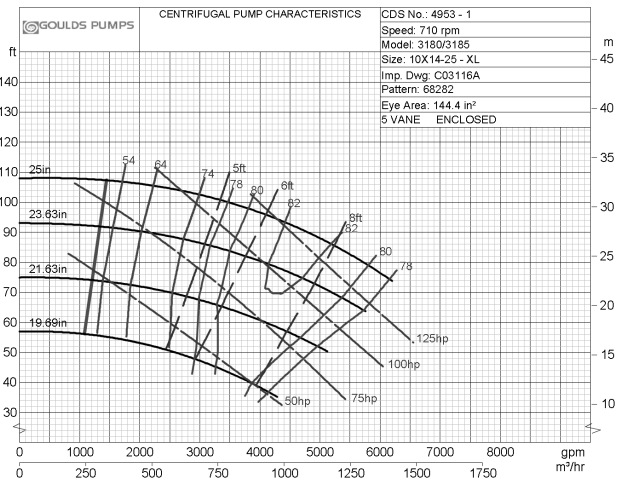
10X14-25 **885rpm**



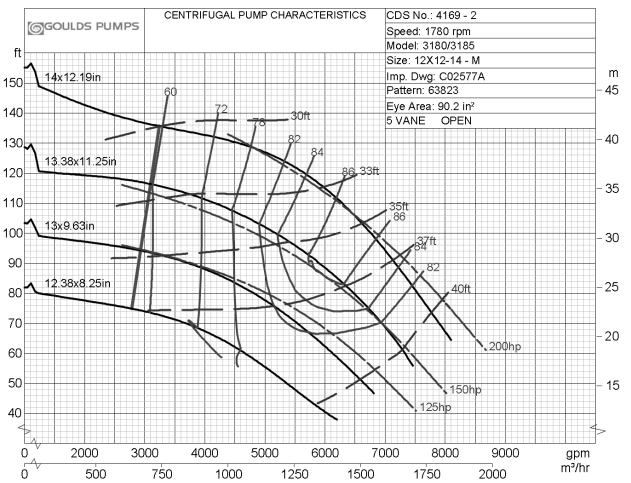
10X14-25 **885rpm**



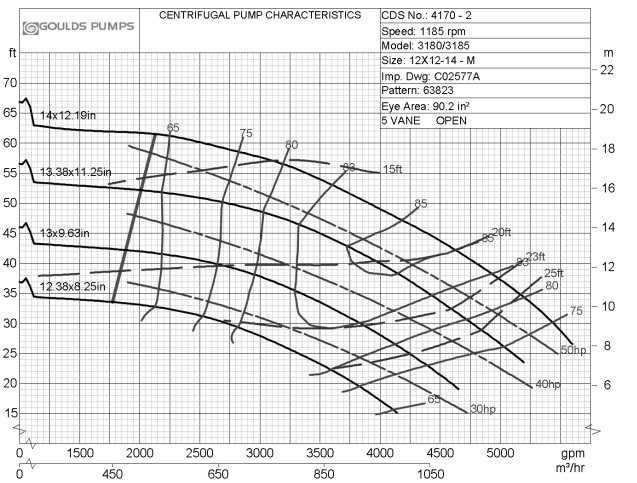
10X14-25 **710rpm**



10X14-25 **710rpm**



12X12-14 **1780rpm**



12X12-14 **1185rpm**

60Hz Curves

Model 3180/3185

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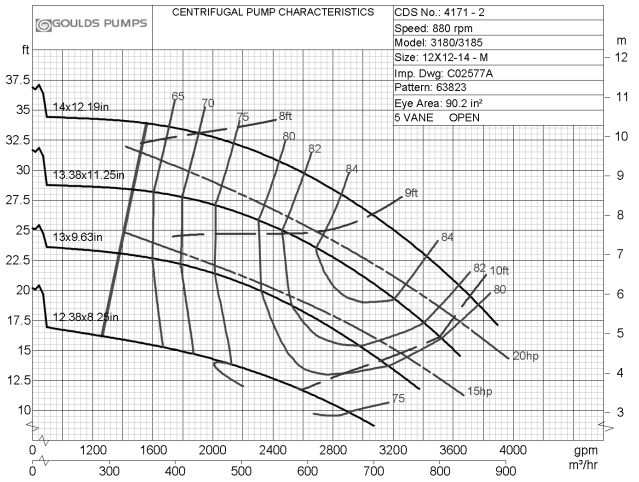
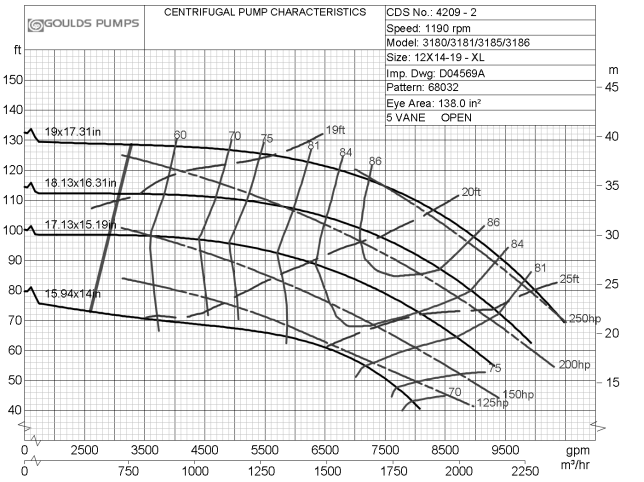
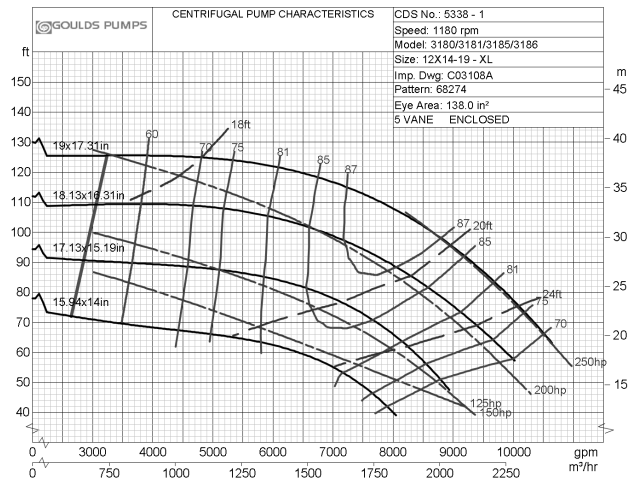


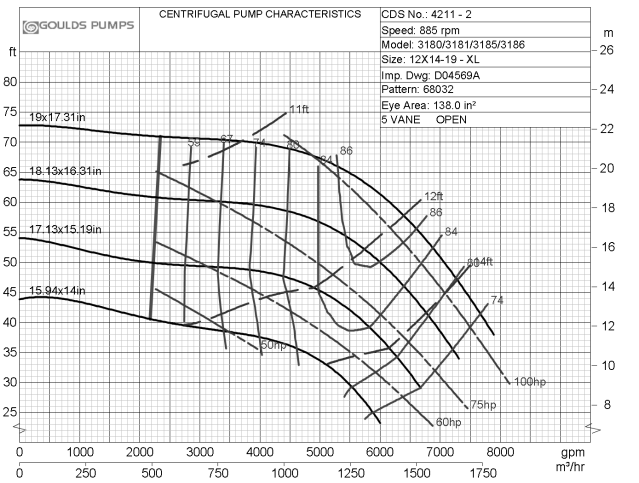
12X12-14 **880rpm**



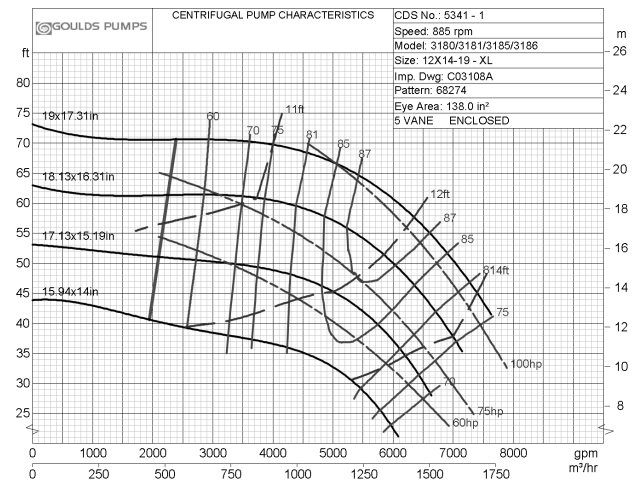
12X14-19 **1190rpm**



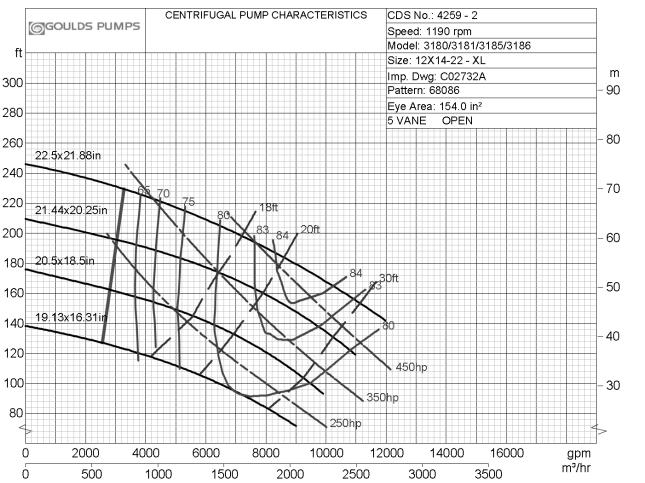
12X14-19 **1180rpm**



12X14-19 **885rpm**



12X14-19 **885rpm**



12X14-22 **1190rpm**

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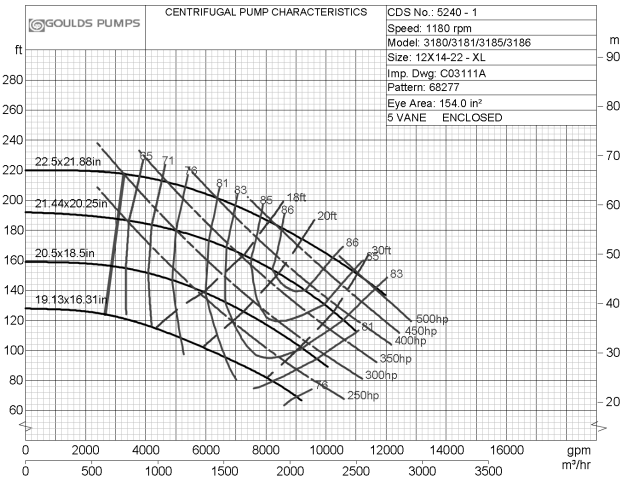
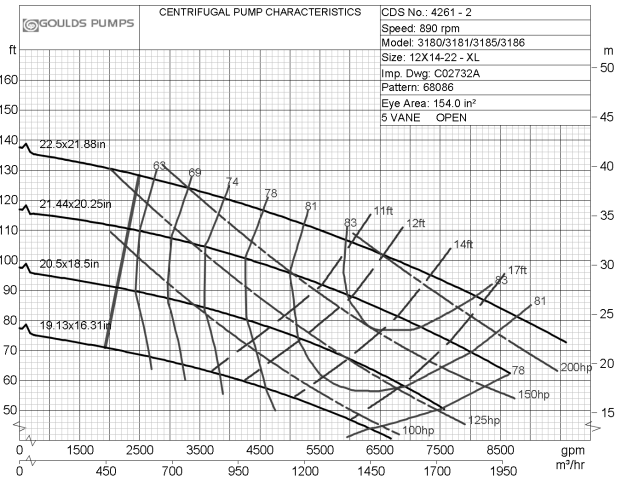
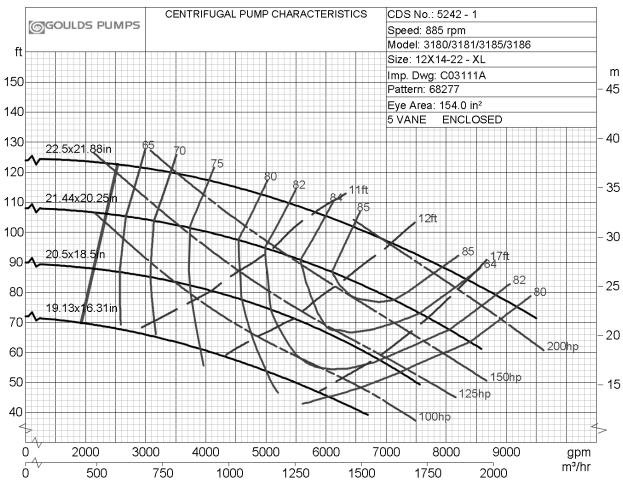


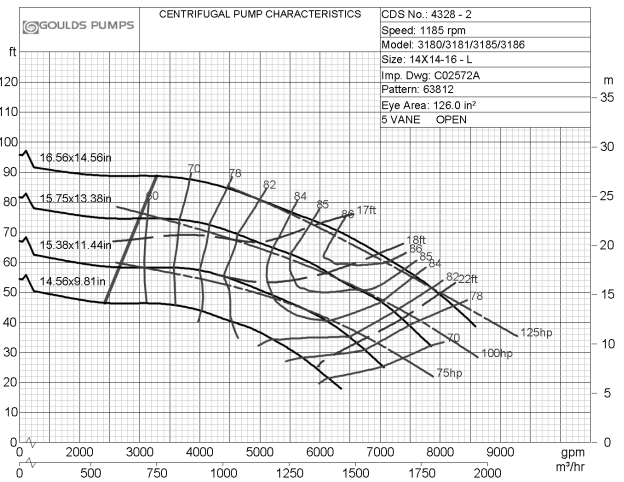
12X14-22 **1180rpm**



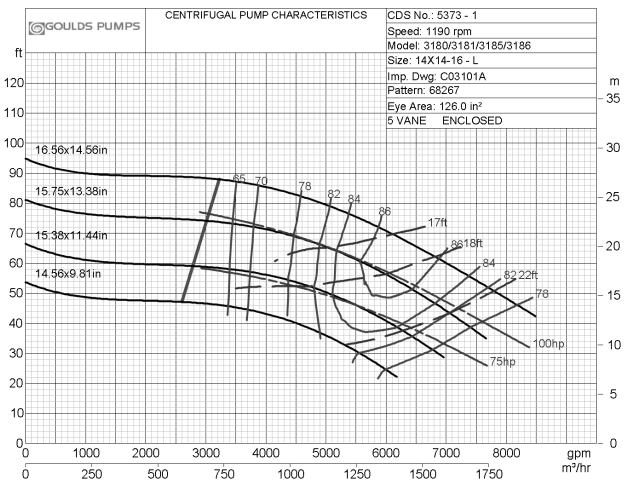
12X14-22 **890rpm**



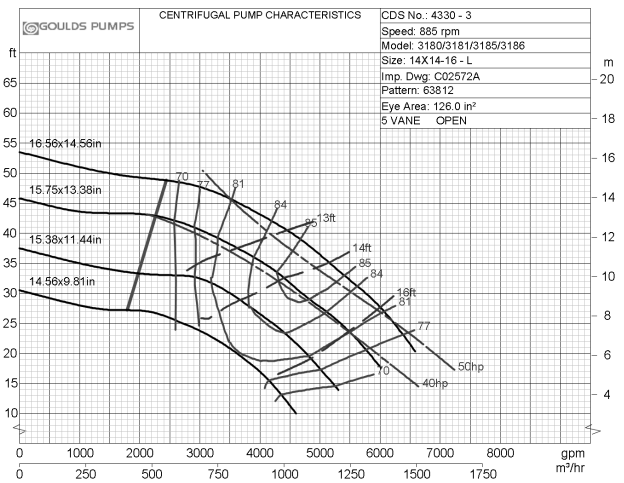
12X14-22 **885rpm**



14X14-16 **1185rpm**

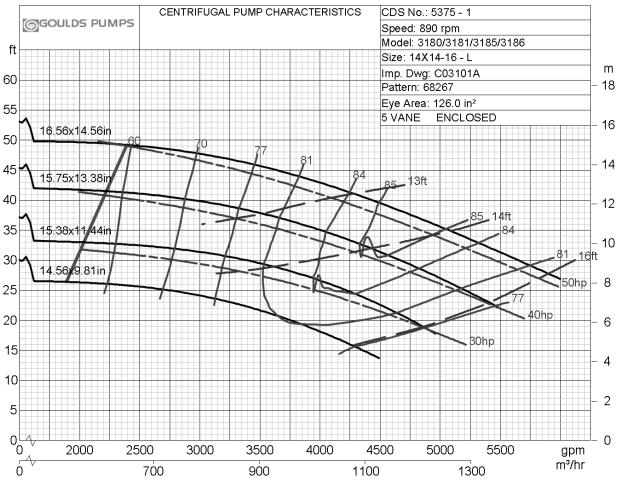


14X14-16 **1190rpm**

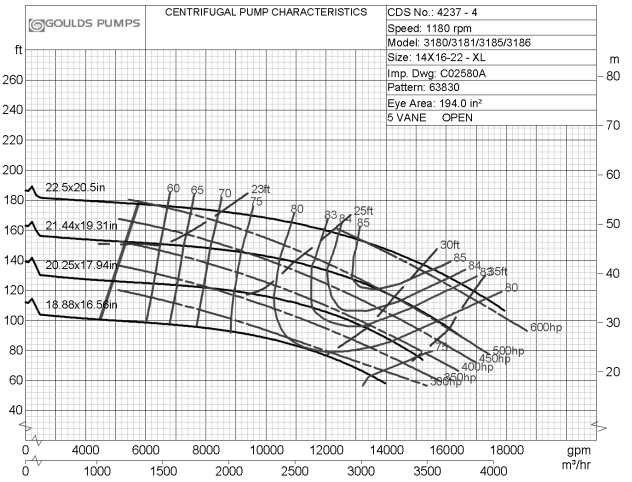


14X14-16 **885rpm**

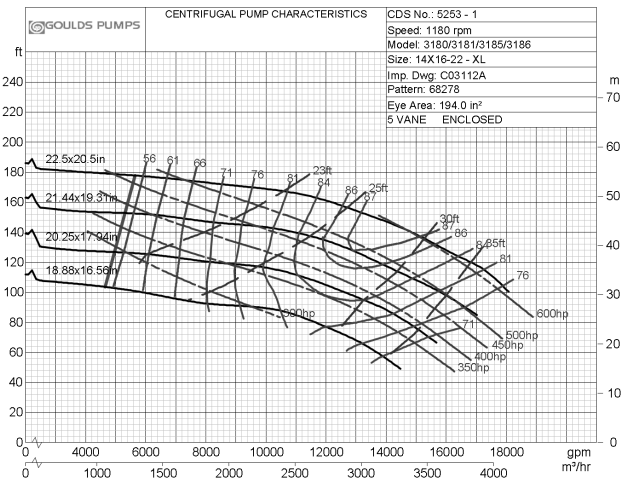
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



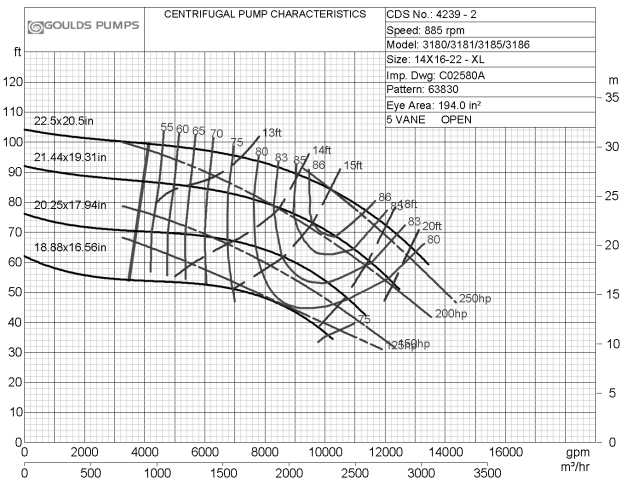
14X14-16 **890rpm**



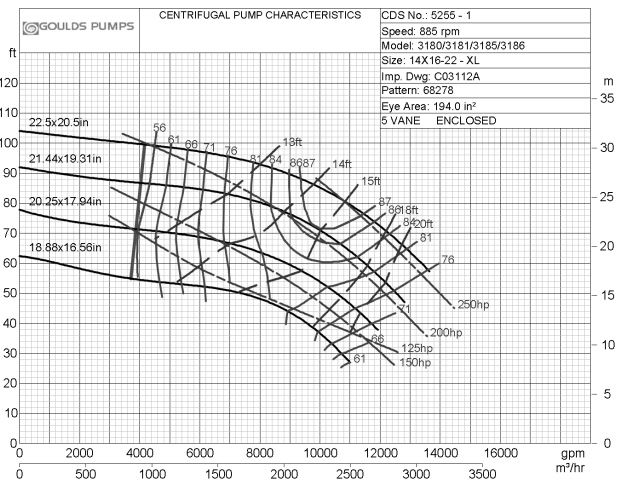
14X16-22 **1180rpm**



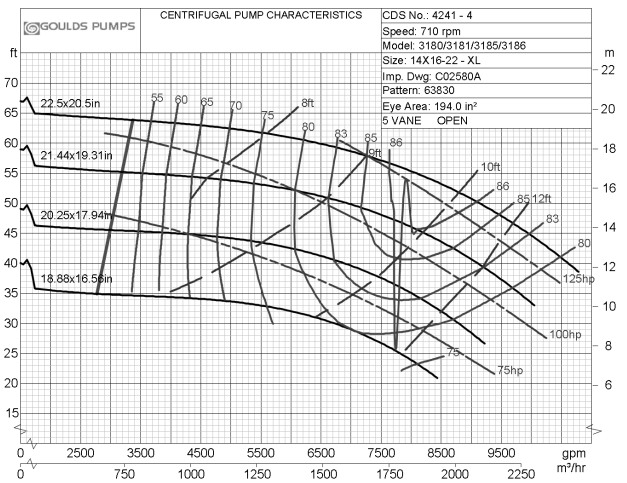
14X16-22 **1180rpm**



14X16-22 **885rpm**

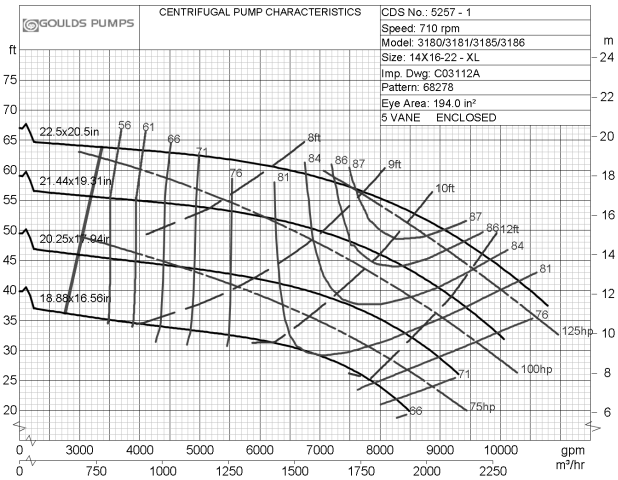


14X16-22 **885rpm**

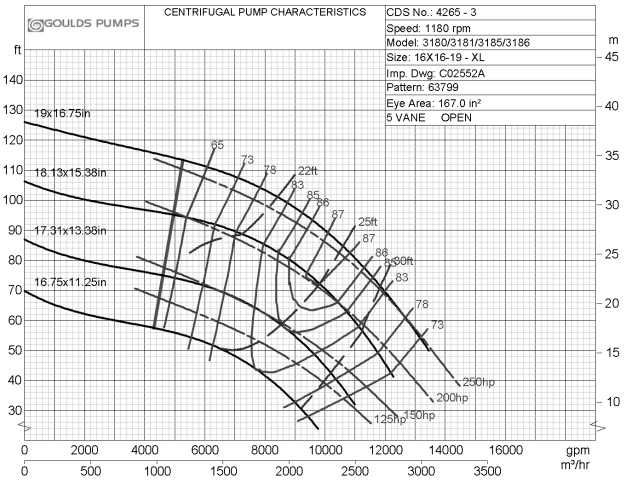


14X16-22 **710rpm**

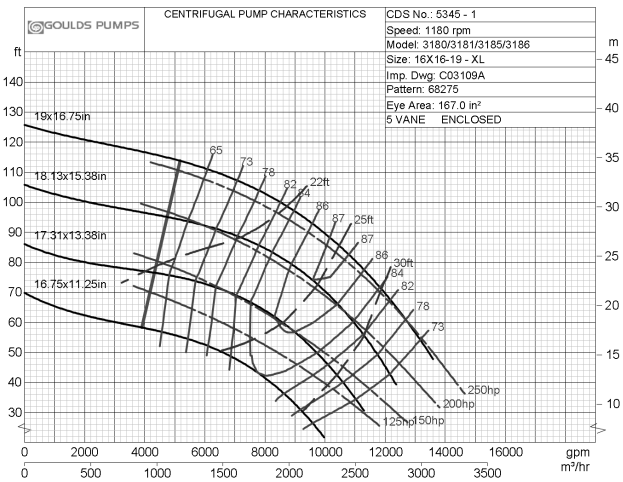
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



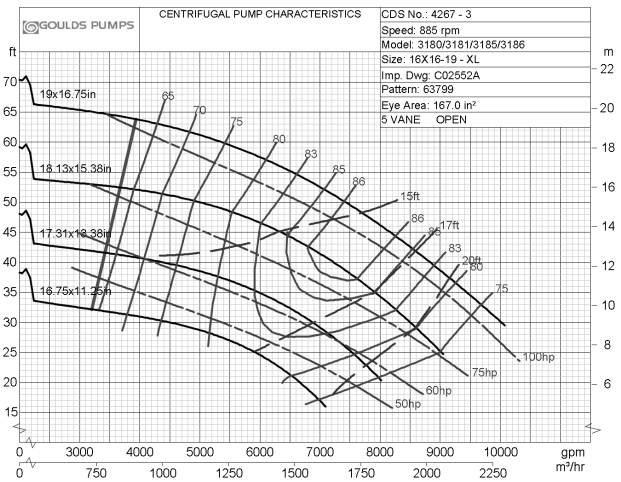
14X16-22 **710rpm**



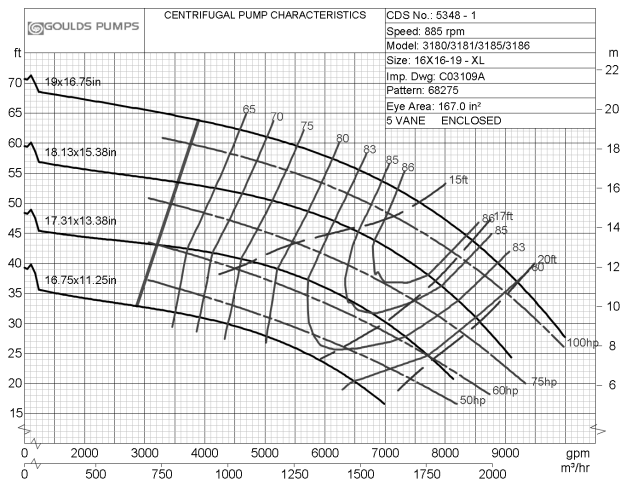
16X16-19 **1180rpm**



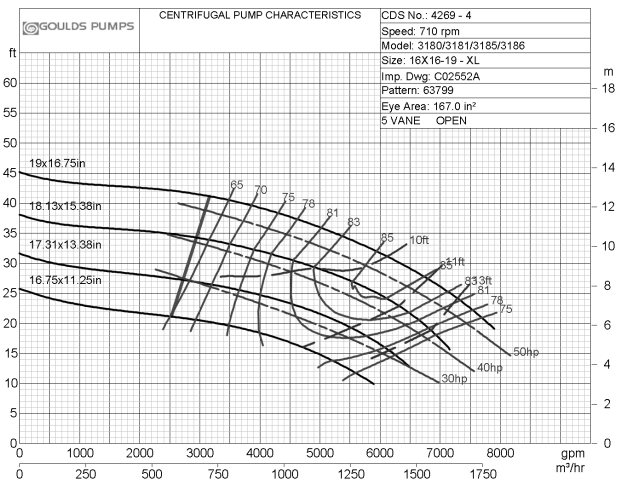
16X16-19 **1180rpm**



16X16-19 **885rpm**



16X16-19 **885rpm**

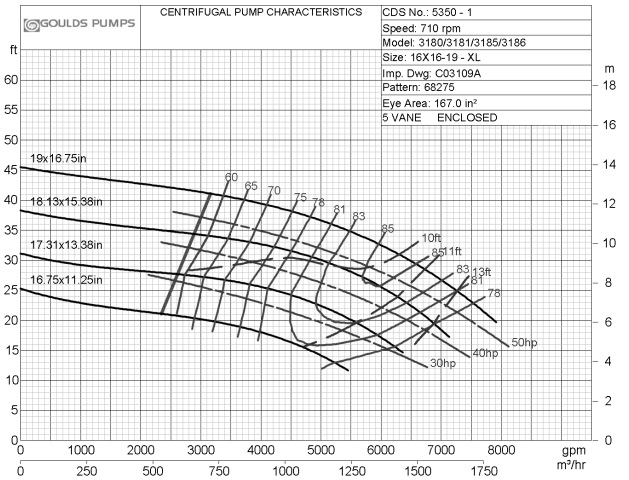


16X16-19 **710rpm**

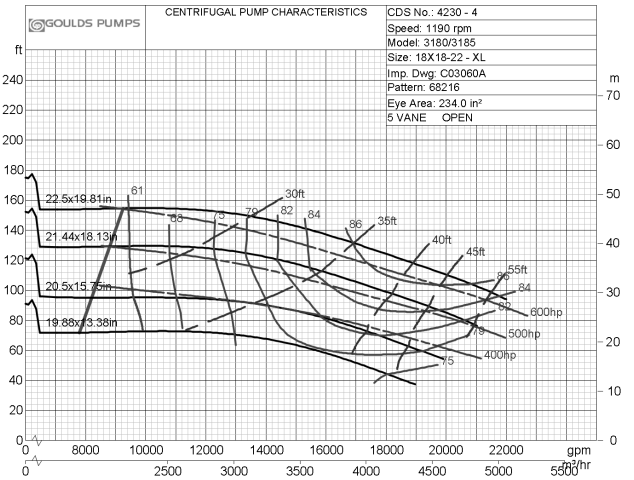
60Hz Curves

Model 3180/3185

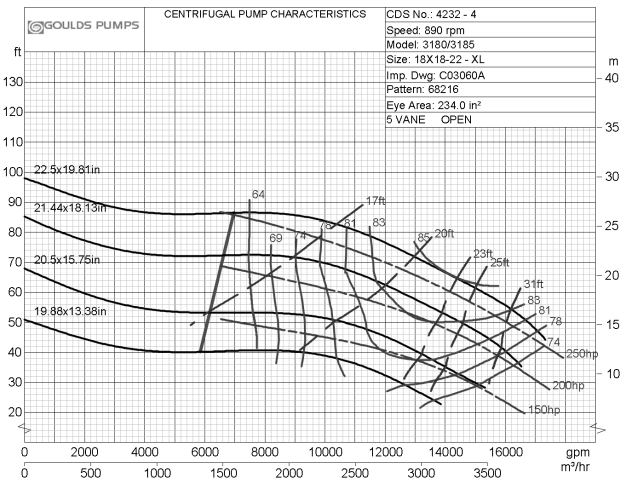
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



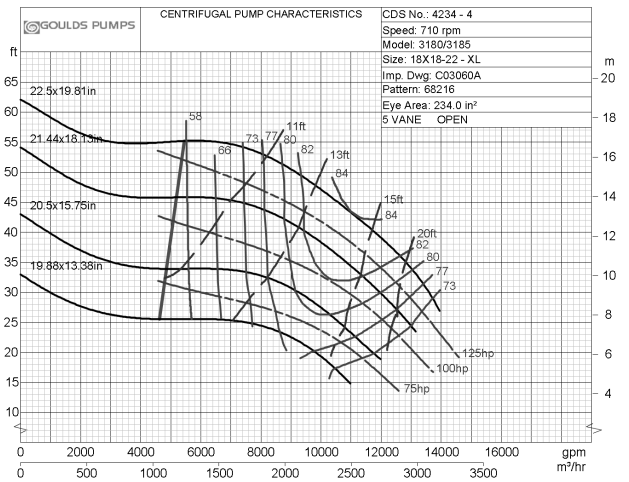
16X16-19 **710rpm**



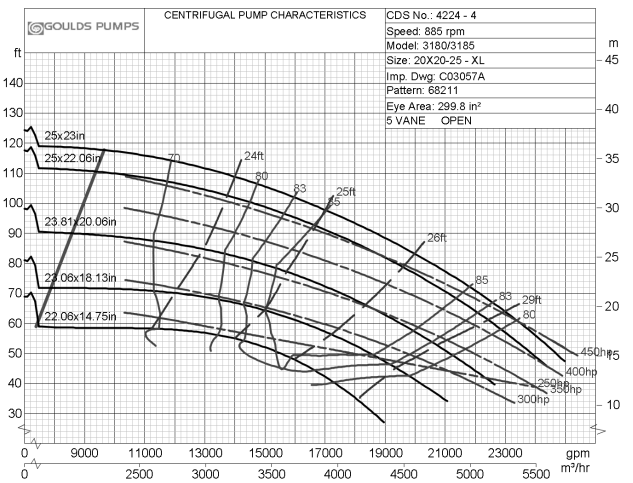
18X18-22 **1190rpm**



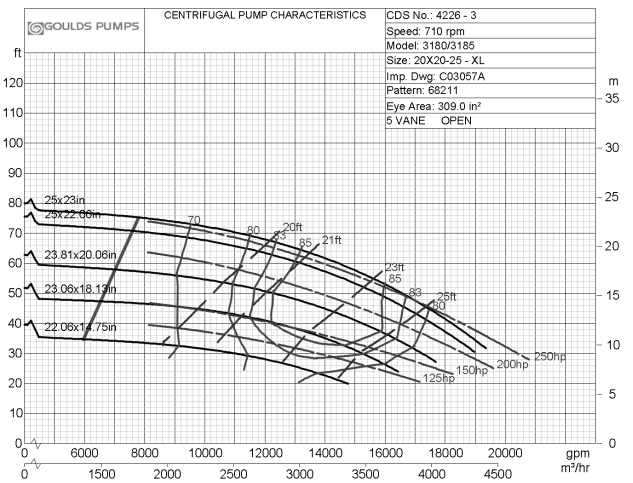
18X18-22 **890rpm**



18X18-22 **710rpm**

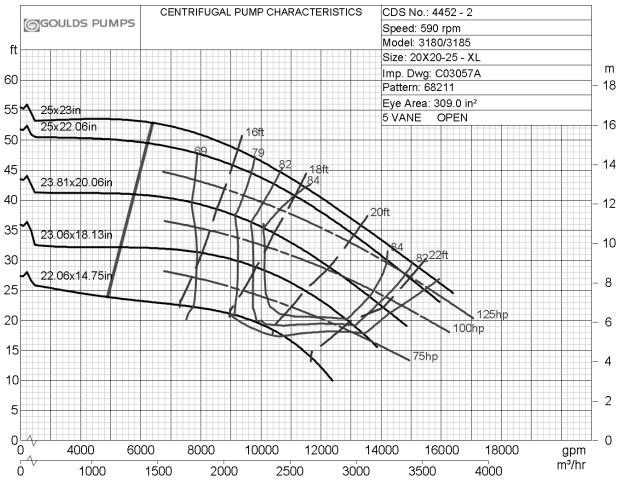


20X20-25 **885rpm**

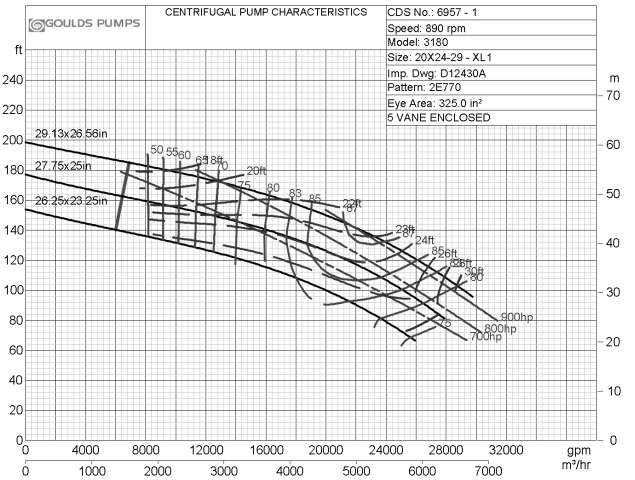


20X20-25 **710rpm**

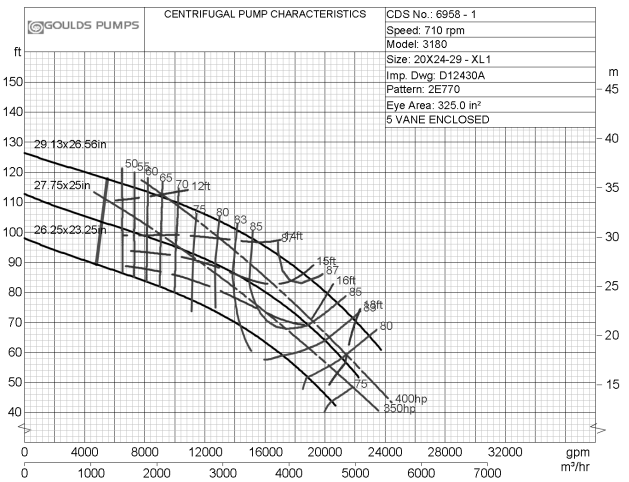
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



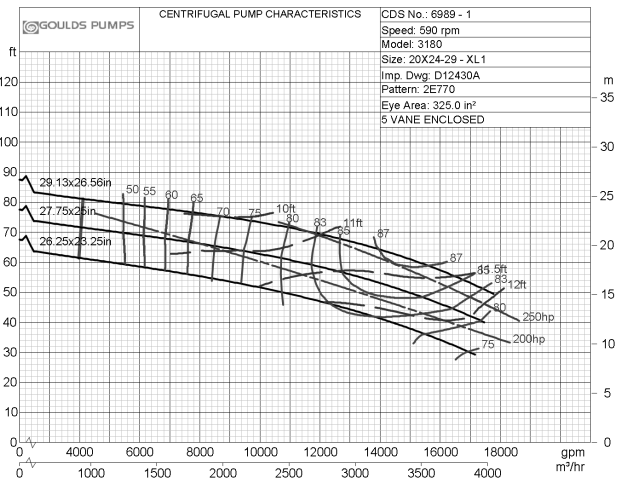
20X20-25 **590rpm**



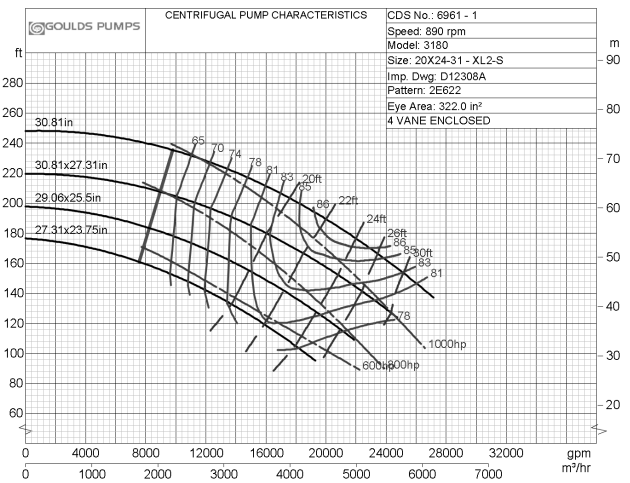
20X24-29 **890rpm**



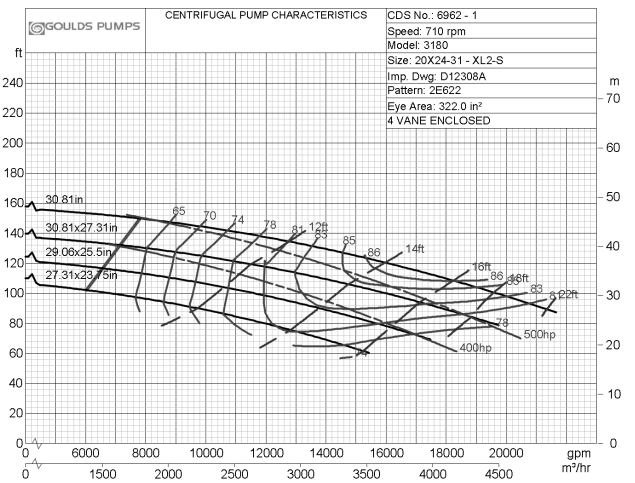
20X24-29 **710rpm**



20X24-29 **590rpm**



20X24-31 **890rpm**

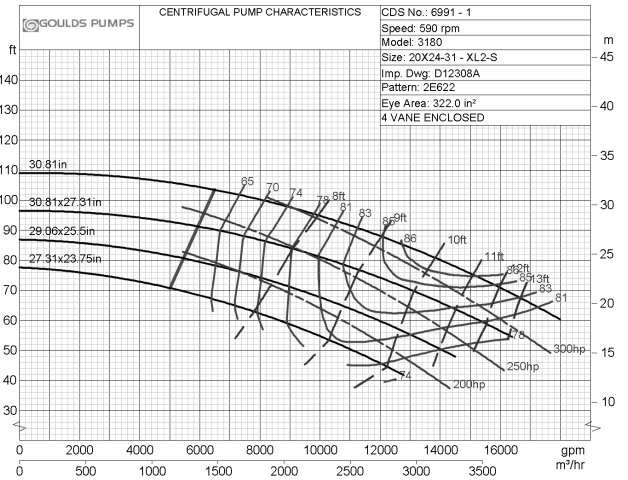


20X24-31 **710rpm**

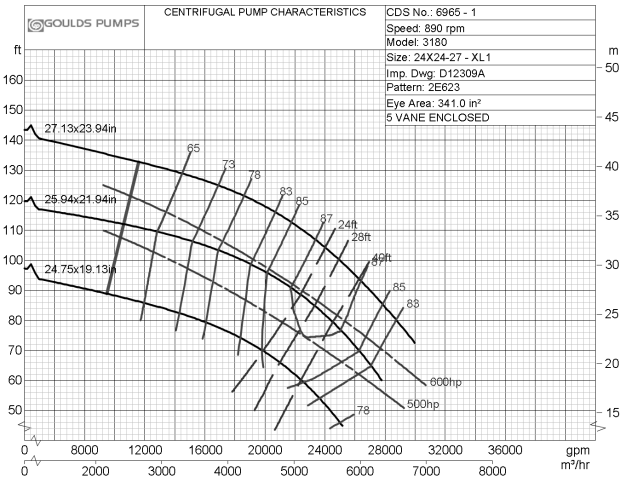
60Hz Curves

Model 3180/3185

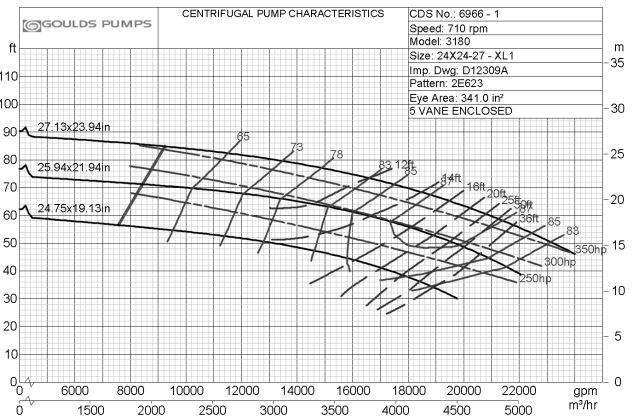
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



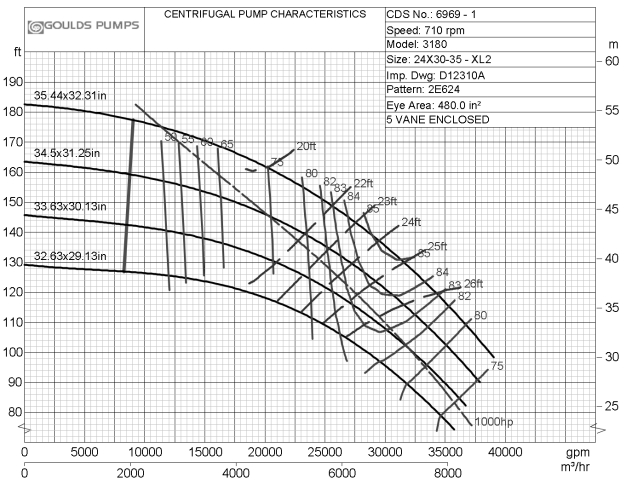
20X24-31 **590rpm**



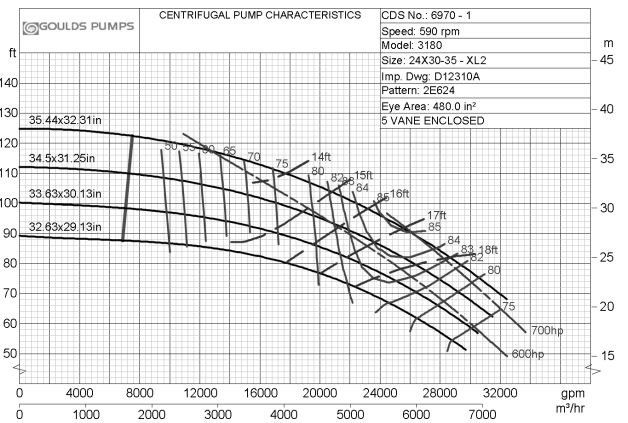
24X24-27 **890rpm**



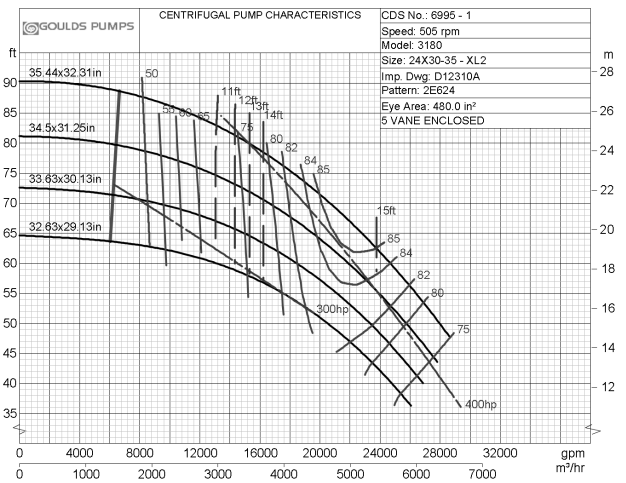
24X24-27 **710rpm**



24X30-35 **710rpm**

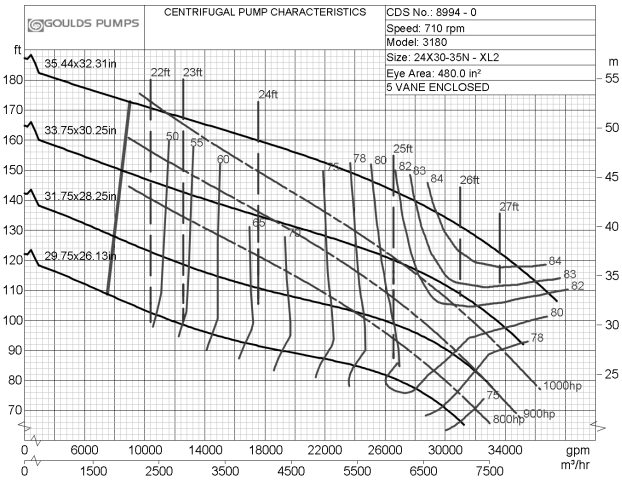


24X30-35 **590rpm**

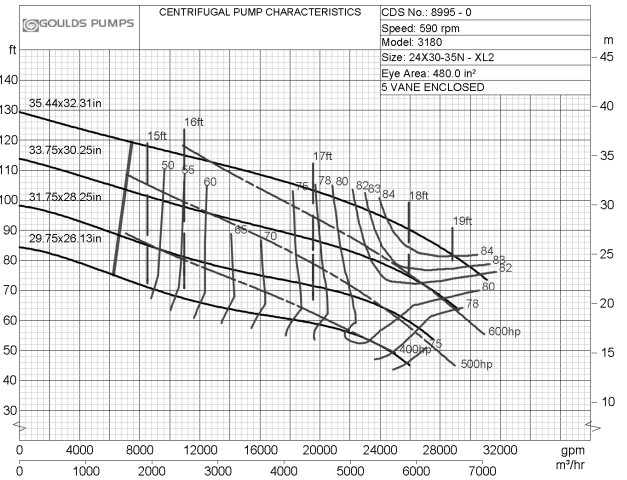


24X30-35 **505rpm**

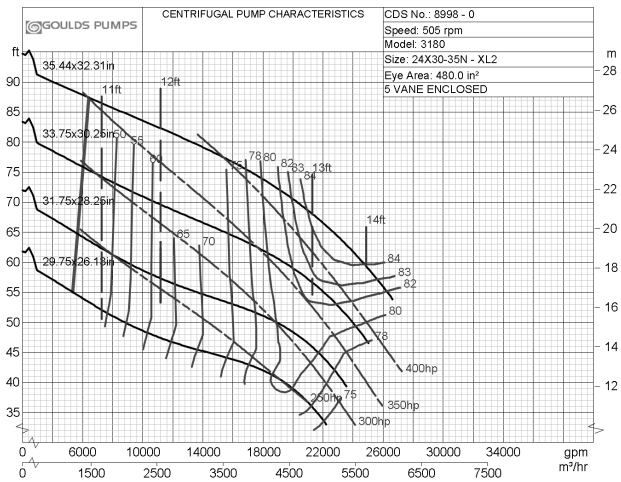
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



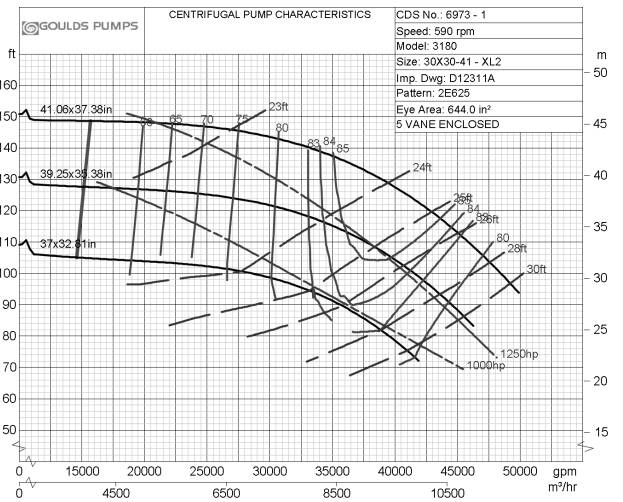
24X30-35N **710rpm**



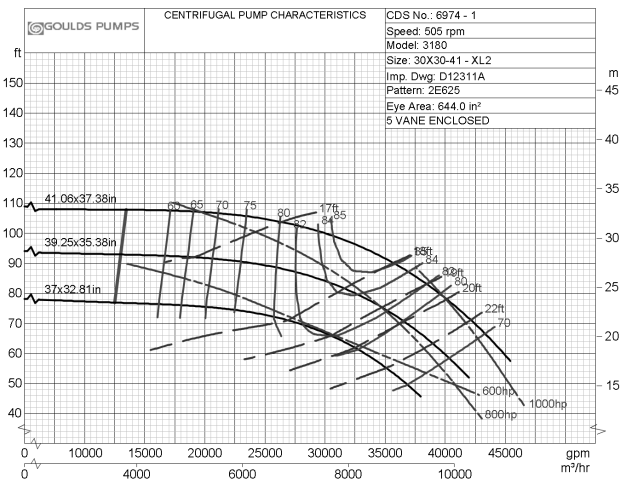
24X30-35N **590rpm**



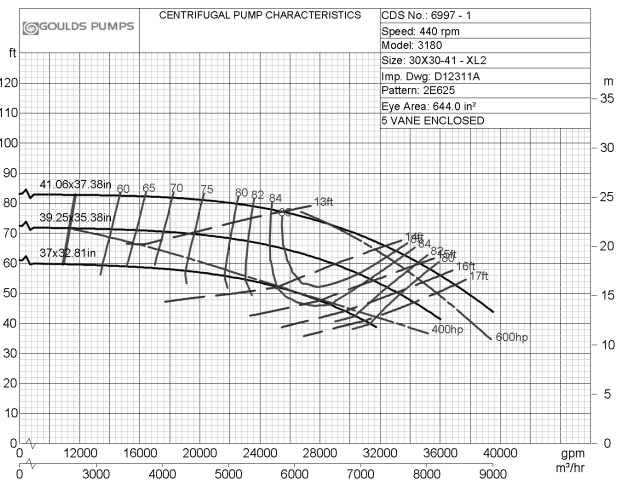
24X30-35N **505rpm**



30X30-41 **590rpm**



30X30-41 **505rpm**



30X30-41 **440rpm**

NOTES

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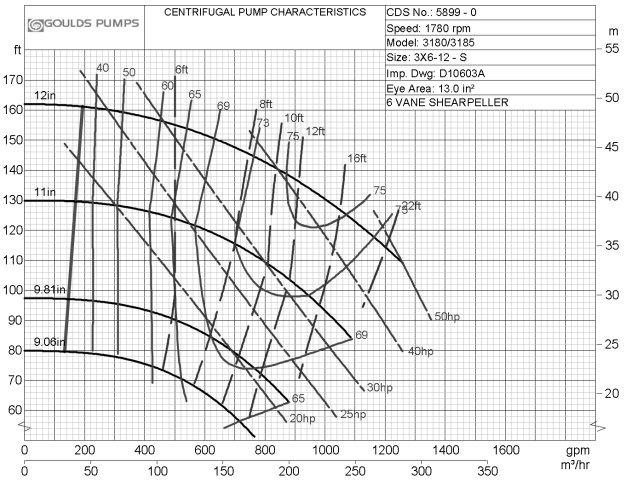
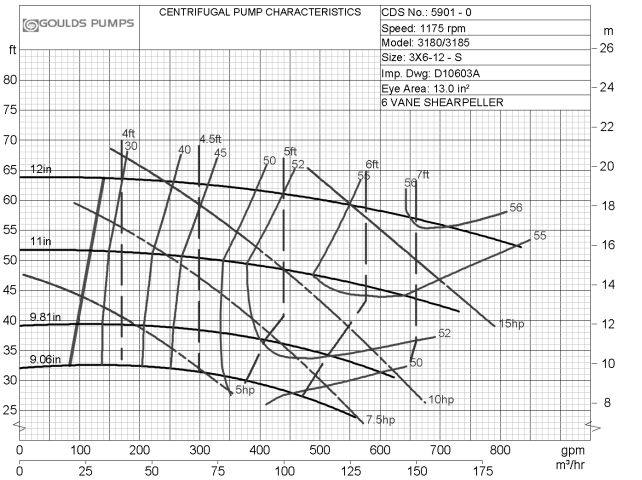
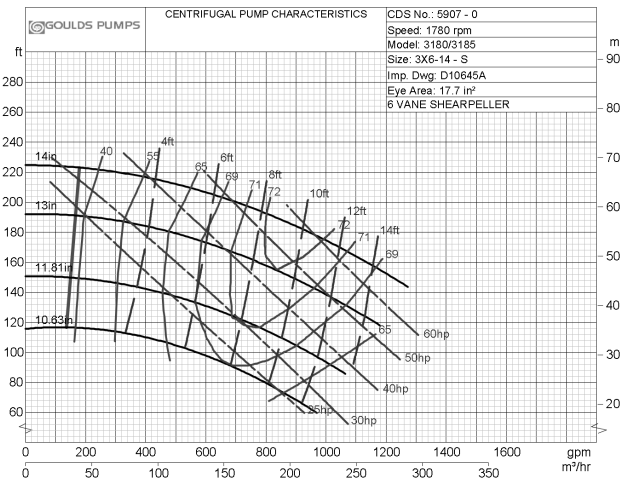


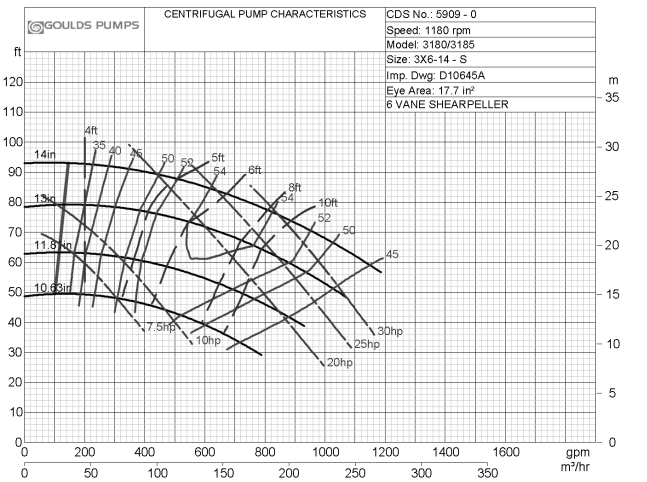
3X6-12 **1780rpm**



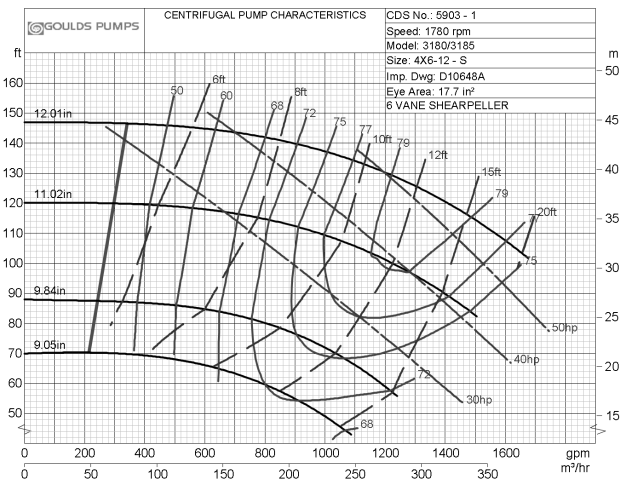
3X6-12 **1175rpm**



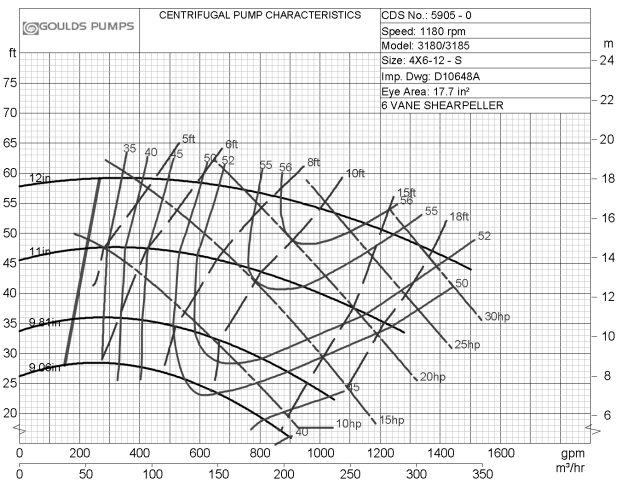
3X6-14 **1780rpm**



3X6-14 **1180rpm**



4X6-12 **1780rpm**

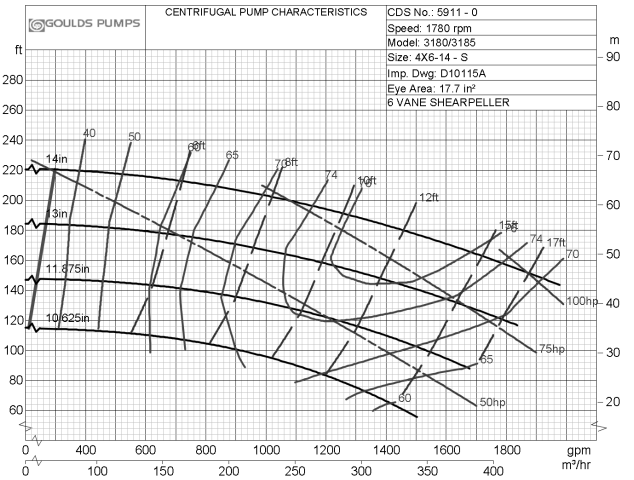


4X6-12 **1180rpm**

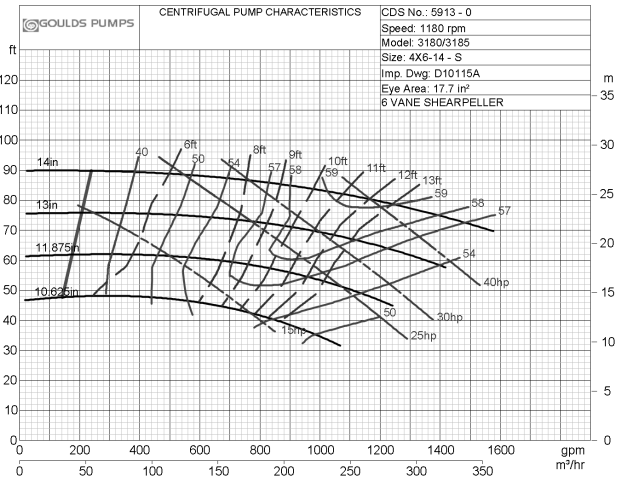
60Hz Curves

Model 3180/3185 Shearpeller

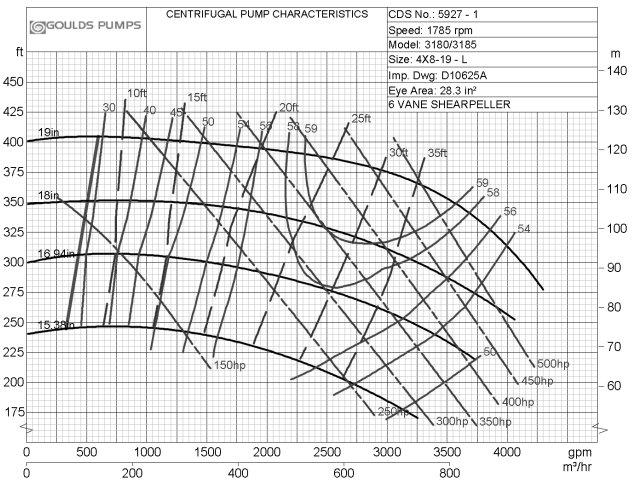
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



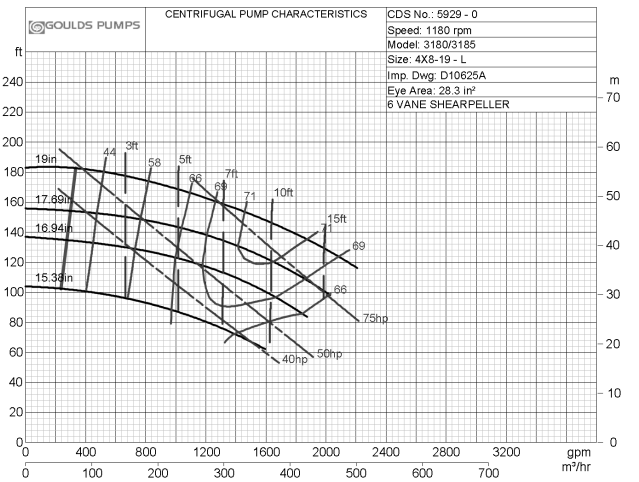
4X6-14 **1780rpm**



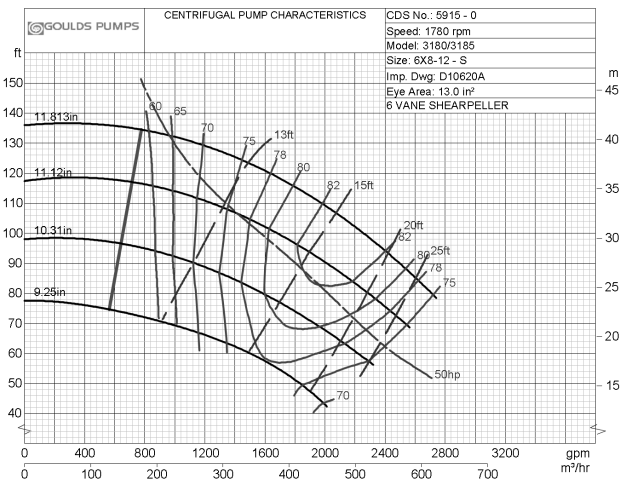
4X6-14 **1180rpm**



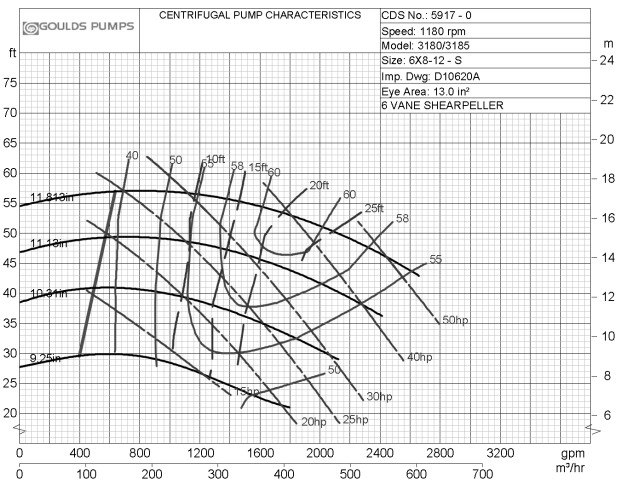
4X8-19 **1785rpm**



4X8-19 **1180rpm**

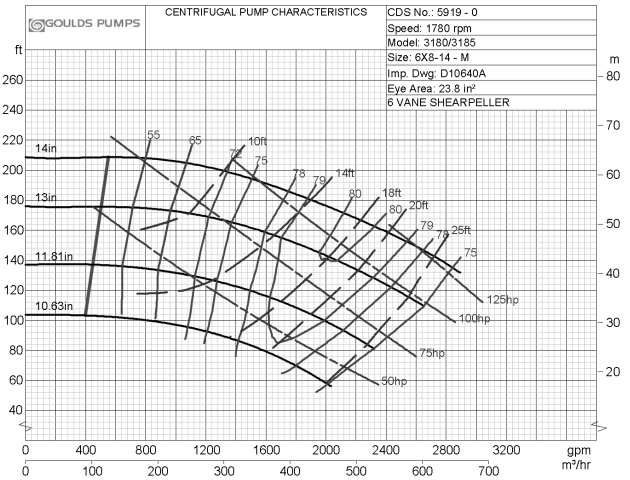


6X8-12 **1780rpm**

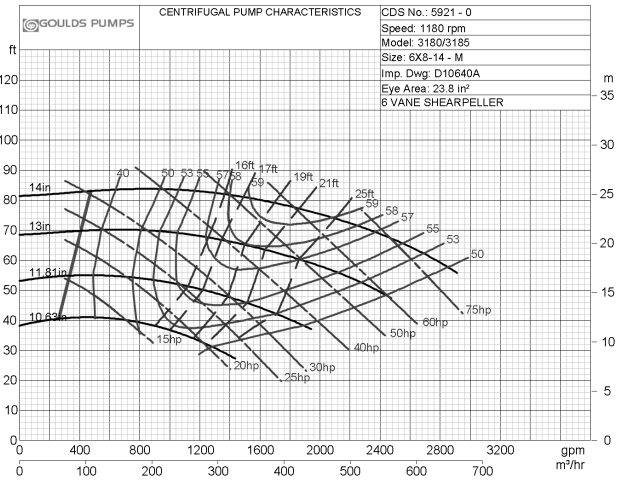


6X8-12 **1180rpm**

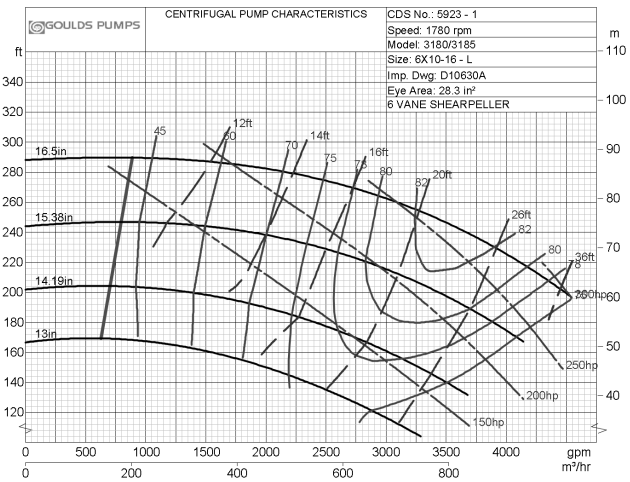
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



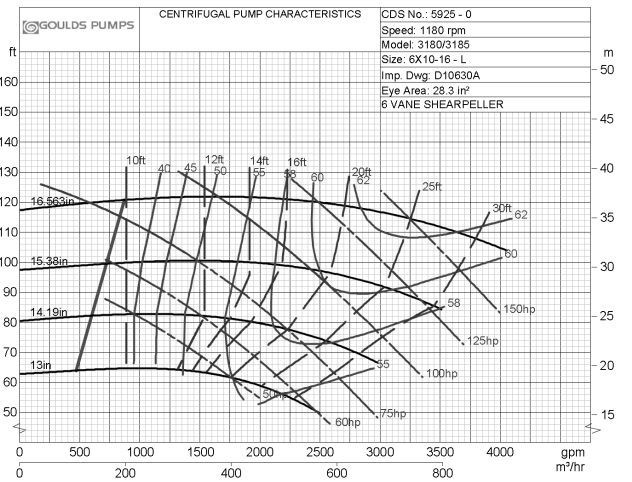
6X8-14 **1780rpm**



6X8-14 **1180rpm**

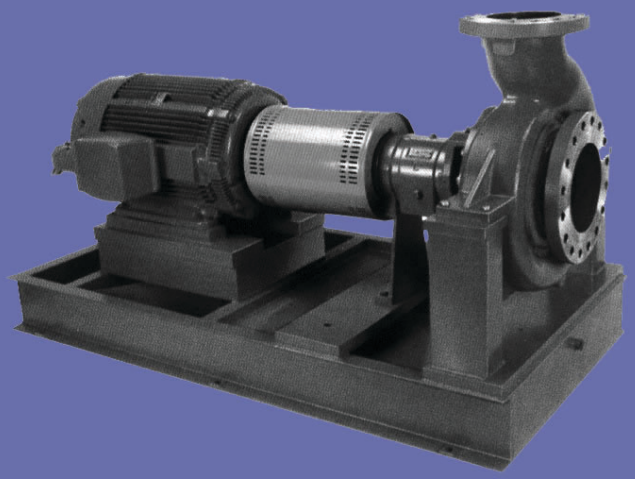


6X10-16 **1780rpm**



6X10-16 **1180rpm**

NOTES



Model 3181

- ANSI Class 300 flange drilling
- Inch-dimensioned O.D. of mechanical seal sleeve
- Inch-dimensioned bearing locknut
- Inch-dimensioned coupling extension

Model 3186

- ISO or JIS 40 bar flange drilling
- mm-dimensioned O.D. of mechanical seal sleeve
- mm-dimensioned bearing locknut
- mm-dimensioned coupling extension

Models 3181/3186

Designed to Handle High Temperature and High Pressure Services of the Pulp & Paper Industries

3181

- Capacities to 13,000 GPM (3000 m^3/h)
- Heads to 410 feet (125 m)
- Temperatures to 508°F (300°C)
- Pressures to 360 PSIG (25 bar)

3186

- Capacities to 3,000 m^3/h (13,000 GPM)
- Heads to 125m (410 feet)
- Temperatures to 300°C (508°F)
- Pressures to 25 bar (360 PSIG)

Design Features

- **Hydraulic Coverage** Line designed for full 50/60 Hz performance.
- **Back Pull-out Construction** Spacer type coupling allows one-craft maintenance.
- **Centerline Supported** High temperature stability.
- **Labyrinth Seals** Eliminate loss of lubricant, prevent lubricant contamination for maximum bearing life.
- **Maximum Interchangeability** Power end and impellers completely interchangeable with Goulds Models 3180/3185.
- **International Design** Metric fasteners and fittings used throughout.

Applications

- Digester Recirculation
- Make-Up Liquor
- White Liquor
- Black Liquor
- High Pressure/High Temperature Pulp Mill Services
- Hot Oil

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Models 3181/3186 Paper Stock/Process Pumps

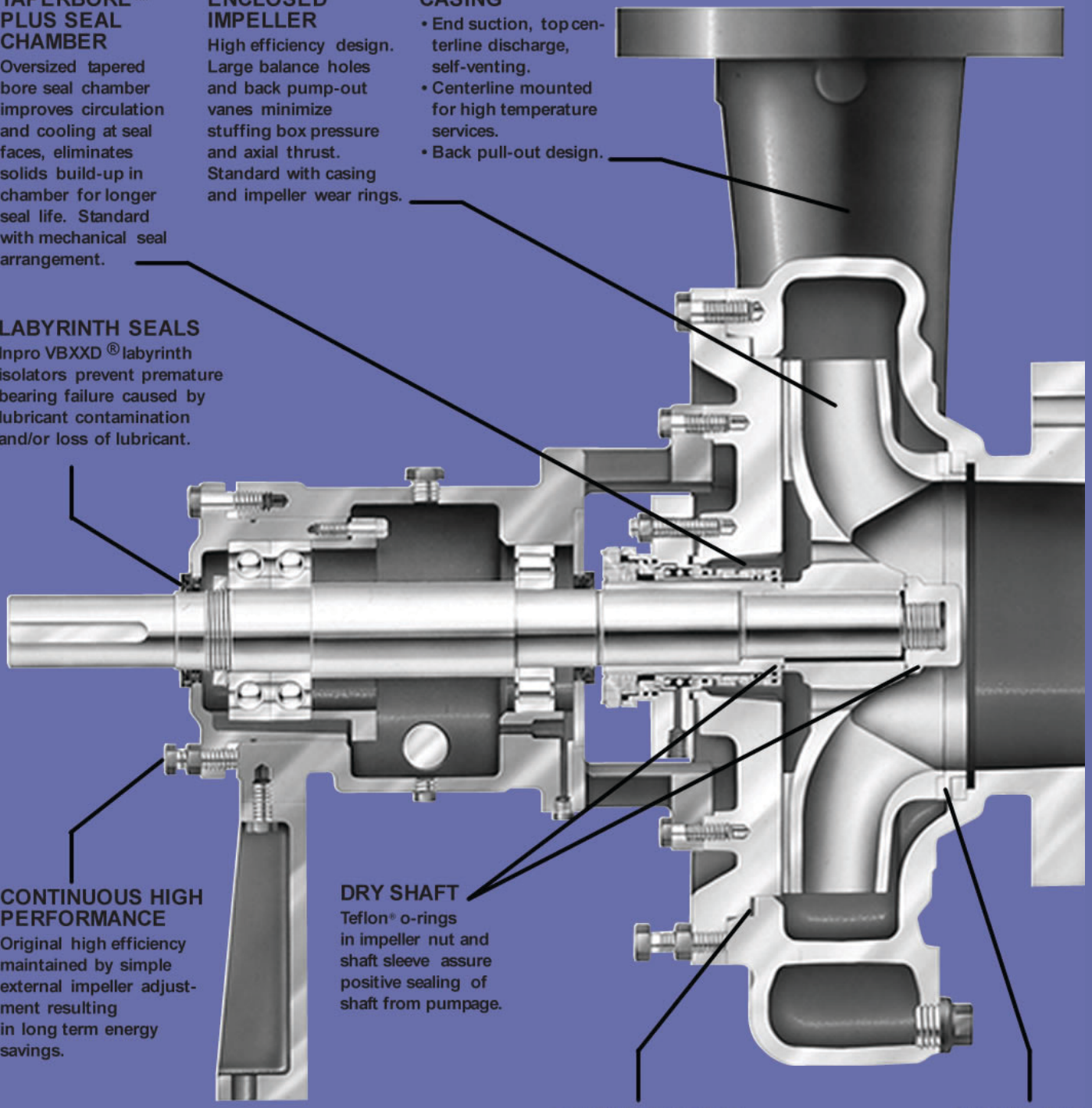
Design Features for Handling Toughest High Temperature/Pressure Services

TAPERBORE™ PLUS SEAL CHAMBER
Oversized tapered bore seal chamber improves circulation and cooling at seal faces, eliminates solids build-up in chamber for longer seal life. Standard with mechanical seal arrangement.

ENCLOSED IMPELLER
High efficiency design. Large balance holes and back pump-out vanes minimize stuffing box pressure and axial thrust. Standard with casing and impeller wear rings.

CASING
- End suction, top centerline discharge, self-venting.
- Centerline mounted for high temperature services.
- Back pull-out design.

LABYRINTH SEALS
Inpro VBXXD® labyrinth isolators prevent premature bearing failure caused by lubricant contamination and/or loss of lubricant.



CONTINUOUS HIGH PERFORMANCE
Original high efficiency maintained by simple external impeller adjustment resulting in long term energy savings.

DRY SHAFT
Teflon® o-rings in impeller nut and shaft sleeve assure positive sealing of shaft from pumpage.

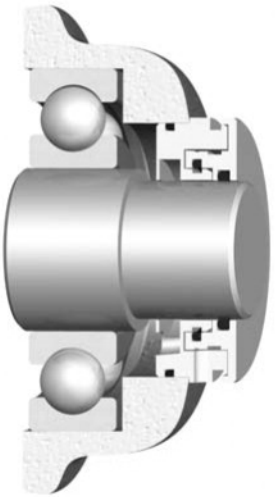
CONFINED SPIRAL WOUND GASKET
Spiral wound stainless steel, provides metal-to-metal fit between casing and cover.

CASING AND IMPELLER WEAR RINGS
Renewable wear rings minimize maintenance costs. Fastened by set screws.

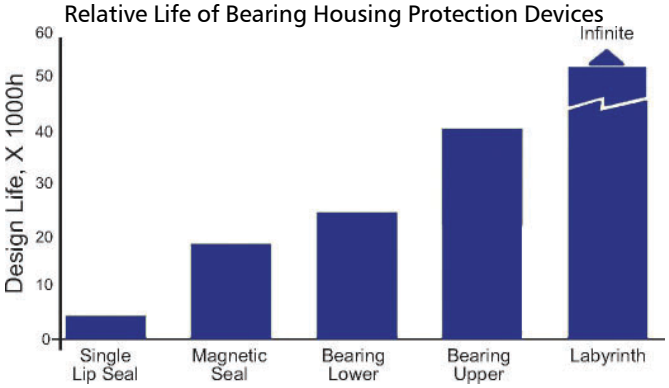
Performance Features For Extended Pump Life

LABYRINTH SEALS ARE STANDARD

Labyrinth isolators are standard to prevent premature bearing failure caused by lubricant contamination or loss of oil.

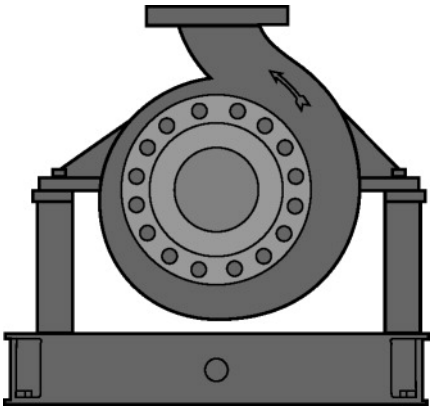


Relative Life of Bearing Housing Protection Devices



TAPERBORE™ SEAL CHAMBER

Enlarged, tapered bore for increased life of mechanical seals through improved lubrication and cooling. Self-venting and draining. VPE ring is optional.



CENTERLINE SUPPORTED

For high temperature services. Eliminates misalignment of pump and motor shafts due to thermal expansion of casing.

Heavy-Duty Shaft/Bearings

Shaft designed for minimum deflection for long seal life and bearing life. Bearings sized for optimum life under tough conditions.

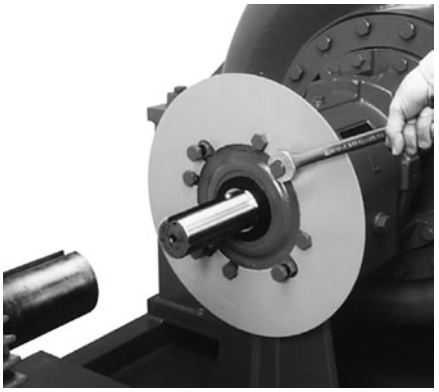
ENCLOSED IMPELLER

High-efficiency design. Large balance holes and back pump-out vanes reduce axial thrust and stuffing box pressure.

Features for Ease of Maintenance

BACK PULL-OUT

Allows unit to be removed without disturbing suction and discharge piping. Simple and fast installation of spare power end.



EXTERNAL IMPELLER ADJUSTMENT

Easy renewal of impeller clearances to maintain original hydraulic performance. Accomplished on-site with minimum downtime.

CONDITION MONITORING SITES

Allow easy and consistent monitoring of temperature and vibration for preventive maintenance.

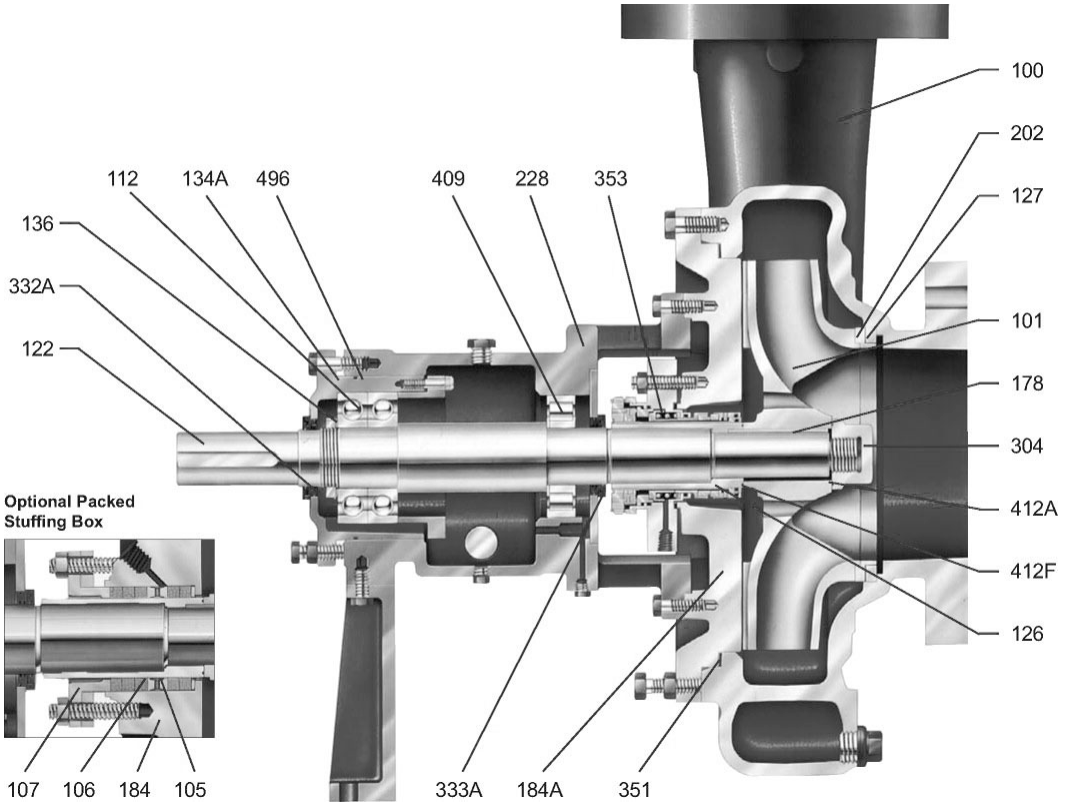
MAXIMUM STUFFING BOX/SEAL CHAMBER ACCESSIBILITY

Allows easy maintenance of packing or mechanical seal.

MAXIMUM INTERCHANGEABILITY

The 3181/3186 utilizes the same power ends as Goulds Models 3180/3185 for reduced spare parts inventory requirements.

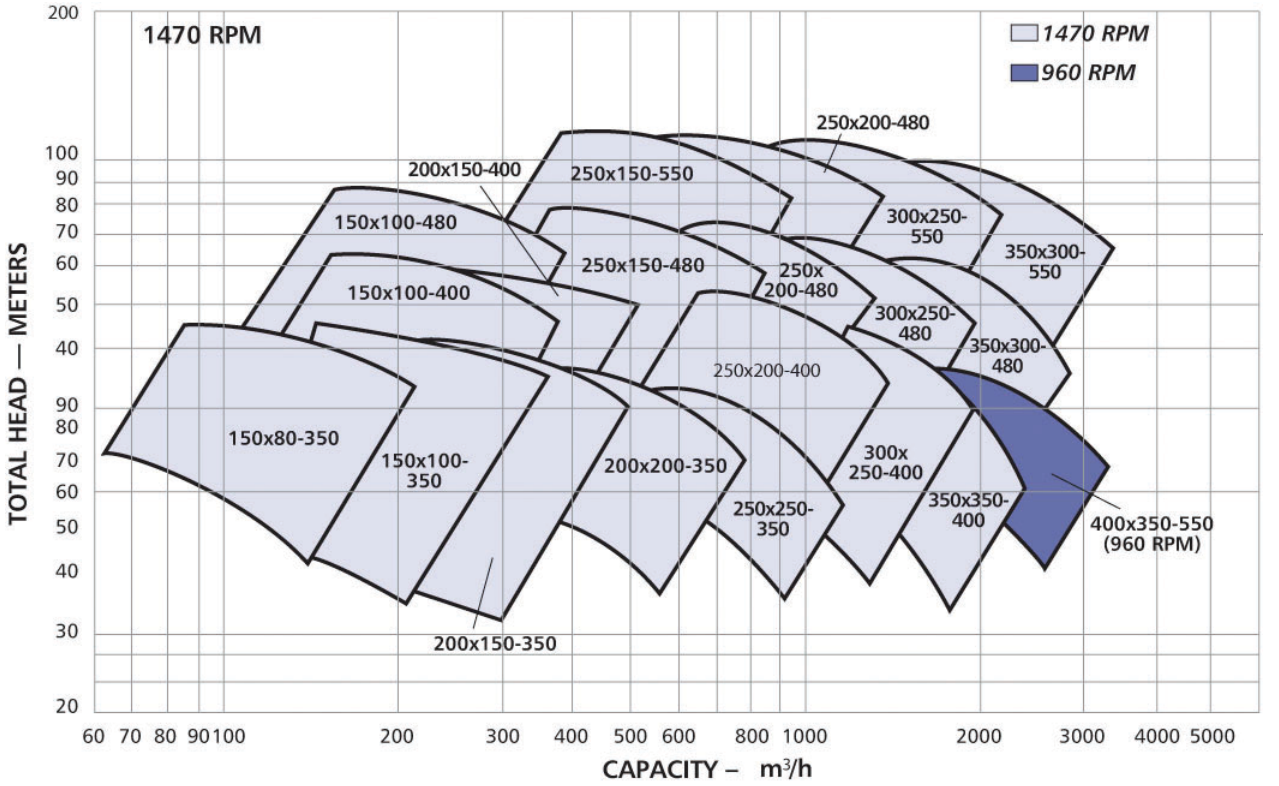
Sectional View Models 3181/3186



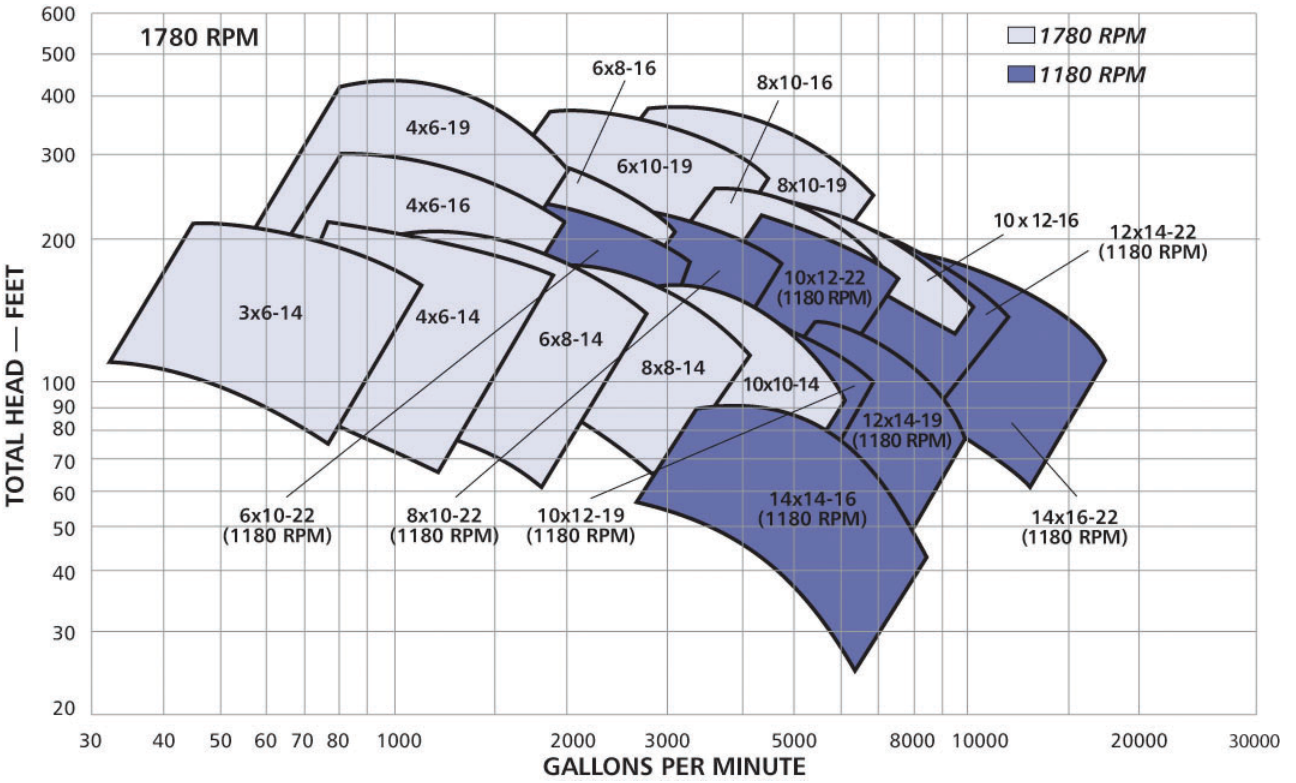
Parts List and Materials of Construction

Item Number	Part Name	Material		
		Duplex (A890 GR. 3A)	316 Stainless Steel	317 Stainless Steel
100	Casing	Duplex (A890 GR. 3A)	316 SS	317 SS
101	Impeller	Duplex (A890 GR. 3A)	316 SS	317 SS
105	Lantern Ring	Teflon®		
106	Packing	Lattice Braid Garfite Yarn (Impregnated with Garfite 200)		
107	Gland	316 SS	316 SS	317 SS
112	Thrust Bearing	Duplex Angular Contact		
122	Shaft	Carbon Steel (4340)		
126	Shaft Sleeve	316 SS		317 SS
127	Casing Wear Ring	Duplex (A890 GR. 3A)	316 SS	317 SS
134A	Bearing Housing	Cast Iron		
136	Bearing Locknut and Lockwasher	Steel		
178	Impeller Key	Carbon Steel		
184A	Taperbore™ Seal Chamber (Mechanical Seal)	Duplex (A890 GR. 3A)	316 SS	317 SS
184	Stuffing Box Cover (Packed Box)	Duplex (A890 GR. 3A)	316 SS	317 SS
202	Impeller Wear Ring	Duplex (A890 GR. 3A)	316 SS	317 SS
228	Bearing Frame	Cast Iron		
304	Impeller Nut	Duplex (A890 GR. 3A)	316 SS	317 SS
332A	Labyrinth Oil Seal (Outboard)	Bronze with Viton O-Rings		
333A	Labyrinth Oil Seal (Inboard)	Bronze with Viton O-Rings		
351	Casing Gasket	Spiral Wound Stainless Steel		
353	Mechanical Seal	(As Required)		
409	Radial Bearing	Cylindrical Roller		
412A	Impeller O-ring	Teflon		
412F	Sleeve O-ring	Teflon		
496	Bearing Housing O-ring	Buna Rubber		

Hydraulic Coverage 50 Hz

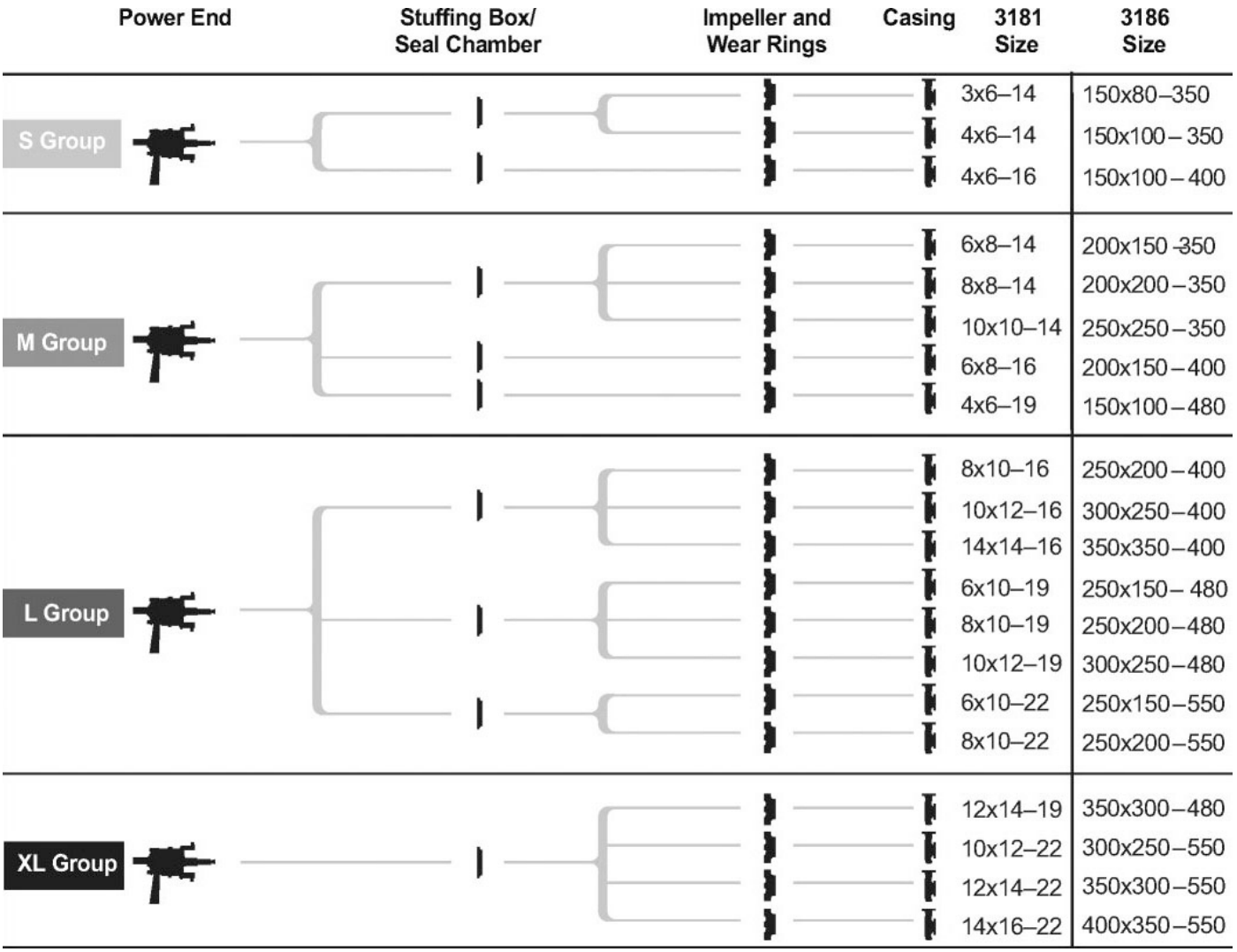


Hydraulic Coverage 60 Hz



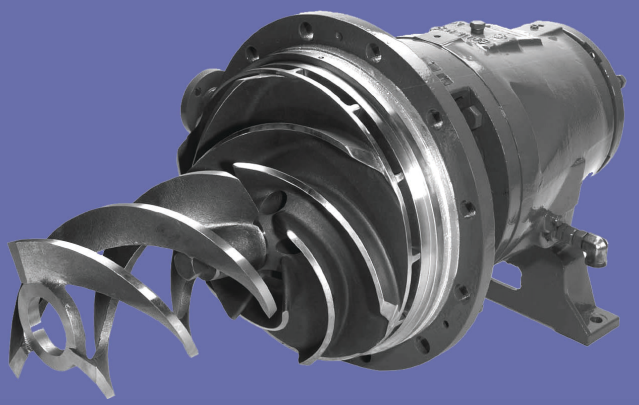
Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

Modular Interchangeability Model 3181/3186



* Shafts for Models 3181 and 3186 are not interchangeable.
Sleeves for mechanical seals on the 3181 and 3186 are not interchangeable.

NOTES



Back Pullout with X-Ducer

Goulds Model 3500XD

Medium-Consistency Pump Systems

- Complete System of Pump, Valves, Standpipe and Controls
- Pulp Consistency to 16% Bone Dry
- Capacities to 4000 GPM (900 m^3/h)
- Direct Drive Design
- Patented Air Separation System
- All Stainless Steel Construction
- Improved Efficiency

3500XD (Front View)

Pump System Advantage

Advantage	Benefit
High Efficiency	• Lower power requirements • X-Ducer design can permit upgrades with minimal investment
Simplicity of Design	• Proven reliability • Familiar to operating and maintenance personnel due to design - components an methods similar to conventional centrifugal pumps • Maintenance is easy to perform
Superior Reliability and Flexibility of External Vacuum Pump Degas System	• X-Ducer design further simplifies the degas system for consistency ranges up to10-11% by not requiring a vacuum pump • Easy to maintain external vacuum pump • Avoids assembly techniques needed to achieve close clearances for proper internal degas operation • Same back pull-out assembly regardless of type of degas system
Control Scheme	• Simple level/flow control scheme • Readily adapted to variable speed operation • Effective response to process changes and upsets
Continued New Technology and Development	• X-Ducer design allows for operation up to 10-11% consistency without a vacuum pump • Higher TDH generation with X-Ducer design • New size now available for higher production rates and high head requirements such as O2 Delignification Reactor Feed service

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Medium-Consistency Pumping & Mixing Solutions

Heavy-Duty Design and Reliable, Efficient Service

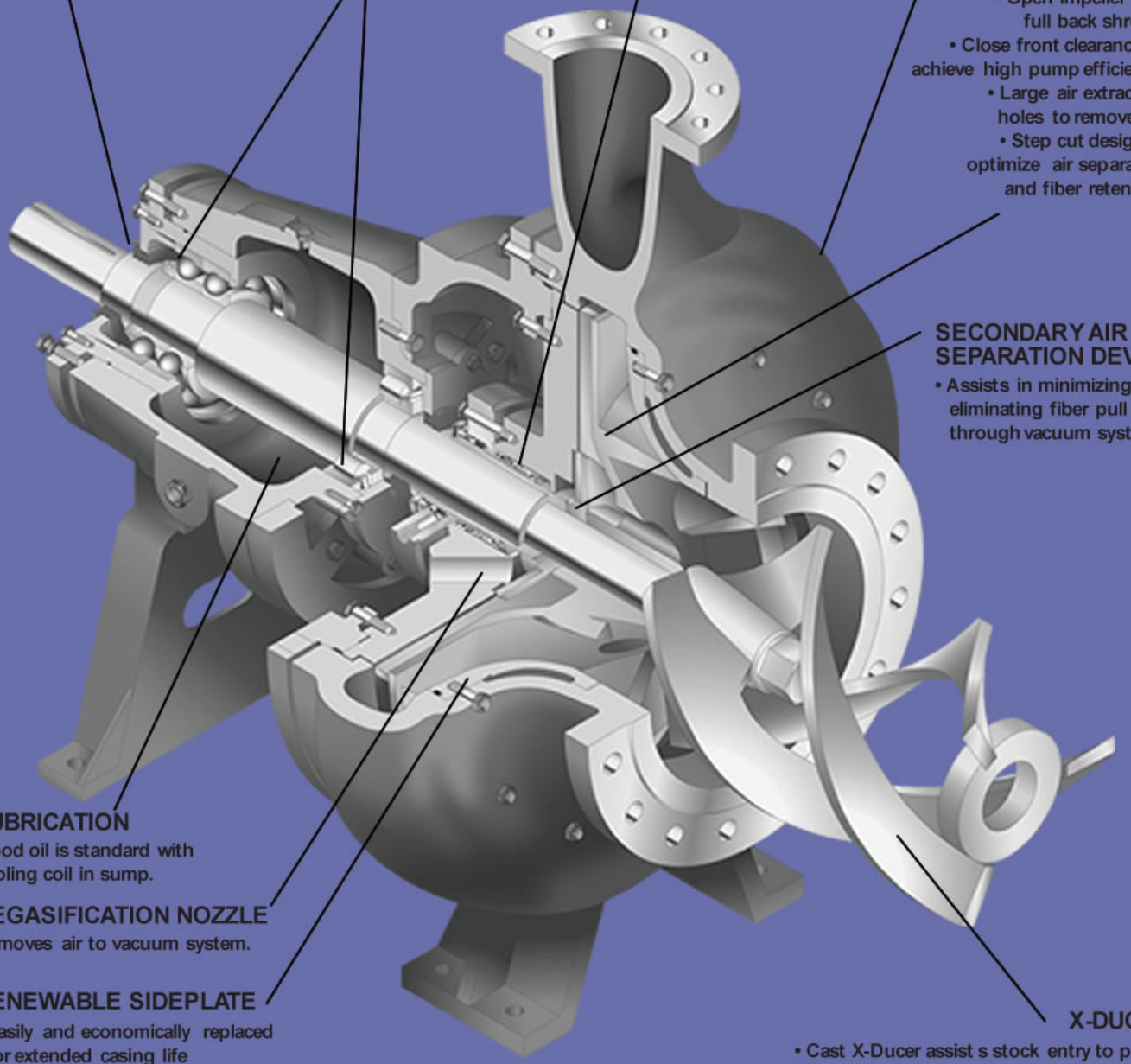
LABYRINTH SEALS STANDARD
Frame is sealed with labyrinth seals to protect against the harsh environments encountered in pulp mills and bleach plants.

BEARINGS
- Thrust bearing is angular contact PumpPac® designed to handle uni-directional thrust loads.
- Radial bearing is cylindrical roller design to handle radial loads.
- Bearings are designed for a 14-year average life based on maximum loads.

DOUBLE-CARTRIDGE MECHANICAL SEALS
- For optimum sealing over full range of operating conditions.
- Seals from various manufacturers are available.

CASING
- Centerline discharge.
- Modified concentric design is key to efficient air removal and allows a wide operating range.
- Readily adapted to horizontal design

IMPELLER
- Open impeller with full back shroud.
- Close front clearance to achieve high pump efficiency.
- Large air extraction holes to remove air.
- Step cut design to optimize air separation and fiber retention.



SECONDARY AIR SEPARATION DEVICE
- Assists in minimizing or eliminating fiber pull through vacuum system.

LUBRICATION
Flood oil is standard with cooling coil in sump.

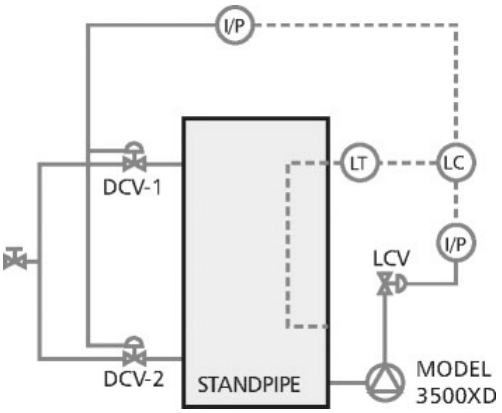
DEGASIFICATION NOZZLE
Removes air to vacuum system.

RENEWABLE SIDEPLATE
- Easily and economically replaced for extended casing life
- Sealed from pumpage

X-DUCER
- Cast X-Ducer assists stock entry to pump.
- Constant pitch, hollow X-Ducer improves air removal.
- For pulp consistencies up to 10-11%, a vacuum pump is not required for effective degas operation.
- Allows for more efficient pump operation.
- Secured to shaft with heavy-duty shaft nut.
- Derived from existing inducer technology with modifications for medium consistency pulp services.

Standard System Controls, Alarms & Interlocks

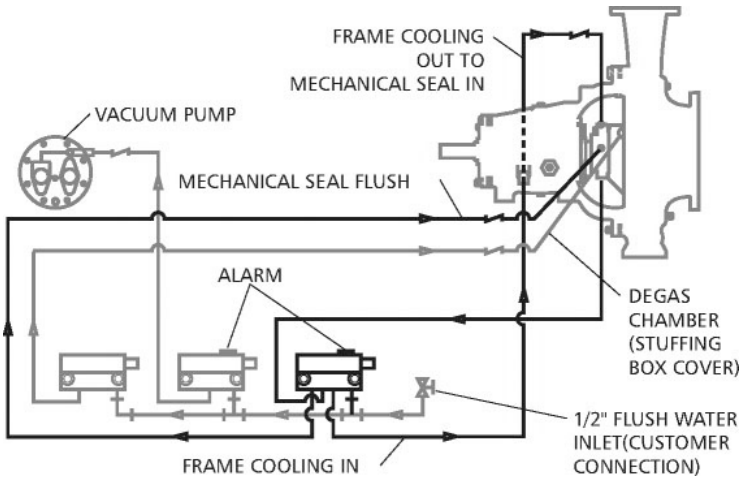
Standpipe Level/Dilution System



DCV-1	UPPER DILUTION VALVE
DCV-2	LOWER DILUTION VALVE
LCV	LEVEL CONTROL VALVE
LT	LEVEL TRANSMITTER
LC	LEVEL CONTROLLER
I/P	SIGNAL CONVERTER

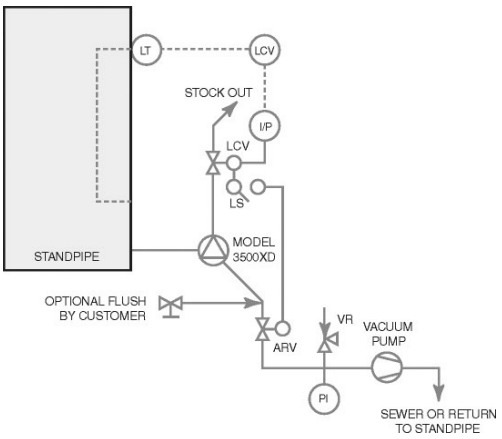
- Constant standpipe level maintained by LC controlling LCV on pump discharge.
- **Alarms** set at 85% and 10% level.
- Start up **Interlock** at minimum of 10% level to prevent dry running of pump.
- Automatic dilution system to assist pumping when standpipe level deviates outside its allowable set point range.

Seal & Flush Water System



- Three separate flow meters control flow to:
  - – Mechanical seal and bearing cooling coil
  - – Vacuum pump make up
  - – Degas chamber
- An **Alarm** sounds if the flow rate drops below 50% of the required value.
- An **Interlock** keeps the pump from starting up without minimum seal and flush water flow.

Degas System



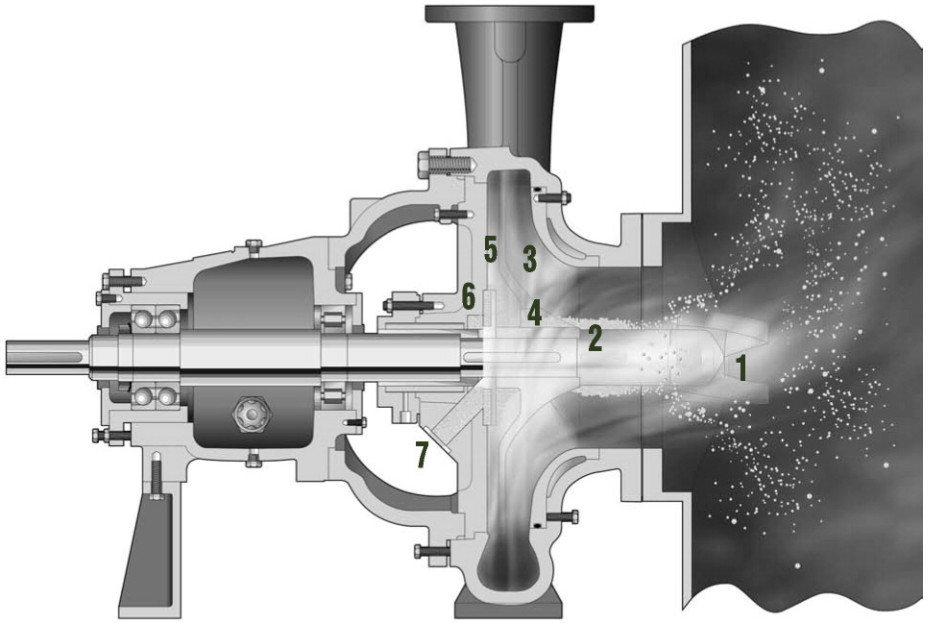
LCV	LEVEL CONTROL VALVE
LT	LEVEL TRANSMITTER
LC	LEVEL CONTROLLER
I/P	SIGNAL CONVERTER
LS	LIMIT SWITCH
ARV	AIR REMOVAL VALVE
VR	VACUUM RELIEF VALVE
PI	COMPOUND PRESSURE GAUGE

- Vacuum pump operates when Model 3500XD operates.
- ARV is open when LCV is open.
- An **Alarm** will sound if the vacuum pump shuts down.
- Closing ARV can isolate air removal system.
- For applications limited to10-11% consistency the vacuum pump is not required.
  - – Unit will use an ARV to prevent water in standpipe from draining.
  - – When in operation ARV will be open and degas line will vent to drain or air separator.

Air Removal System Model 3500XD

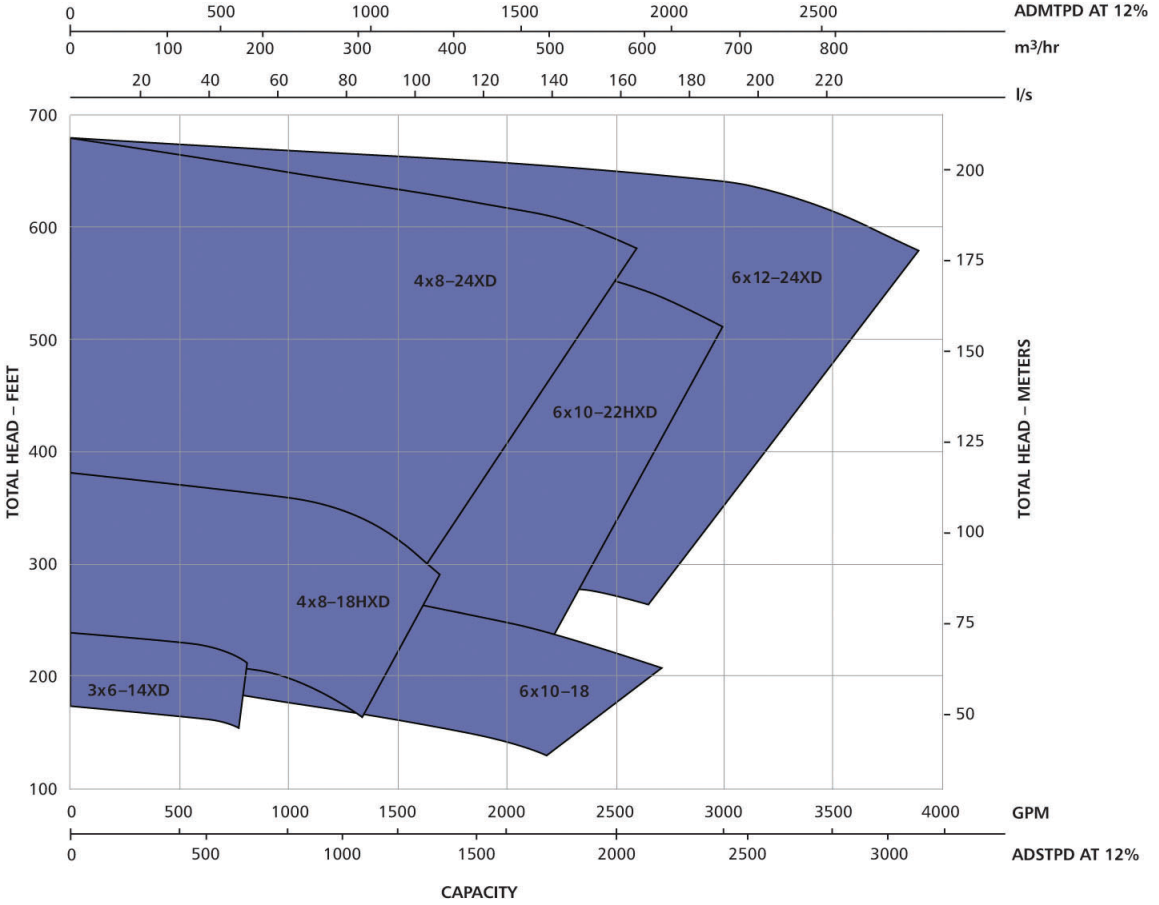
Without effective air removal, medium consistency pumps will not operate reliably.

The efficient air removal system of the Model 3500XD and the simple degas system result in easy operation and very low maintenance.



1	***X-Ducer initiates flowand begins air separation***	X-Ducer agitates pulp to assist flow into pump inlet. X-Ducer also separates air from water and fiber.
2	***X-Ducer concentrates aircore and develops pumping action***	X-Ducer utilizes conventional technology to concentrate air in core and prepare it for removal. Fiber and water move to the periphery of the X-Ducer, then is picked up by the impeller vanes. The air is concentrated near the center of the X-Ducer and is removed through the air extraction holes in the impeller. Using previous technology from inducers, sufficient pressure is generated to allow air to be removed for operation at pulp consistencies up to at least 10%.
3	***Fiber and water are pumped by impeller vanes***	Fiber and water suspension are subjected to pumping action by impeller vanes. Modified concentric casing allows for operation over wide flow range.
4	***Pumping action and degas system moves air, water, and fiber through extraction holes***	Air and water, plus a small amount of residual fiber, pass through impeller air extraction holes.
5	***Fiber and water pumped to impeller periphery***	The large pump-out vanes pump the fiber and water to the periphery of the impeller.
6	***Air with water is extracted past secondary air separation device***	Air with water is extracted across the top surface of the patented (US Patent#5,087,171) secondary air separation removal device into the vacuum system. This device permits separation of any remaining fiber which may be present at this point. Fiber pull through the vacuum system is virtually eliminated.
7	***Air and water are removed through degas system***	The air and water from the degas system is discharged to drain or returned to the standpipe. Depending on the service conditions and design pulp consistency, a vacuum pump may not be needed.

Hydraulic Coverage Model 3500XD



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

Pumping Solutions – Upgrade Existing Systems

Model 3500XD System Upgrade Opportunities

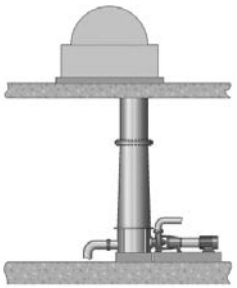
- Reduced power requirements for existing systems
- Increased TDH capabilities with X-Ducer design for new operating conditions
- Existing units readily modified to X-Ducer design — does not require new casing or suction sideplate and fits in current dimensional envelope
- For existing systems operating at 10% consistency or less can allow removal of vacuum pump
- Can adapt to new and future operating conditions with minimal changes and lower power requirements

Proven Goulds Applications

Extensive worldwide installations operate reliably on services in pulping and bleaching operations. These successful installations result from :

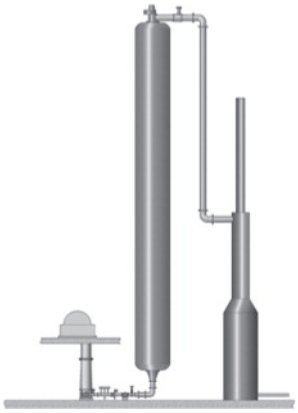
1.	**Defining Requirements**	Understanding and defining the requirements for operation — operating data parameters, piping layouts and knowledge of related equipment (washers, mixers and system components)
2.	**Designing Systems**	Designing systems to meet the operating criteria
3.	**Commissioning**	Commissioning the systems when required by the users

Pumping Solutions



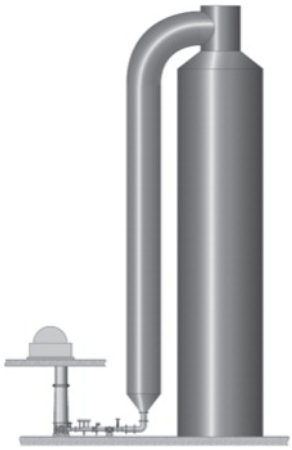
Pumping from Washers, Presses and Disc Filters

Pulp at consistencies up to 14% from different washer types feed into Goulds' standpipes to be pumpedto the next operation.



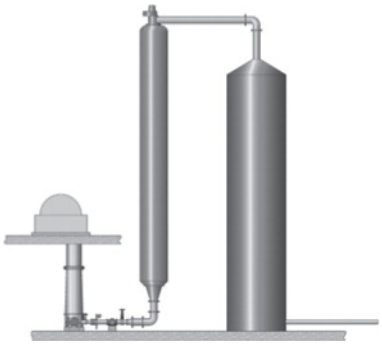
O_2 Delignification Reactor

Pumping from a standpipe to an O_2 mixer adding oxygen before the reaction tower. Steam can also be added to elevate the stock temperatures to the required levels.



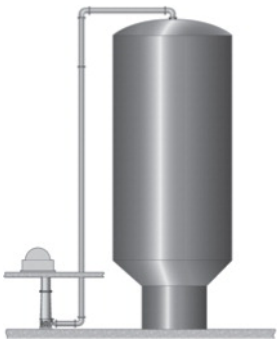
D Stage Feed Pumping

Pumping from a standpipe to a titanium ClO_2 mixer and feeding the chlorine dioxide tower.



Eop Stage Pumping

Pumping through an O_2 mixer into a retention tube and extraction tower. Back pressure may be applied at the top of the upflow retention tube. Hydrogen peroxide and caustic may also be added at the pump suction.

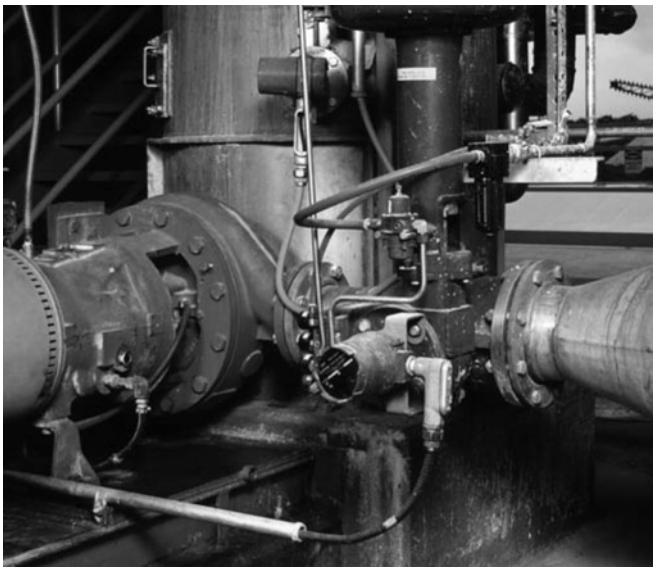


High Density Tower

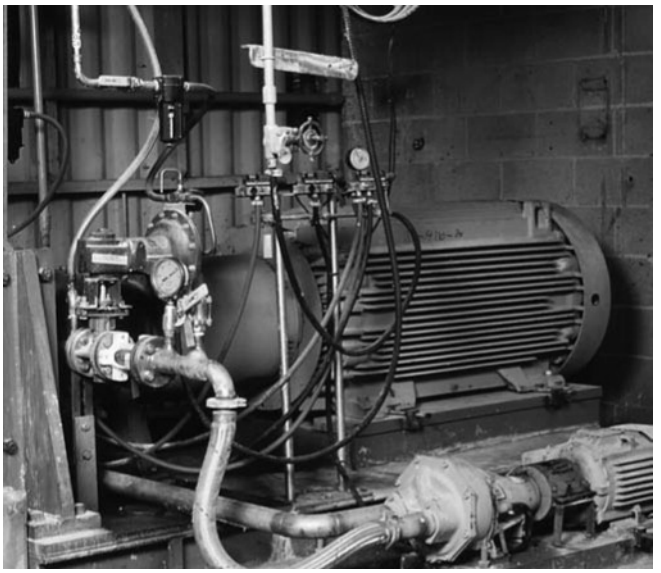
Pumping to a HD tower with a conventional standpipe unit or pumping from a HD tower with a tower bottom installation. Pumping to multiple HD towers is also possible. Long distances may require booster units.

Pumping Solutions

Typical Model 3500XD Installations



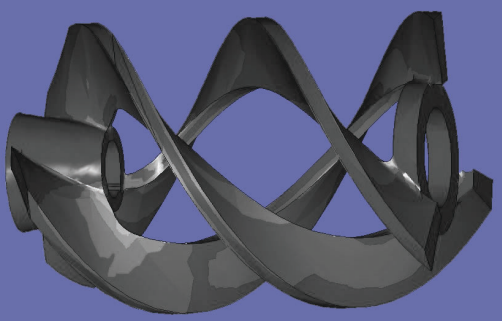
Caustic stage pumping from washer operating at 1200 TPD at 12% consistency. One of seven units in complete bleach line.



Bleached pulp from final wash stage being pumped to HD storage.

The Goulds X-Ducer Performance Advantage:

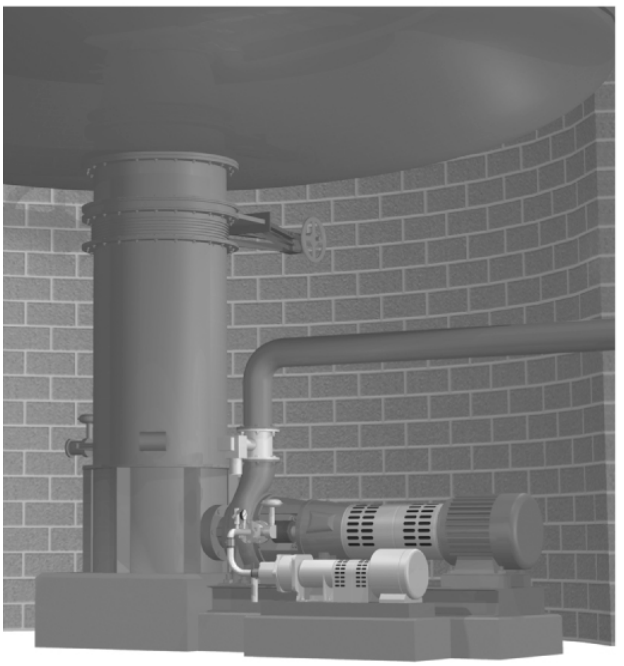
- **Improved Pumping Efficiencies**
  - An increase of up to 8 efficiency points
  - Performance which exceeds or rivals all competitors
- **Expanded Coverage**
  - Higher TDH generation for existing sizes
  - New, larger size to handle production rates to 2200 ADStpd (2000 ADMtpd) and heads to 650 feet (198 m)
- **Dramatic Degas System Improvements**
  - Allows for operation up to 10-11% consistency without a vacuum pump
- **Lower Suction Head Requirements**
  - Allows for lower standpipe elevations and higher operating temperatures
- **Existing Units Readily Converted to the X-Ducer Design**

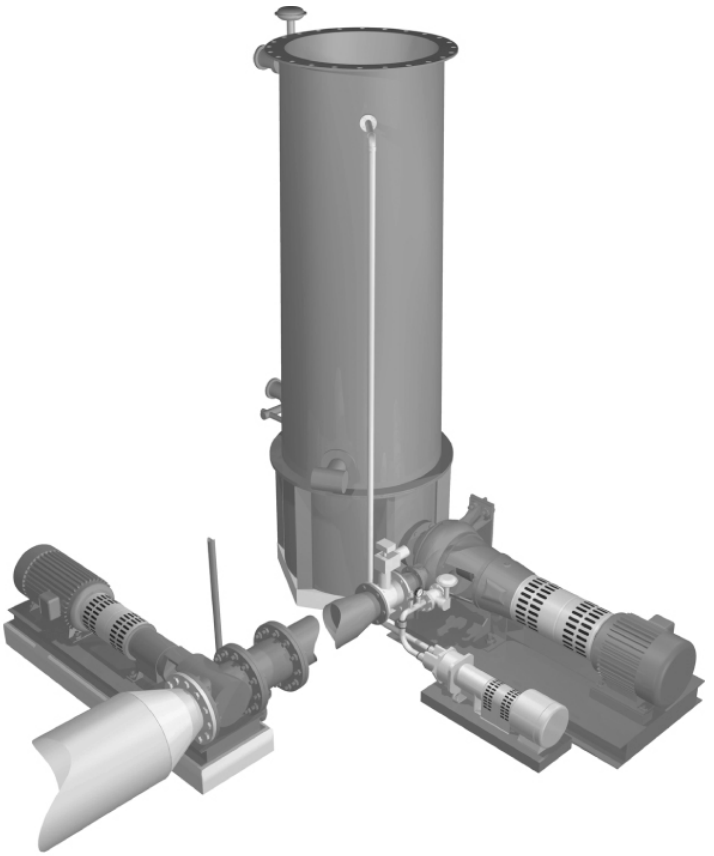


System Configurations

Tower Bottom Arrangement

Stock from bleach/storage towers falls into Goulds feed chute connected to the tower with expansion joint and isolation valve. Depending on tower level and consistency, a vacuum pump may not be required.





Standpipe Arrangement with ClO_2 Mixing

Stock from washers, presses and thickeners feed special Goulds standpipes that are reverse tapered to prevent stock bridging. Systems include controls for vacuum, dilution, level and flow.

Booster Arrangement

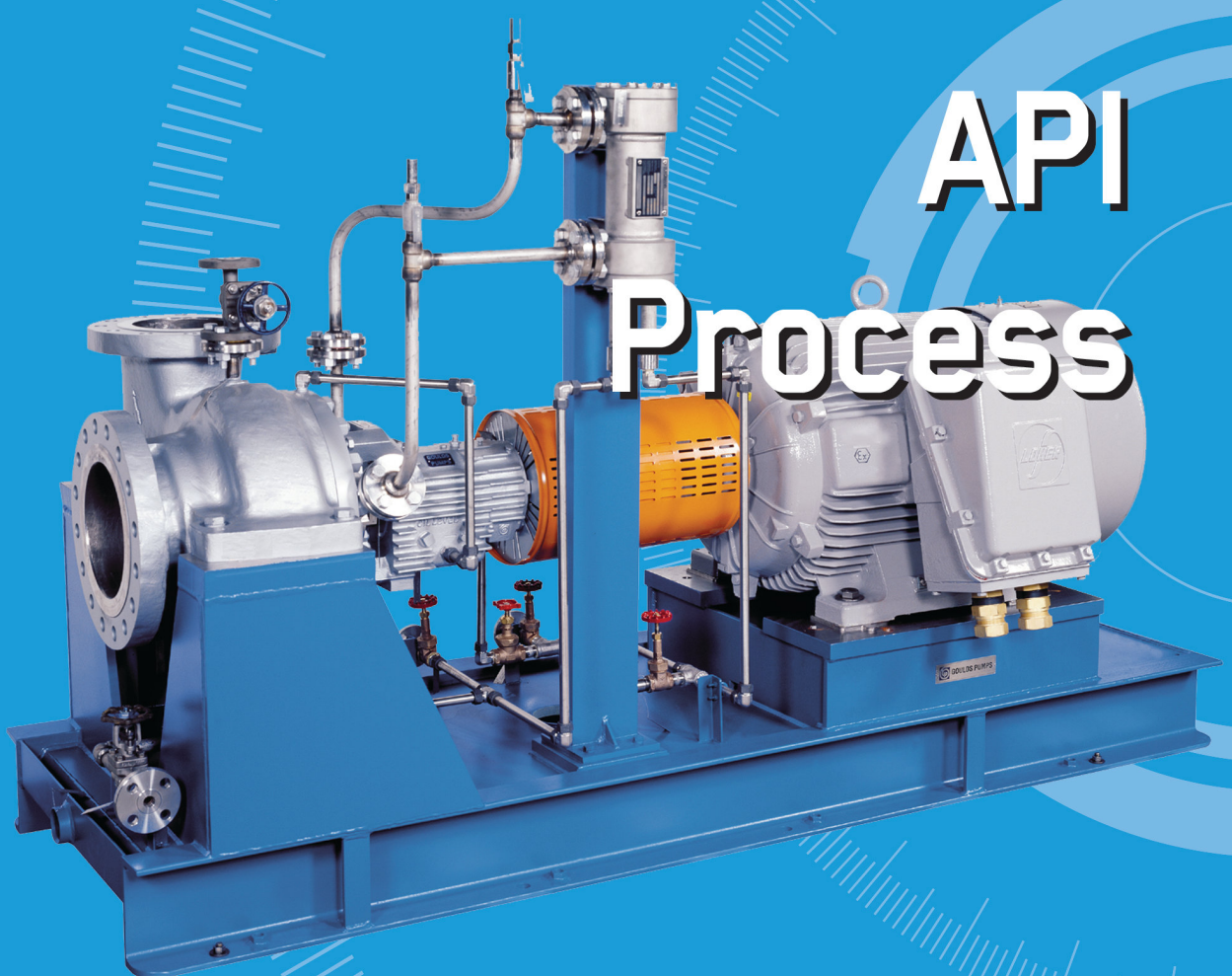
Goulds booster pump will increase pressure but does not require standpipe or degassing system.

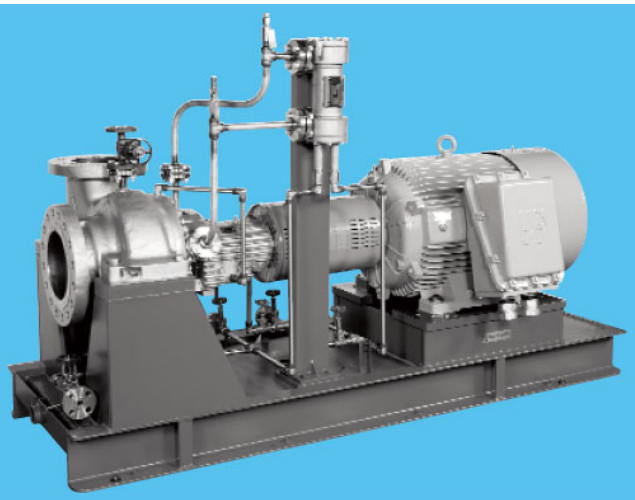
NOTES

NOTES

3

API Process

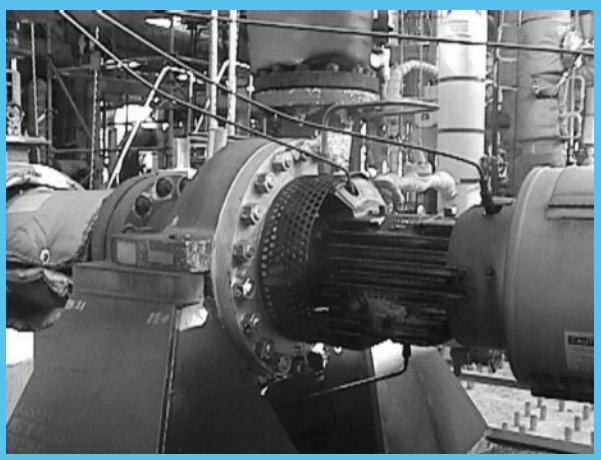




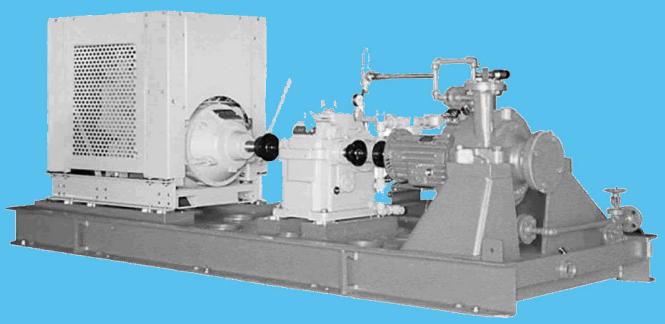
Model 3700

End Suction API-610/ISO 13709 Process Pump

- **Designed for optimum reliability**
- **State-of-the-art mechanical design features**
- **54 casing sizes–choice of impellers with most casings**



Model 3700 on high temperature service at a U.S. Gulf Coast refinery.



Goulds Model 3700

High Temperature and Pressure Process that Pumps that Meet or Exceed API-610 11th Edition and ISO 13709

Safety and Reliability

Safety, reliability, and versatility are the key words for our end-suction, centerline mounted, overhung (OH-2) API 610 process pump.

We provide engineered solutions with true conformance to the latest API specifications including the stringent emissions containment per API 682. The result is a safe and rugged overhung API process pump designed for a 20-year life.

Versatility

- Capacities to 8,500 GPM (1930 m^3/h)
- Total Dynamic Head to 1,200 feet (360m)
- Temperatures to 800° F (425° C)
- Pressures to 870 PSIG (60 bar)

Materials - Available in a wide range of materials including all API 610 constructions and custom applicaiton needs.

Engineered Hydraulics - An industry leading 135 hydrualic combinations to better match your process for efficiency and reliability. Custom hydraulics are available.

Engineered Packaging with a wide range of drivers, seals, piping, nozzle configurations, flanges, baseplates, and QC testing.

Applications

- Column Reflux
- Column Bottoms
- Reboiler
- Injection
- Fuel Blending
- Heat Transfer
- Slop Gas Oil
- Heavy Gas Oil
- Hot Oil
- Column Charge
- Reactor Feed
- Stabilizer Overhead
- Scrubber Circulation
- Tower Bottoms
- Offsite Hydrocarbon Transfer
- Stripper Overhead

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3700 ISO 13709 / API-610 Process Pumps

Design Features for Wide Range of High Temperature/High Pressure Services

DUAL VOLUTE CASING
Standard on 3-inch discharge and larger. Minimizes radial load and reduces shaft deflection for increased mechanical seal life.

HEAVY DUTY BEARING FRAME
Piloted and metal-to-metal fits assure runouts and concentricities well within limits specified in API-610/ISO 13709. Large oil sump capacity. Cast fins enhance cooling.

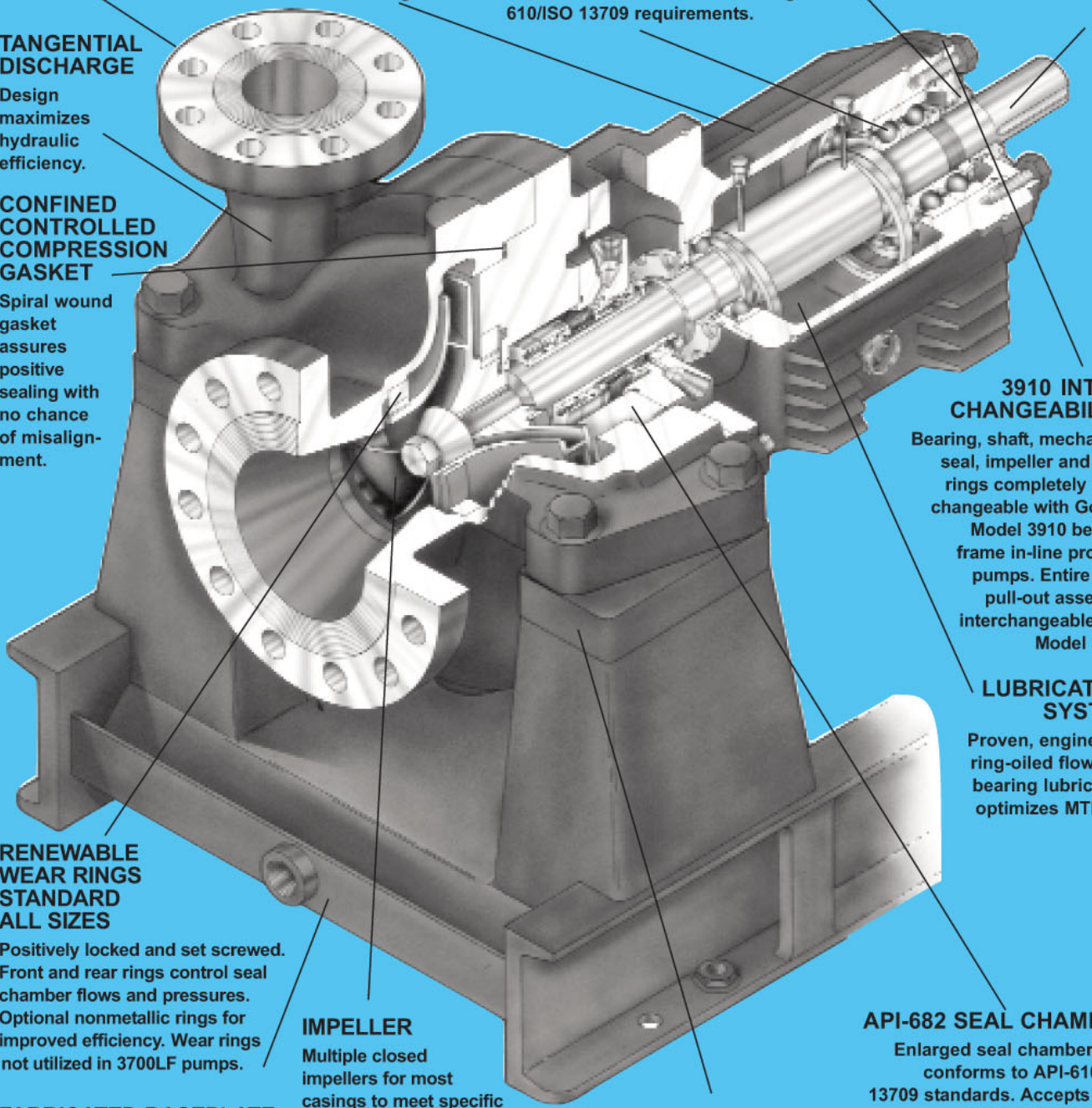
BEARINGS
Duplex 40° angular contact thrust bearings and deep groove (Conrad) radial bearings sized for minimum three-year bearing life under most severe operating conditions. Exceeds API-610/ISO 13709 requirements.

LABYRINTH OIL SEALS
Labyrinth seal design prevents oil from leaking out and contaminants from intruding. Made from non-sparking metal.

RIGID, HEAVY DUTY SHAFT
Minimizes shaft deflection, maximizes bearing and mechanical seal life.

TANGENTIAL DISCHARGE
Design maximizes hydraulic efficiency.

CONFINED CONTROLLED COMPRESSION GASKET
Spiral wound gasket assures positive sealing with no chance of misalignment.



3910 INTER-CHANGEABILITY
Bearing, shaft, mechanical seal, impeller and wear rings completely interchangeable with Goulds Model 3910 bearing frame in-line process pumps. Entire back pull-out assembly interchangeable with Model 3710.

LUBRICATION SYSTEM
Proven, engineered ring-oiled flow-thru bearing lubrication optimizes MTBPM.

RENEWABLE WEAR RINGS STANDARD ALL SIZES
Positively locked and set screwed. Front and rear rings control seal chamber flows and pressures. Optional nonmetallic rings for improved efficiency. Wear rings not utilized in 3700LF pumps.

IMPELLER
Multiple closed impellers for most casings to meet specific hydraulic requirements. Balanced to stringent ISO 1940 Grade 1.0 (exceeds API minimum). Low-flow pumps use a semi-open impeller design.

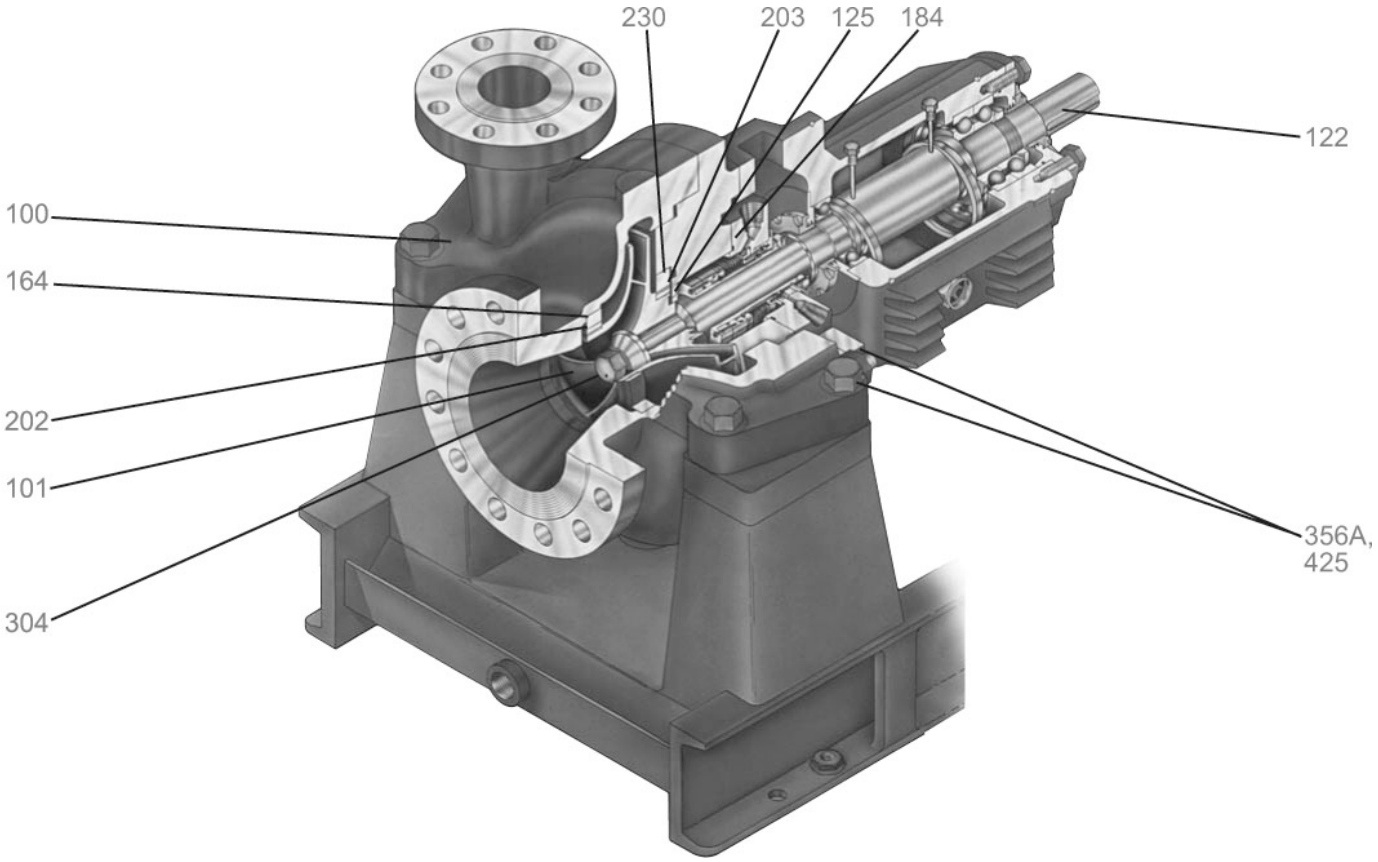
FABRICATED BASEPLATE
Enlarged drain connectin to prevent buildup of debris. All joints are continuously welded. Extra-width sizes available to ease maintenance of seal systems.

NOZZLE LOAD CAPABILITY
Casing/baseplate design optimized to meet toughest API/ISO nozzle load criteria.

API-682 SEAL CHAMBER
Enlarged seal chamber fully conforms to API-610/ISO 13709 standards. Accepts wide range of API-682/ISO 21049 cartridge mechanical seals. Renewable throat bushing standard for controlled seal chamber environment.

Sectional View

Model 3700



Parts List and Materials of Construction

Item	Part Name	S-4	S-6	S-8	C-6	A-8	D-1	D-2
100	Casing	Carbon Steel			12% Chrome	316L SS	Duplex SS	S.Duplex SS
101	Impeller	Carbon Steel	12% Chrome	316L SS	12% Chrome	316L SS	Duplex SS	S.Duplex SS
122	Shaft	ANSI 4140 *		316L SS	410 SS	316L SS	Duplex SS	S.Duplex SS
125	Throat Bushing	Cast iron	410 SS	316L SS	410 SS	316L SS	Duplex SS	S.Duplex SS
164, 230	Wear Ring - Casing **	Cast iron	12% Chrome	316L SS	12% Chrome	316L SS	Duplex SS/ Stellite 12	S.Duplex SS/ Stellite 6
202, 203	Wear Ring - Impeller **	Cast iron	12% Chrome	Nitronic 60	12% Chrome	Nitronic 60	Duplex SS/ Stellite 12	S. Duplex SS/ Stellite 6
184	Seal Chamber Cover	Carbon Steel			12% Chrome	316L SS	Duplex SS	S.Duplex SS
304	Impeller Nut	Steel	316 SS				Duplex SS	S.Duplex SS
356A, 425	Casing studs / nuts	ANSI 4140						

* 410 SS on S-6 when temperature exceeds 350F (175C)
* Not utilized on 3700LF low flow pumps.

Standard Features for Optimum Reliability

Proven API-610 Nozzle Load Design

Rugged casing and baseplate/pedestal support system provides flange loading capability exceeding API-610/ISO 13709 requirements without the use of a bearing frame support.

Full Flange Rating Pressure Capability

All pumps designed to operate at two pole running speeds have casings designed for the full pressure capability of a 300 RF flange.

Spiral Wound Casing Gasket

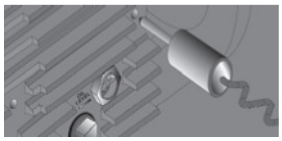
Casing to cover joint sealed with a spiral wound, controlled compression gasket required by API-610. Provides positive sealing up to the maximum design pressure and temperature.

API-610/ISO 13709 Seal Chamber

Designed to provide ideal seal environment for specified sealing arrangements. Full conformance with standardized dimensional requirements of API-610/ISO 13709. Accepts full range of API-682/ISO 21049 mechanical seals. Interchangeable with Model 3910.

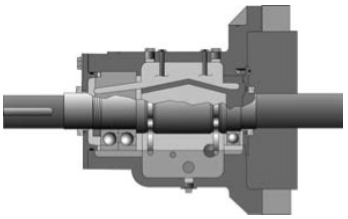
Performance Options

MULTIPLE IMPELLERS
Meet specific user operating requirements. Available for most pump sizes.



Improved Bearing Environment

- Bearing frame fins provide optimum heat dissipation.
- Condition monitoring sites allow easy and consistent monitoring of temperature and vibration. Provision for instrumentation mounting per API-670 available.
- Extra large oil sump provides cooler running bearings.
- Proven channeled oil lubrication system assures flow-thru of cooled oil to thrust and radial bearings.
- Standard dual oil rings, positively located, provide oil flow to channeled oil lubrication system and prevent oil foaming.

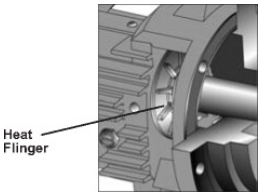


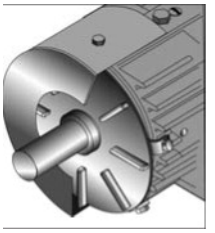
Optional Features for Application Flexibility

Goulds offers users a range of options to meet specific plant and process requirements.

High Temperature Capability

For high temperature applications, these options are available.





HEAT FLINGER

Heat flinger dissipates shaft-conducted heat and circulates air to reduce heat build-up.

AIR COOLING

High capacity fan and shroud mounted on power end effectively reduce bearing frame temperature for cooler running bearings without using cooling water.

WATER COOLING

Finned cooler for maintaining oil/bearing temperature. Corrosion resistant material.

EXTRA WIDE BASEPLATE

Provided for seal systems with auxiliary components to improve maintenance access.

HEAVY DUTY PEDESTAL

Unique trapezoidal design provides superior resistance to deflections from flange loads.

TOP SUCTION NOZZLE OPTION

Model 3710 reduces space requirements and installation costs for unique applications.

SOLIDS HANDLING

Model 3703 with semi-open impeller for increased solids handling.

ABRASIVE SERVICES

Hardened coatings are available for services with abrasive solids.

INDUCER OPTION

Under certain conditions, reduction in NPHSR can be provided with an axial flow inducer.

COKE CRUSHER OPTION

Allows coke particles to be easily pumped by crushing coke with a cutter screw.

HIGH SUCTION PRESSURE

Applications requiring high suction pressure can be accommodated with minor design modifications..

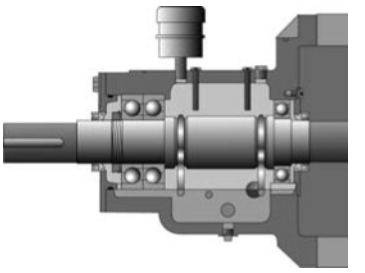
NON METALLIC RINGS

Non-metallic rings are available for increased efficiency and limited dry run capability.

Lubrication Flexibility

OIL MIST LUBRICATION SYSTEM

Connections for pure or purge oil mist lubrication can be provided for immediate use or future requirements.

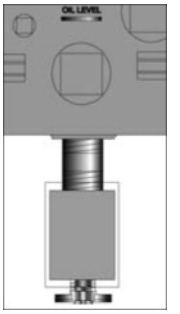


SEALED POWER END

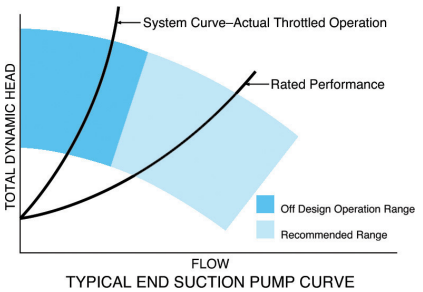
Designed with magnetic end face seals and expansion chamber to prevent contaminants from entering the power end.

LUBRICANT SIGHT GLASS AND SAMPLING BOTTLE

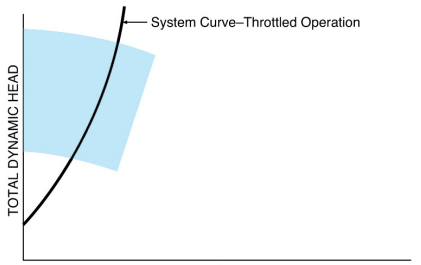
For visual inspection and sampling of oil.



Designed for Low Flow Services



TYPICAL END SUCTION PUMP CURVE



3700 LF PUMP CURVE

Not All Pumps are Designed for Low Flows

Many users throttle pumps to attain low flow rates - yet create bearing and seal issues. The traditional enclosed impeller passage ways would be too small to properly manufacture at these low flow rates.

3700 LF Low Flow Solution

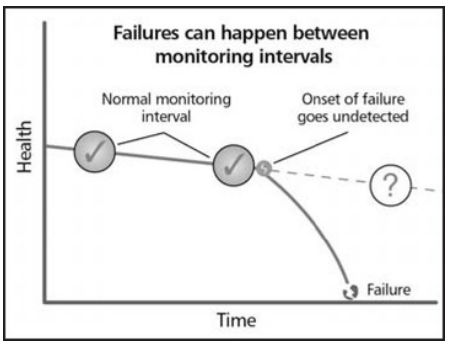
The 3700 LF semi-open radial vane impeller eliminates these enclosed impeller limitations. The unique circular volute casing eliminates diffusers thus reducing the pump size, footprint and lifetime costs.

i-ALERT™ Condition Monitor

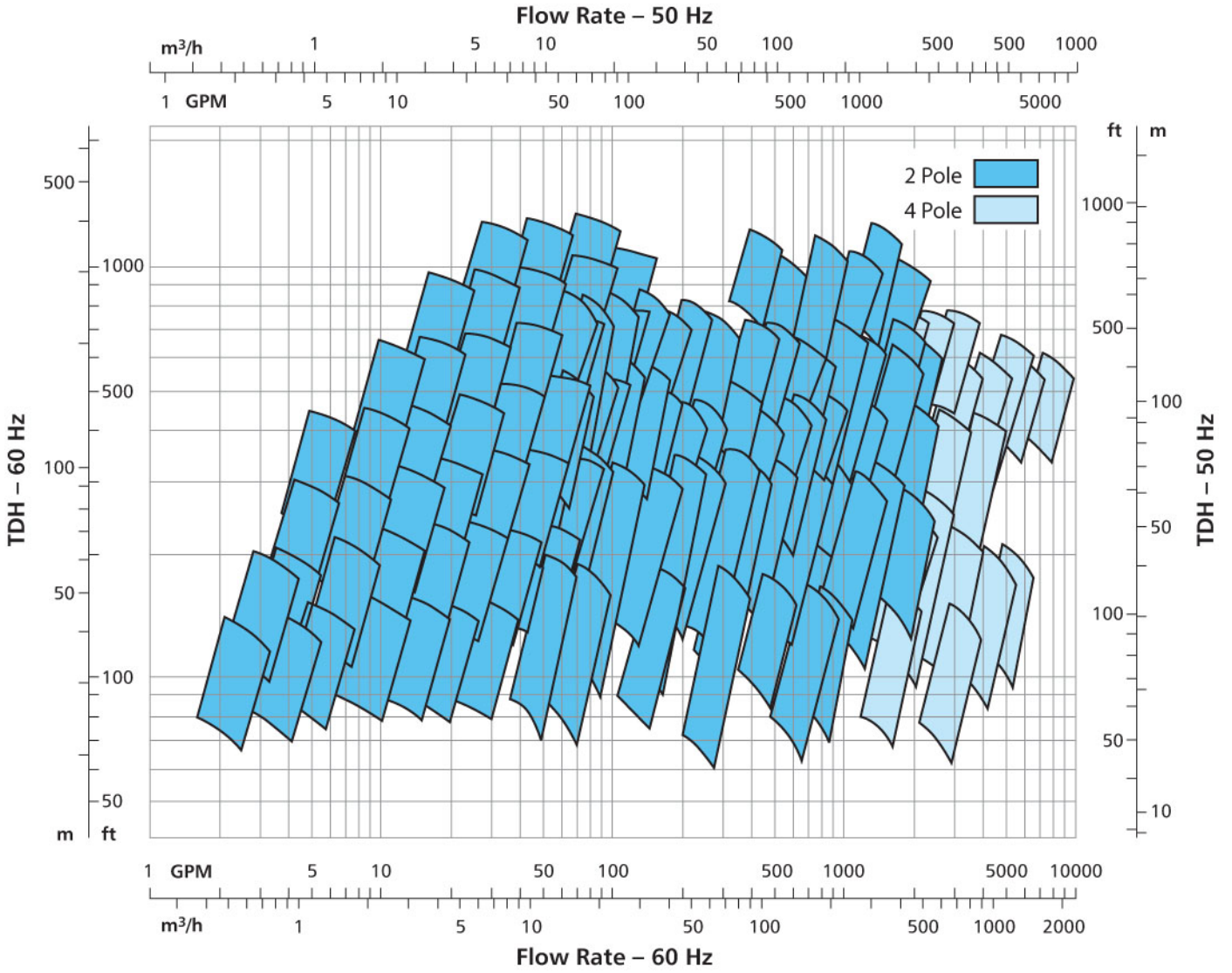
The heart of the *i*- FRAME, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.

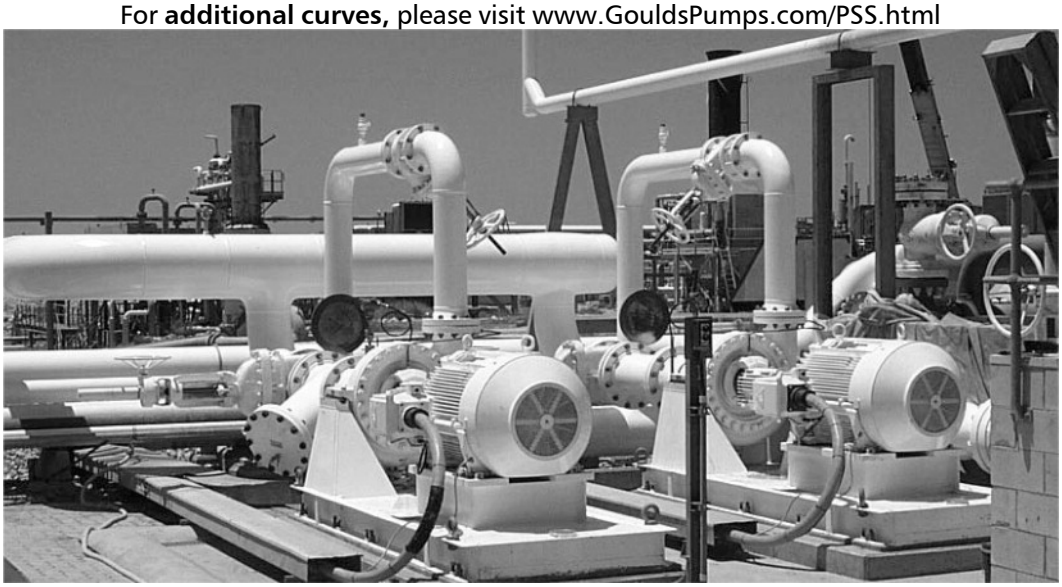
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.



Hydraulic Coverage



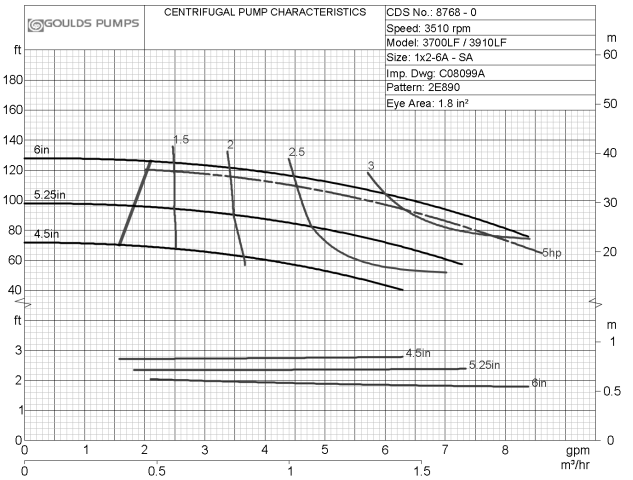
For **additional curves,** please visit www.GouldsPumps.com/PSS.html



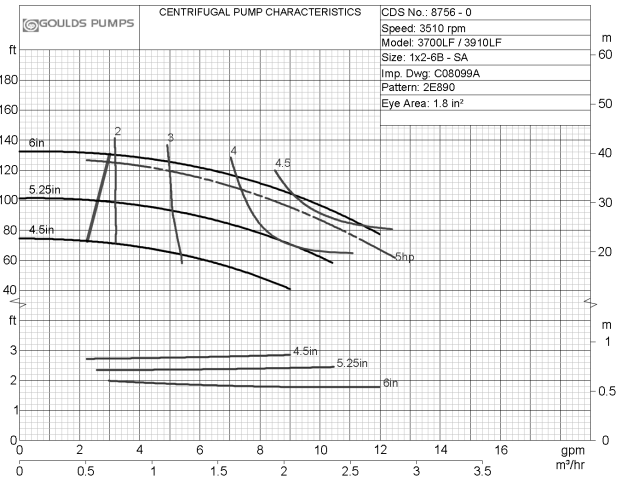
Typical 3700 Installation

NOTES

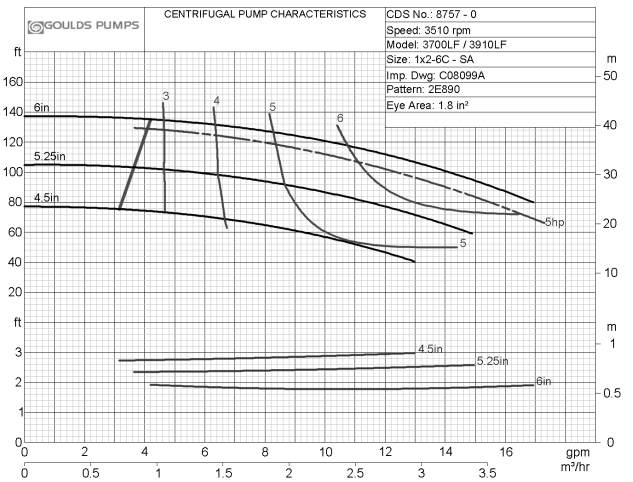
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



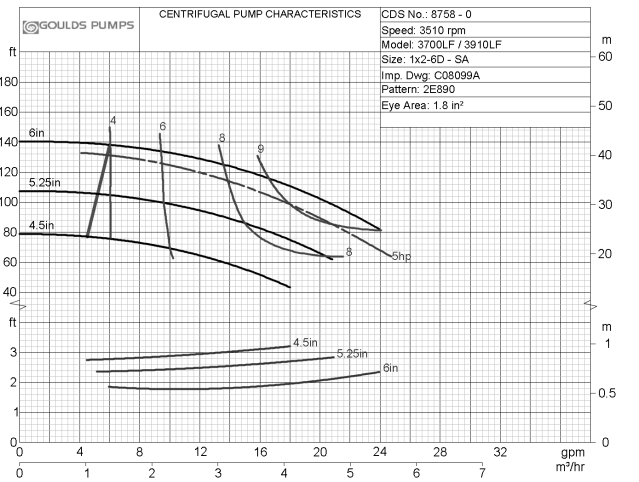
1x2-6A **3510rpm**



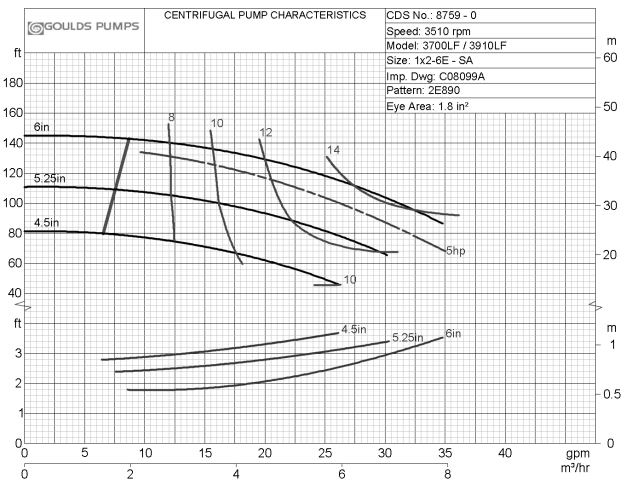
1x2-6B **3510rpm**



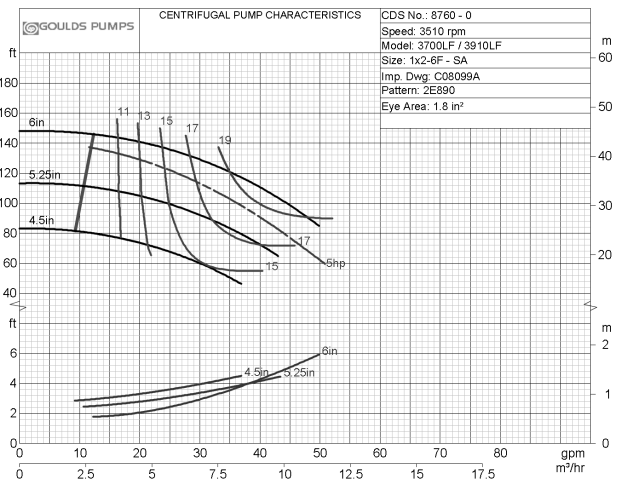
1x2-6C **3510rpm**



1x2-6D **3510rpm**



1x2-6E **3510rpm**

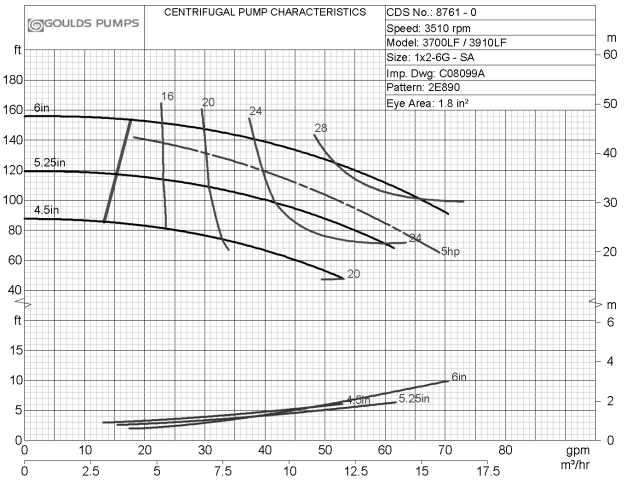


1x2-6F **3510rpm**

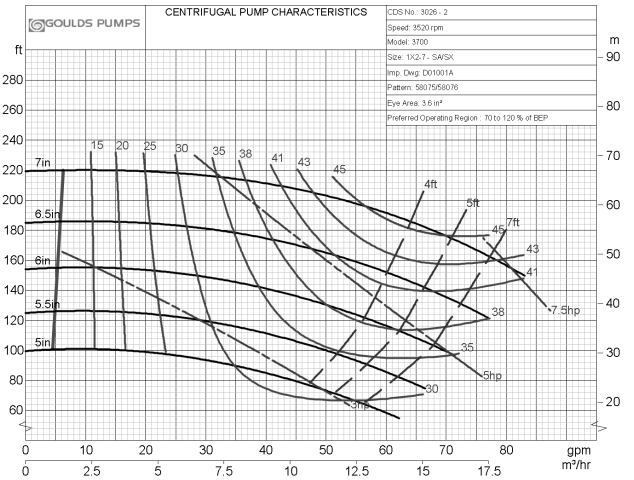
60Hz Curves

Model 3700

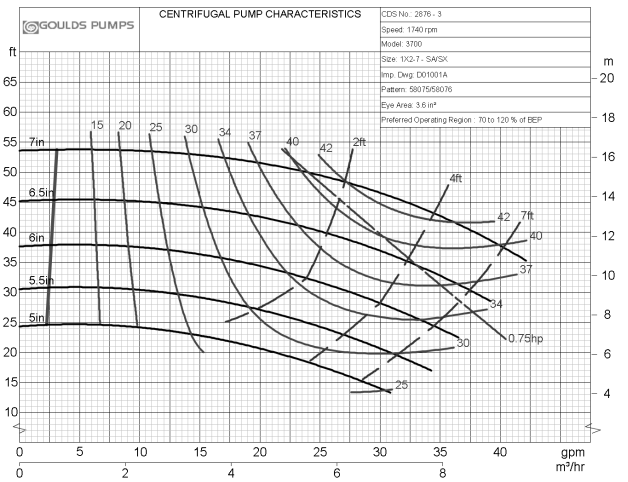
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



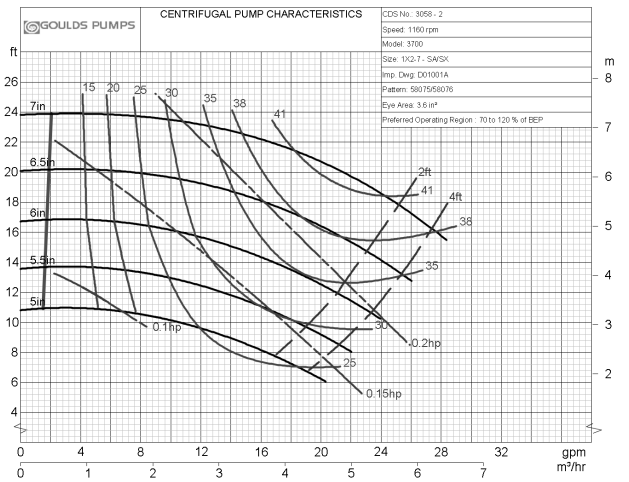
1x2-6G **3510rpm**



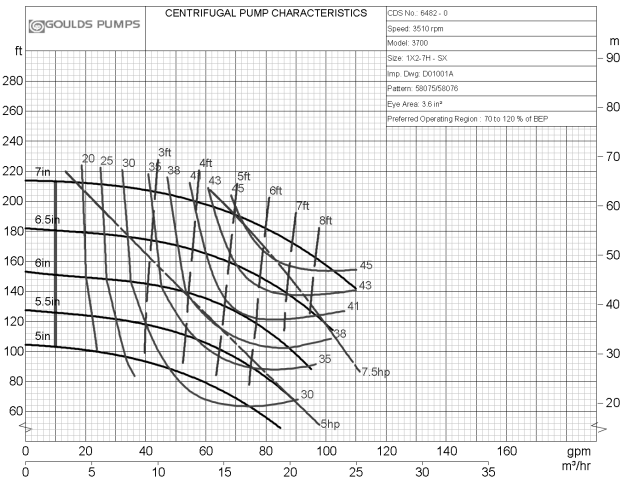
1X2-7 **3520rpm**



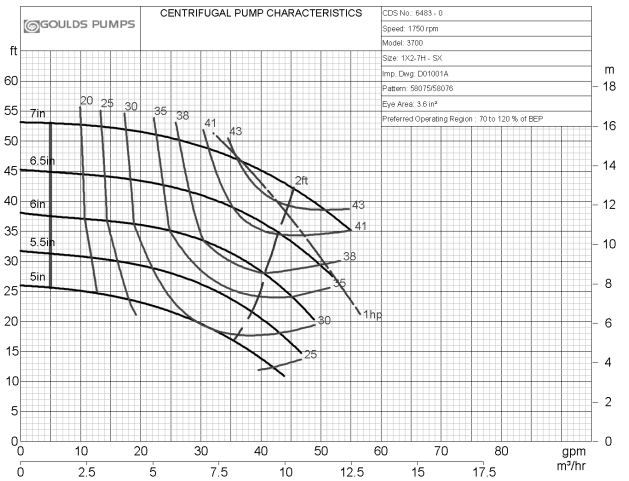
1X2-7 **1740rpm**



1X2-7 **1160rpm**

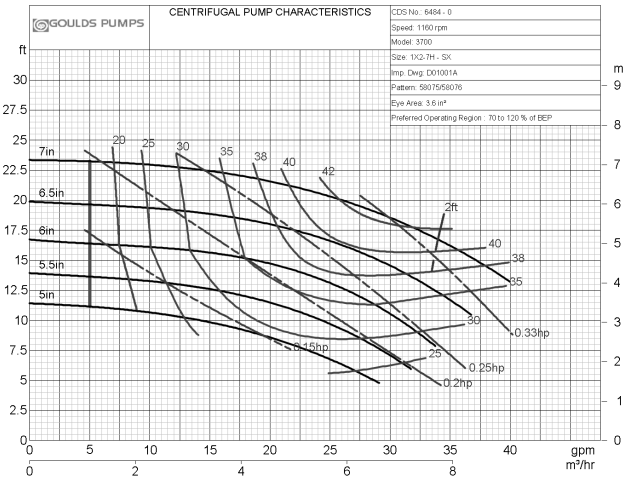


1X2-7H **3510rpm**

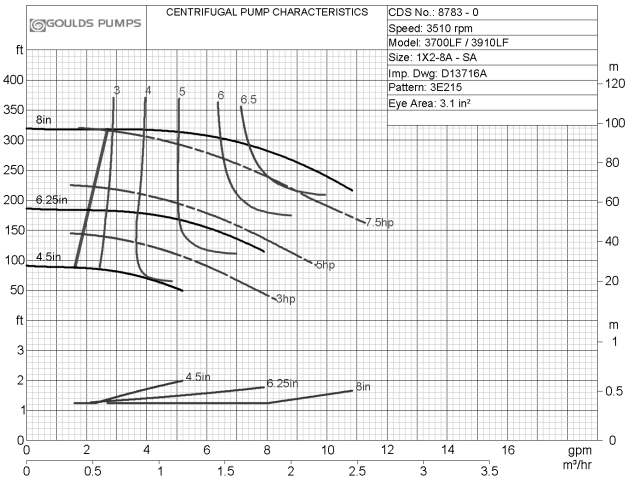


1X2-7H **1750rpm**

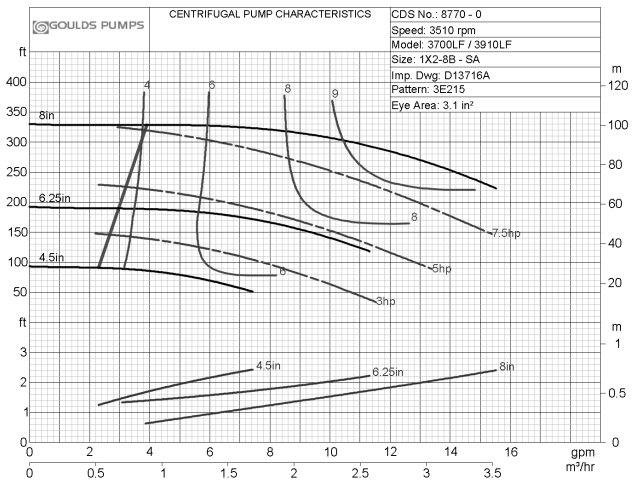
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



1X2-7H **1160rpm**

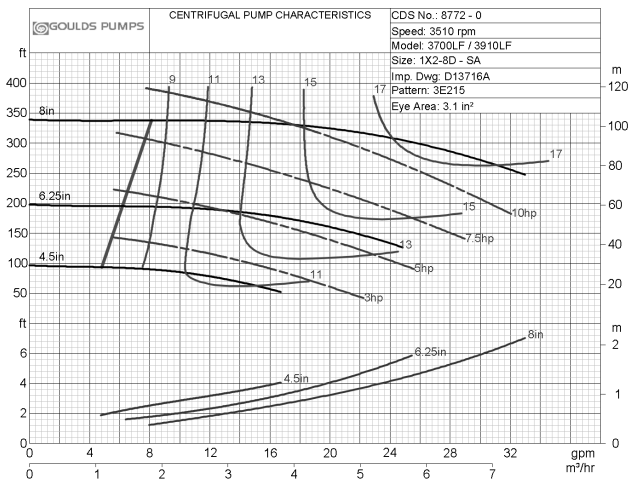


1X2-8A **3510rpm**

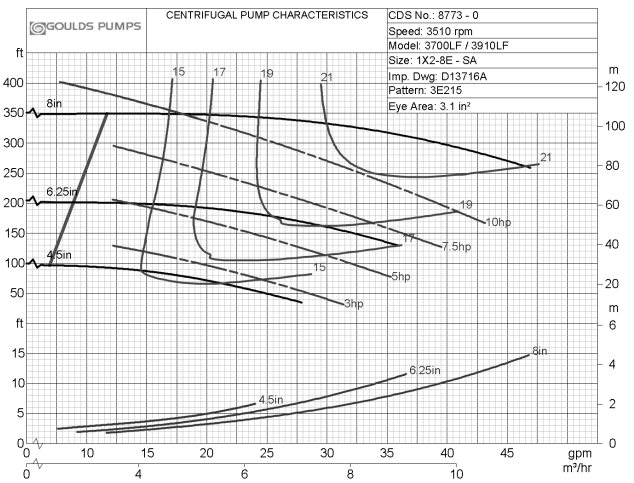


1X2-8B **3510rpm**

1X2-8C **3510rpm**

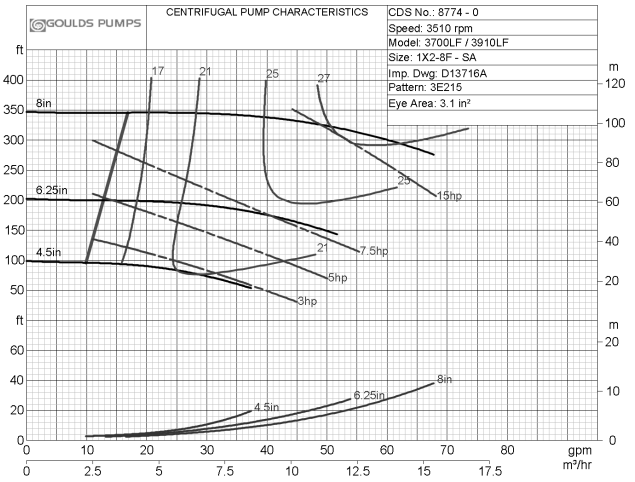


1X2-8D **3510rpm**

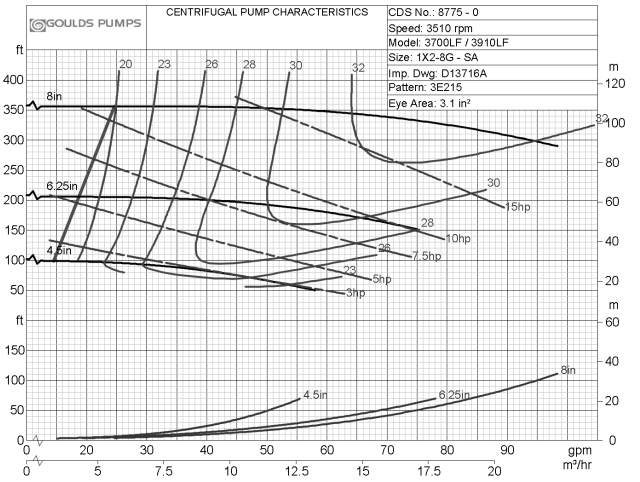


1X2-8E **3510rpm**

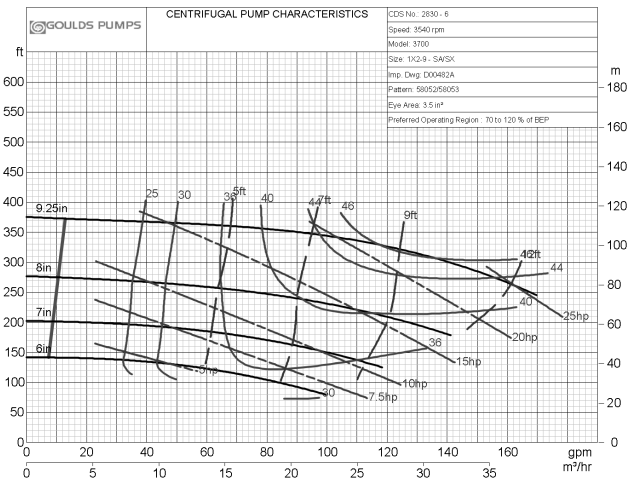
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



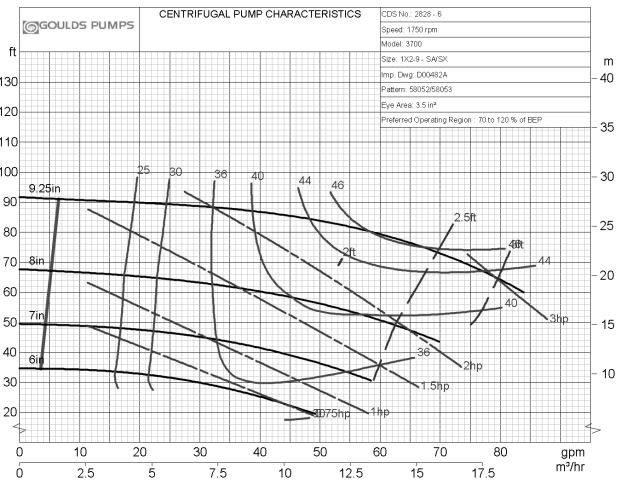
1X2-8F **3510rpm**



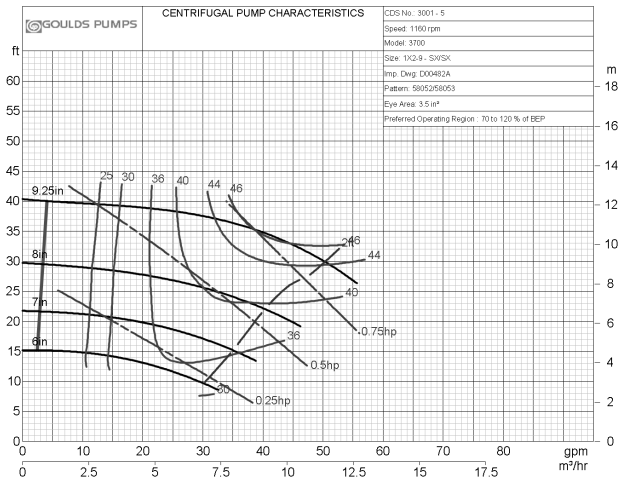
1X2-8G **3510rpm**



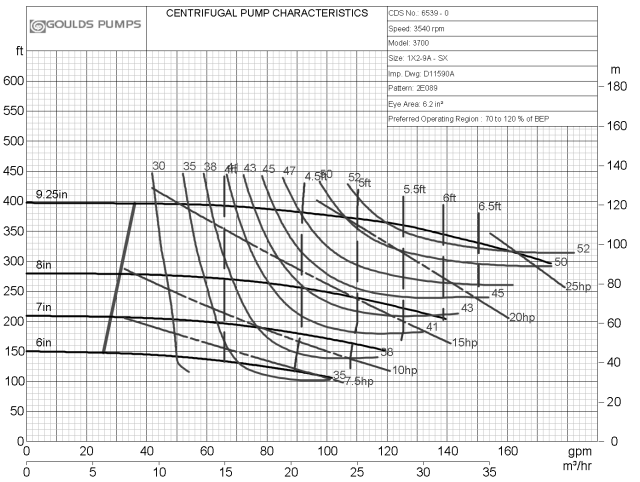
1X2-9 **3540rpm**



1X2-9 **1750rpm**

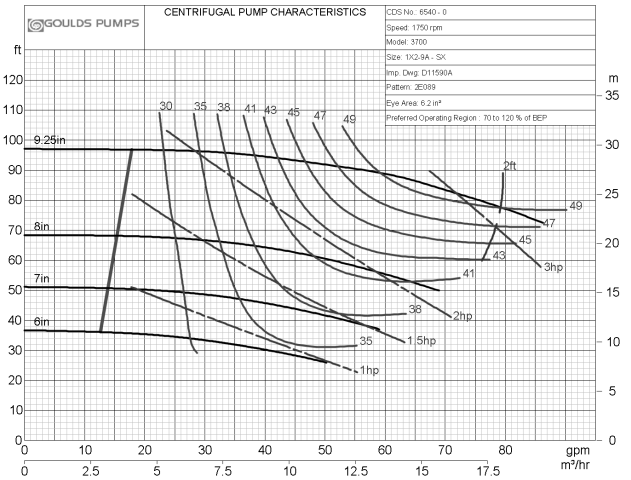


1X2-9 **1160rpm**

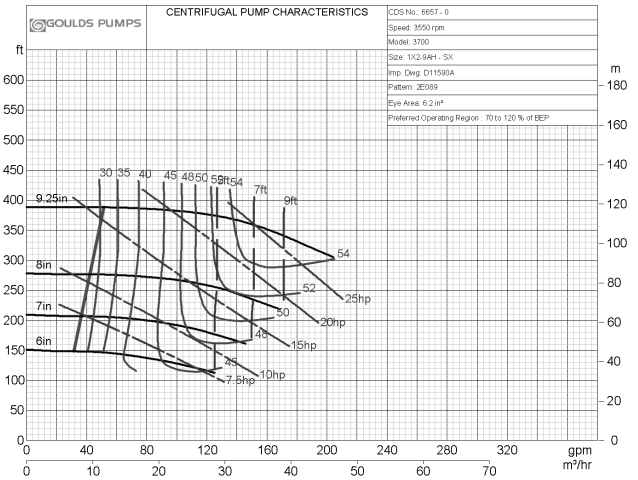


1X2-9A **3540rpm**

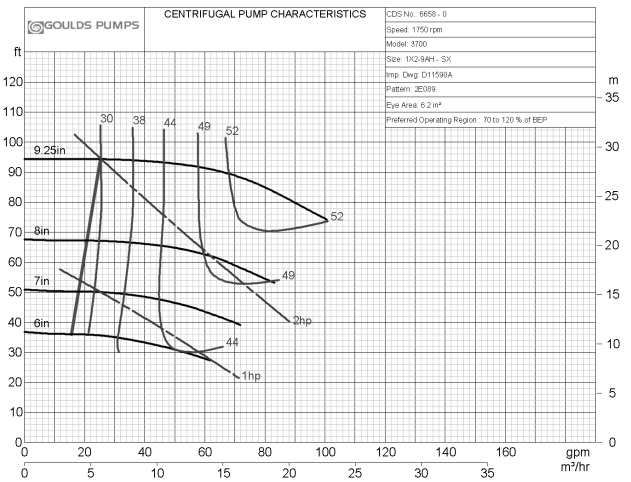
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



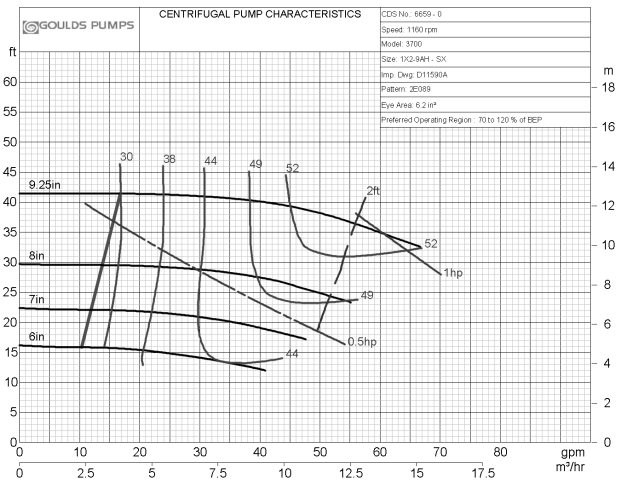
1X2-9A **1750rpm**



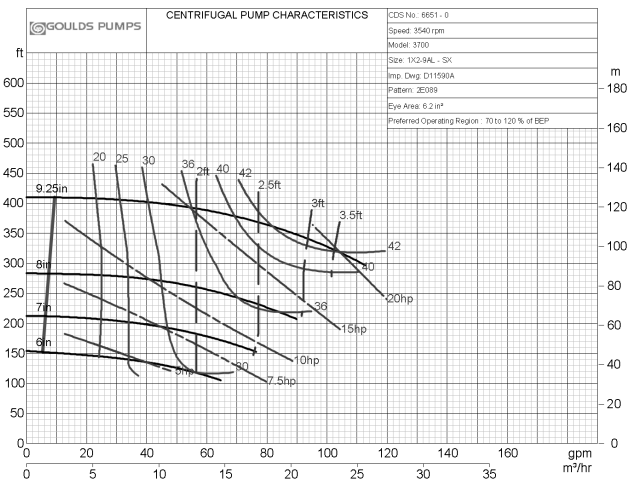
1X2-9AH **3550rpm**



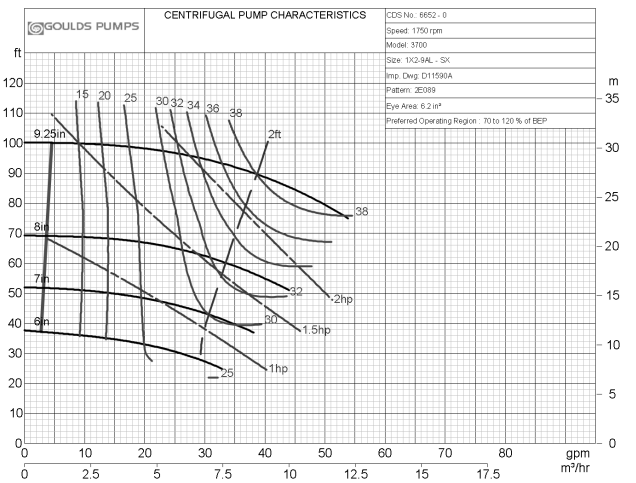
1X2-9AH **1750rpm**



1X2-9AH **1160rpm**



1X2-9AL **3540rpm**

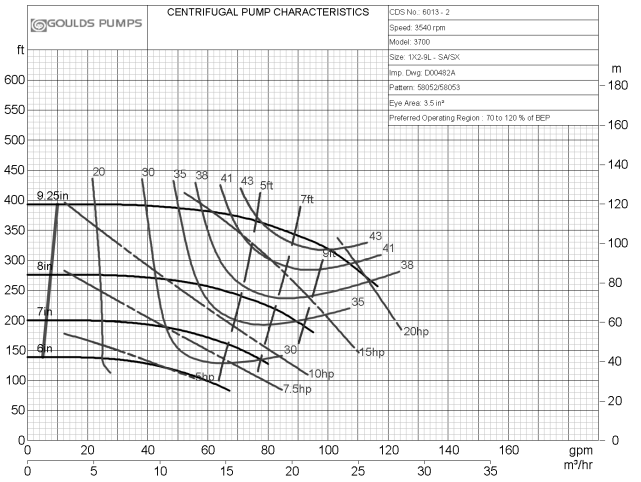


1X2-9AL **1750rpm**

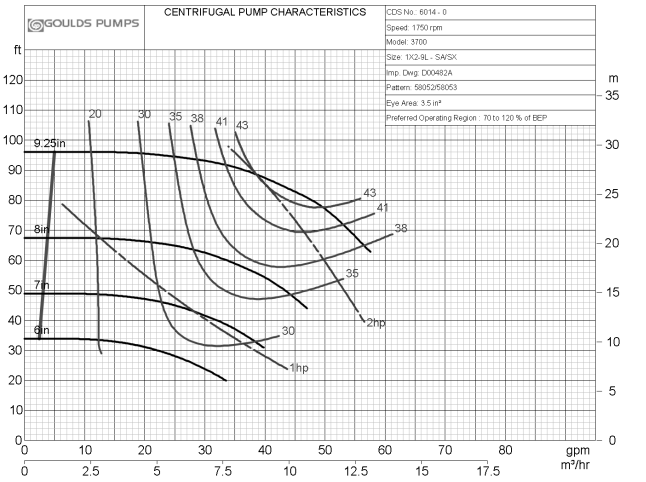
60Hz Curves

Model 3700

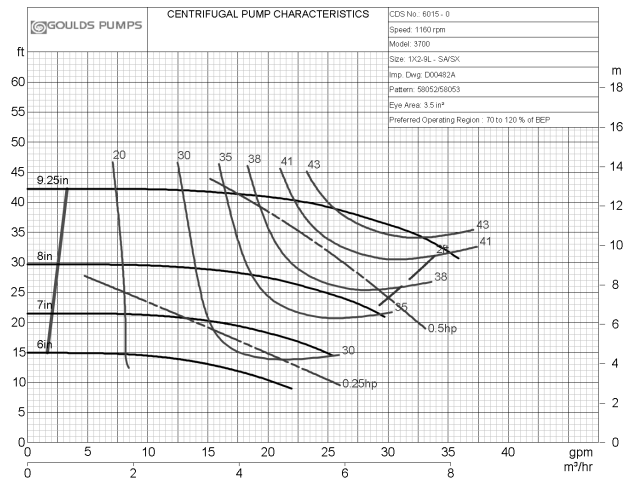
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



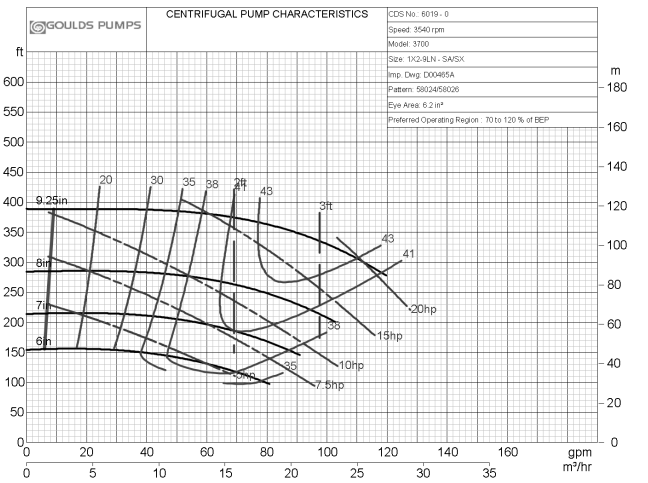
1X2-9L **3540rpm**



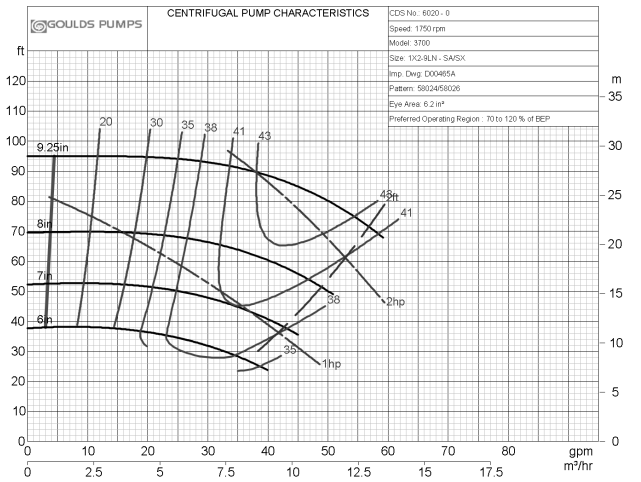
1X2-9L **1750rpm**



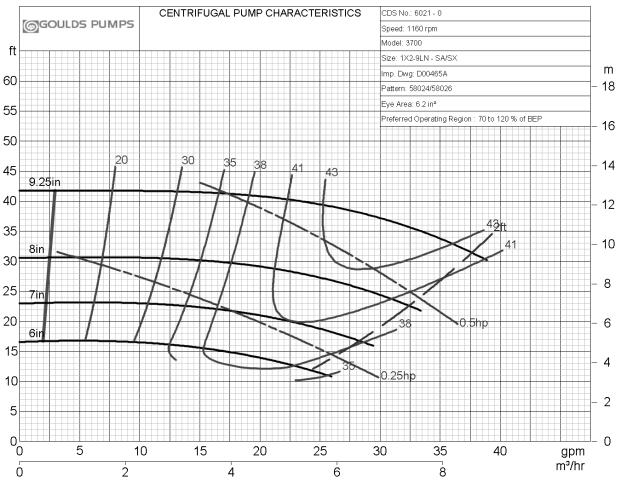
1X2-9L **1160rpm**



1X2-9LN **3540rpm**

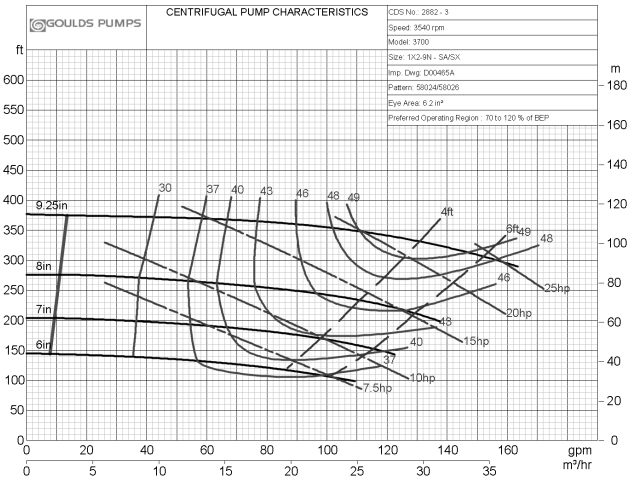


1X2-9LN **1750rpm**

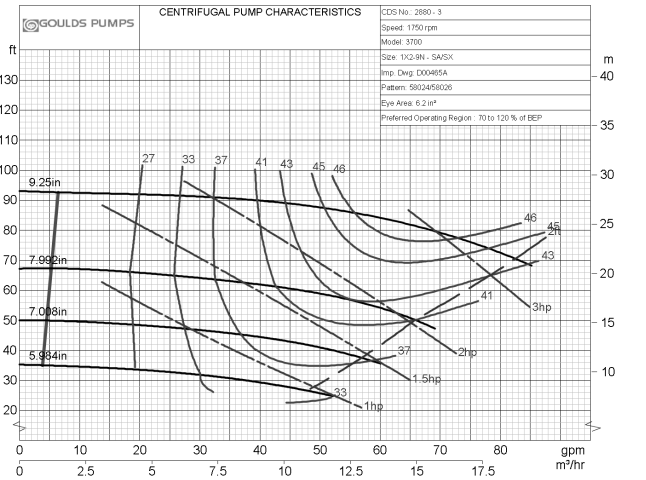


1X2-9LN **1160rpm**

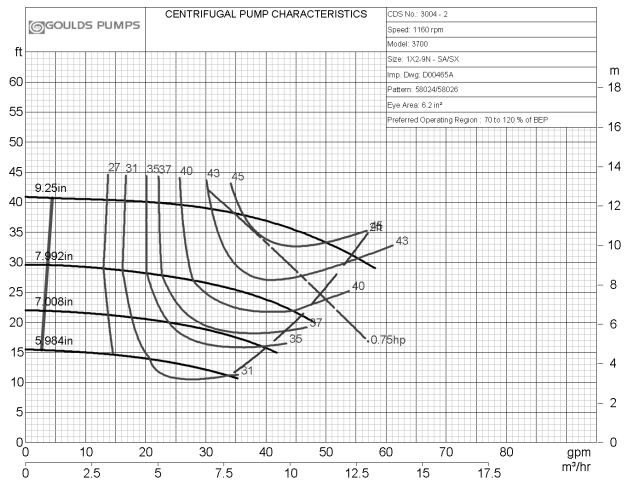
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



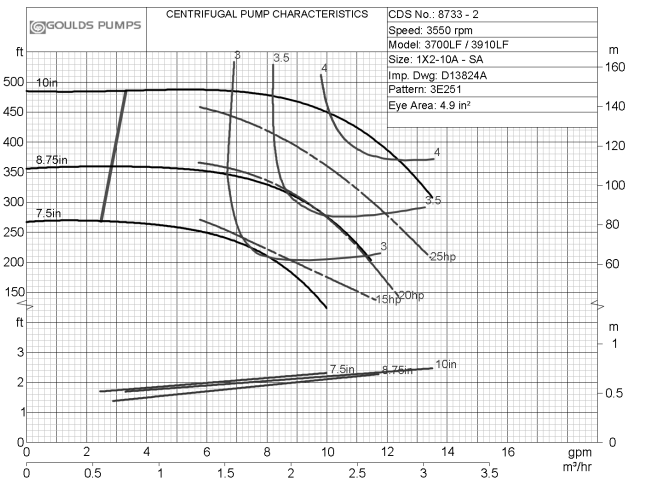
1X2-9N **3540rpm**



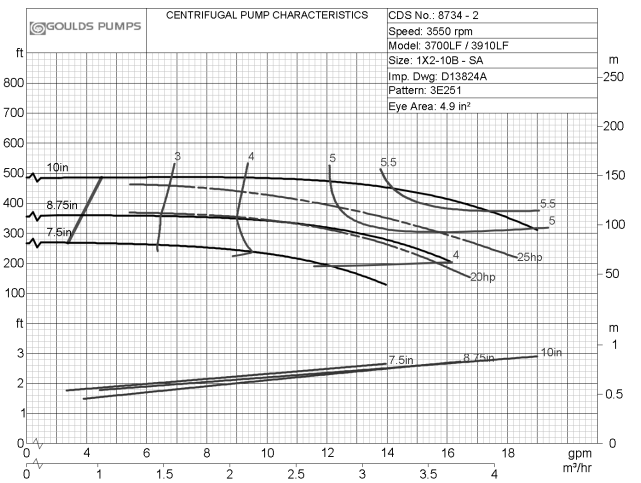
1X2-9N **1750rpm**



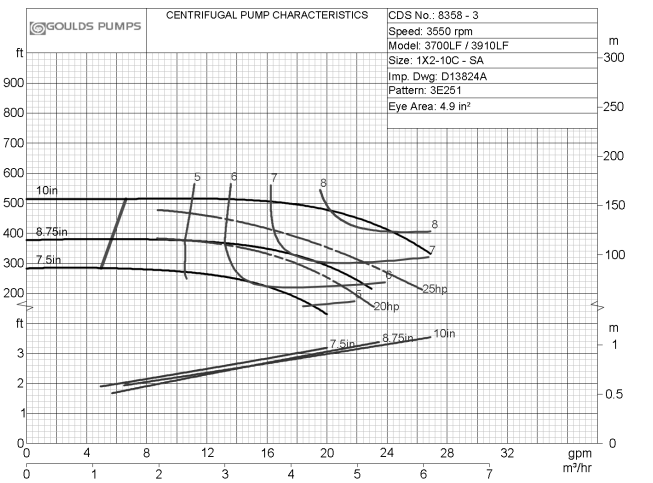
1X2-9N **1160rpm**



1X2-10A **3550rpm**



1X2-10B **3550rpm**

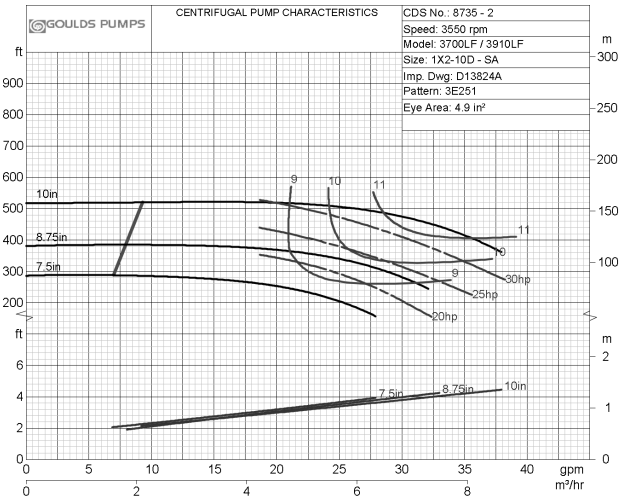


1X2-10C **3550rpm**

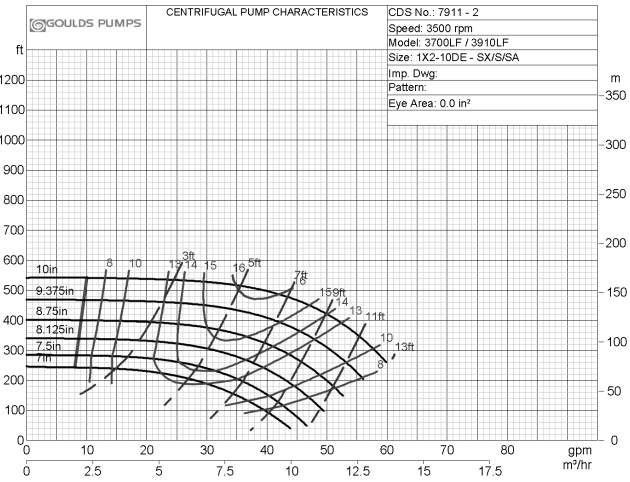
60Hz Curves

Model 3700

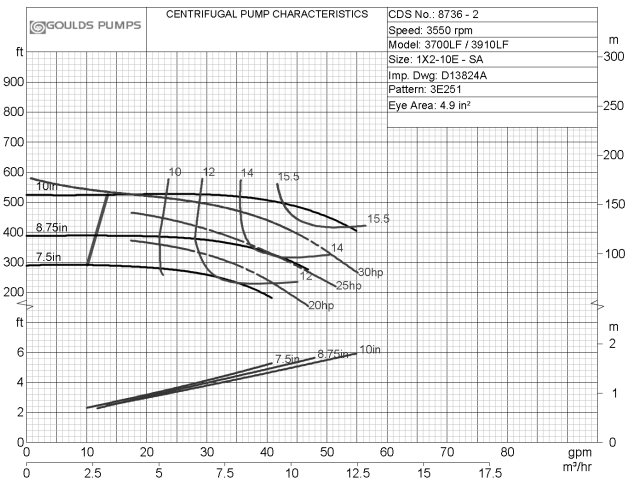
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



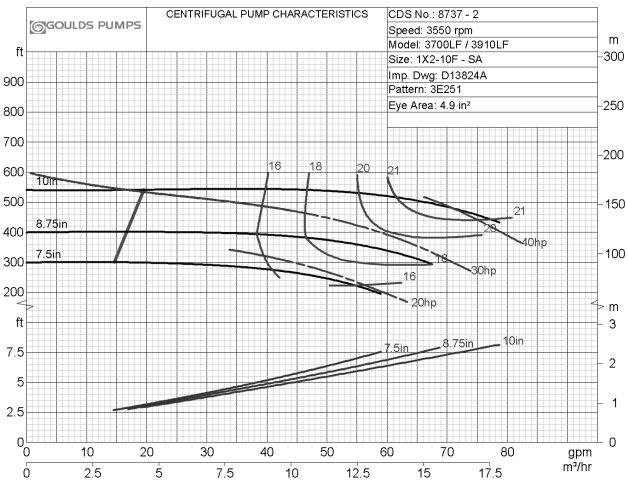
1X2-10D **3550rpm**



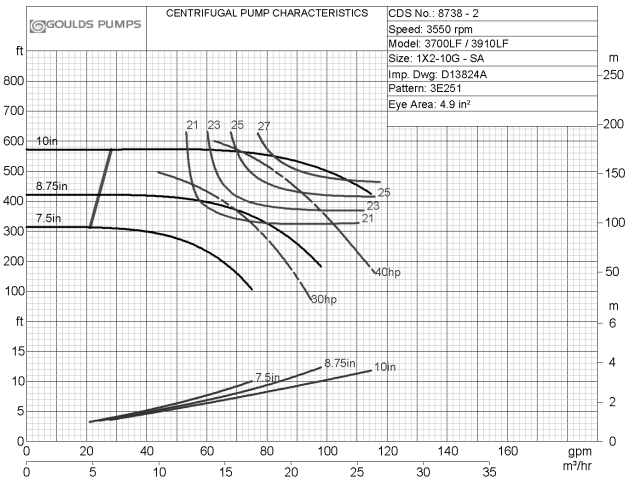
1X2-10DE **3500rpm**



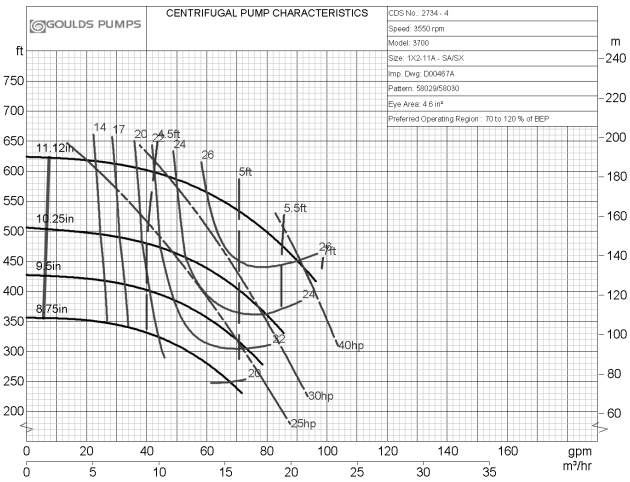
1X2-10E **3550rpm**



1X2-10F **3550rpm**

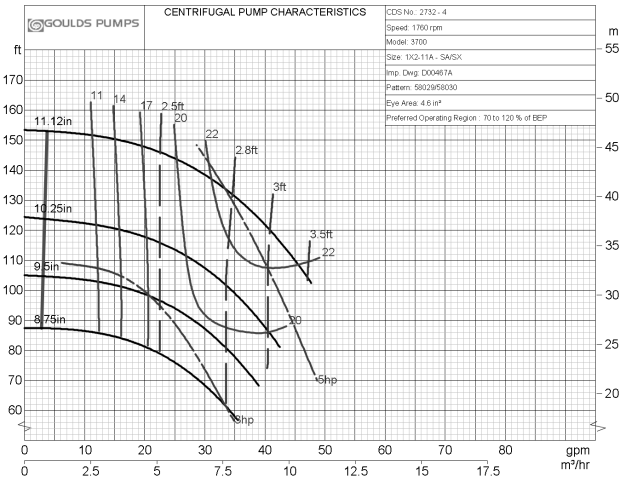


1X2-10G **3550rpm**

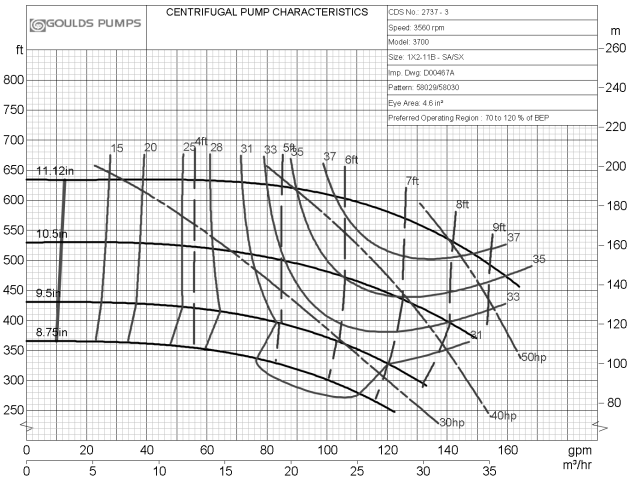


1X2-11A **3550rpm**

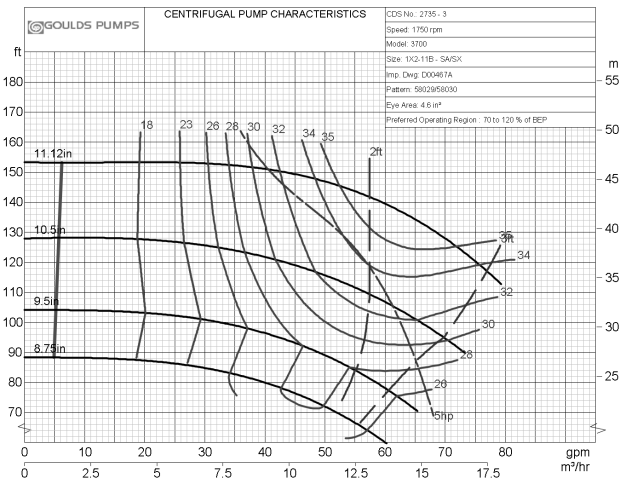
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



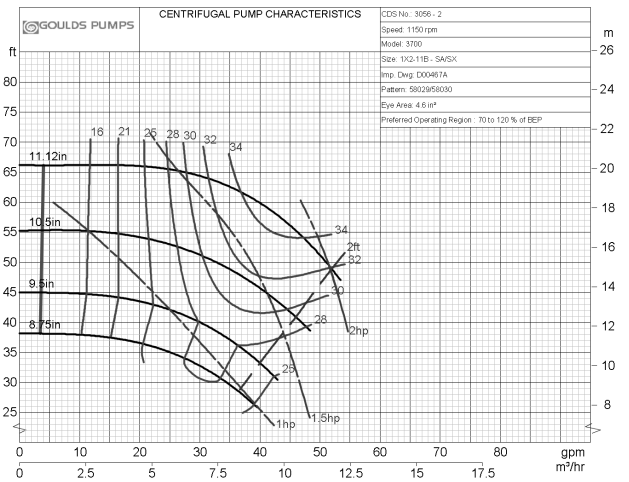
1X2-11A **1760rpm**



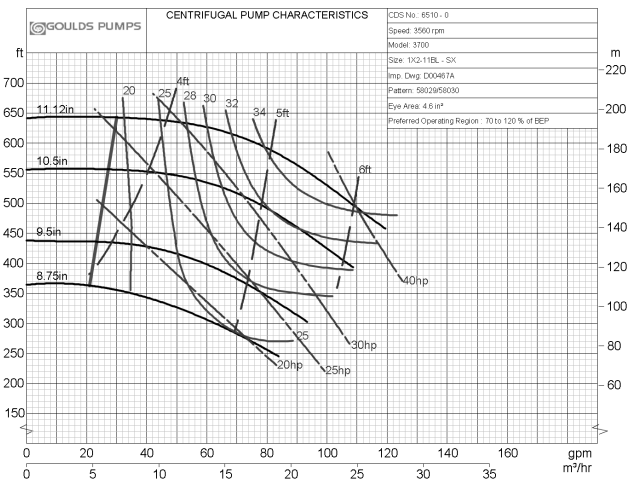
1X2-11B **3560rpm**



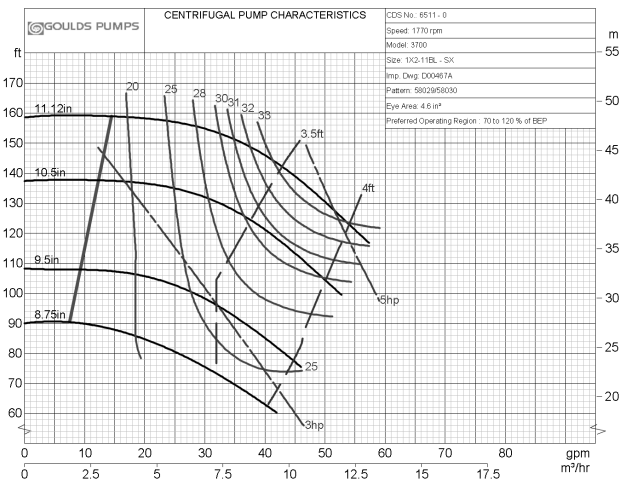
1X2-11B **1750rpm**



1X2-11B **1150rpm**



1X2-11BL **3560rpm**

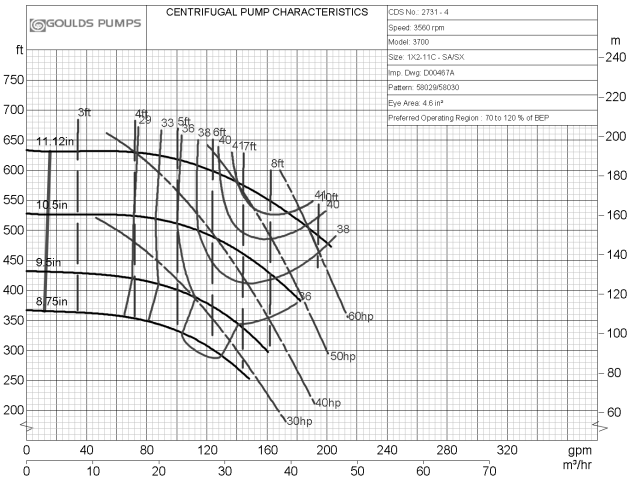


1X2-11BL **1770rpm**

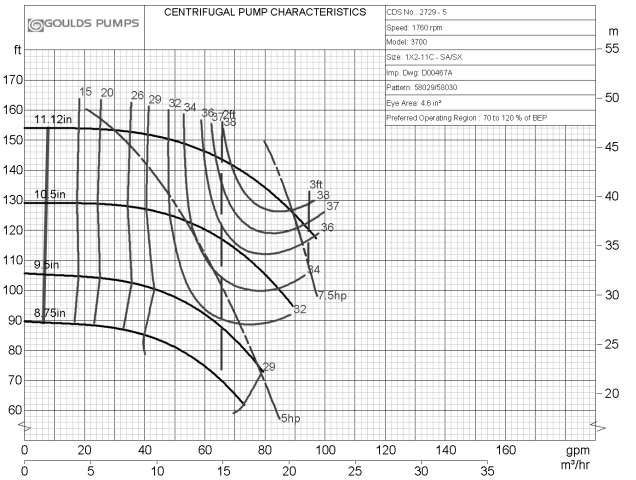
60Hz Curves

Model 3700

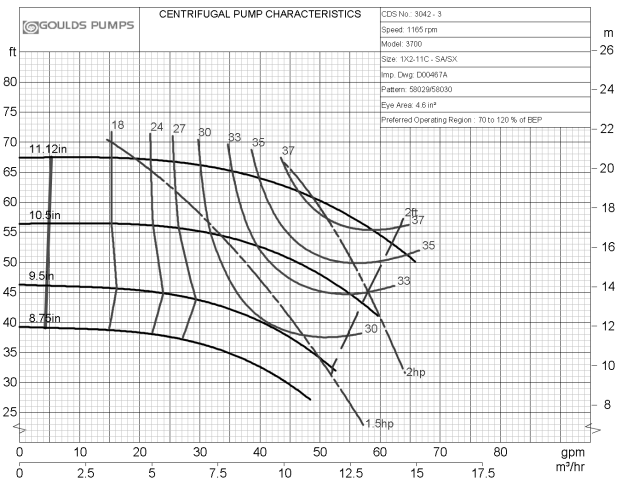
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



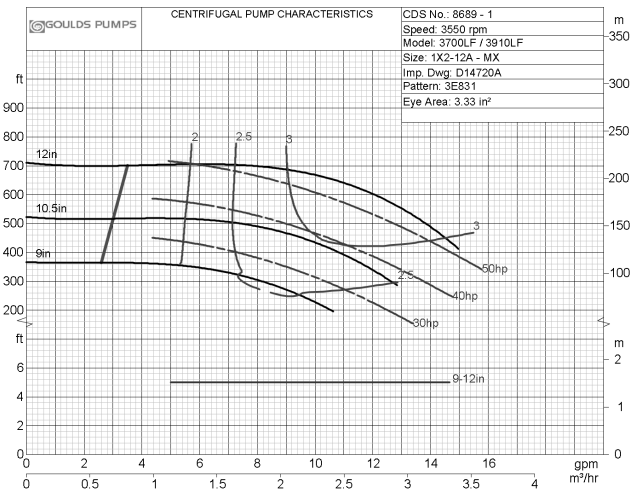
1X2-11C **3560rpm**



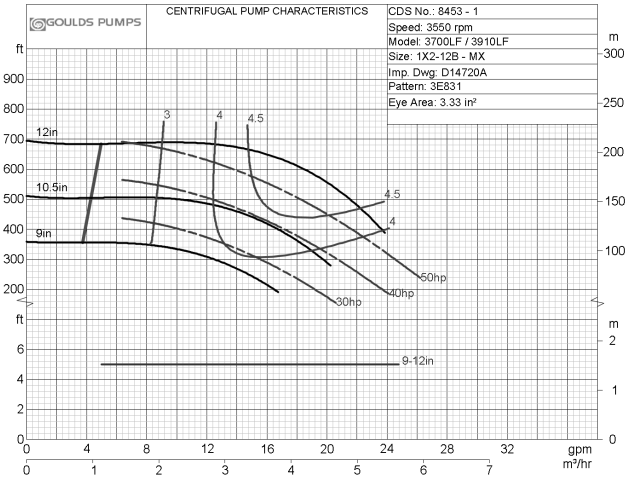
1X2-11C **1760rpm**



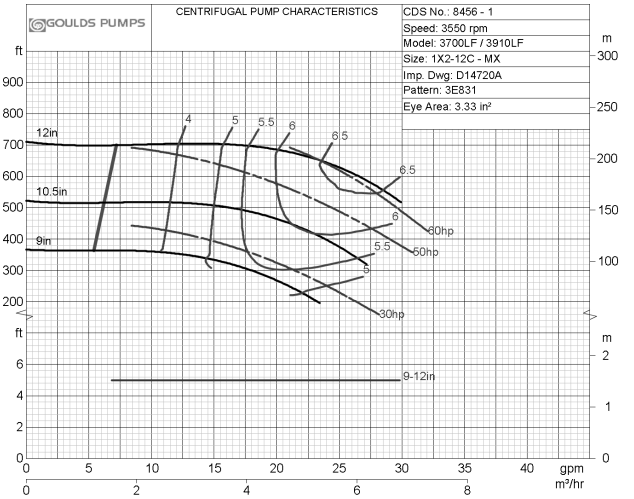
1X2-11C **1165rpm**



1X2-12A **3550rpm**

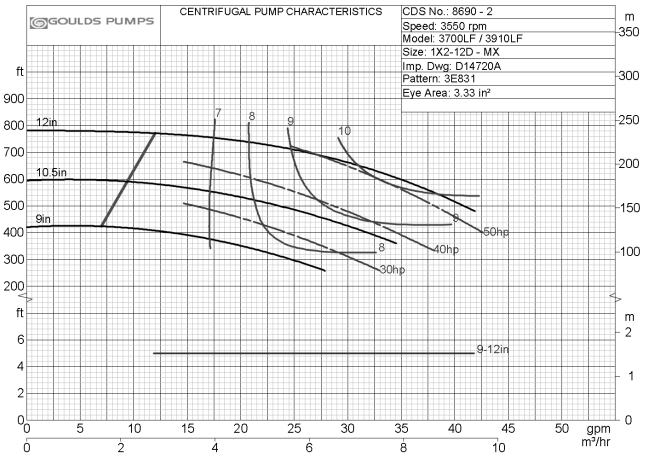


1X2-12B **3550rpm**

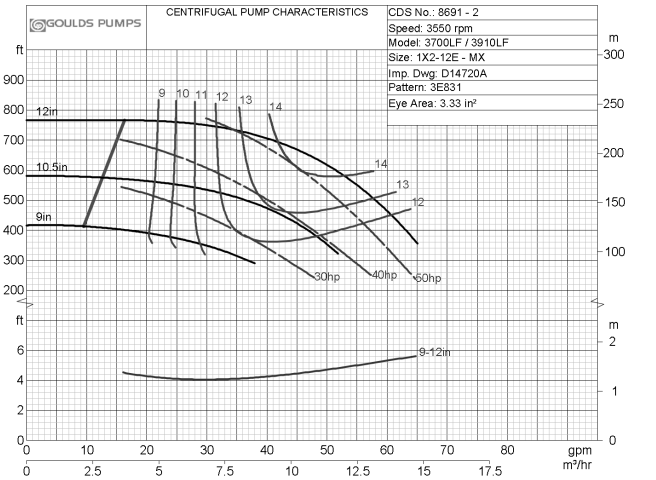


1X2-12C **3550rpm**

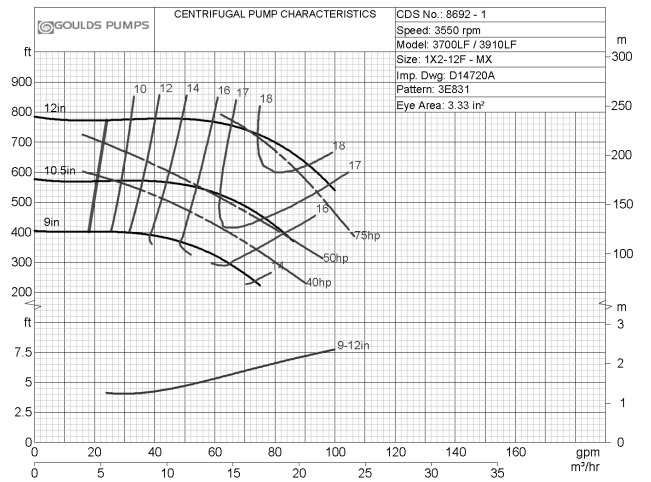
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



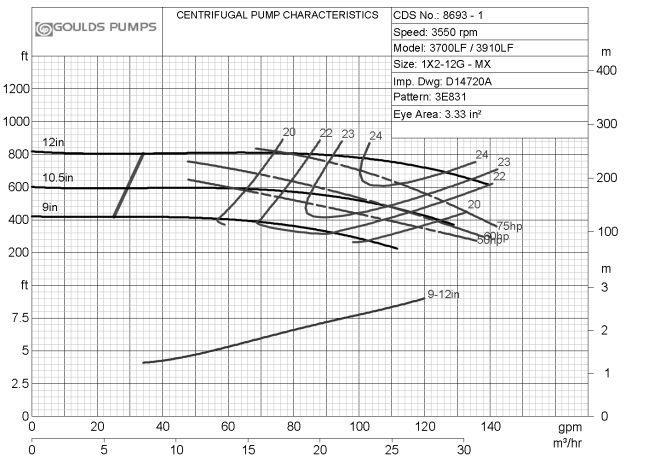
1X2-12D **3550rpm**



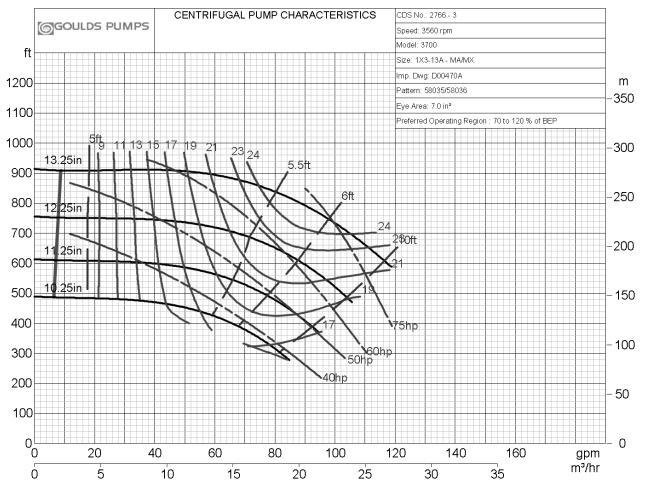
1X2-12E **3550rpm**



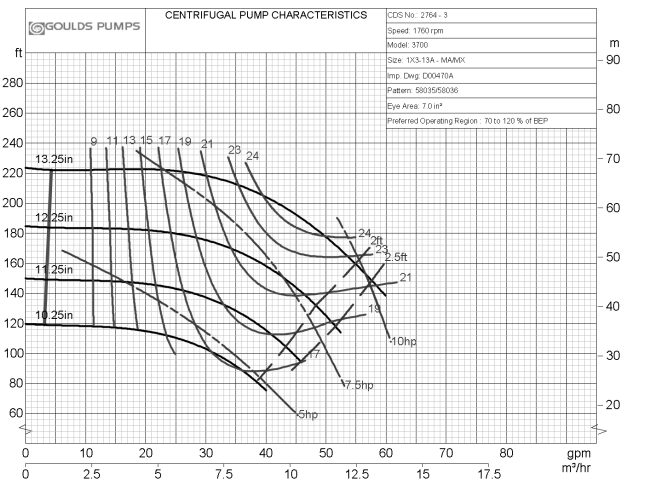
1X2-12F **3550rpm**



1X2-12G **3550rpm**

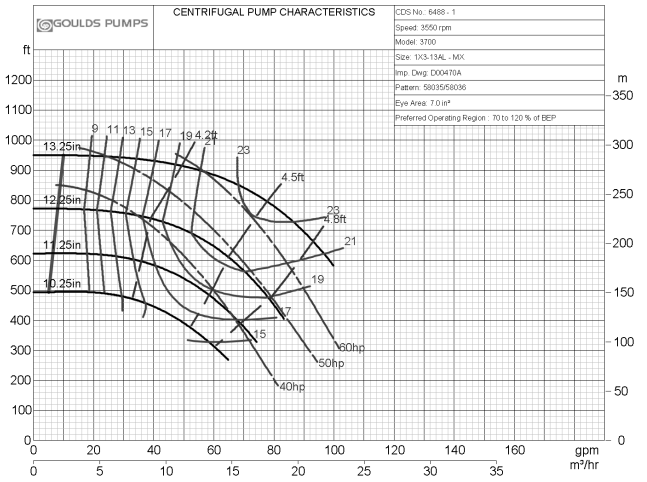


1X3-13A **3560rpm**

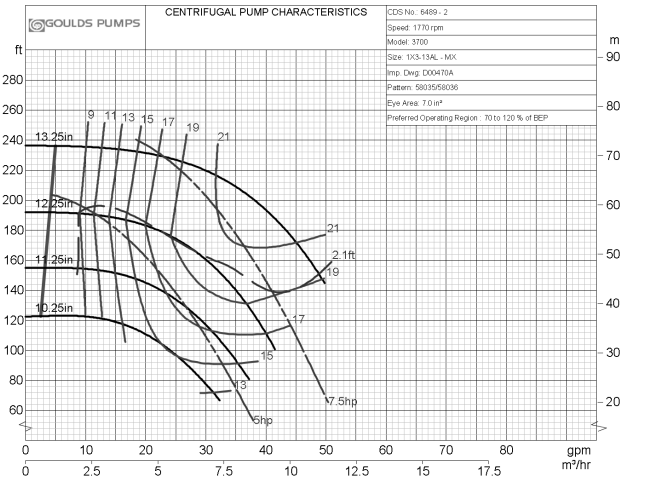


1X3-13A **1760rpm**

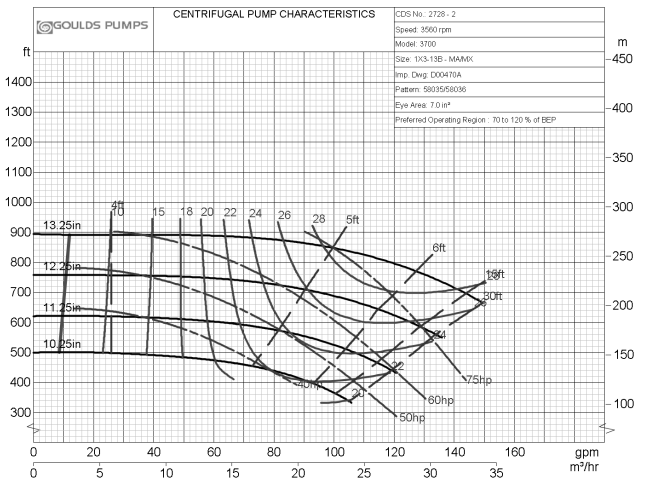
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



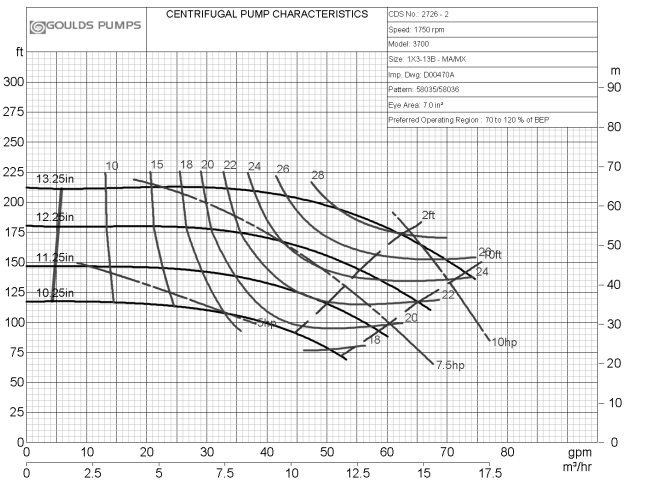
1X3-13AL **3550rpm**



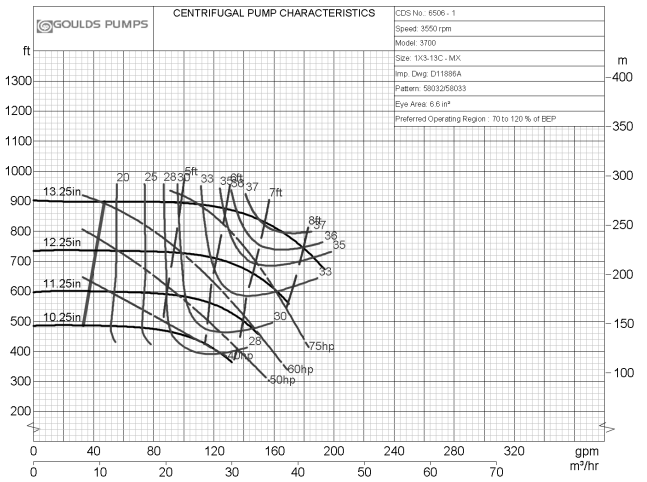
1X3-13AL **1770rpm**



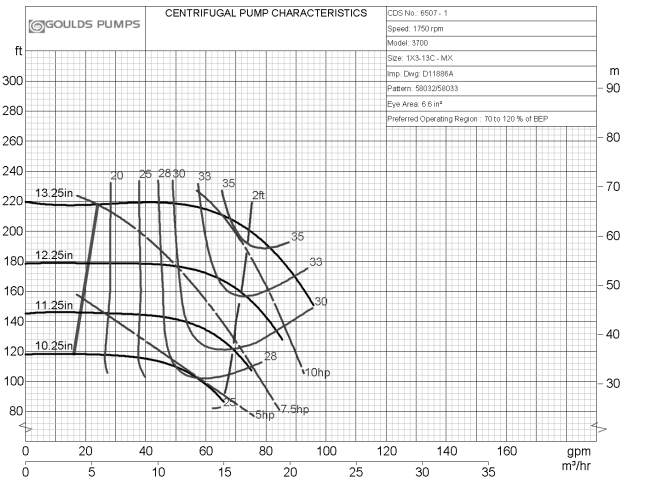
1X3-13B **3560rpm**



1X3-13B **1750rpm**

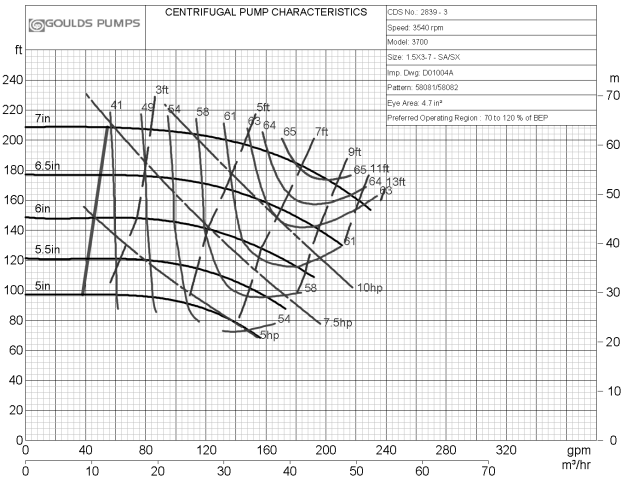


1X3-13C **3550rpm**

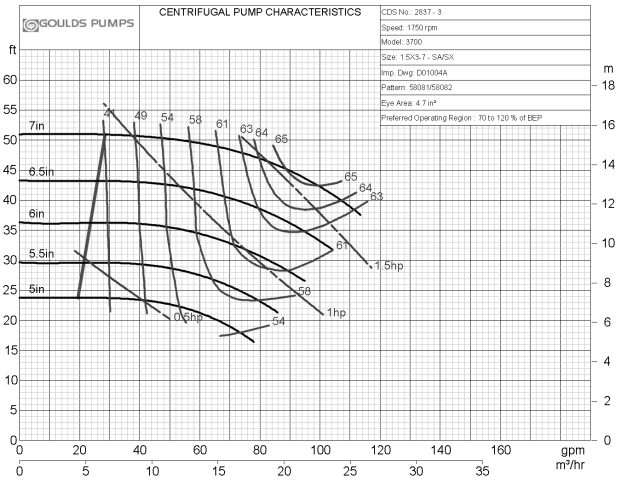


1X3-13C **1750rpm**

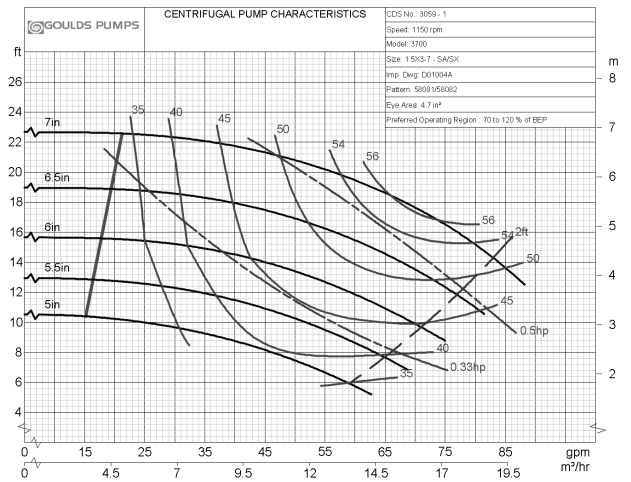
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



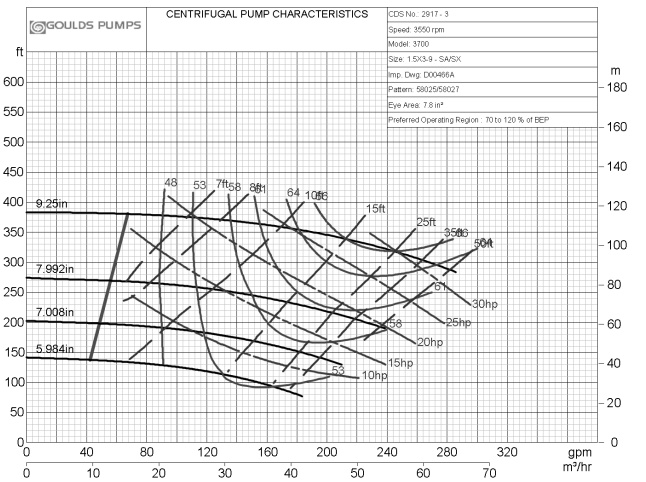
1.5X3-7 **3540rpm**



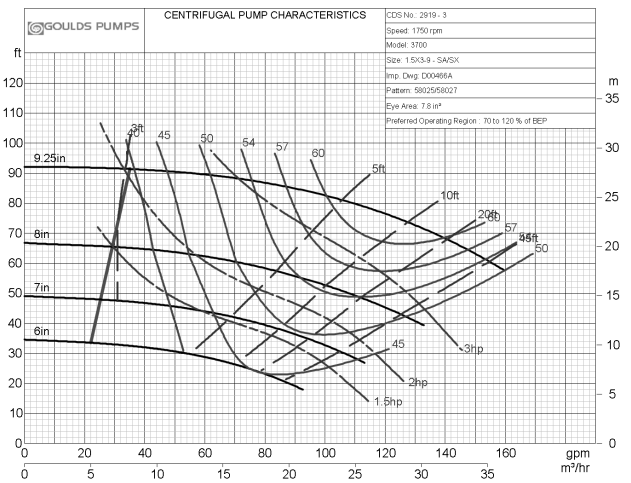
1.5X3-7 **1750rpm**



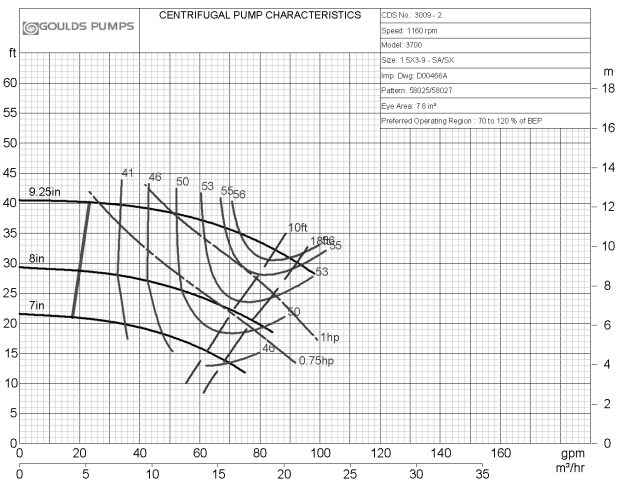
1.5X3-7 **1150rpm**



1.5X3-9 **3550rpm**



1.5X3-9 **1750rpm**

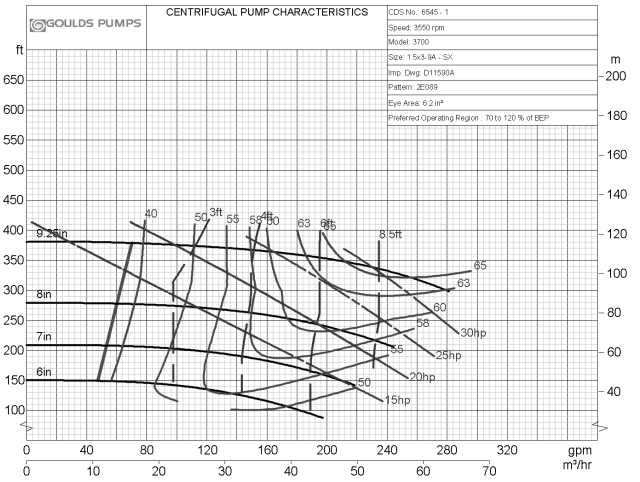


1.5X3-9 **1160rpm**

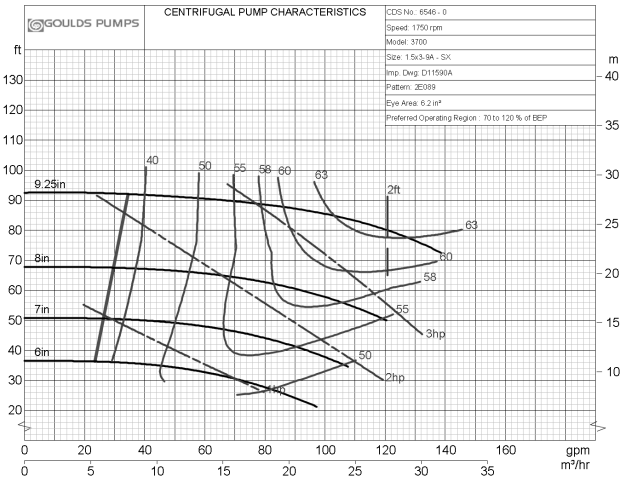
60Hz Curves

Model 3700

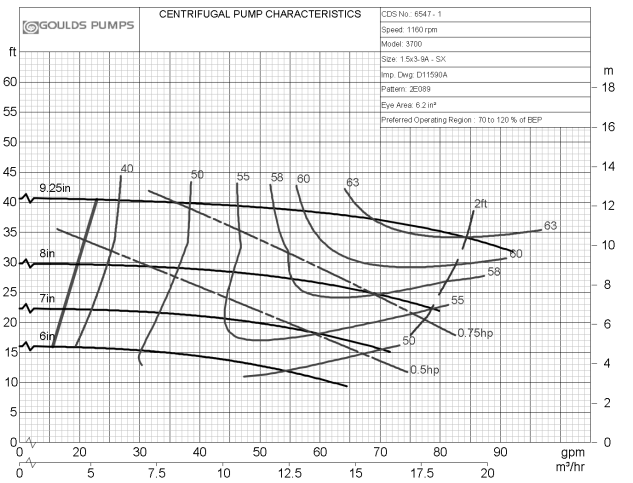
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



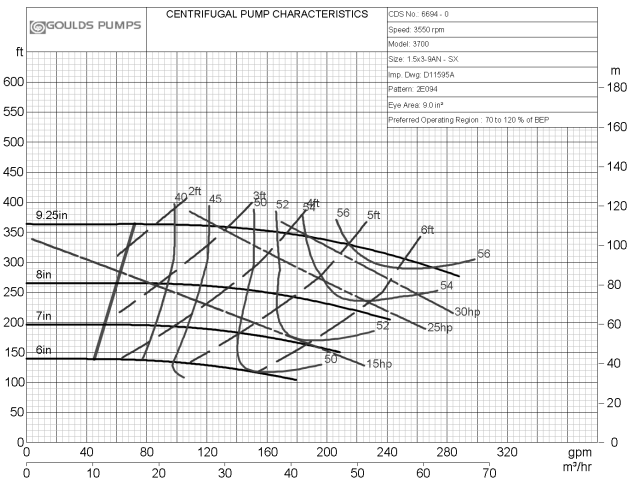
1.5x3-9A **3550rpm**



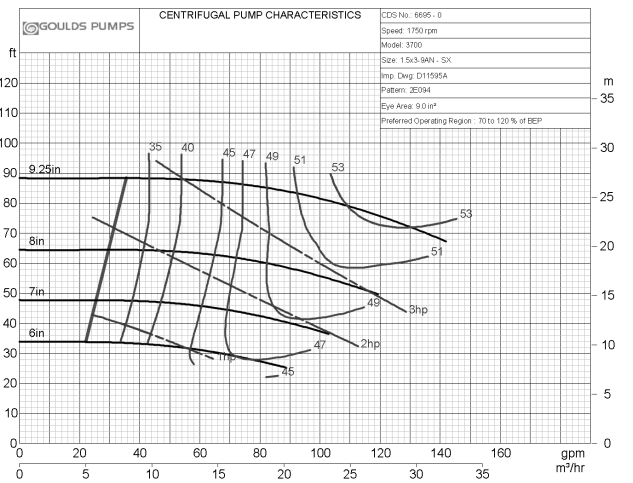
1.5x3-9A **1750rpm**



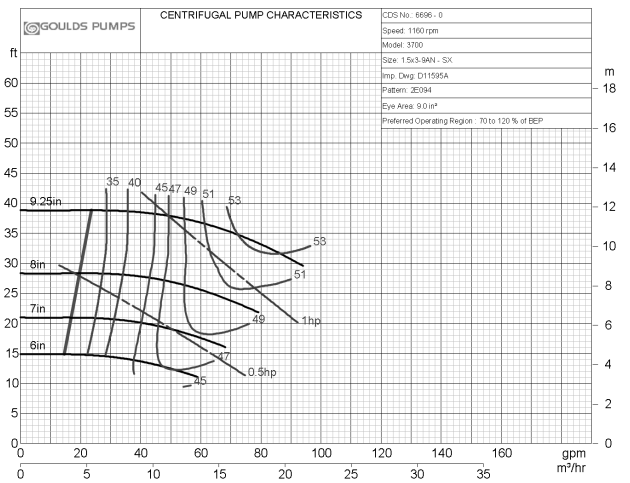
1.5x3-9A **1160rpm**



1.5x3-9AN **3550rpm**



1.5x3-9AN **1750rpm**

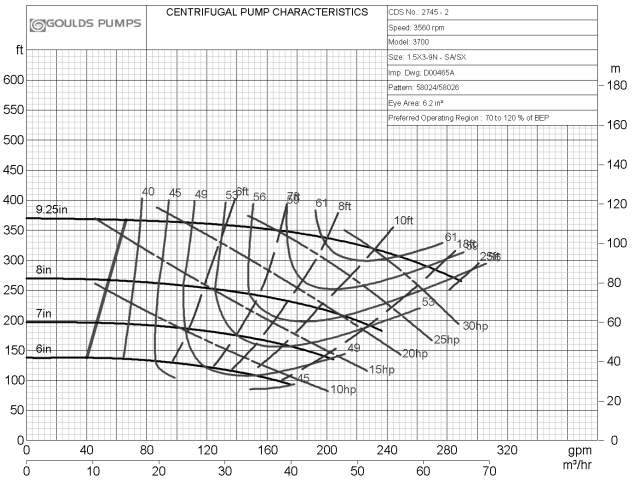


1.5x3-9AN **1160rpm**

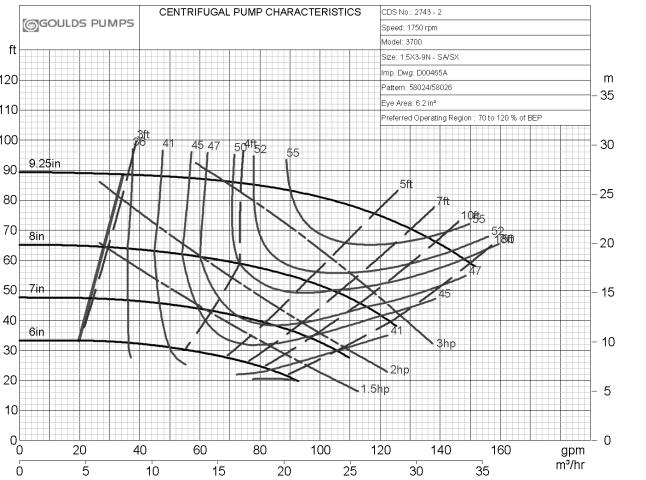
60Hz Curves

Model 3700

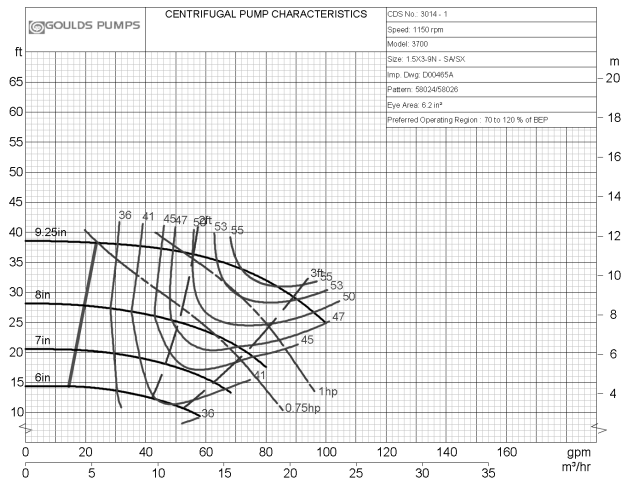
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



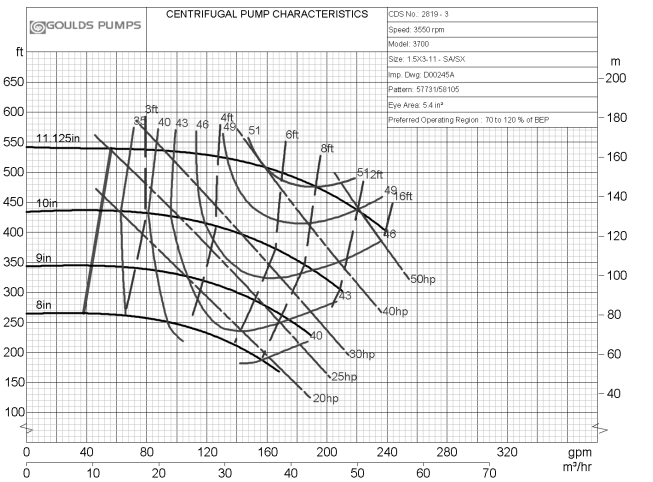
1.5X3-9N **3560rpm**



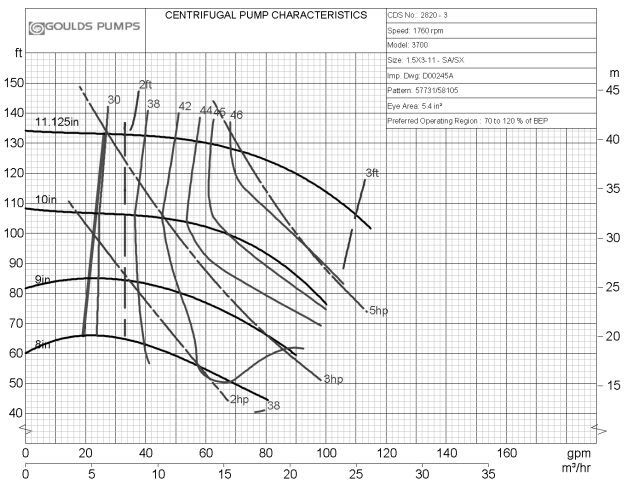
1.5X3-9N **1750rpm**



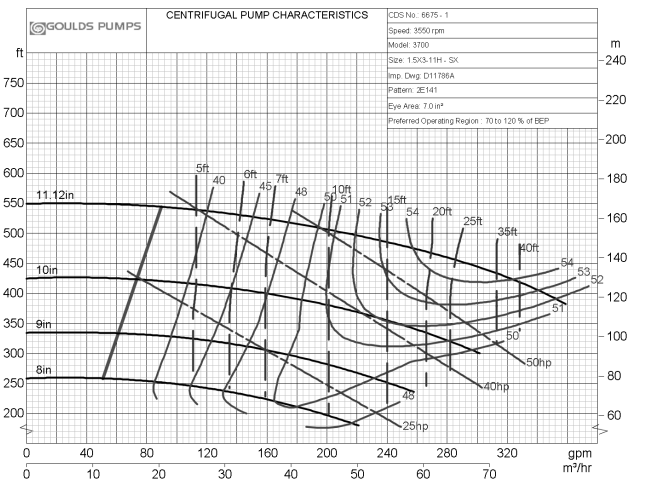
1.5X3-9N **1150rpm**



1.5X3-11 **3550rpm**

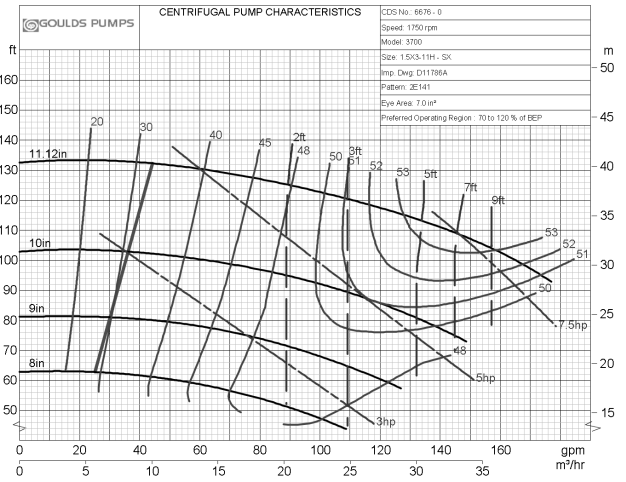


1.5X3-11 **1760rpm**

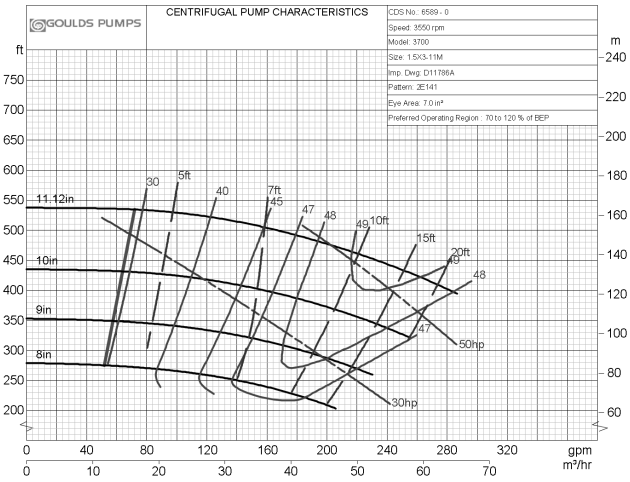


1.5X3-11H **3550rpm**

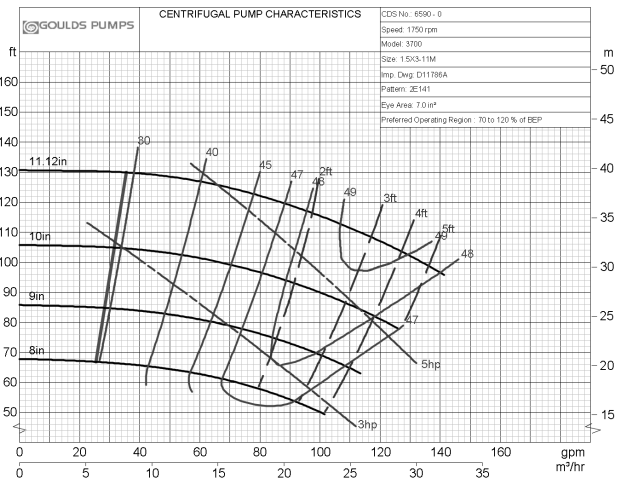
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



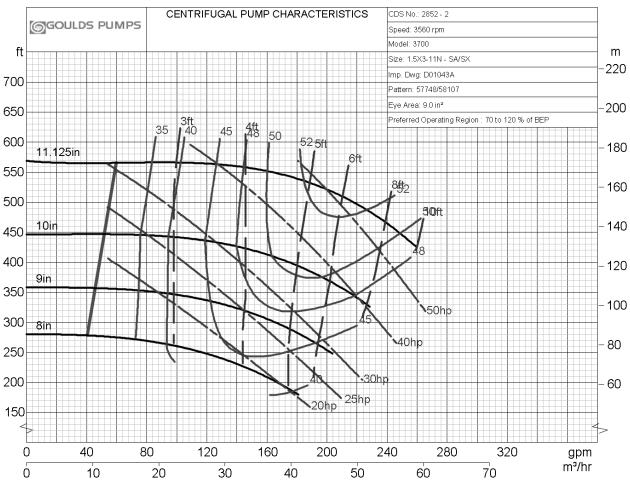
1.5X3-11H **1750rpm**



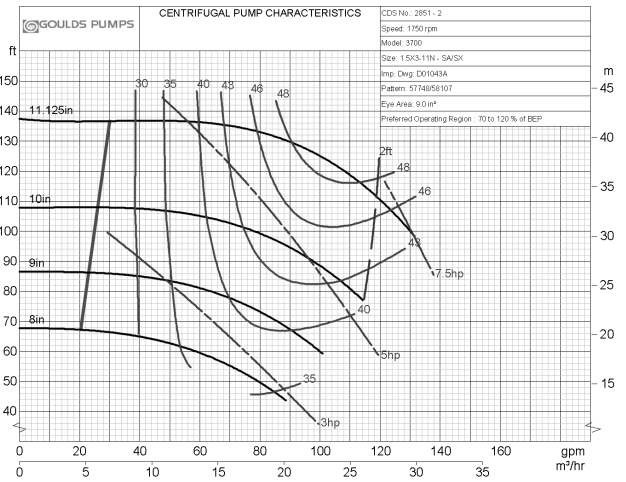
1.5X3-11M **3550rpm**



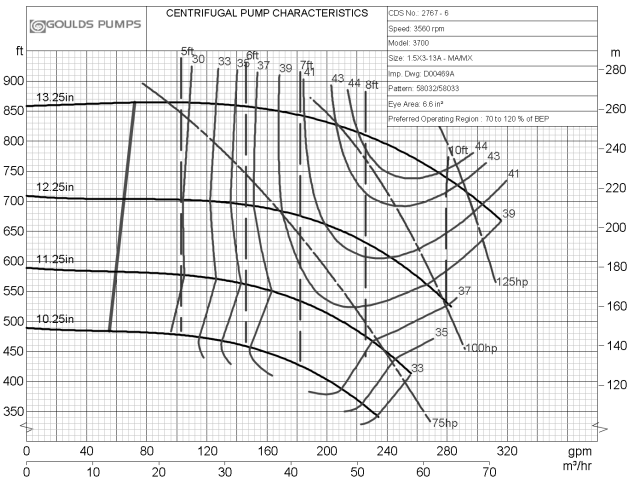
1.5X3-11M **1750rpm**



1.5X3-11N **3560rpm**



1.5X3-11N **1750rpm**



1.5X3-13A **3560rpm**

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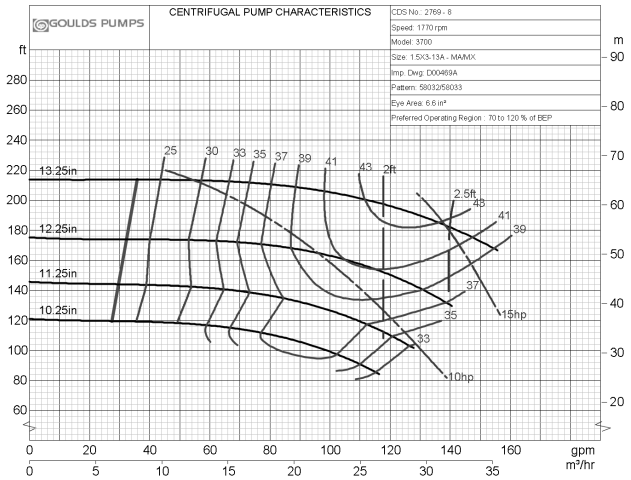
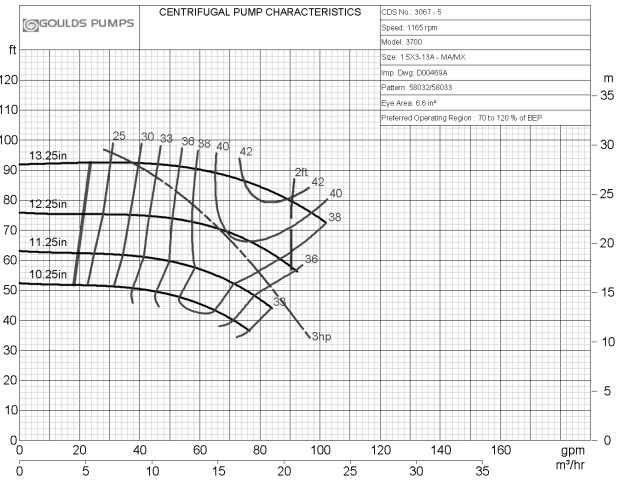
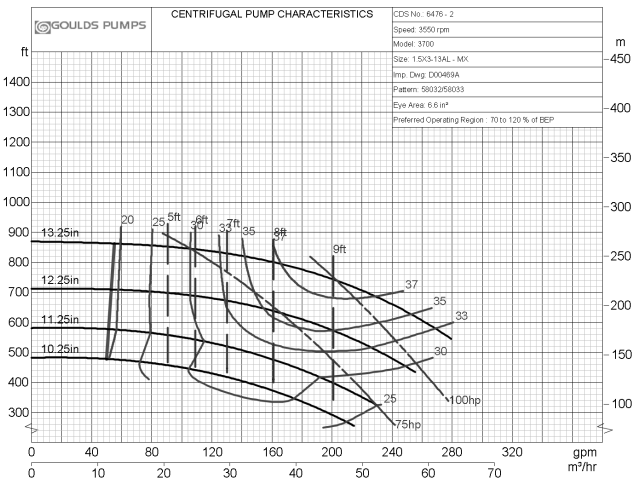


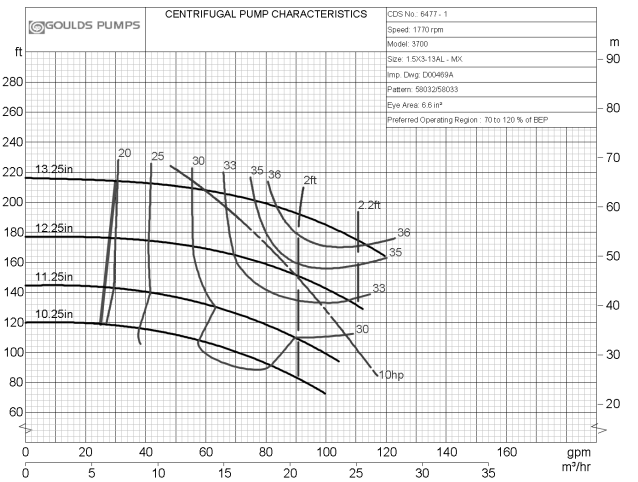
1.5X3-13A **1770rpm**



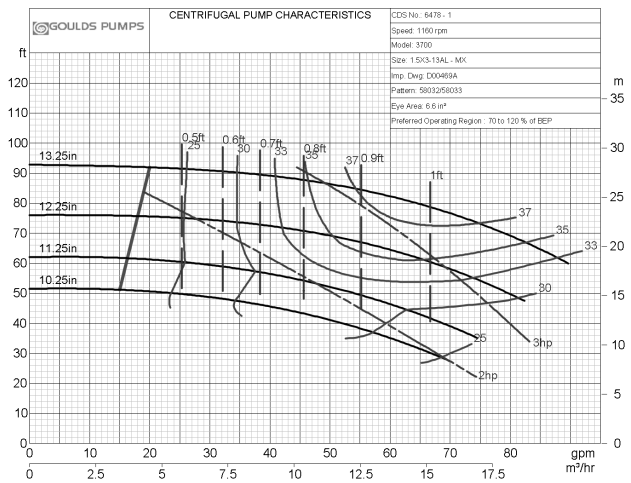
1.5X3-13A **1165rpm**



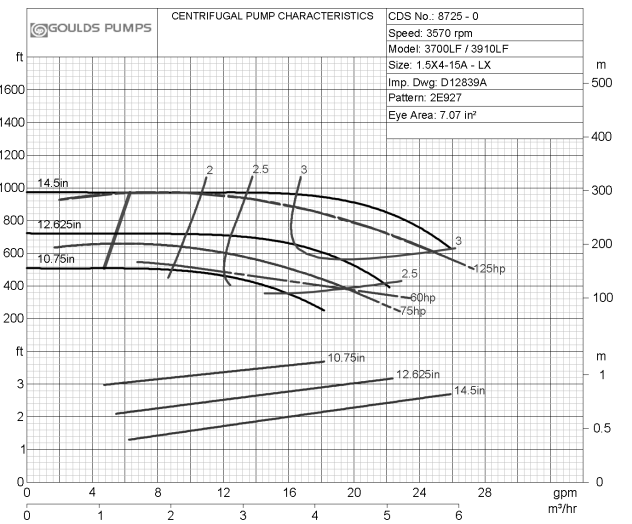
1.5X3-13AL **3550rpm**



1.5X3-13AL **1770rpm**



1.5X3-13AL **1160rpm**



1.5X4-15A **3570rpm**

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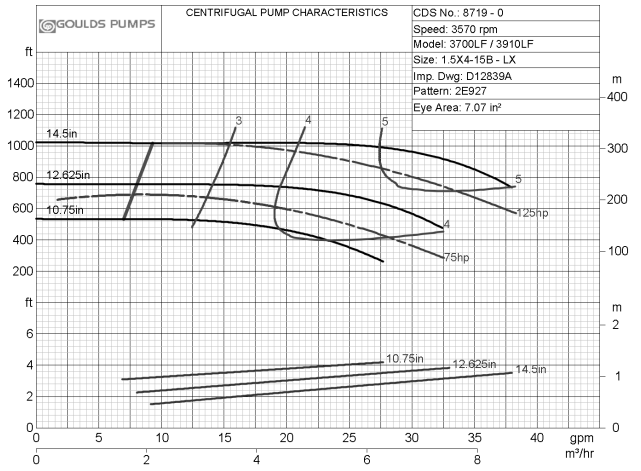
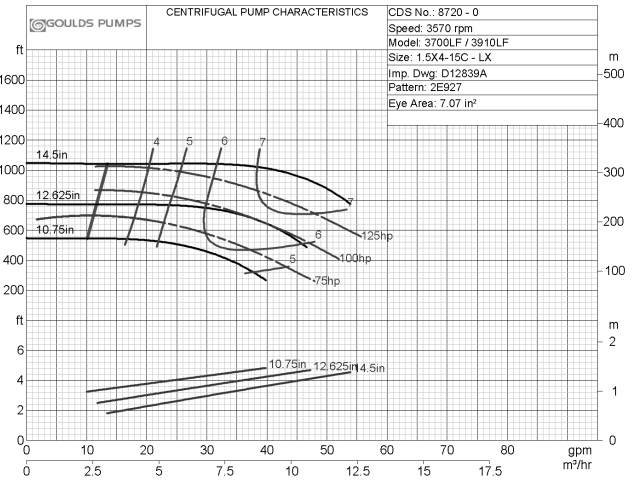
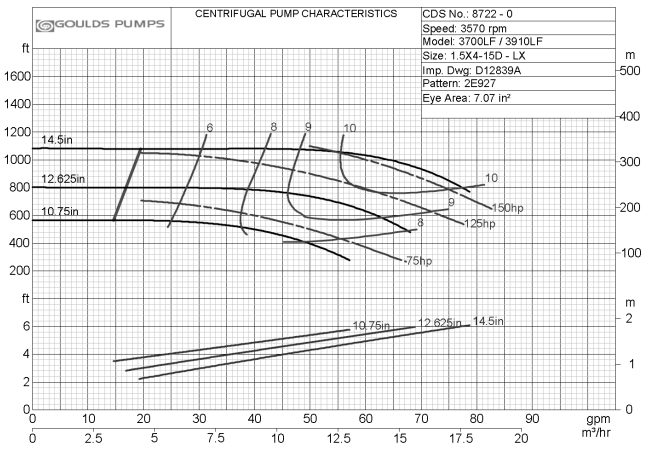


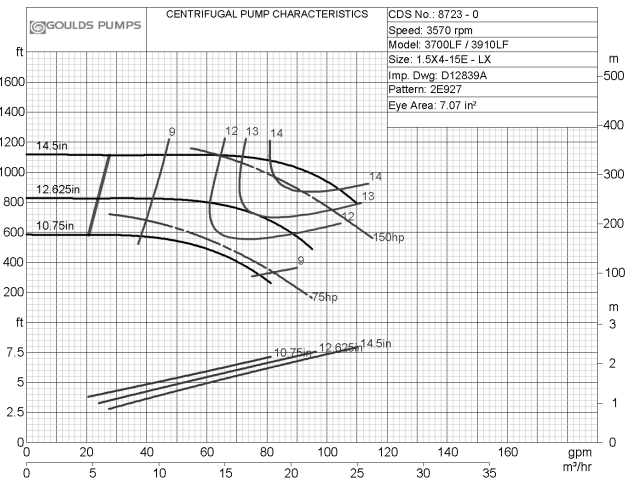
1.5X4-15B **3570rpm**



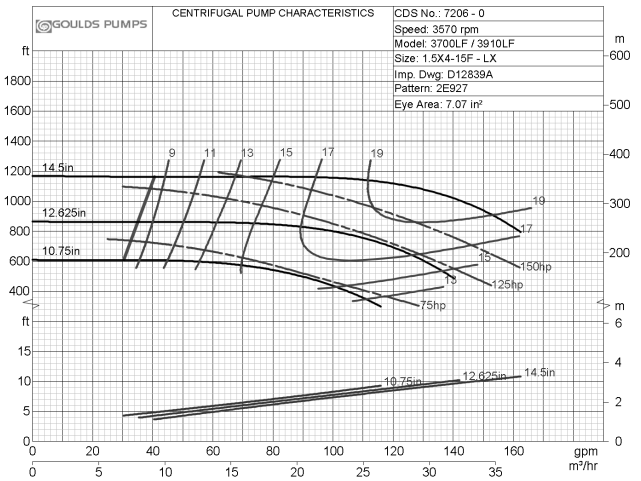
1.5X4-15C **3570rpm**



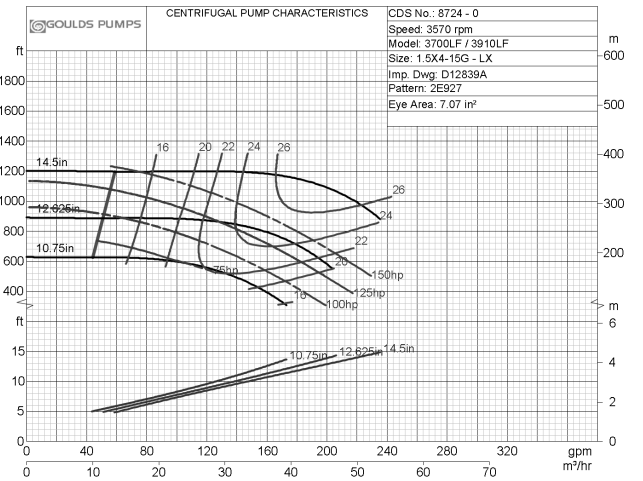
1.5X4-15D **3570rpm**



1.5X4-15E **3570rpm**

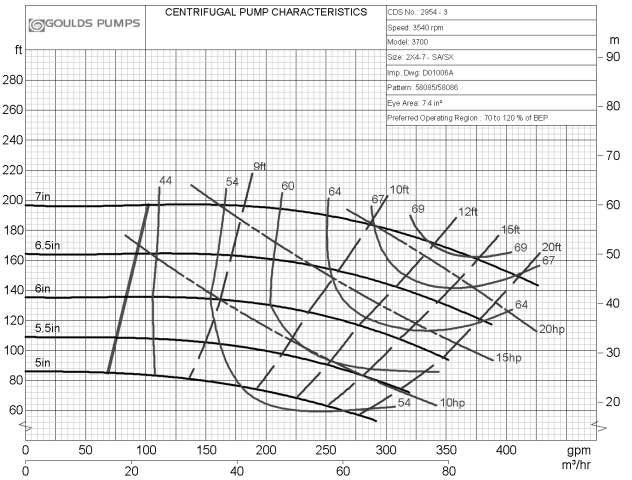


1.5X4-15F **3570rpm**

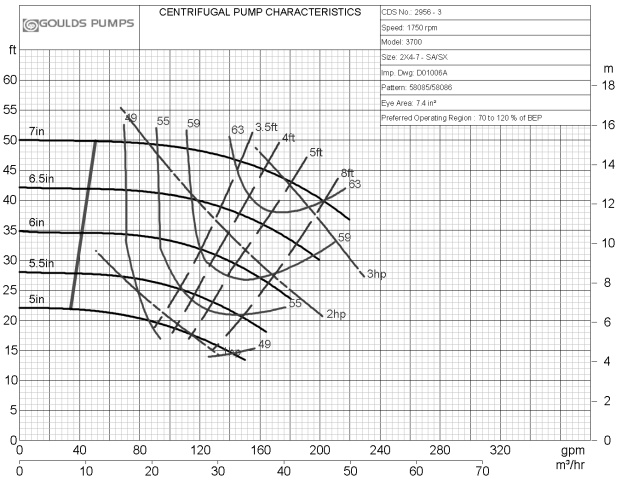


1.5X4-15G **3570rpm**

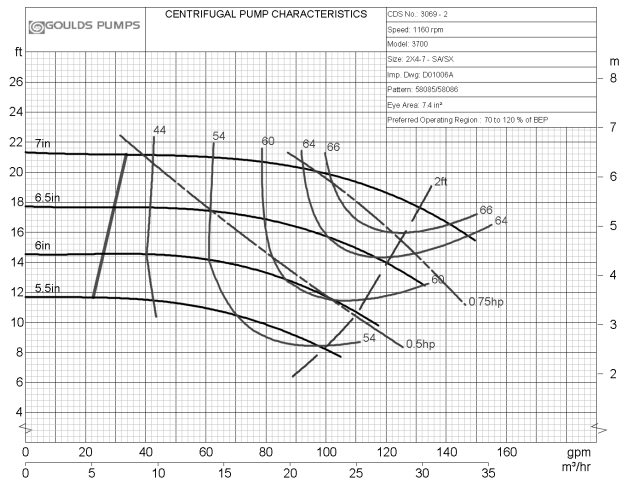
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



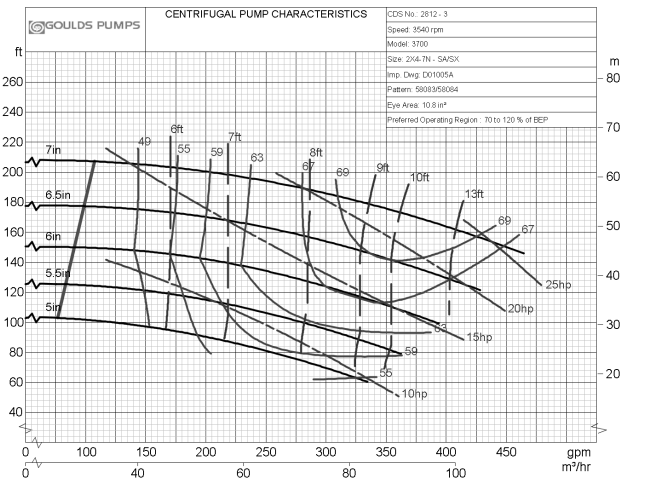
2X4-7 **3540rpm**



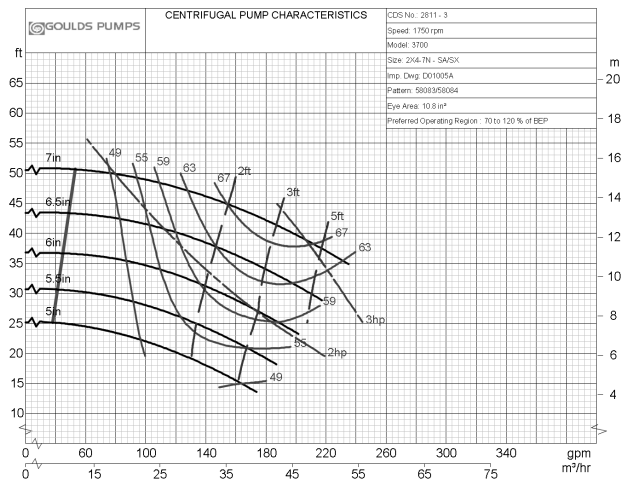
2X4-7 **1750rpm**



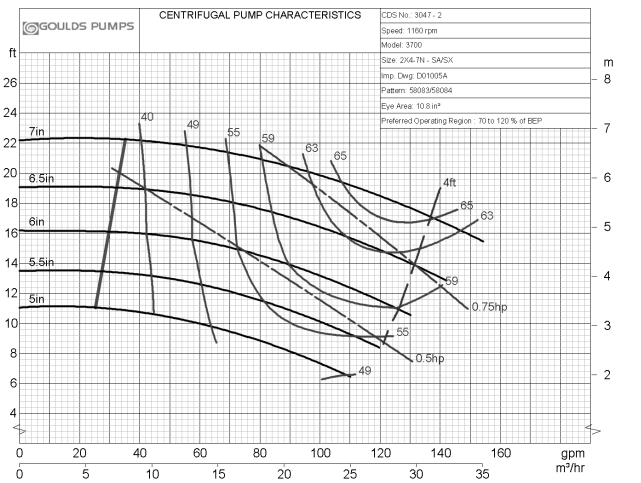
2X4-7 **1160rpm**



2X4-7N **3540rpm**



2X4-7N **1750rpm**

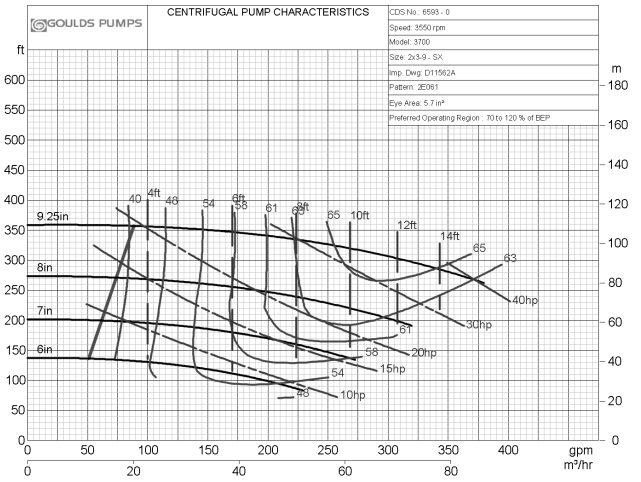


2X4-7N **1160rpm**

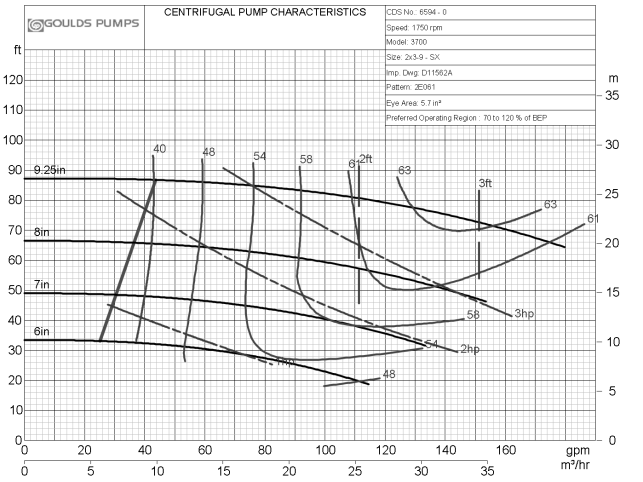
60Hz Curves

Model 3700

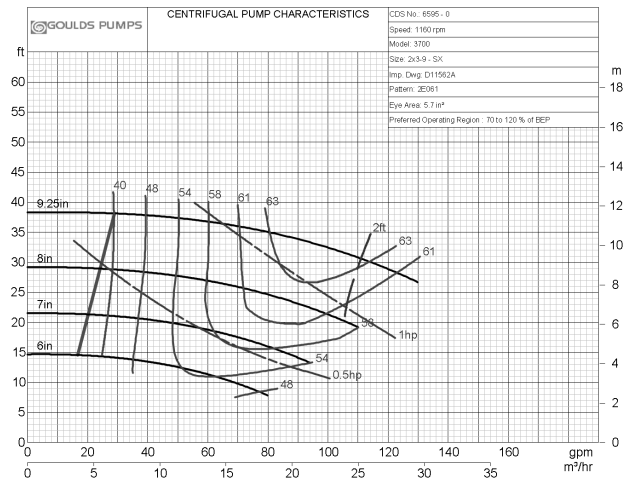
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



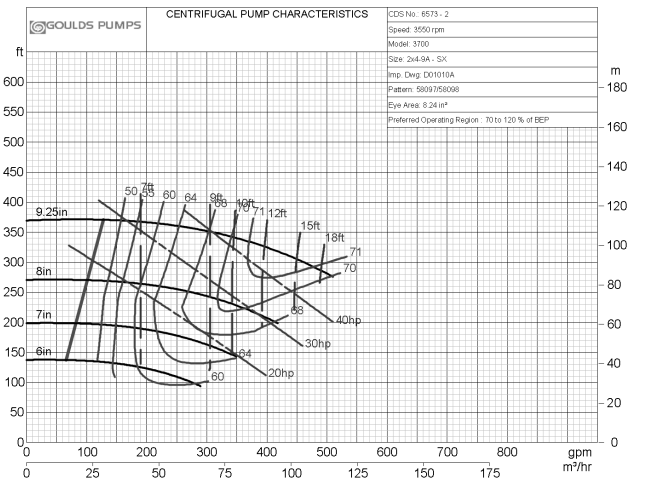
2x3-9 **3550rpm**



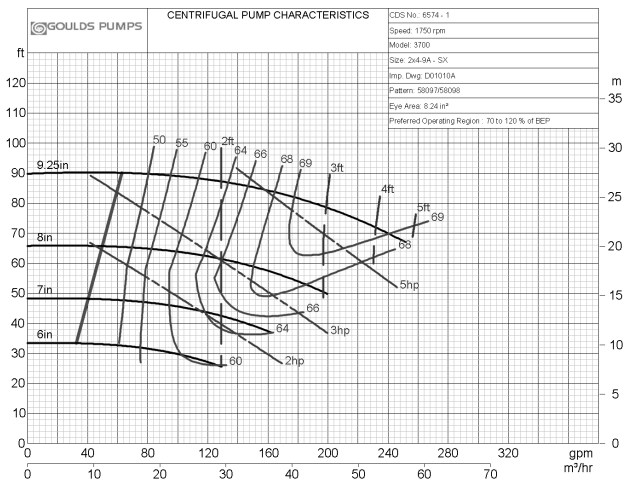
2x3-9 **1750rpm**



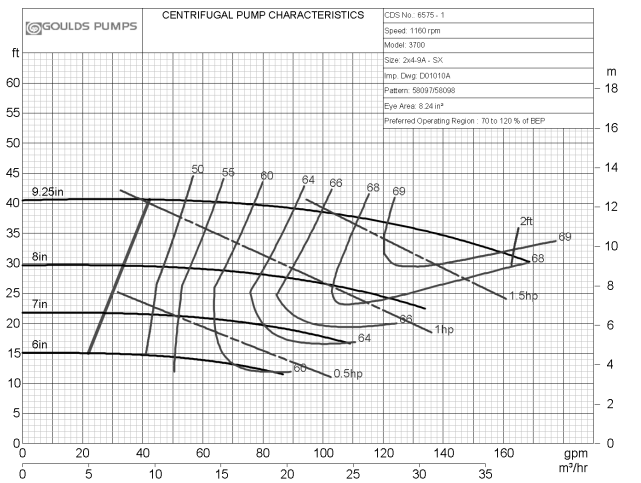
2x3-9 **1160rpm**



2x4-9A **3550rpm**

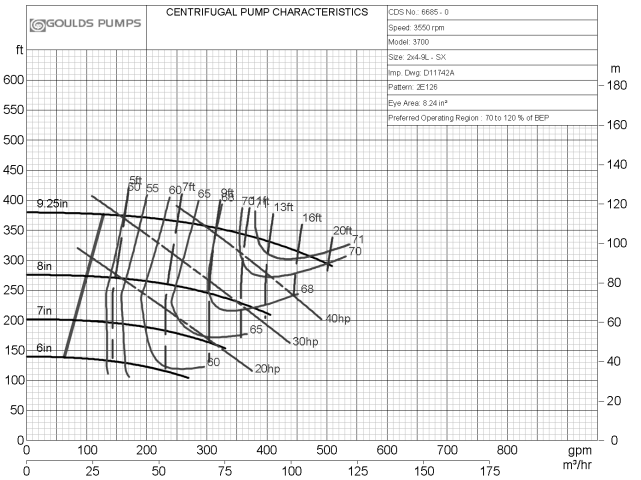


2x4-9A **1750rpm**

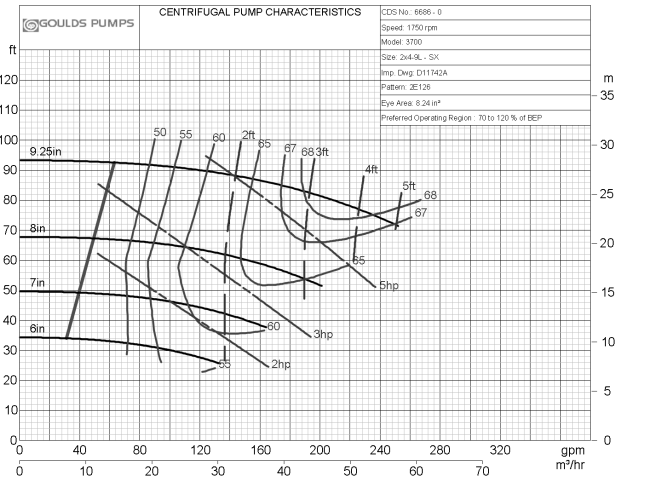


2x4-9A **1160rpm**

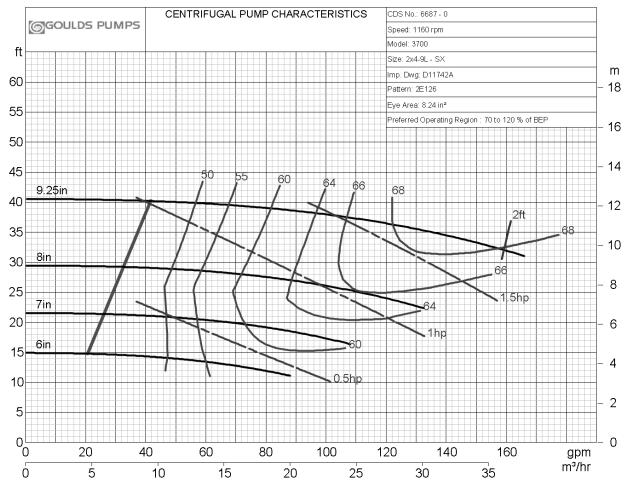
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



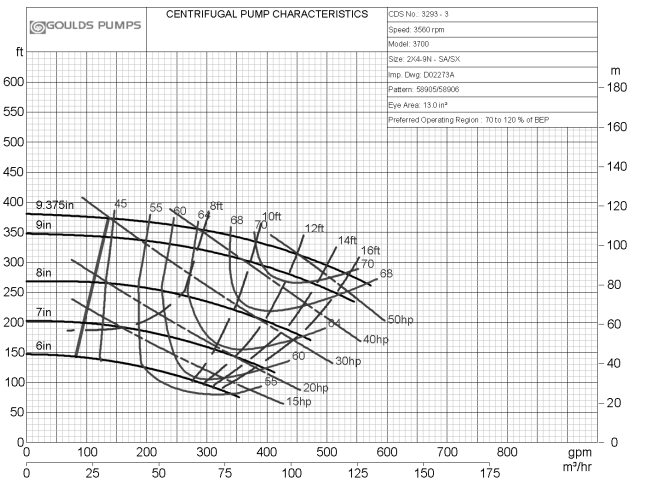
2x4-9L **3550rpm**



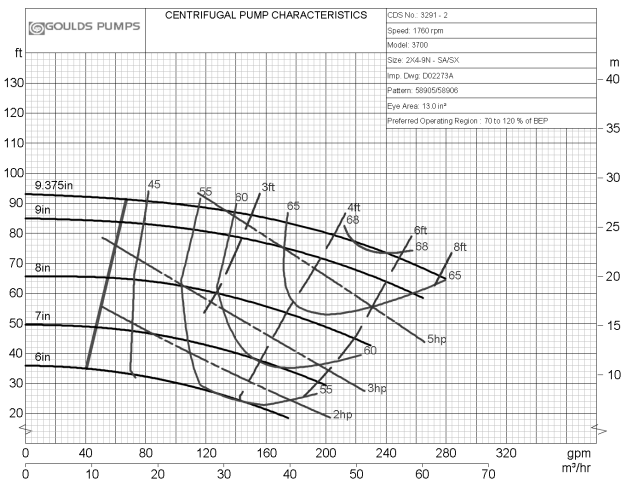
2x4-9L **1750rpm**



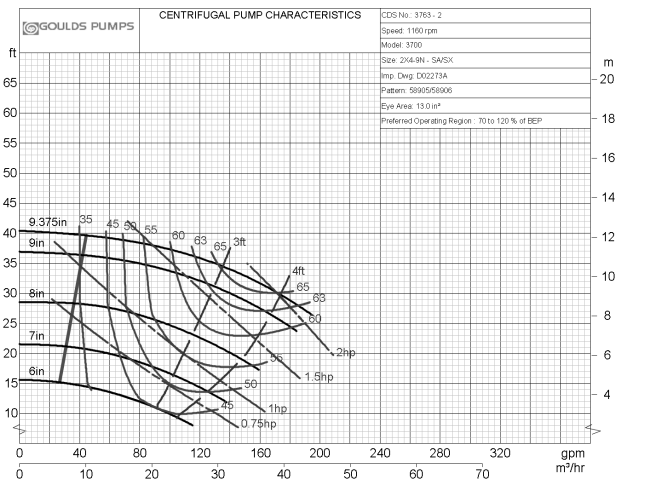
2x4-9L **1160rpm**



2X4-9N **3560rpm**



2X4-9N **1760rpm**

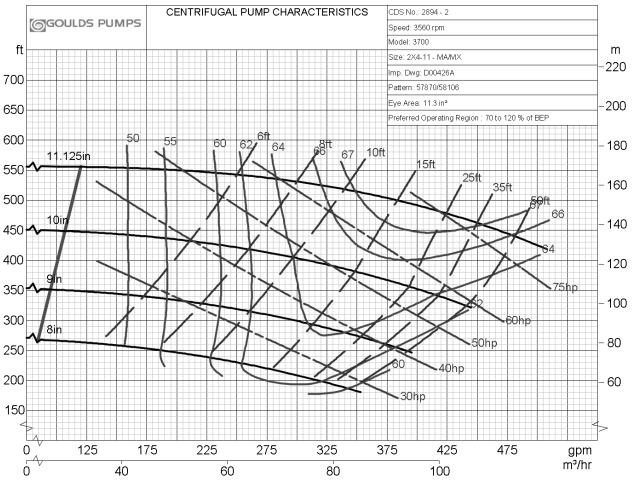


2X4-9N **1160rpm**

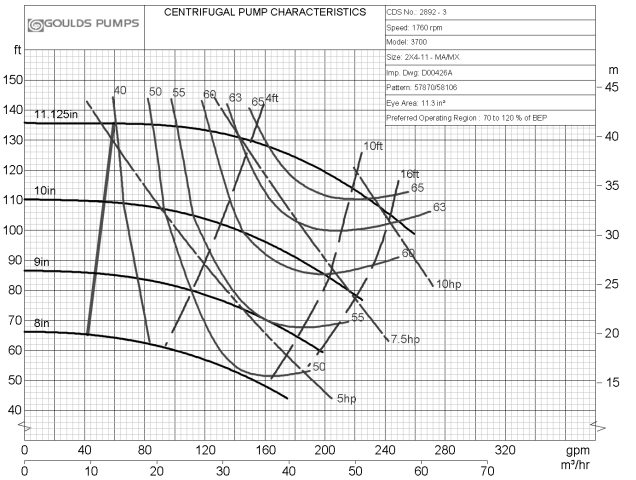
60Hz Curves

Model 3700

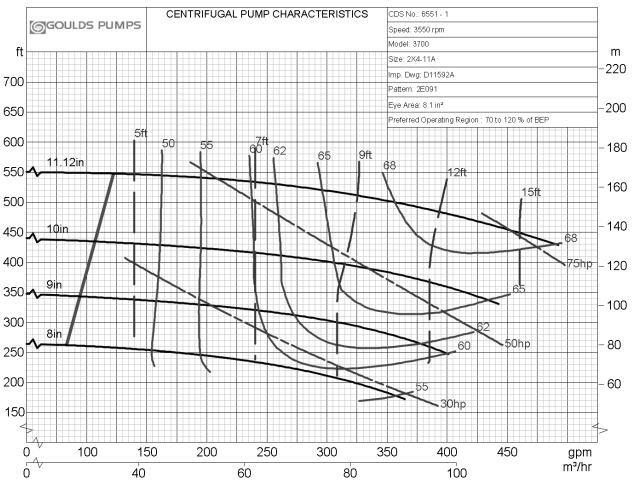
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



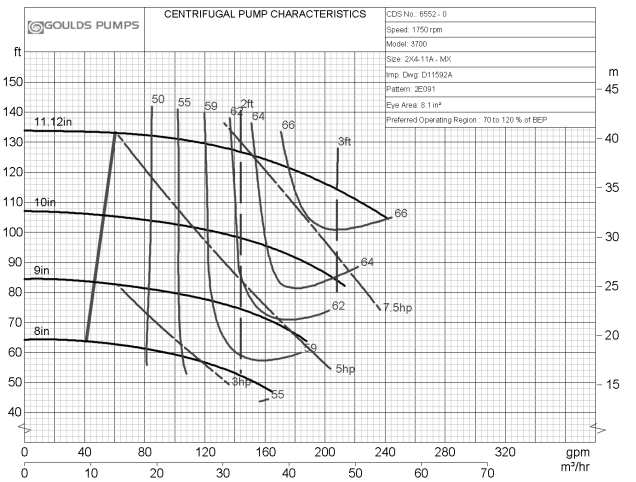
2X4-11 **3560rpm**



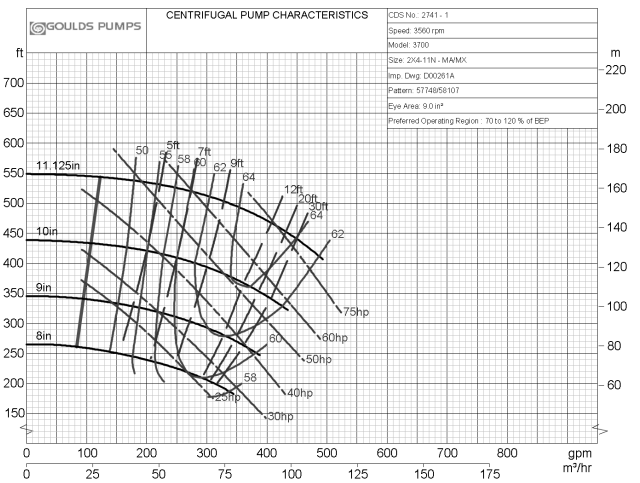
2X4-11 **1760rpm**



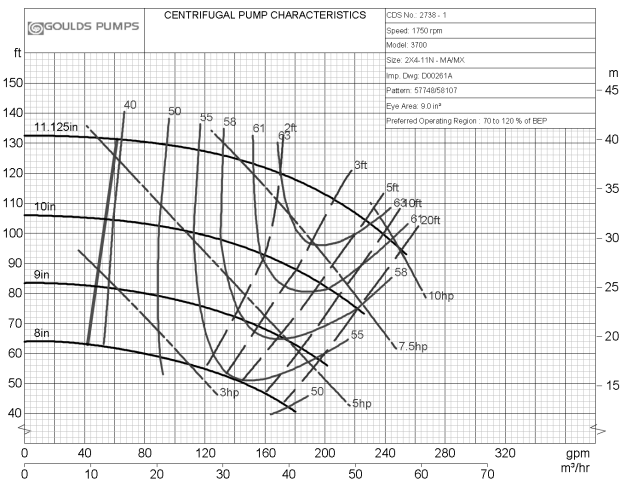
2X4-11A **3550rpm**



2X4-11A **1750rpm**

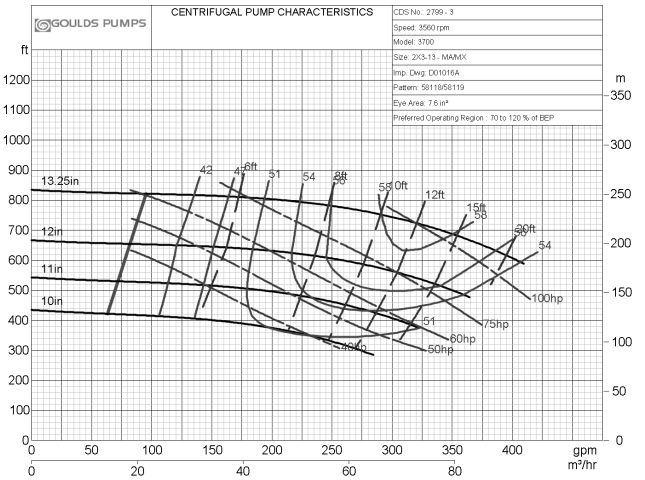


2X4-11N **3560rpm**

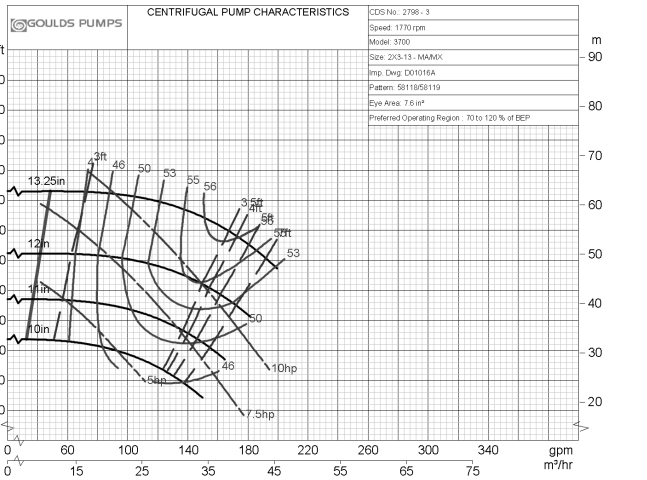


2X4-11N **1750rpm**

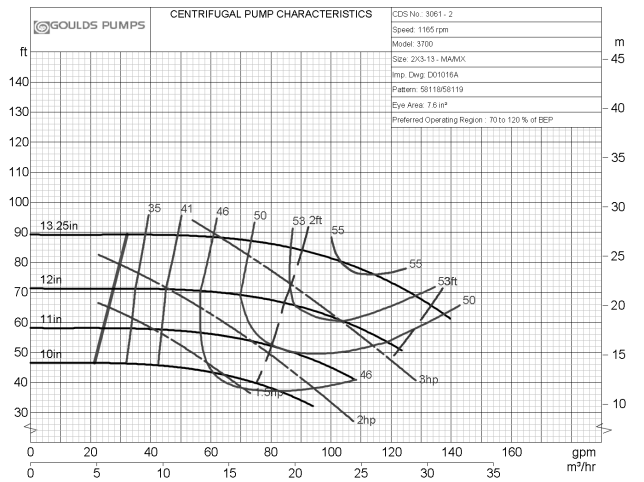
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



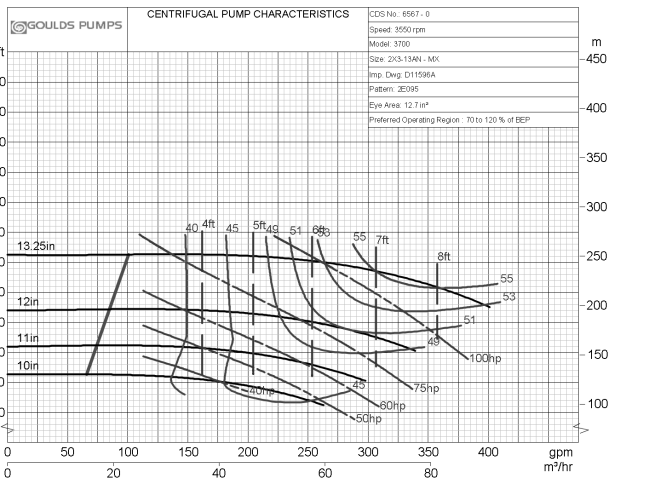
2X3-13 **3560rpm**



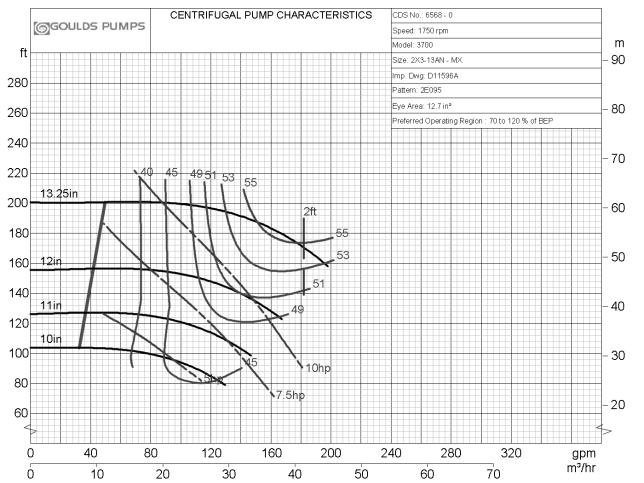
2X3-13 **1770rpm**



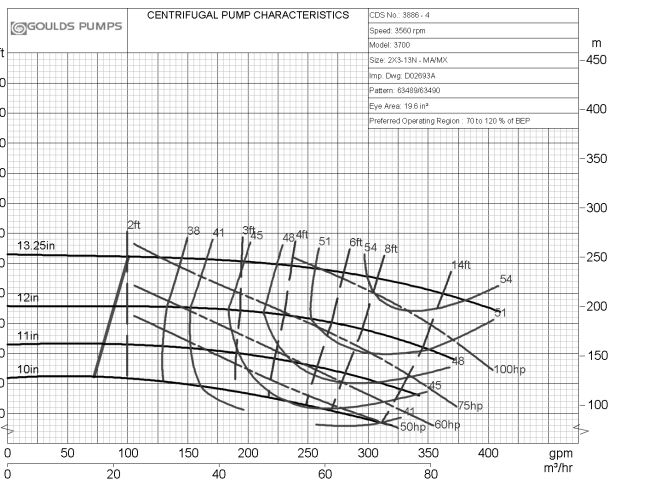
2X3-13 **1165rpm**



2X3-13AN **3550rpm**



2X3-13AN **1750rpm**

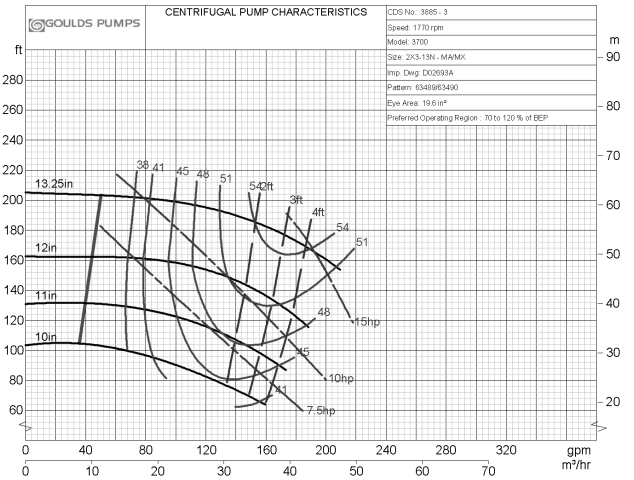


2X3-13N **3560rpm**

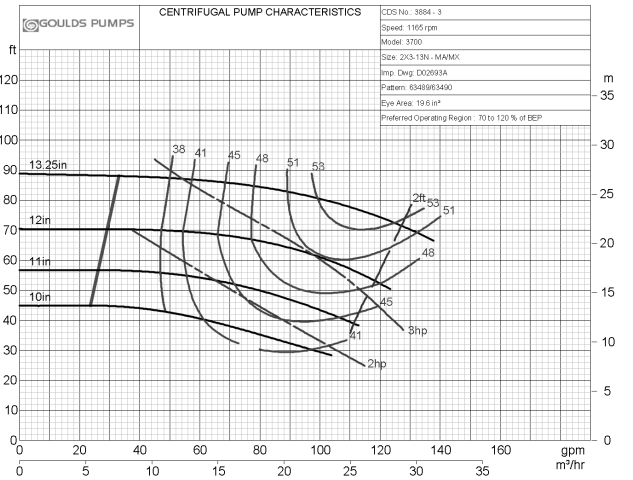
60Hz Curves

Model 3700

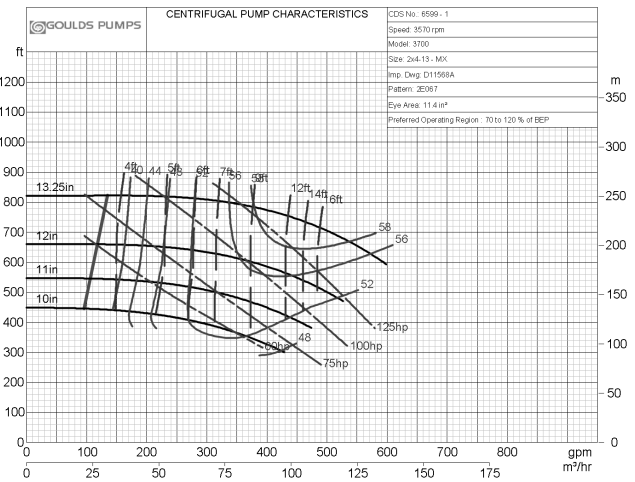
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



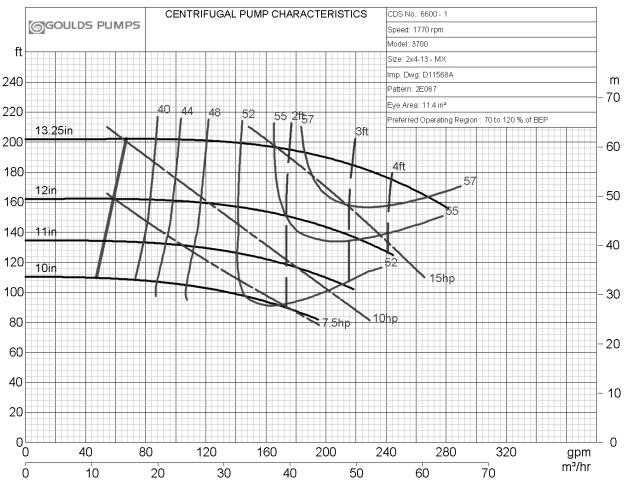
2X3-13N **1770rpm**



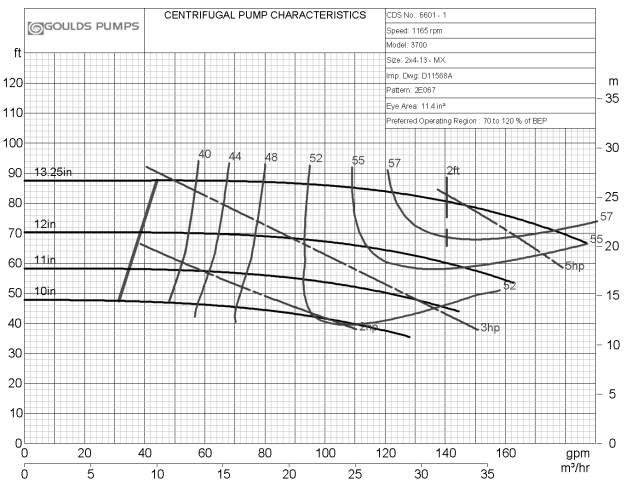
2X3-13N **1165rpm**



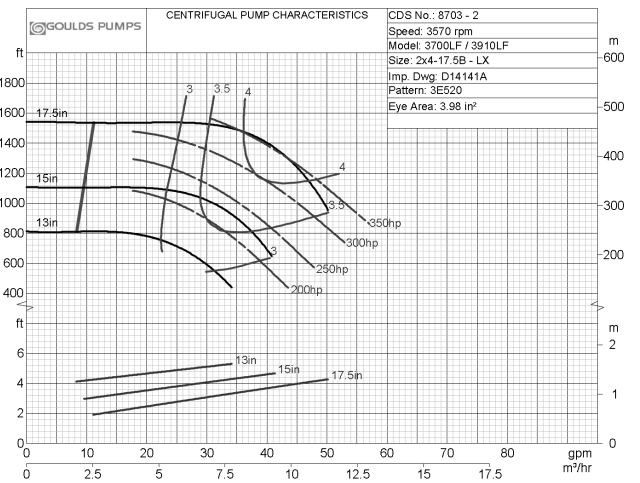
2x4-13 **3570rpm**



2x4-13 **1770rpm**

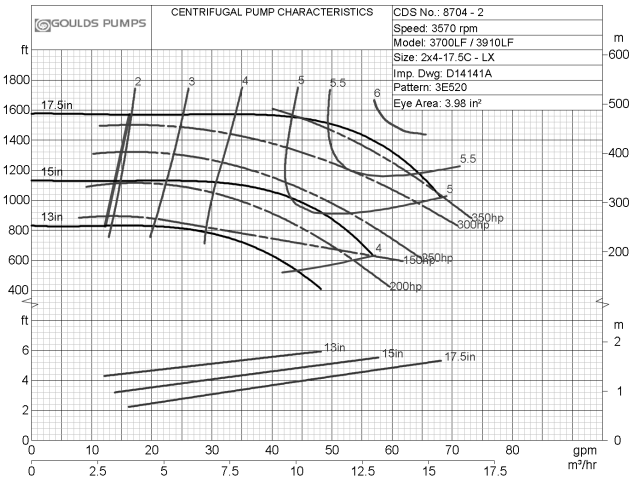


2x4-13 **1165rpm**

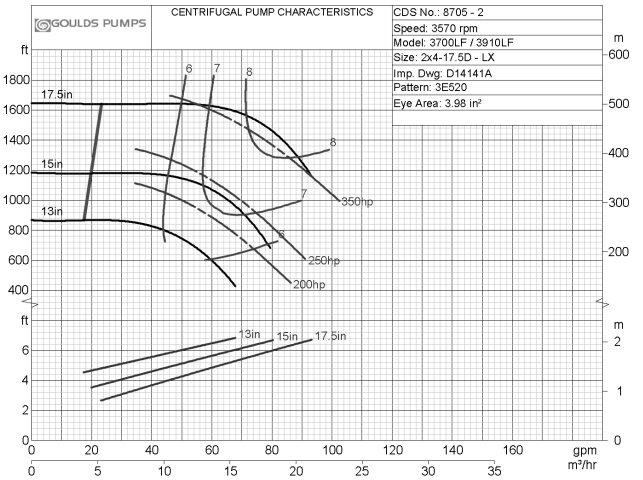


2x4-17.5B **3570rpm**

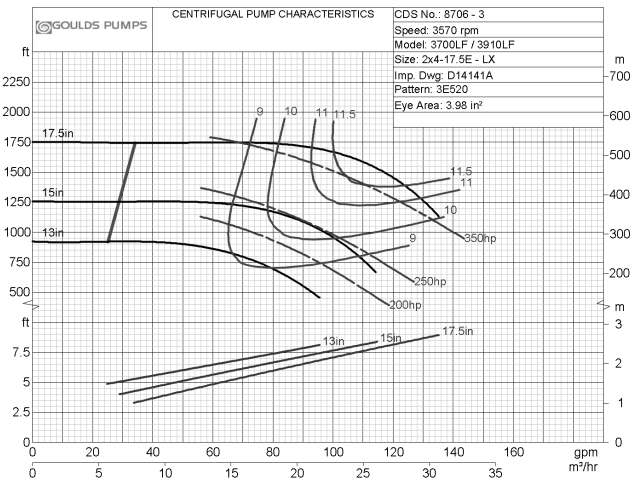
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



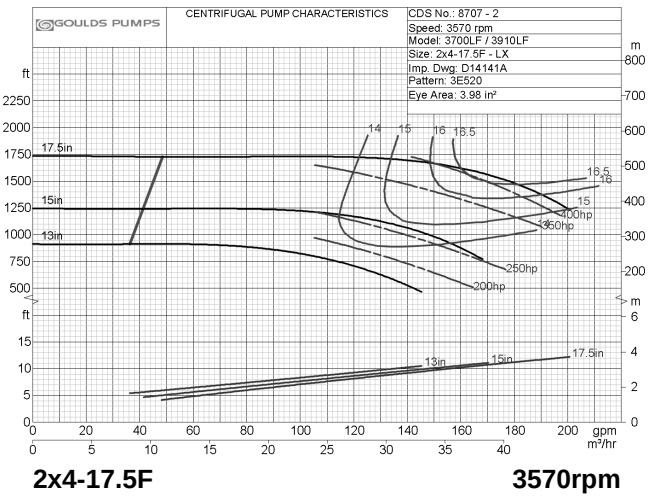
2x4-17.5C **3570rpm**



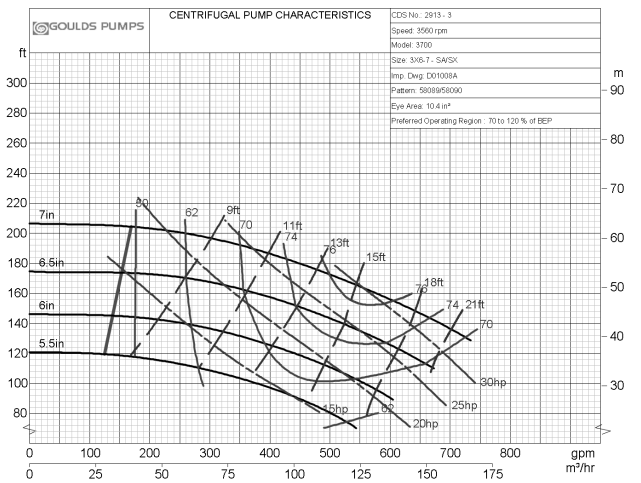
2x4-17.5D **3570rpm**



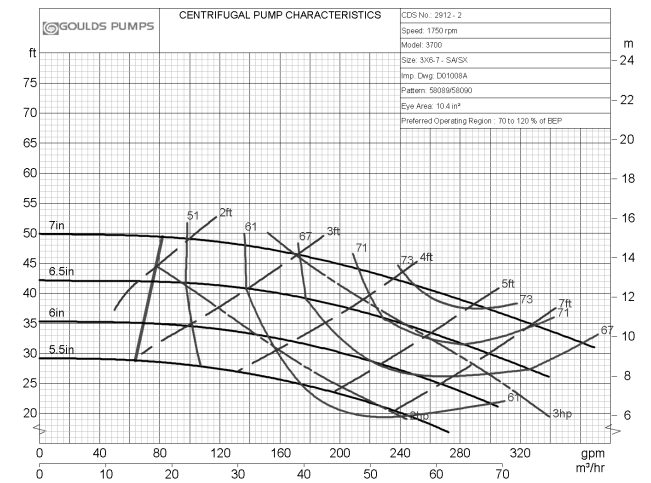
2x4-17.5E **3570rpm**



2x4-17.5F **3570rpm**



3X6-7 **3560rpm**

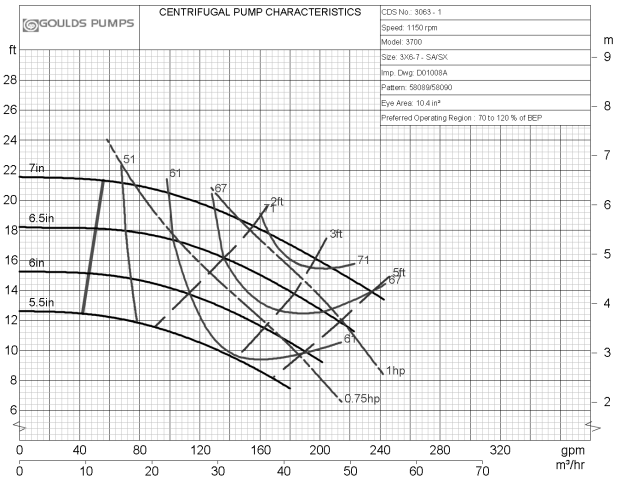


3X6-7 **1750rpm**

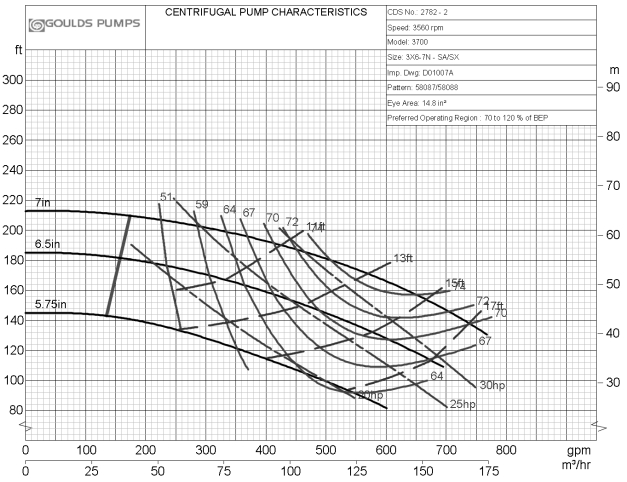
60Hz Curves

Model 3700

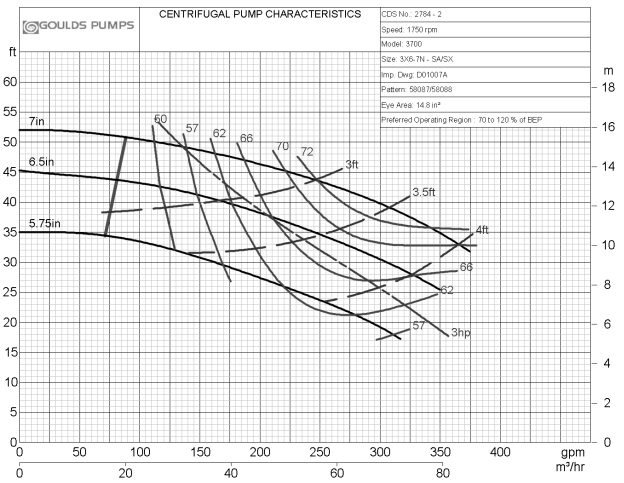
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



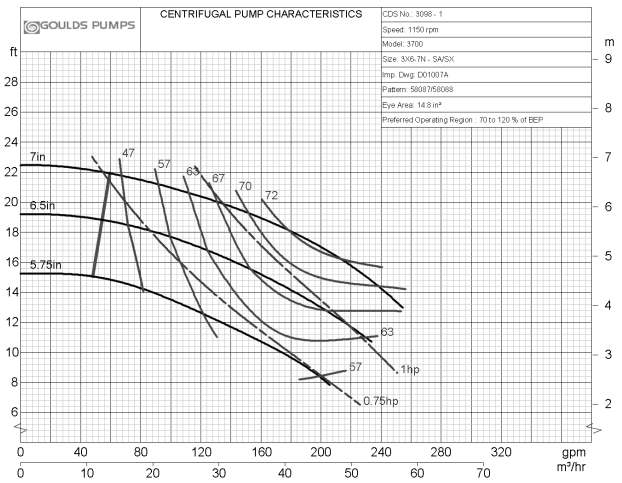
3X6-7 **1150rpm**



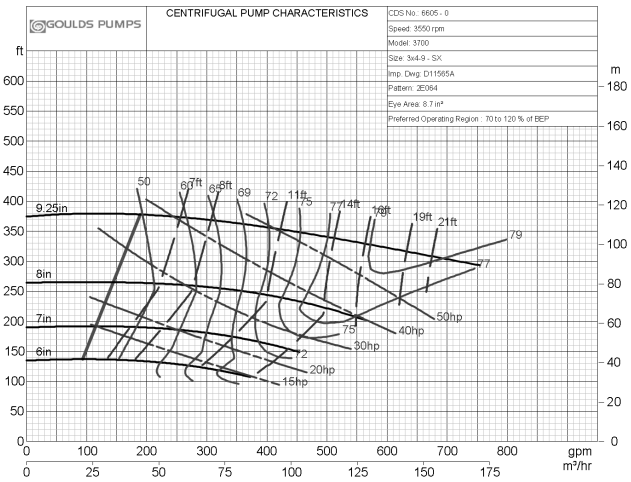
3X6-7N **3560rpm**



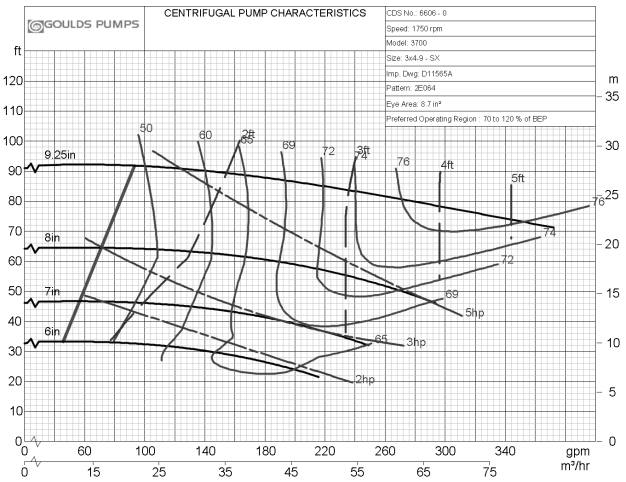
3X6-7N **1750rpm**



3X6-7N **1150rpm**



3x4-9 **3550rpm**



3x4-9 **1750rpm**

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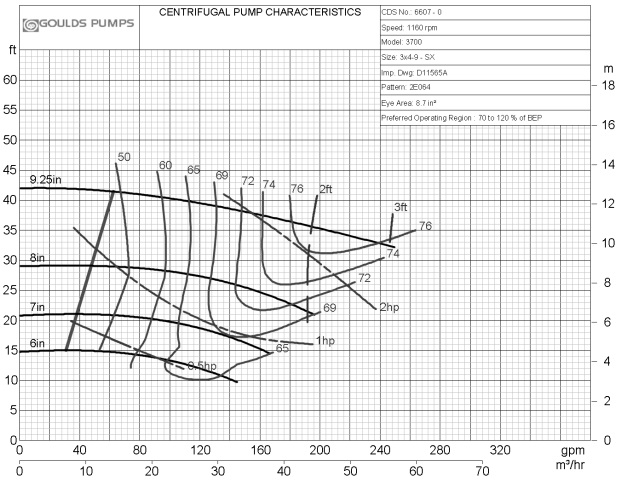
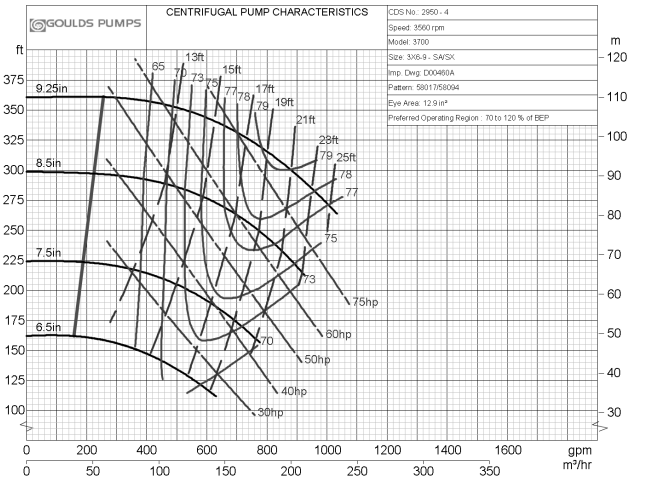
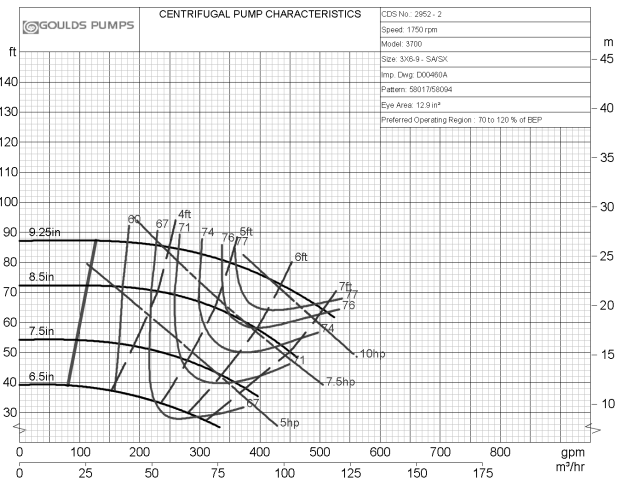


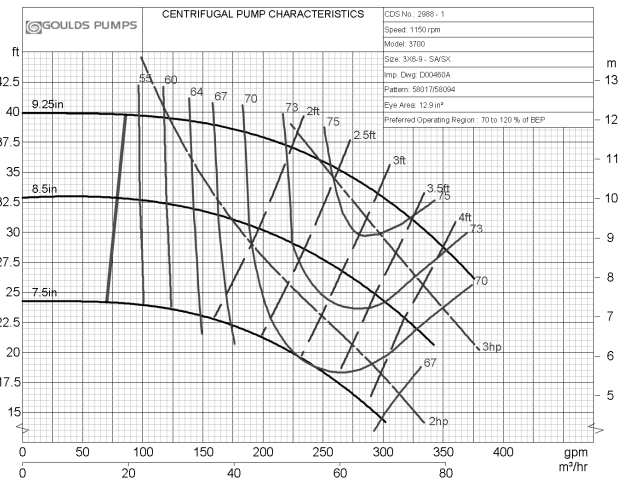
3x4-9 **1160rpm**



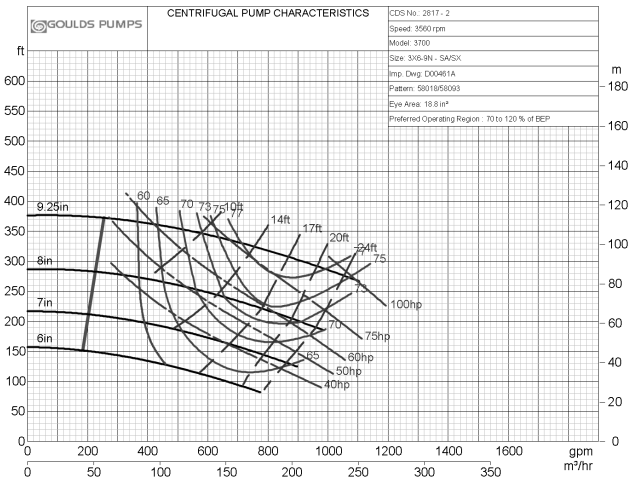
3X6-9 **3560rpm**



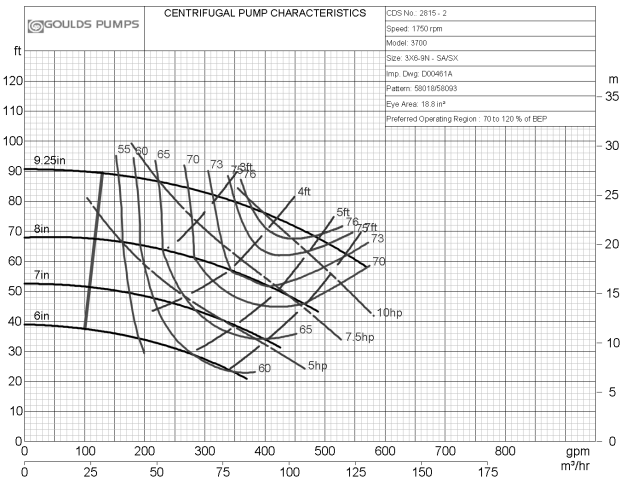
3X6-9 **1750rpm**



3X6-9 **1150rpm**



3X6-9N **3560rpm**

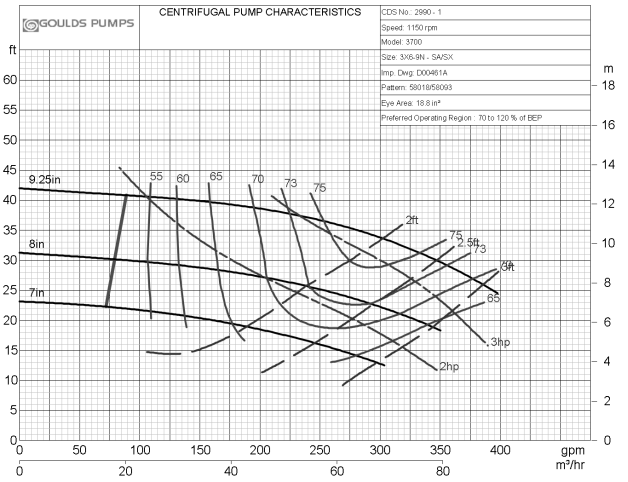


3X6-9N **1750rpm**

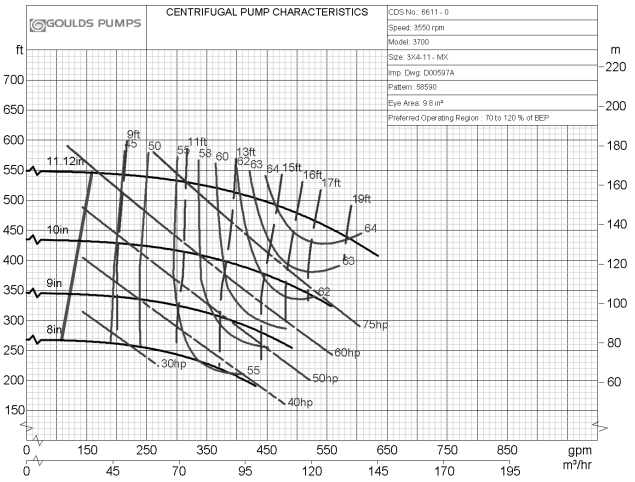
60Hz Curves

Model 3700

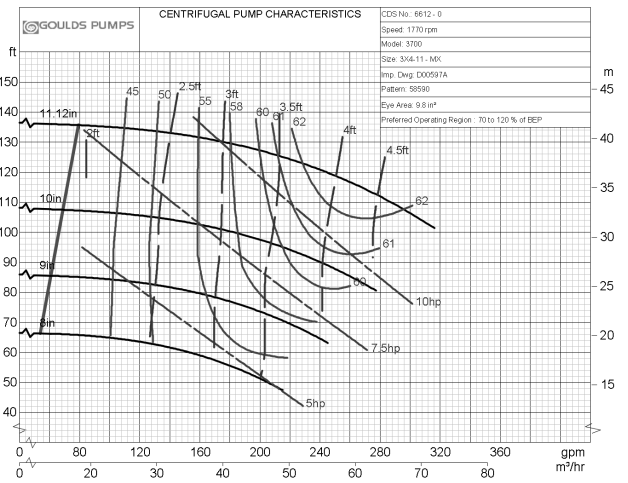
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



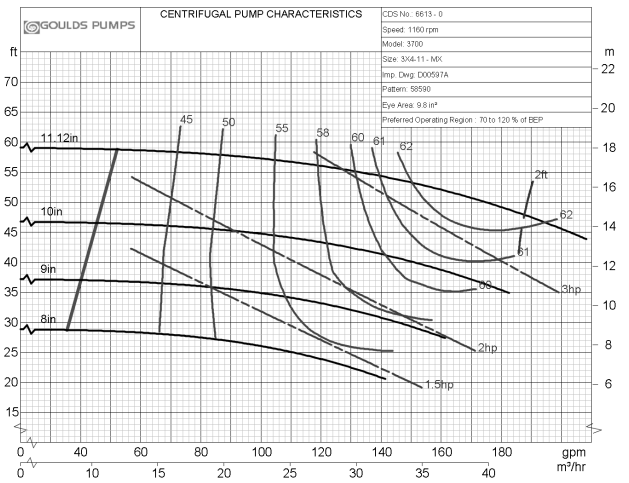
3X6-9N **1150rpm**



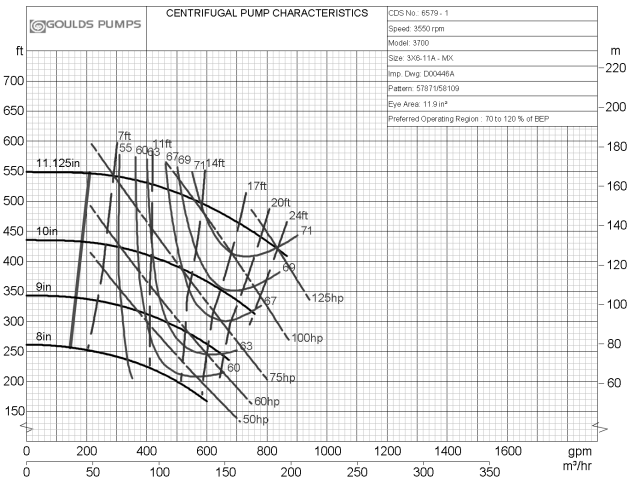
3X4-11 **3550rpm**



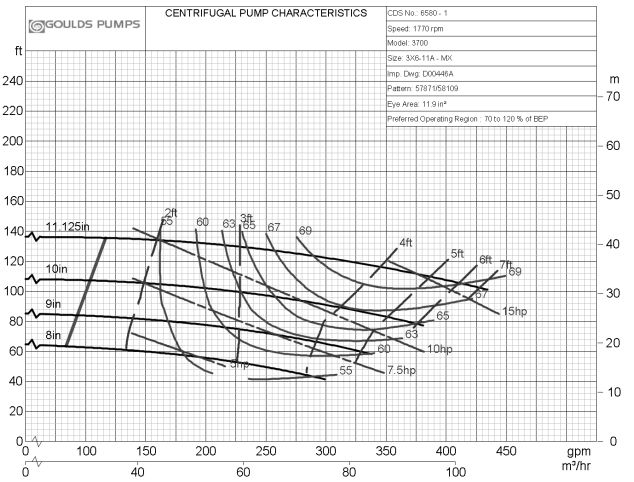
3X4-11 **1770rpm**



3X4-11 **1160rpm**



3X6-11A **3550rpm**

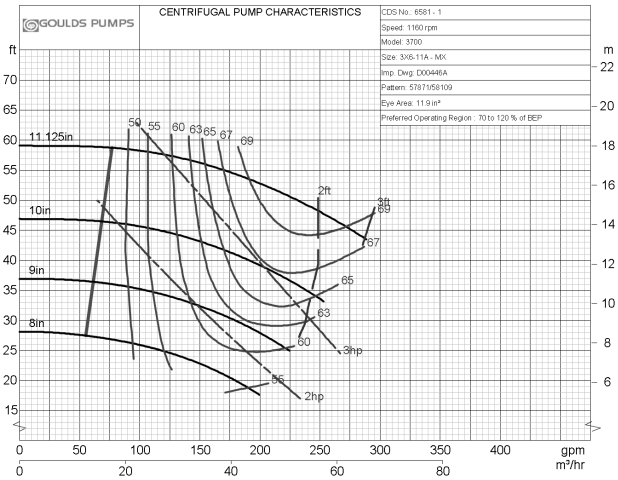


3X6-11A **1770rpm**

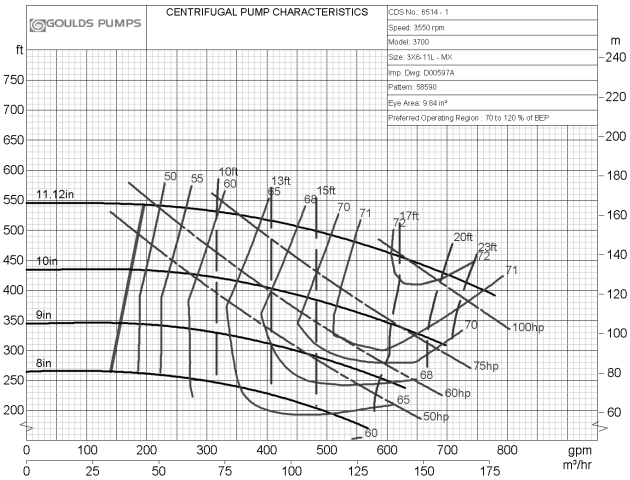
60Hz Curves

Model 3700

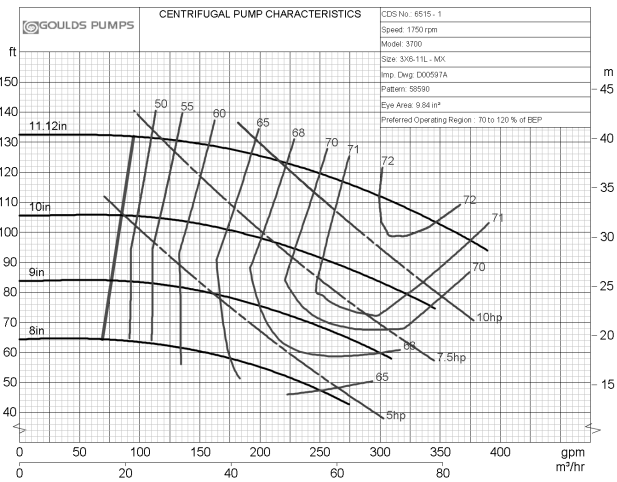
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



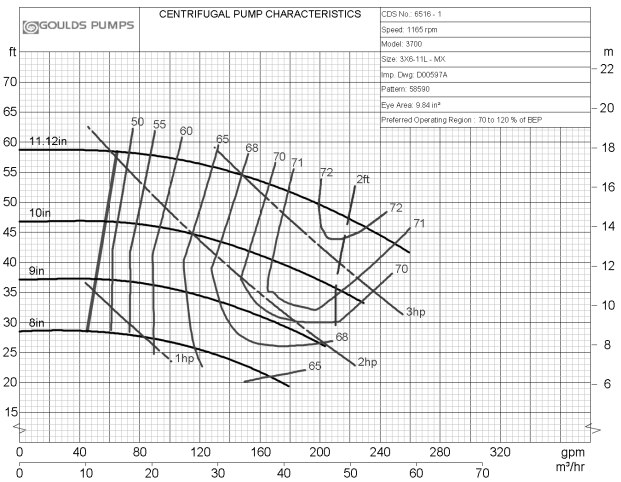
3X6-11A **1160rpm**



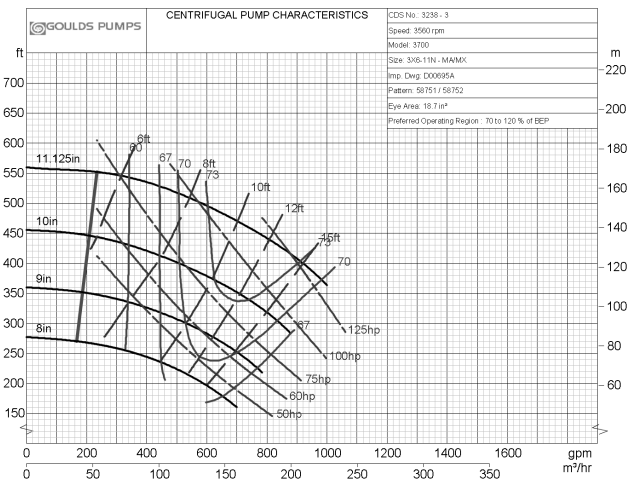
3X6-11L **3550rpm**



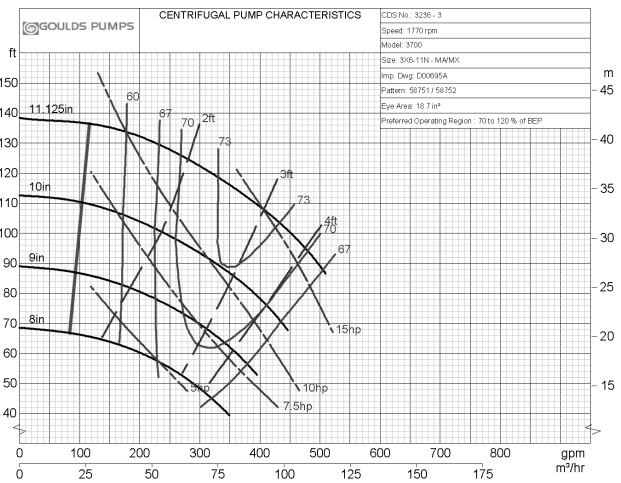
3X6-11L **1750rpm**



3X6-11L **1165rpm**



3X6-11N **3560rpm**

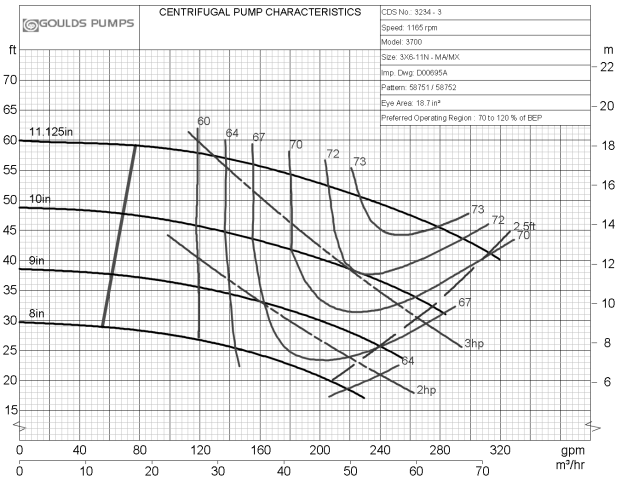


3X6-11N **1770rpm**

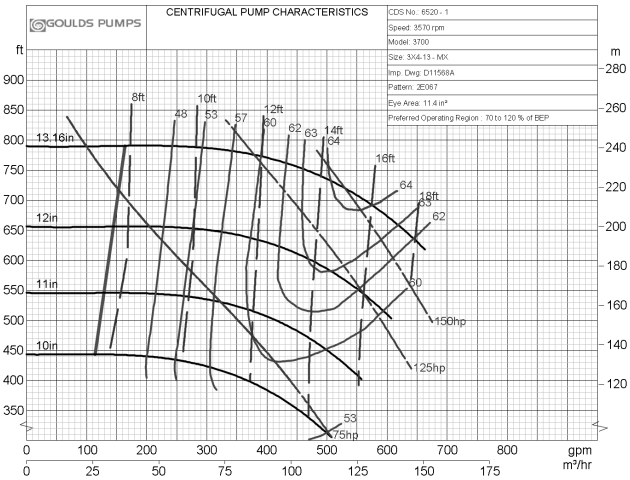
60Hz Curves

Model 3700

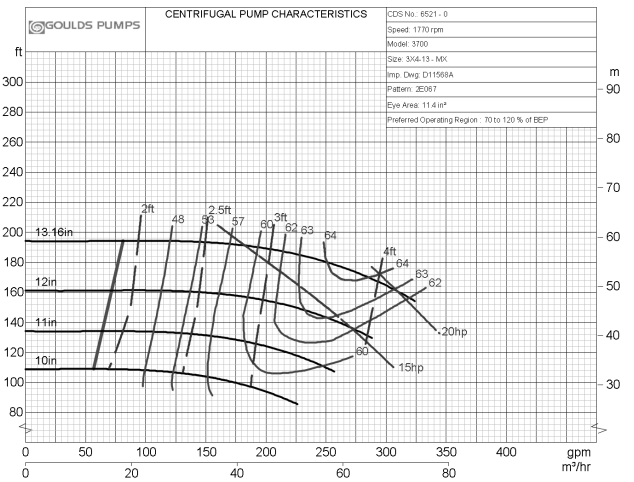
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



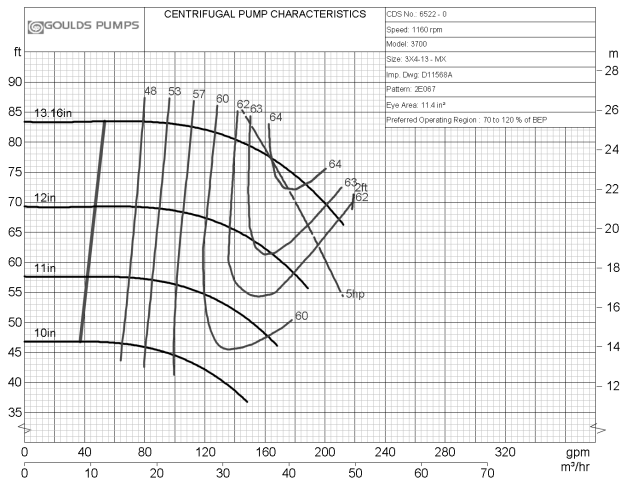
3X6-11N **1165rpm**



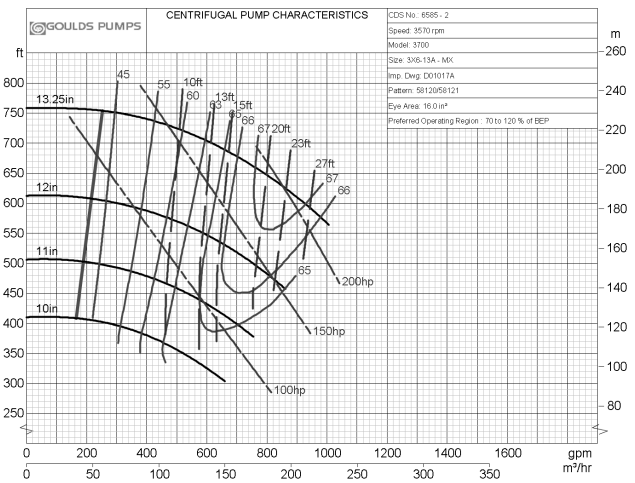
3X4-13 **3570rpm**



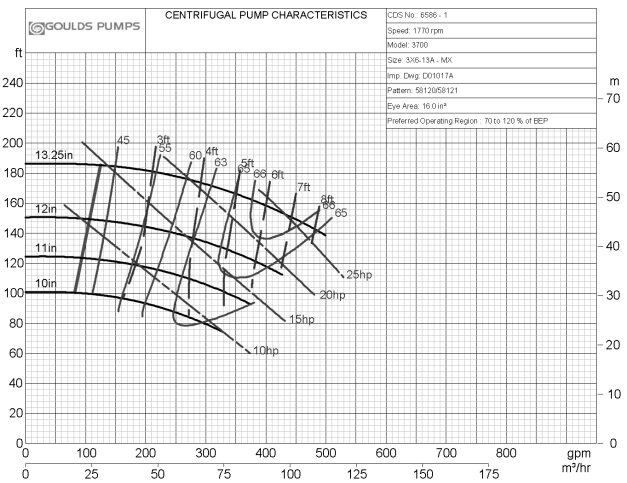
3X4-13 **1770rpm**



3X4-13 **1160rpm**

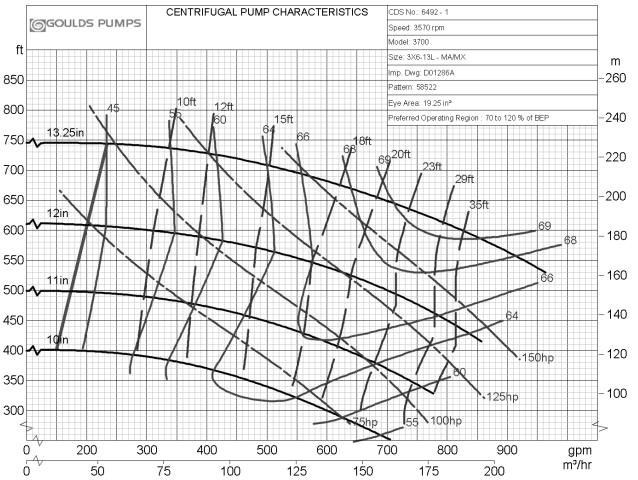


3X6-13A **3570rpm**

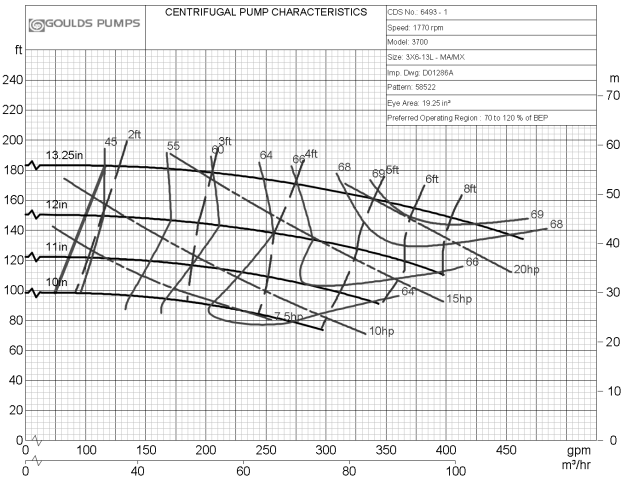


3X6-13A **1770rpm**

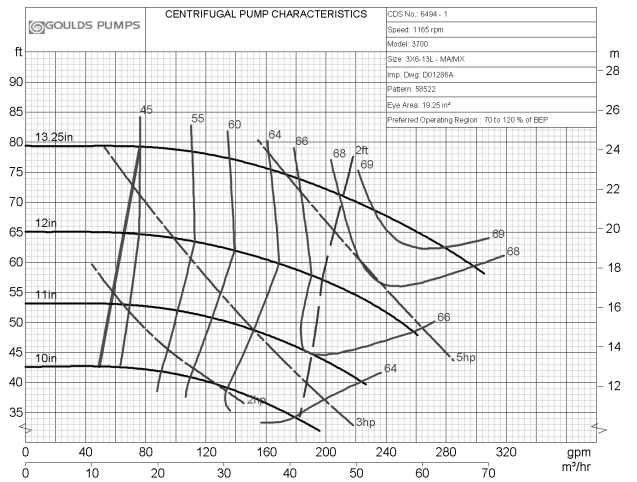
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



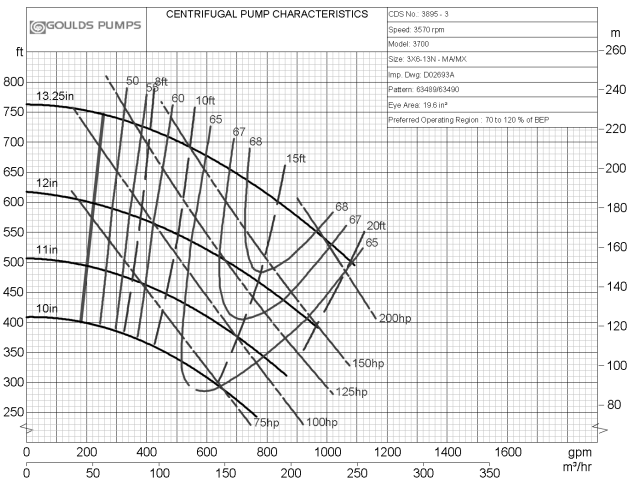
3X6-13L **3570rpm**



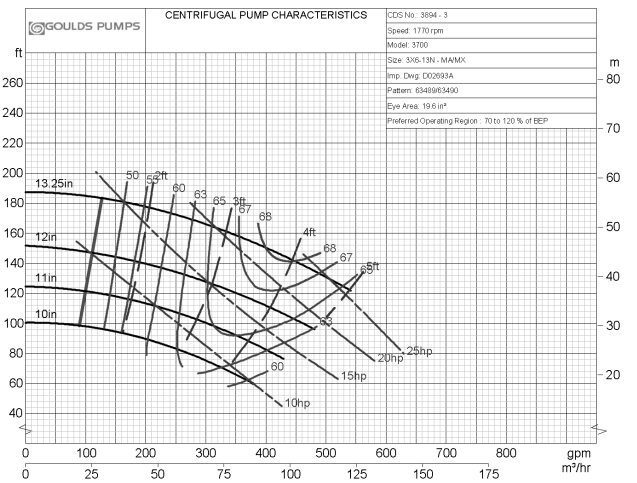
3X6-13L **1770rpm**



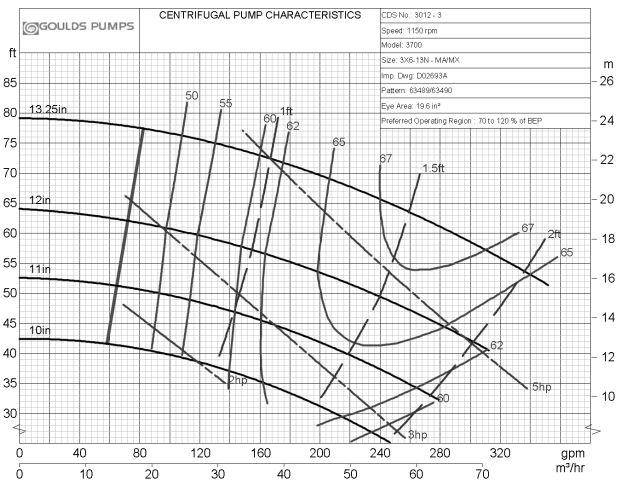
3X6-13L **1165rpm**



3X6-13N **3570rpm**

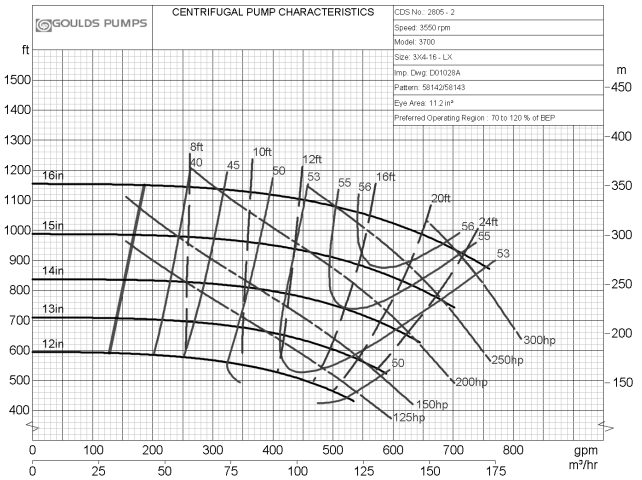


3X6-13N **1770rpm**

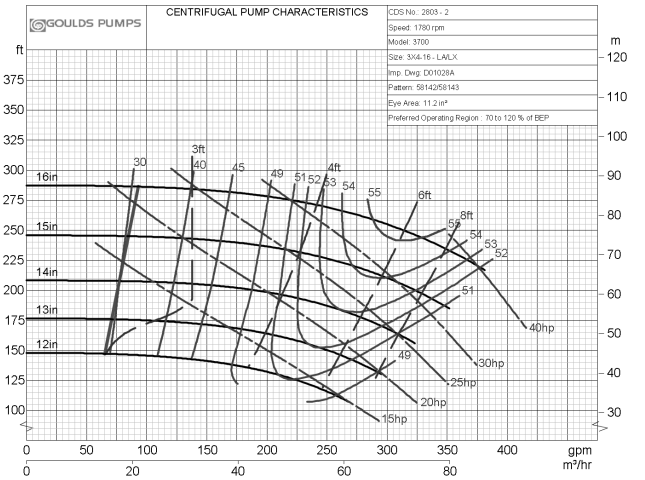


3X6-13N **1150rpm**

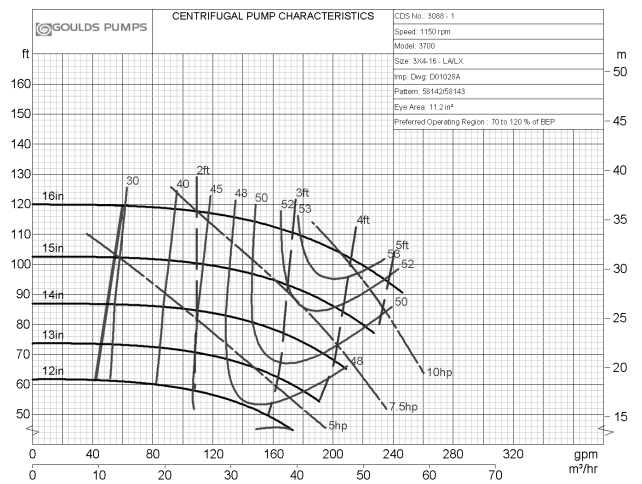
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



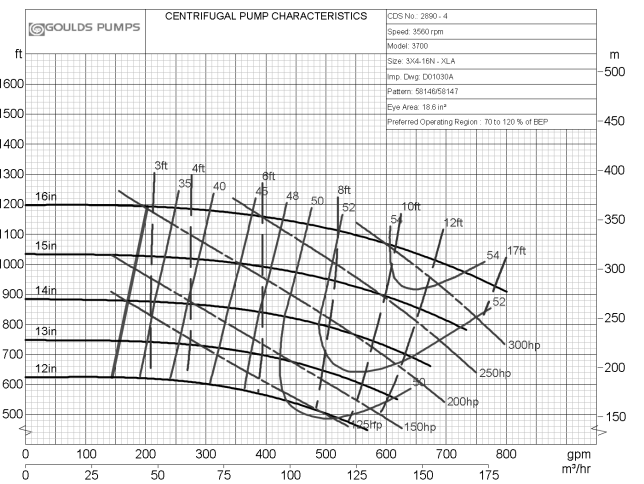
3X4-16 **3550rpm**



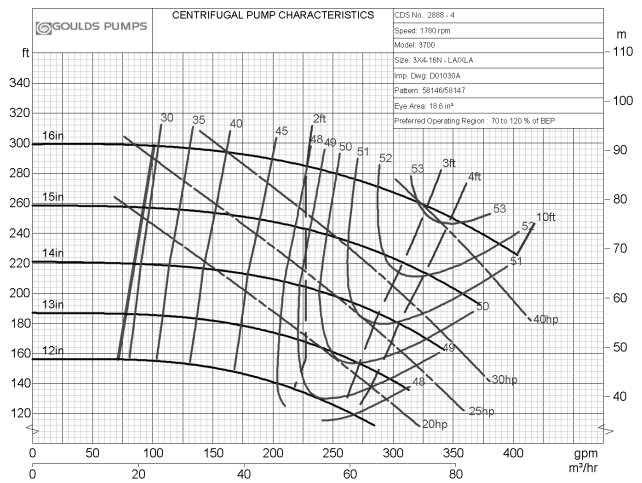
3X4-16 **1780rpm**



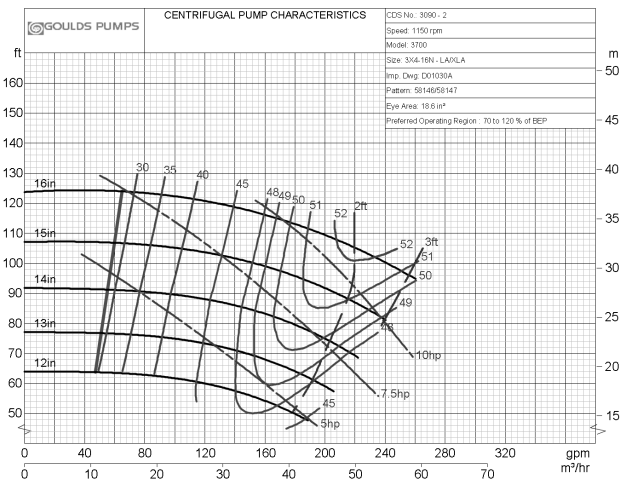
3X4-16 **1150rpm**



3X4-16N **3560rpm**

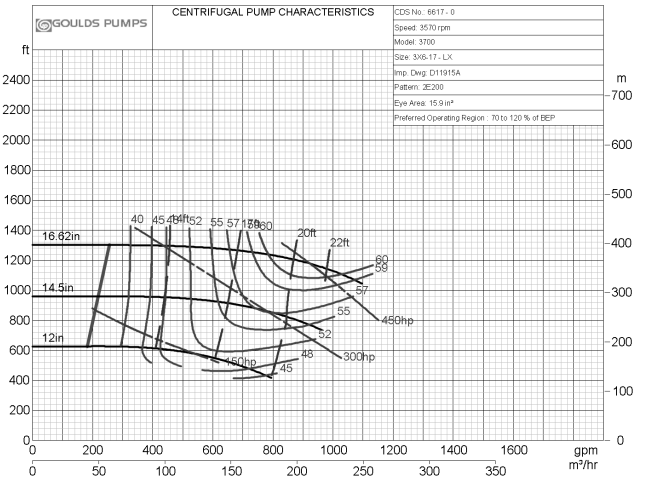


3X4-16N **1780rpm**

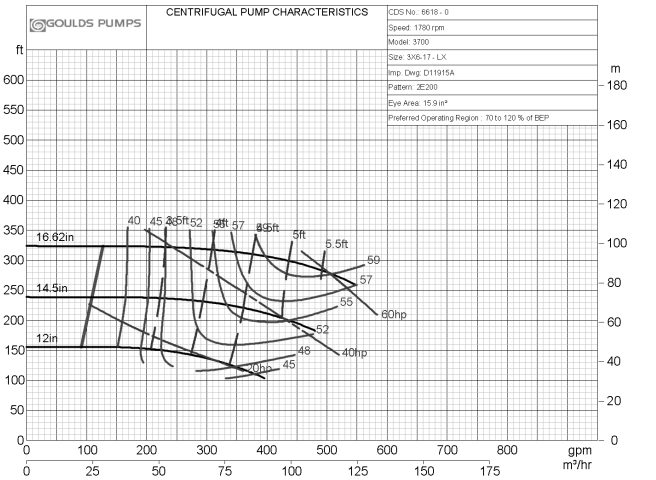


3X4-16N **1150rpm**

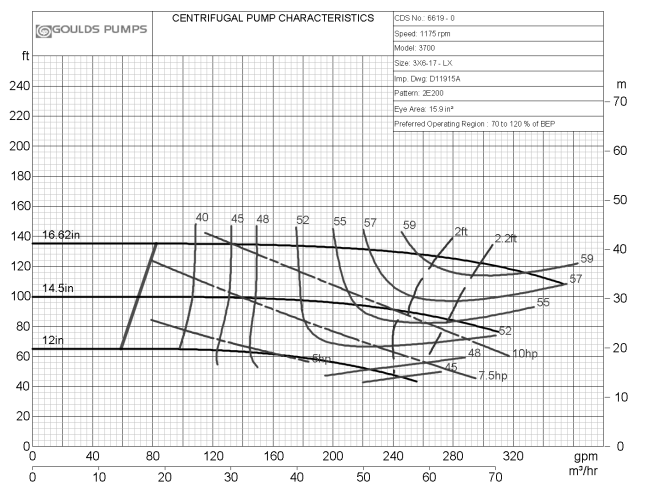
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



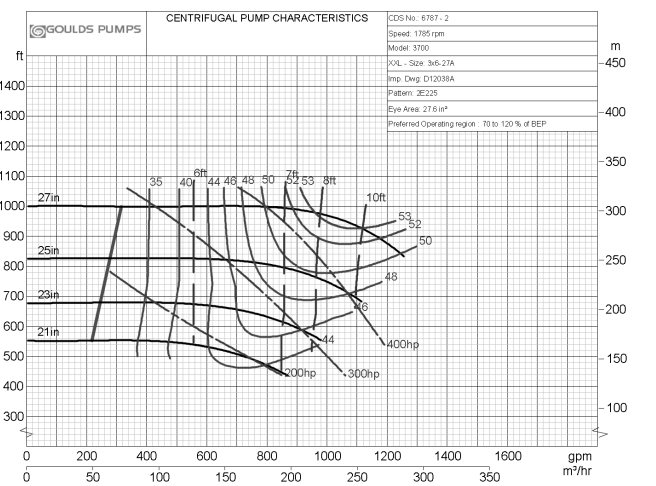
3X6-17 **3570rpm**



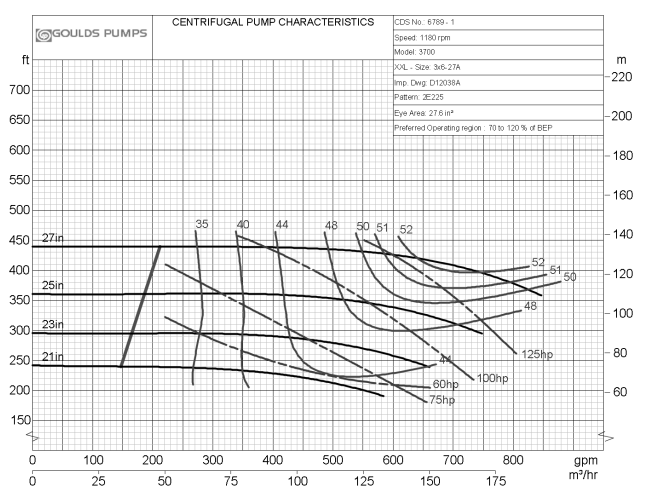
3X6-17 **1780rpm**



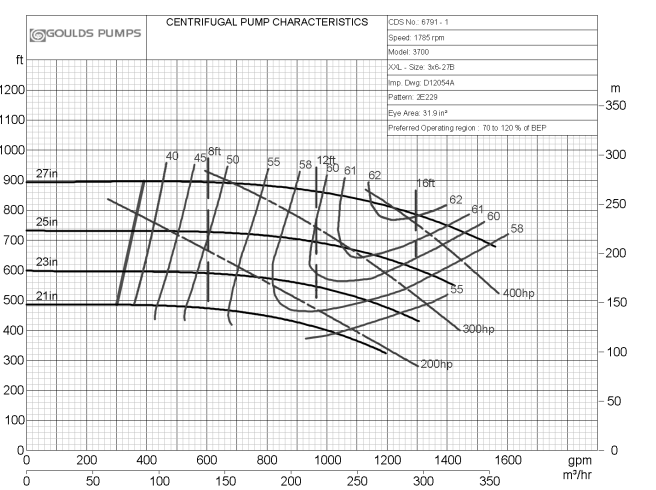
3X6-17 **1175rpm**



3x6-27A **1785rpm**



3x6-27A **1180rpm**

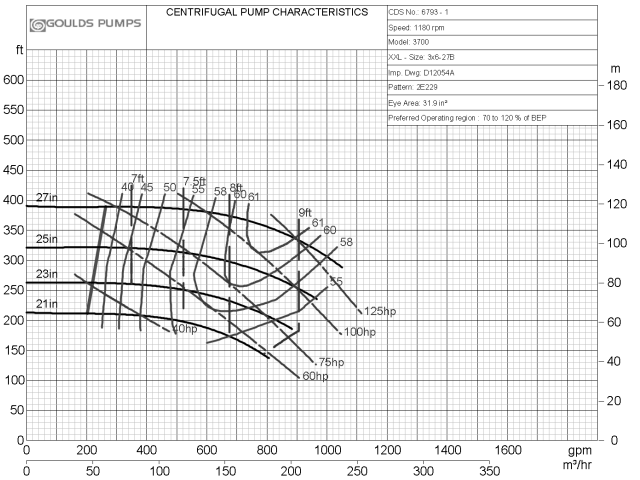


3x6-27B **1785rpm**

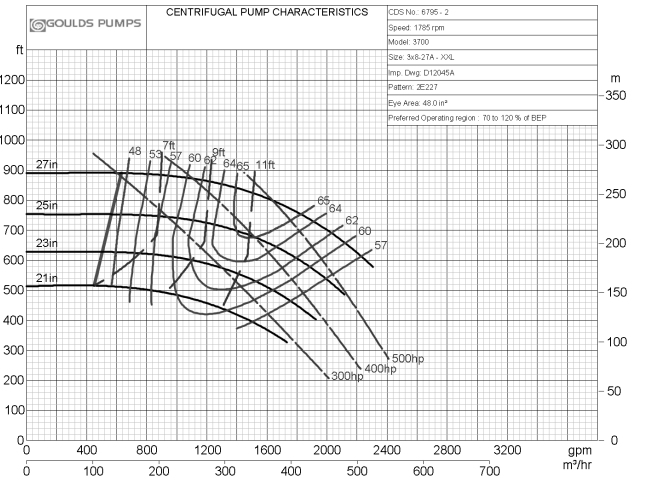
60Hz Curves

Model 3700

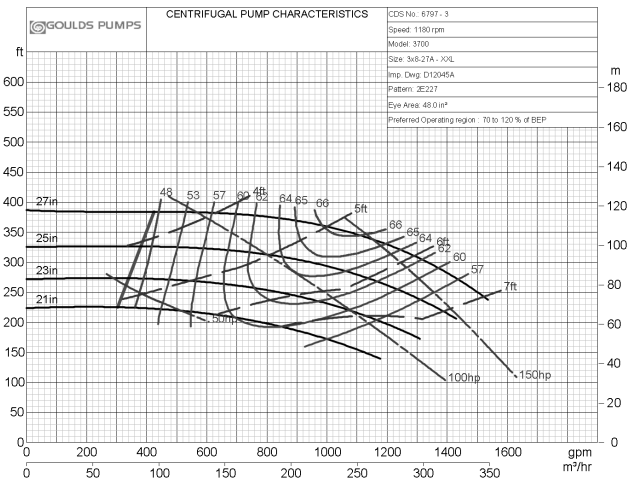
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



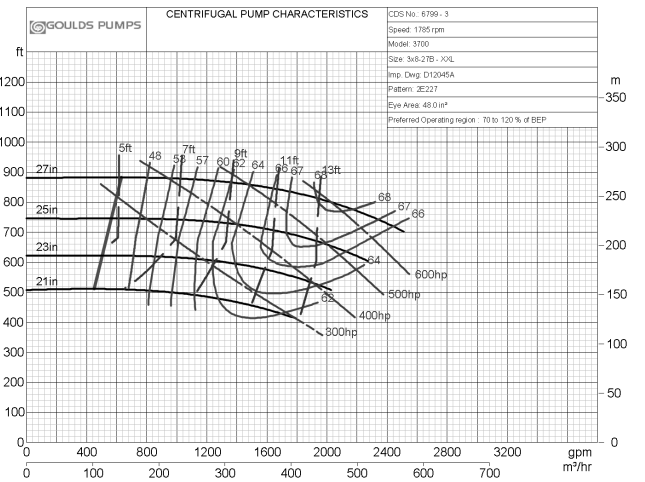
3x6-27B **1180rpm**



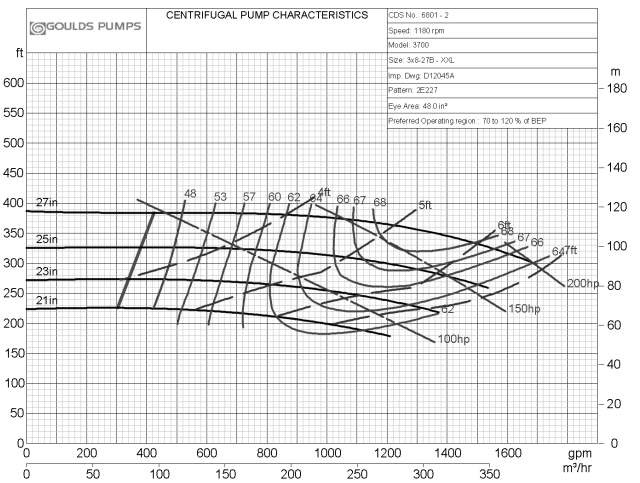
3x8-27A **1785rpm**



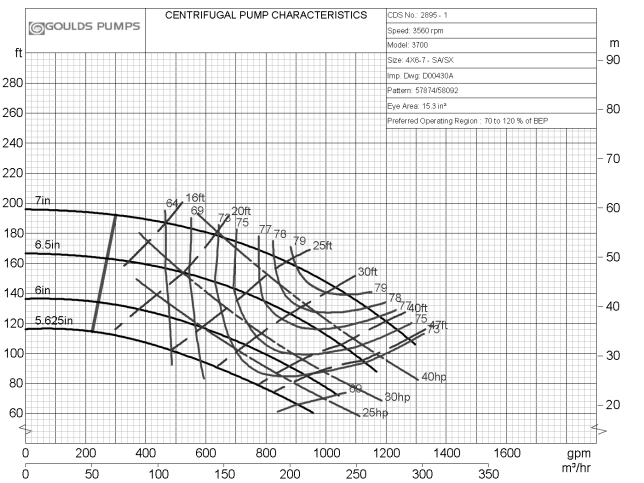
3x8-27A **1180rpm**



3x8-27B **1785rpm**

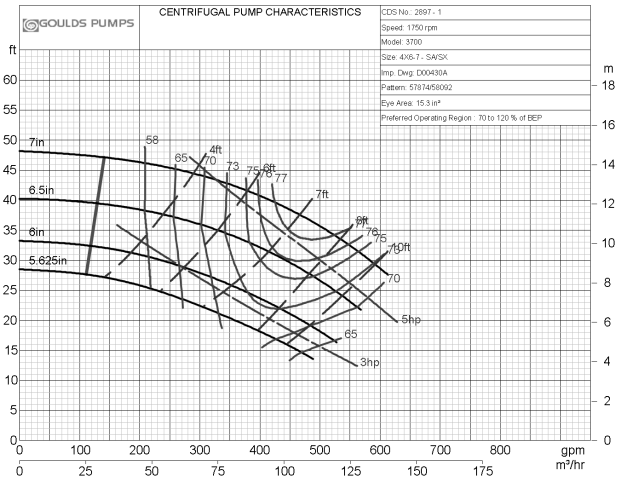


3x8-27B **1180rpm**

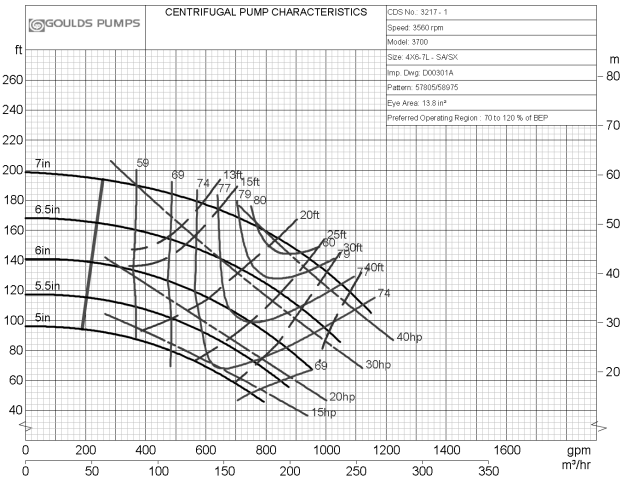


4X6-7 **3560rpm**

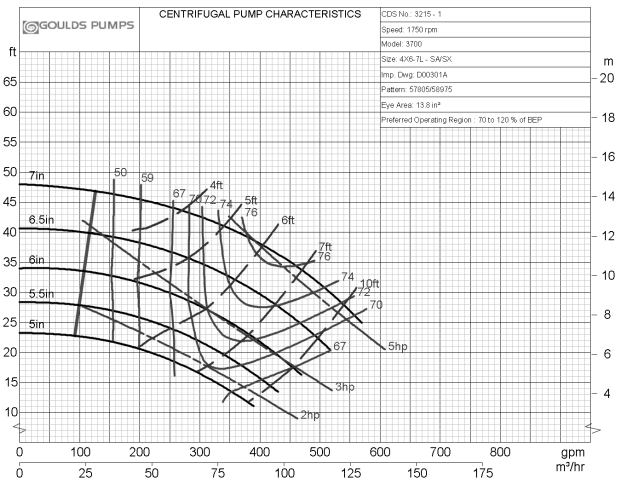
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



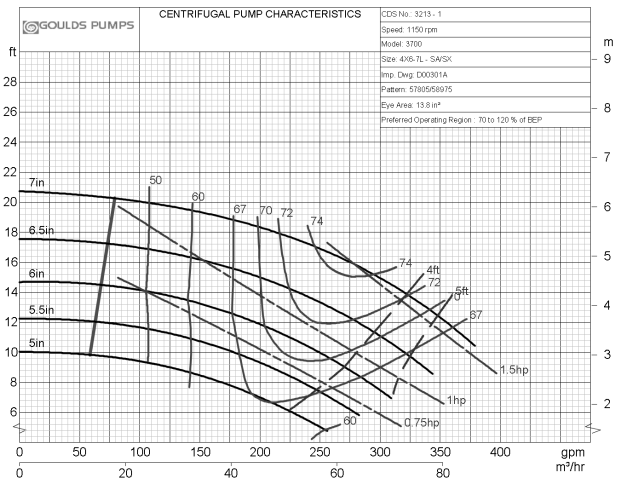
4X6-7 **1750rpm**



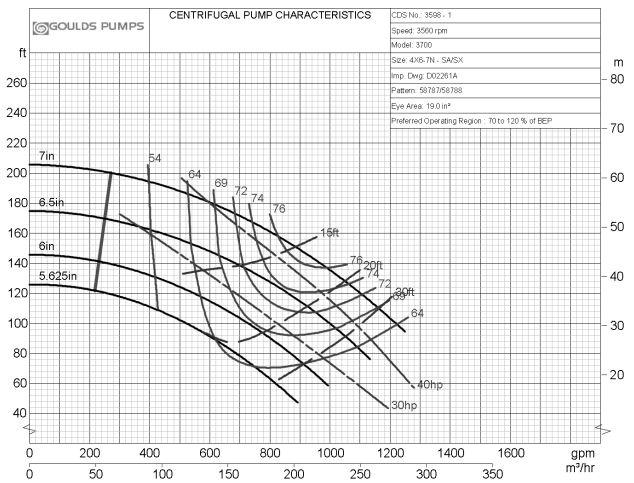
4X6-7L **3560rpm**



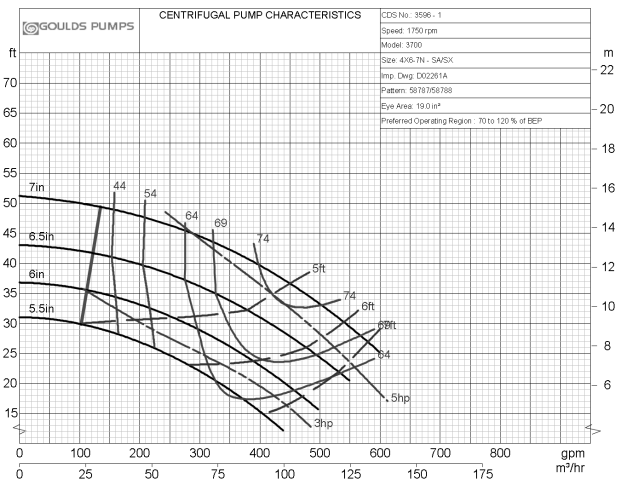
4X6-7L **1750rpm**



4X6-7L **1150rpm**



4X6-7N **3560rpm**

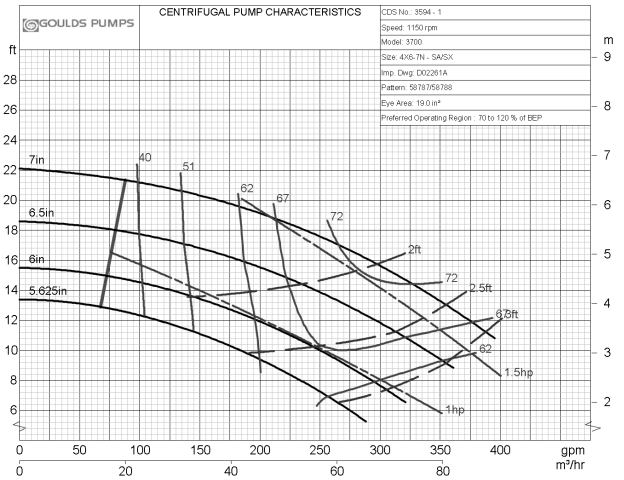


4X6-7N **1750rpm**

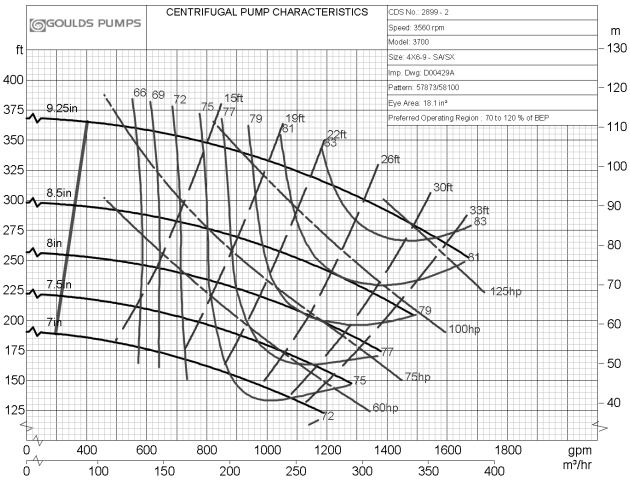
60Hz Curves

Model 3700

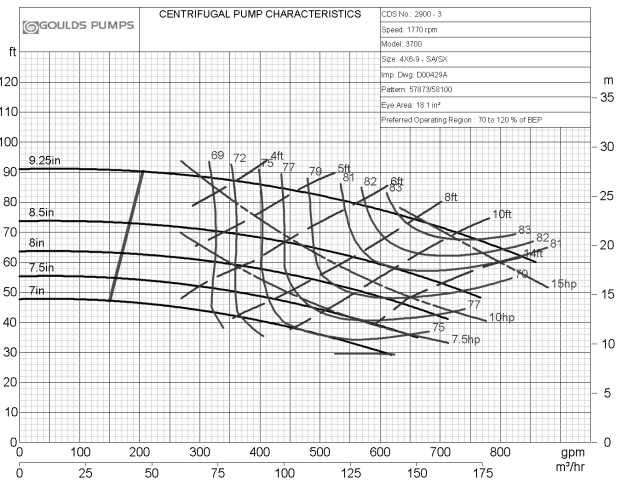
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



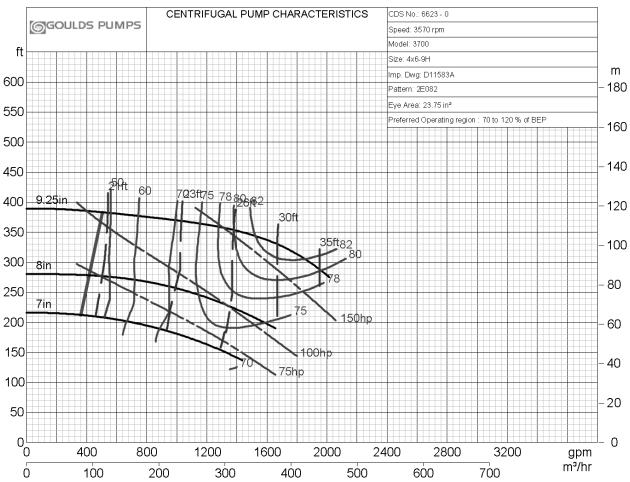
4X6-7N **1150rpm**



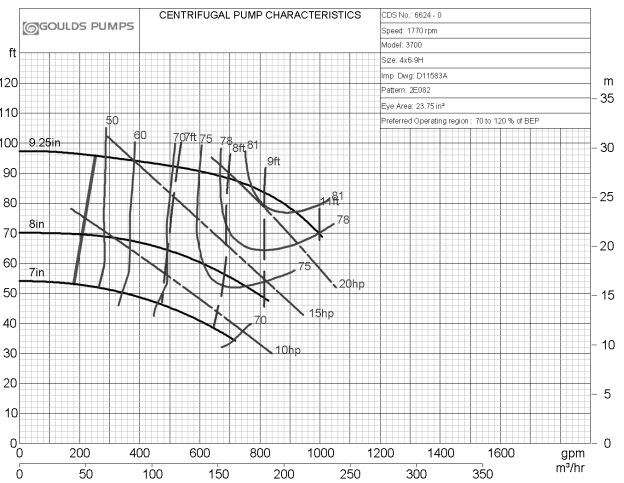
4X6-9 **3560rpm**



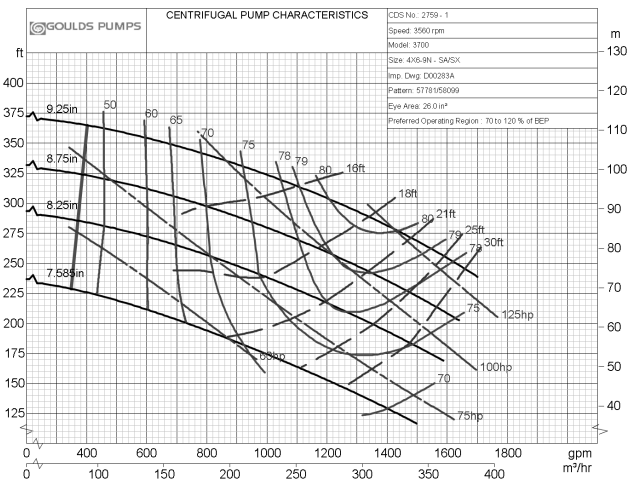
4X6-9 **1770rpm**



4x6-9H **3570rpm**



4x6-9H **1770rpm**

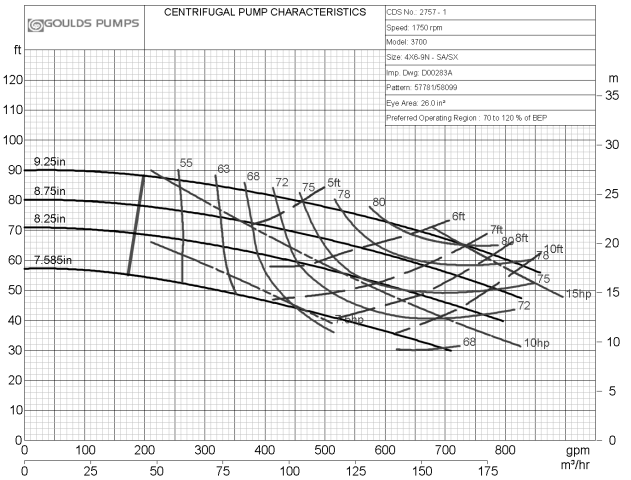


4X6-9N **3560rpm**

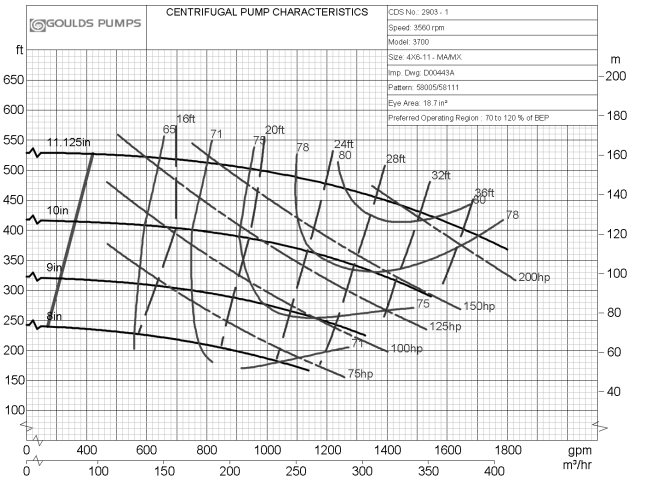
60Hz Curves

Model 3700

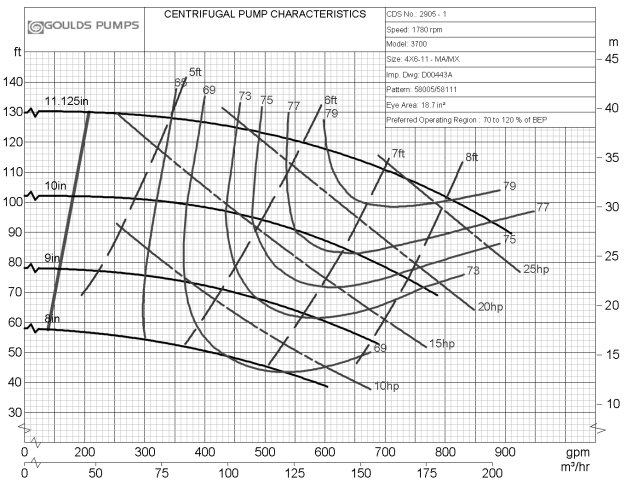
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



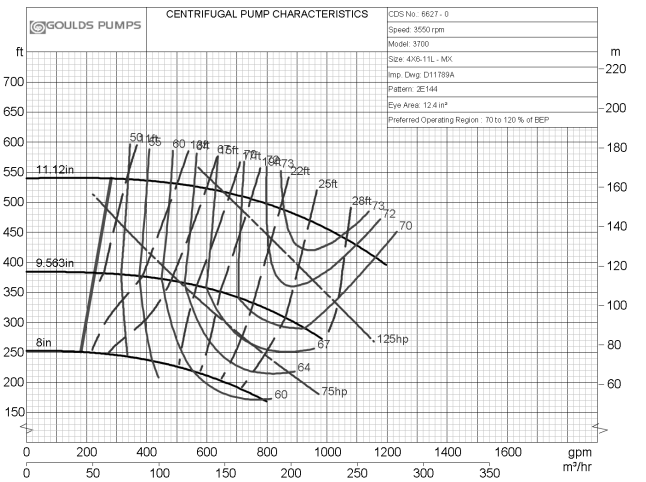
4X6-9N **1750rpm**



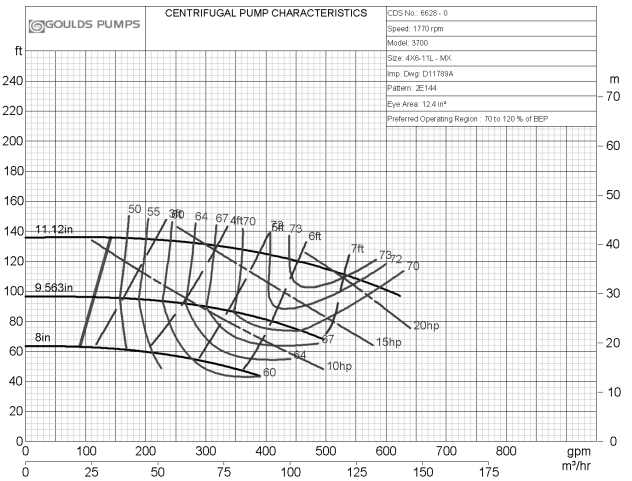
4X6-11 **3560rpm**



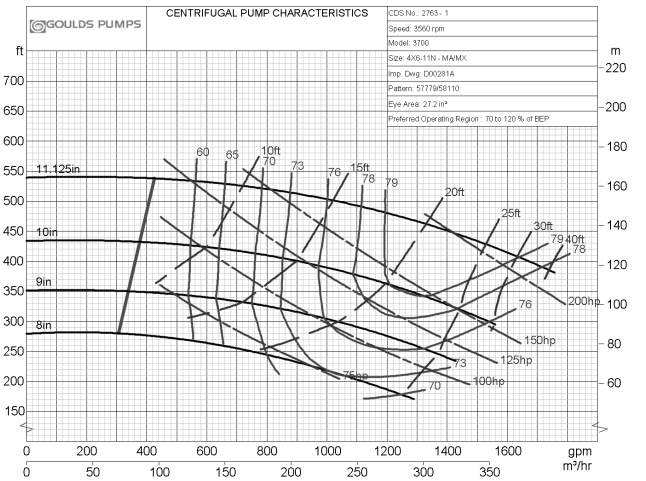
4X6-11 **1780rpm**



4X6-11L **3550rpm**



4X6-11L **1770rpm**

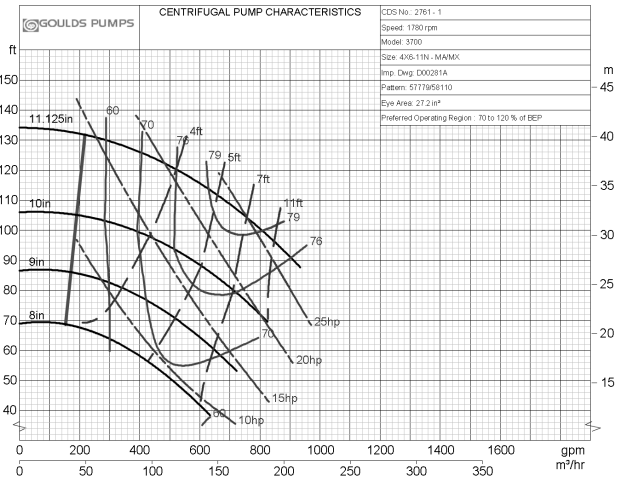


4X6-11N **3560rpm**

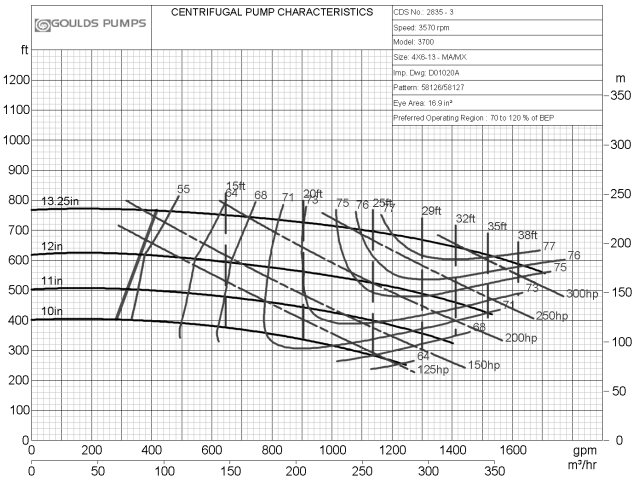
60Hz Curves

Model 3700

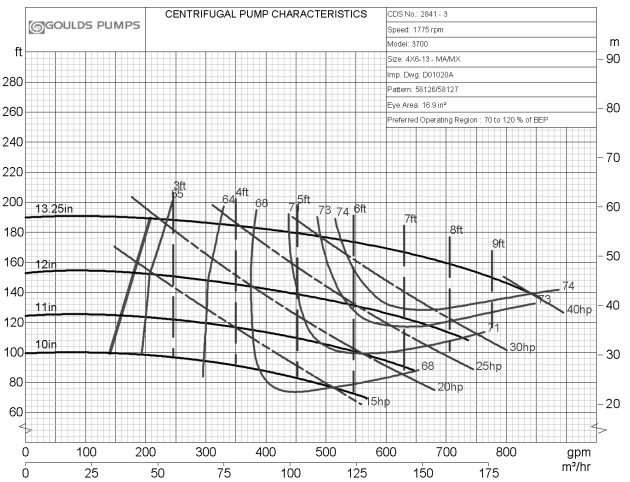
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



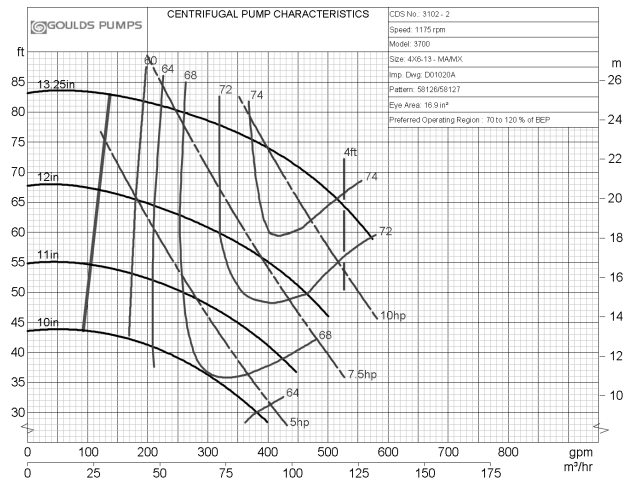
4X6-11N **1780rpm**



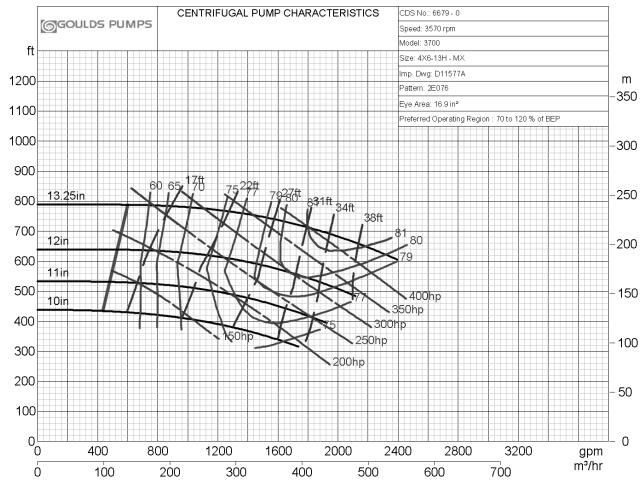
4X6-13 **3570rpm**



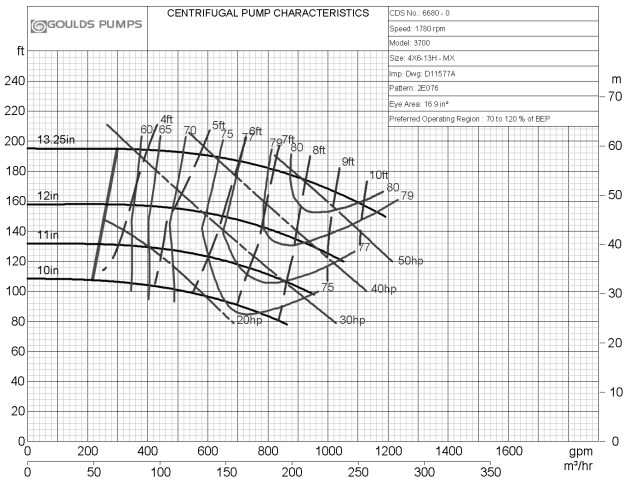
4X6-13 **1775rpm**



4X6-13 **1175rpm**

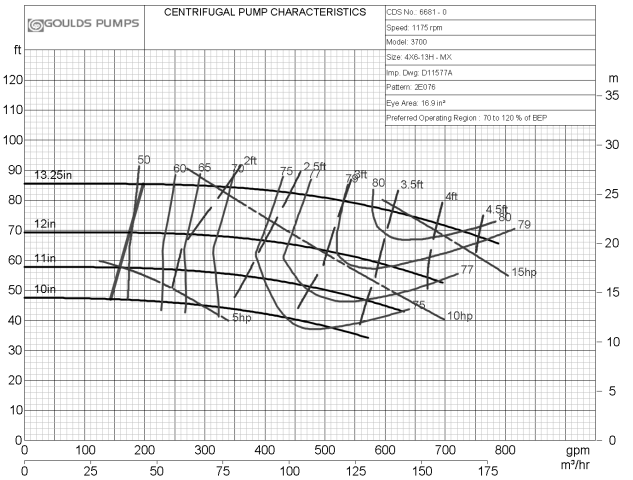


4X6-13H **3570rpm**

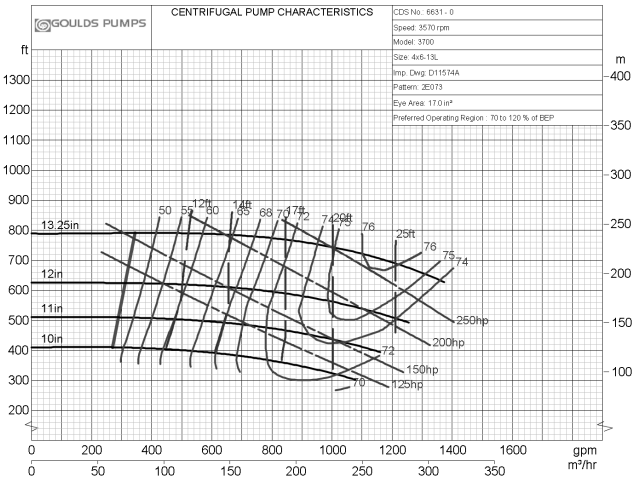


4X6-13H **1780rpm**

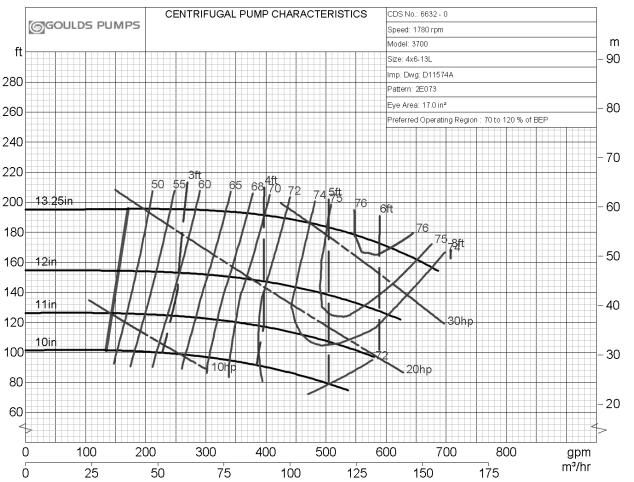
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



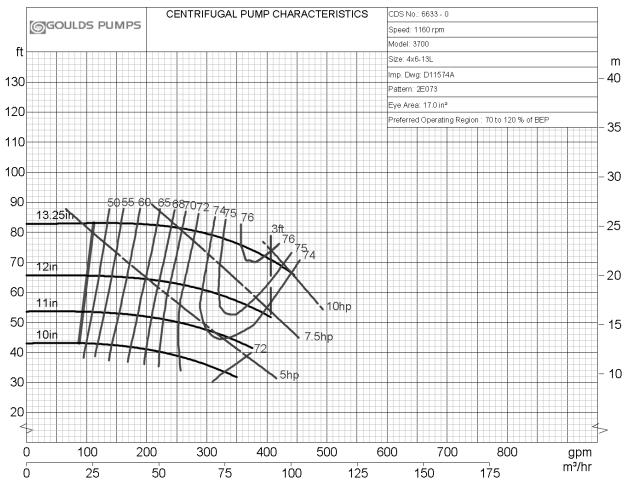
4X6-13H **1175rpm**



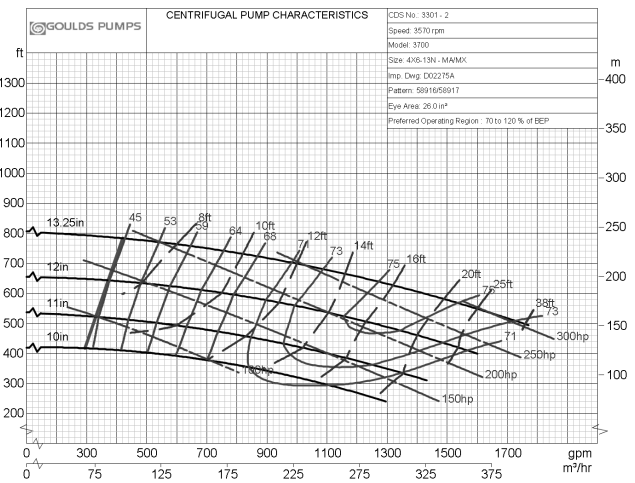
4x6-13L **3570rpm**



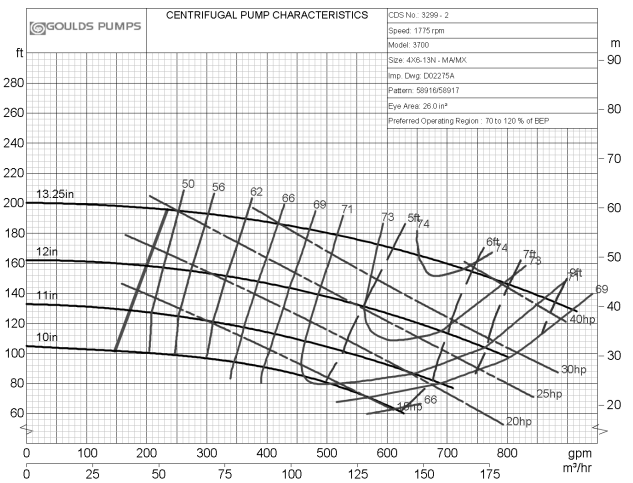
4x6-13L **1780rpm**



4x6-13L **1160rpm**

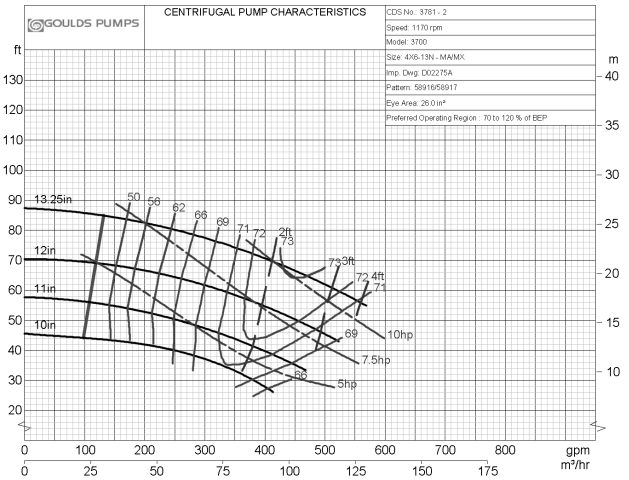


4X6-13N **3570rpm**

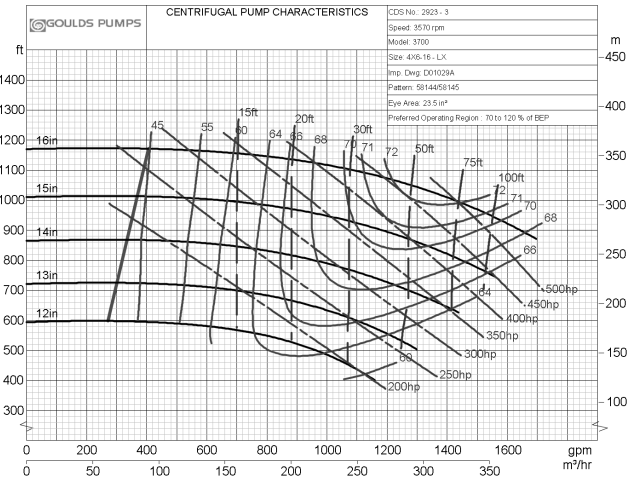


4X6-13N **1775rpm**

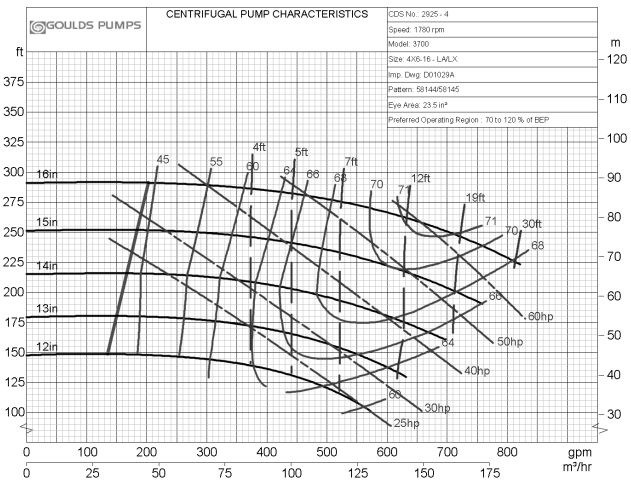
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



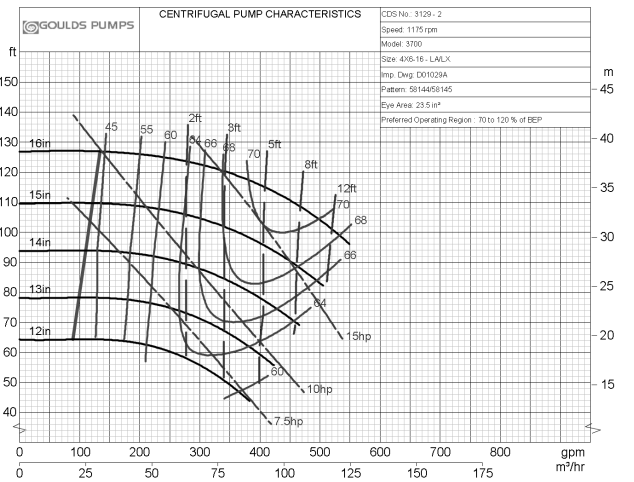
4X6-13N **1170rpm**



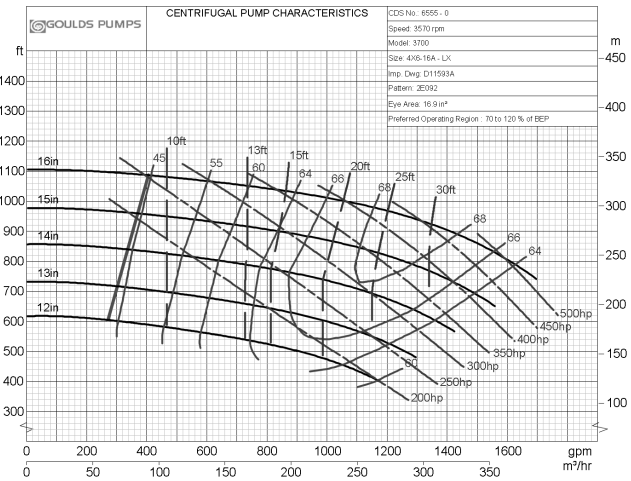
4X6-16 **3570rpm**



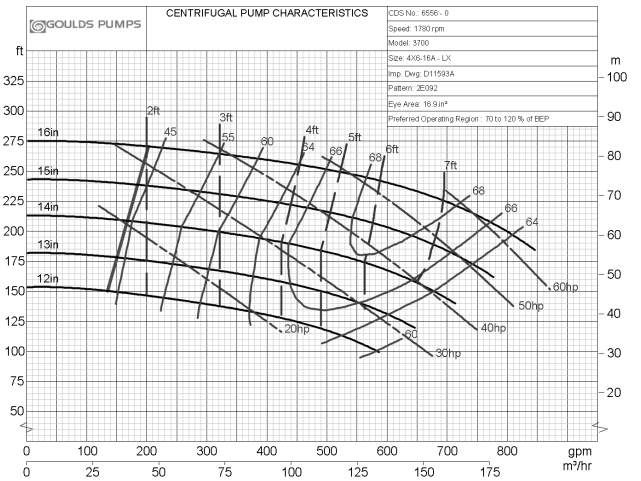
4X6-16 **1780rpm**



4X6-16 **1175rpm**



4X6-16A **3570rpm**



4X6-16A **1780rpm**

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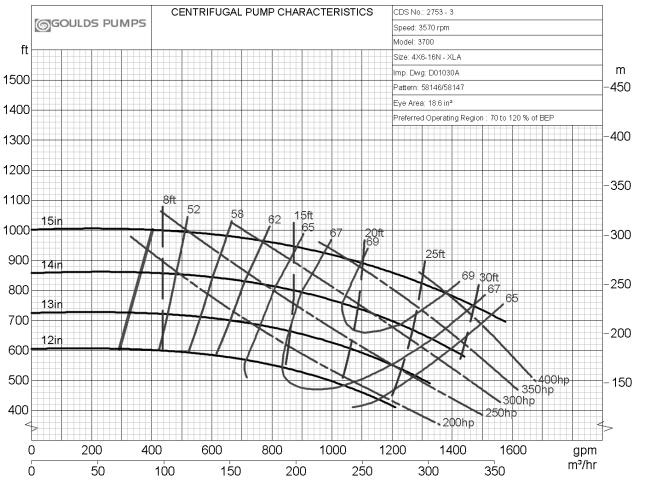
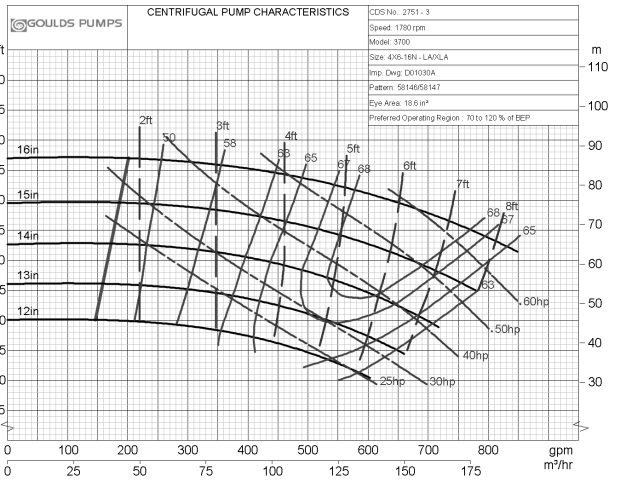
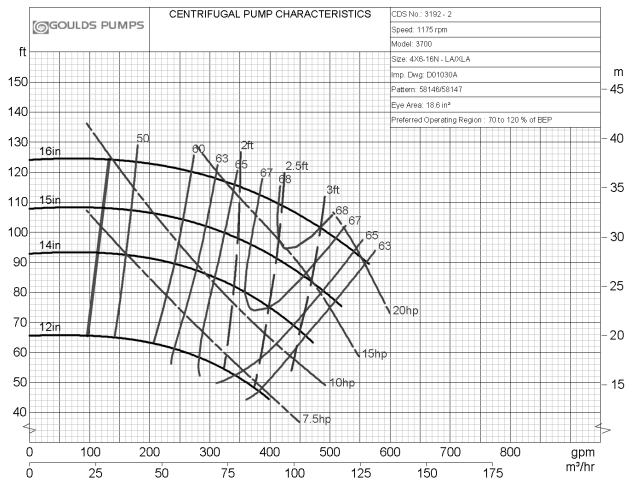


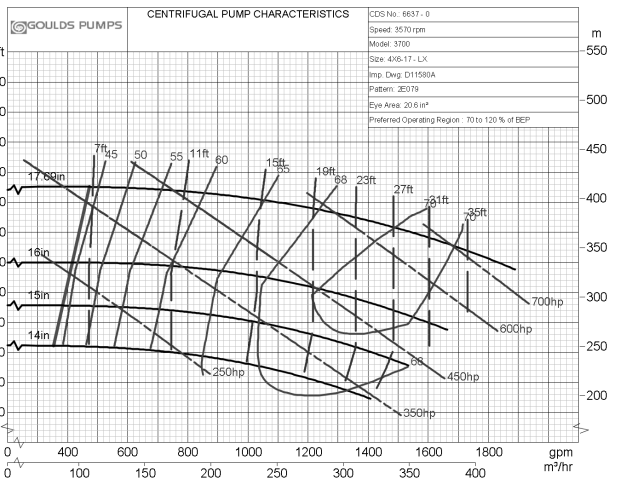
4X6-16N **3570rpm**



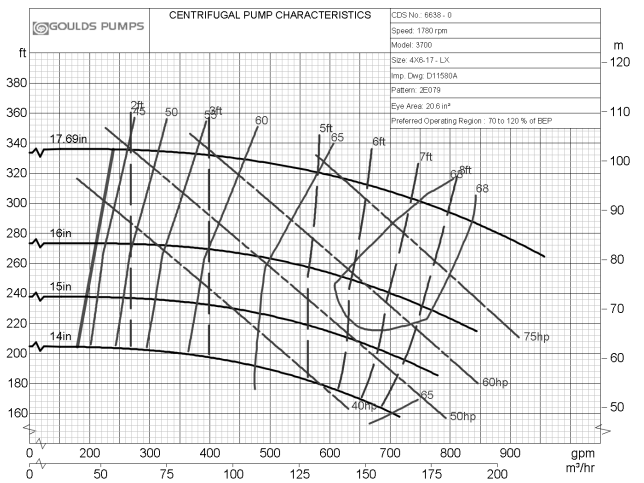
4X6-16N **1780rpm**



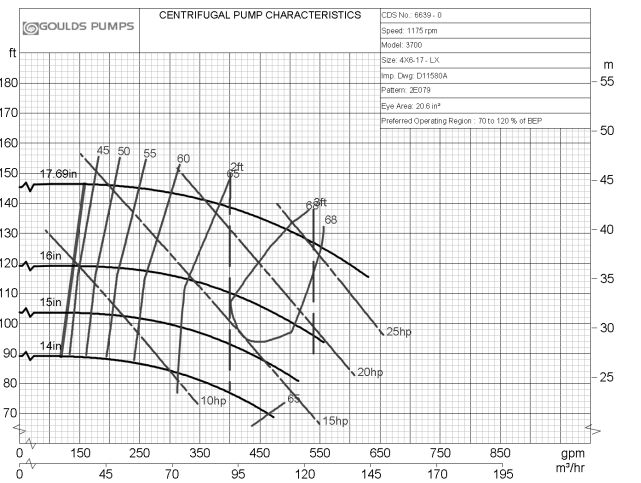
4X6-16N **1175rpm**



4X6-17 **3570rpm**



4X6-17 **1780rpm**

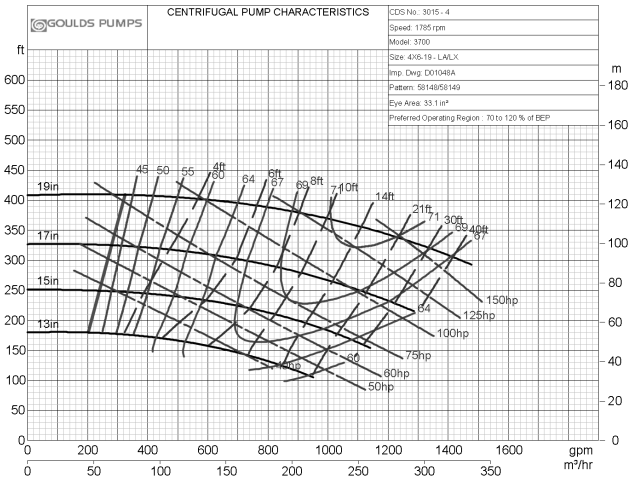


4X6-17 **1175rpm**

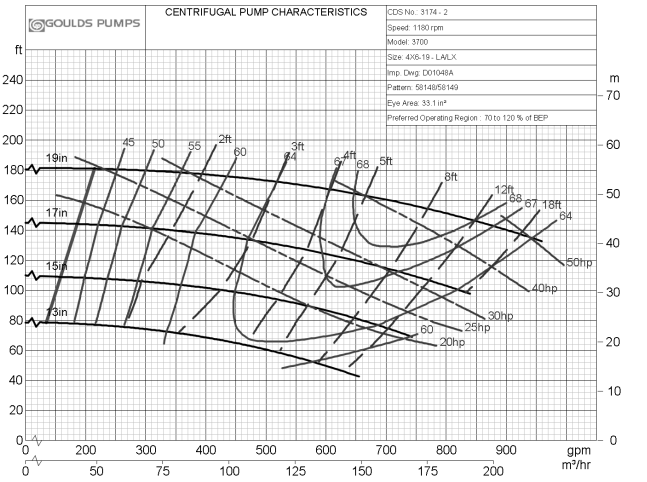
60Hz Curves

Model 3700

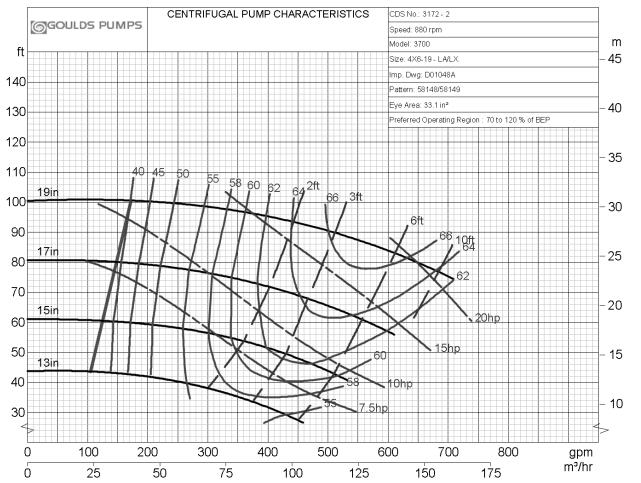
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



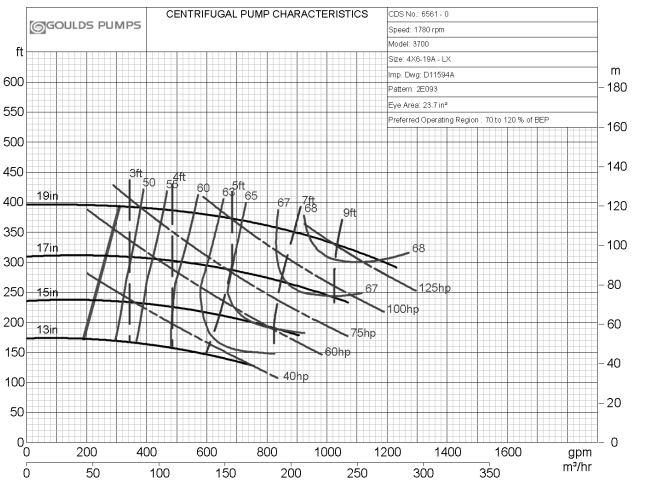
4X6-19 **1785rpm**



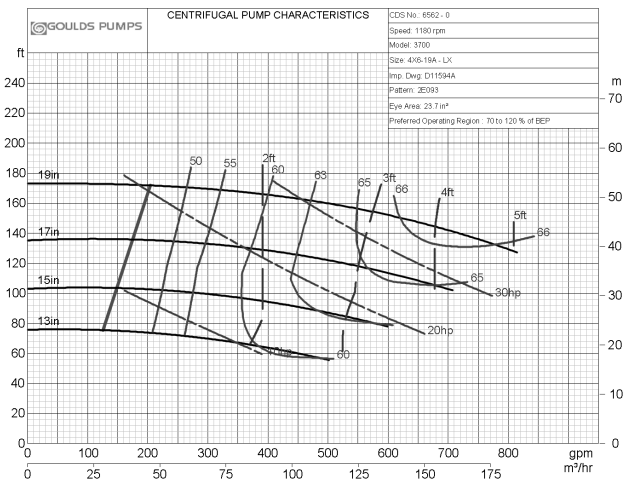
4X6-19 **1180rpm**



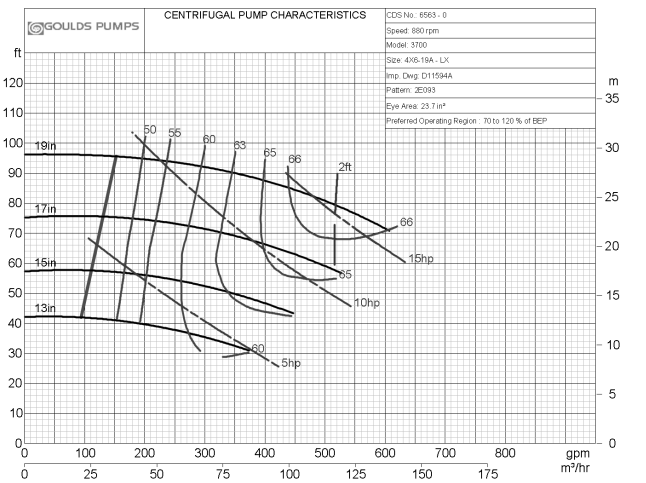
4X6-19 **880rpm**



4X6-19A **1780rpm**



4X6-19A **1180rpm**



4X6-19A **880rpm**

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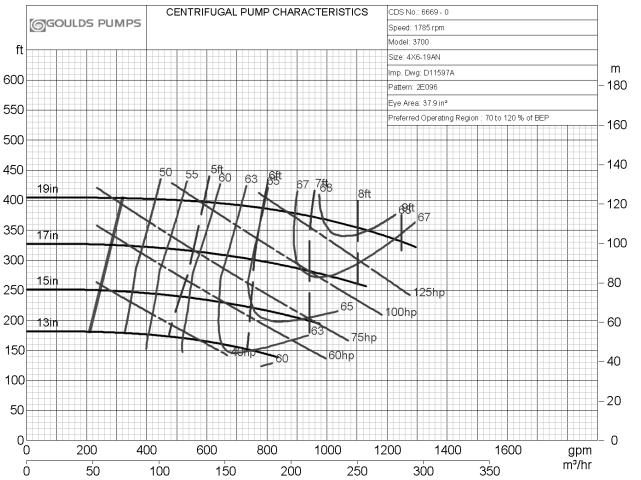
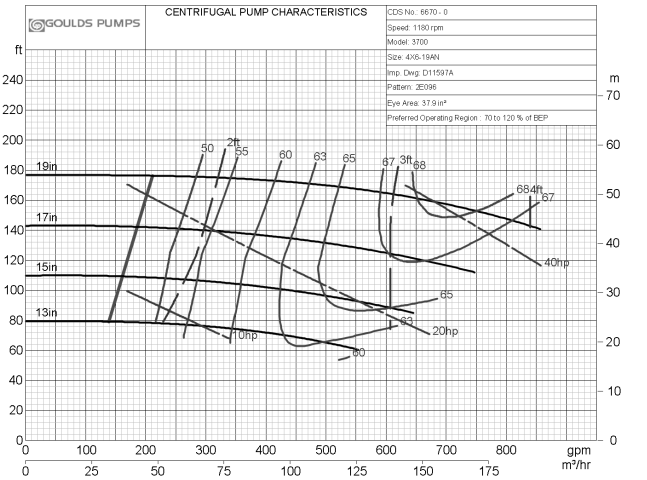
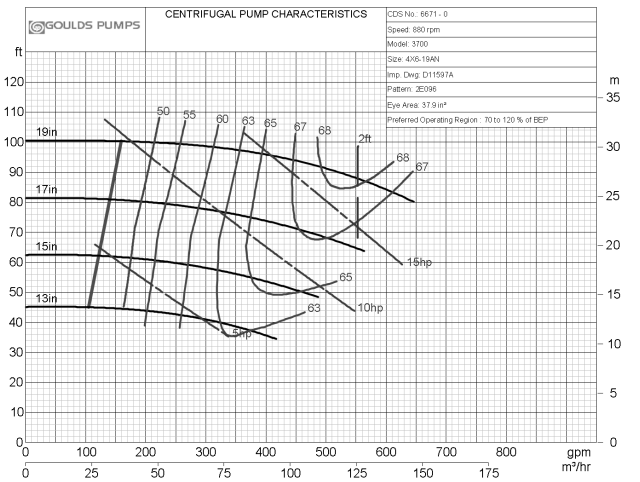


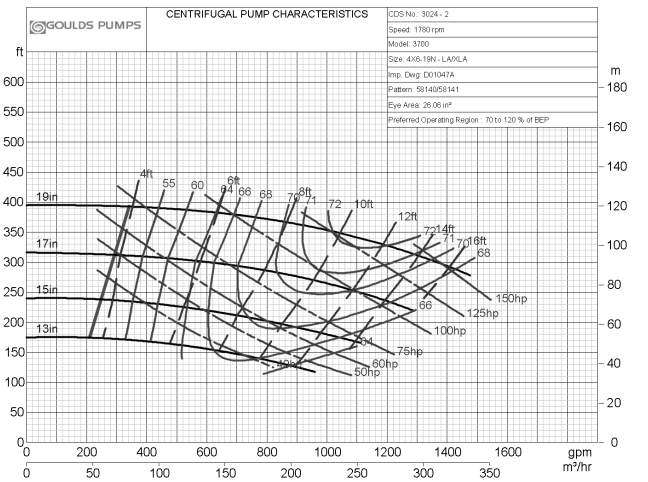
4X6-19AN **1785rpm**



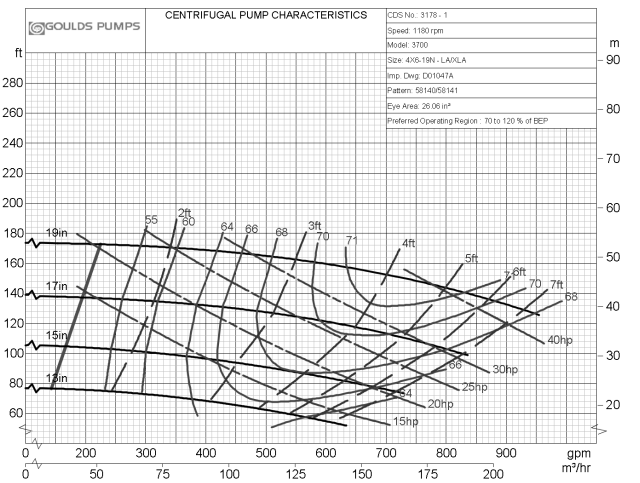
4X6-19AN **1180rpm**



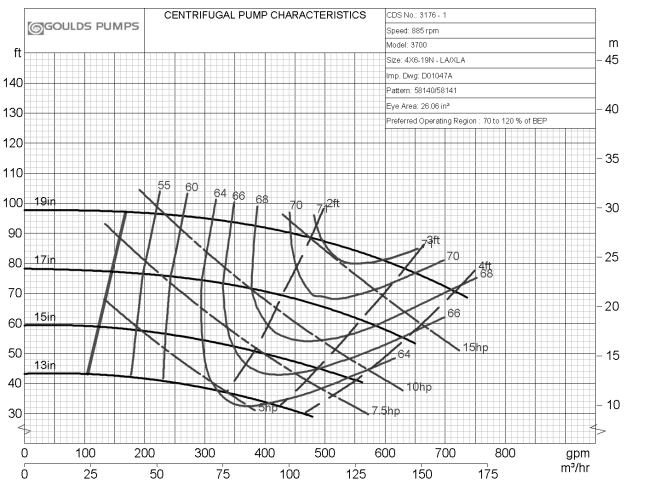
4X6-19AN **880rpm**



4X6-19N **1780rpm**



4X6-19N **1180rpm**

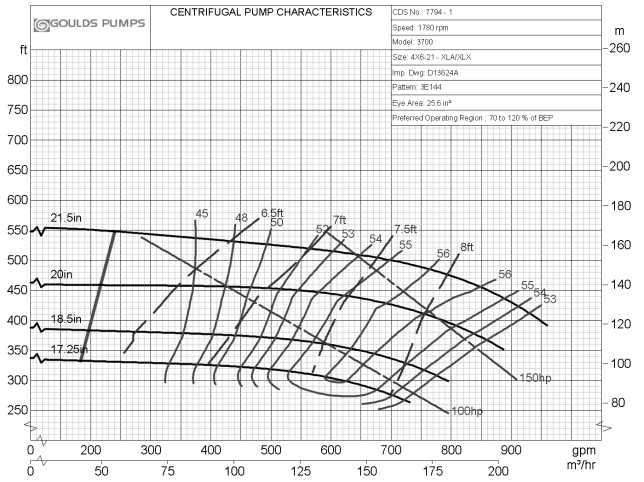


4X6-19N **885rpm**

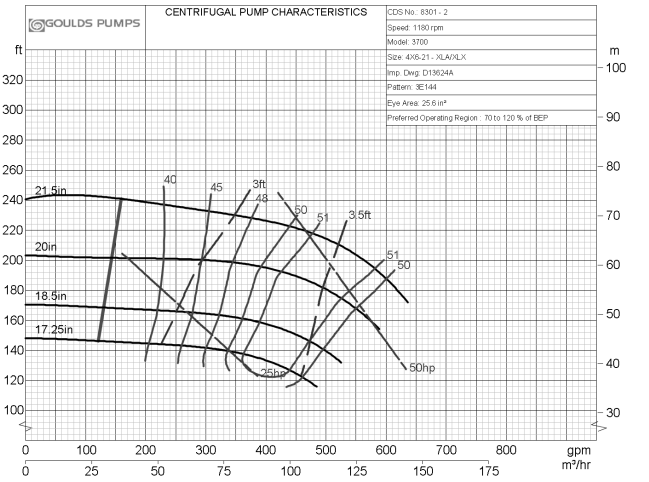
60Hz Curves

Model 3700

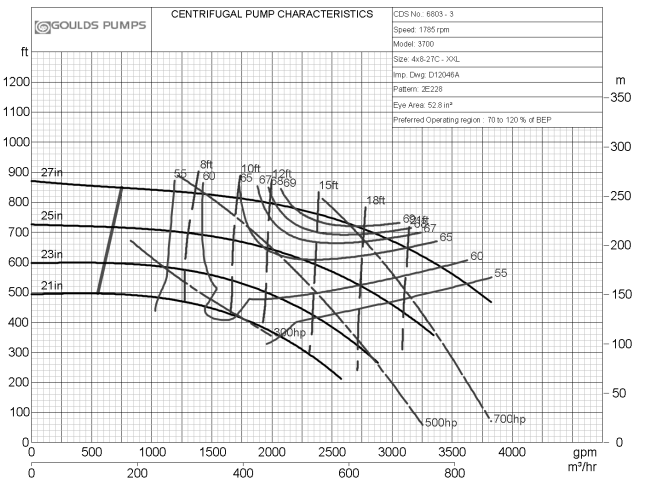
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



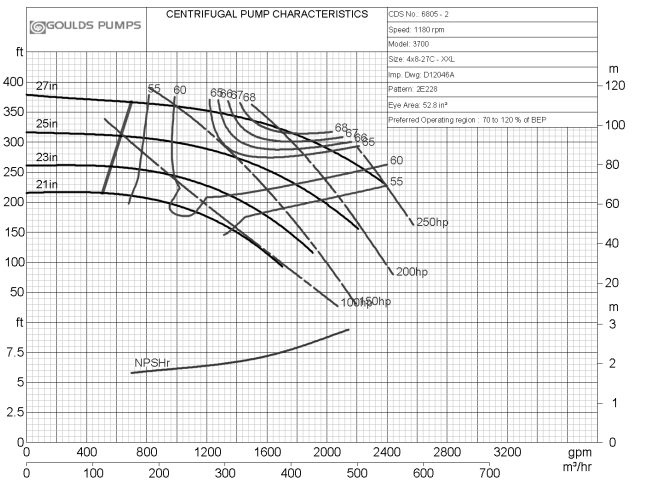
4X6-21 **1780rpm**



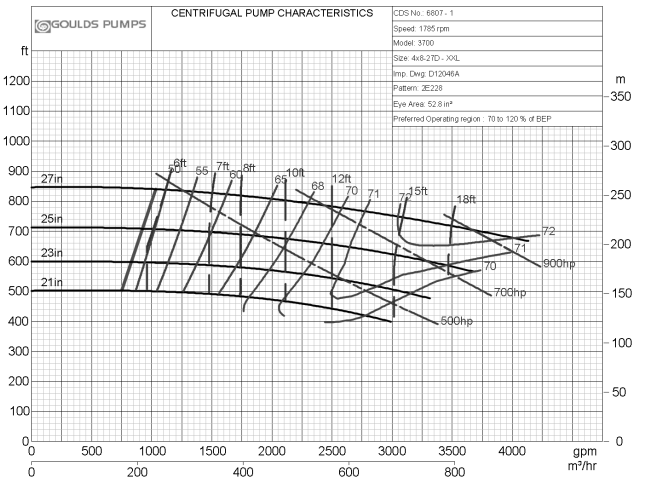
4X6-21 **1180rpm**



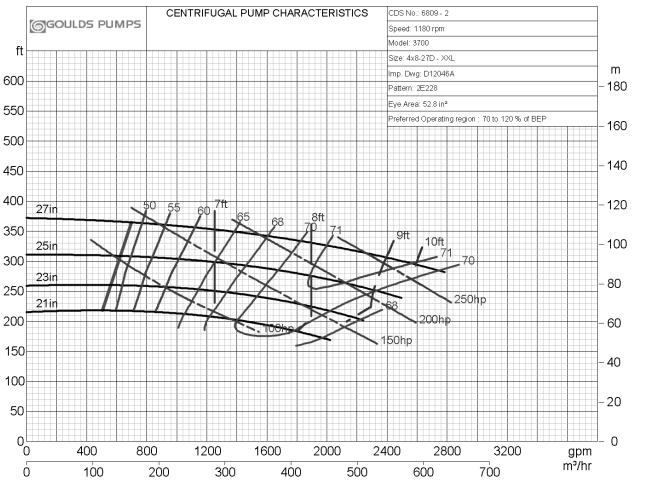
4x8-27C **1785rpm**



4x8-27C **1180rpm**

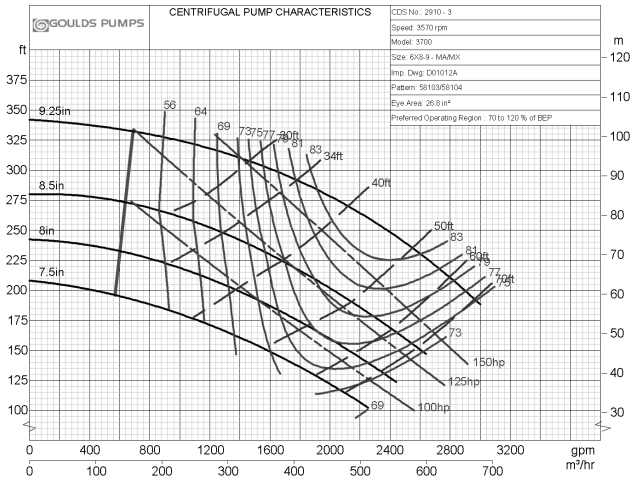


4x8-27D **1785rpm**

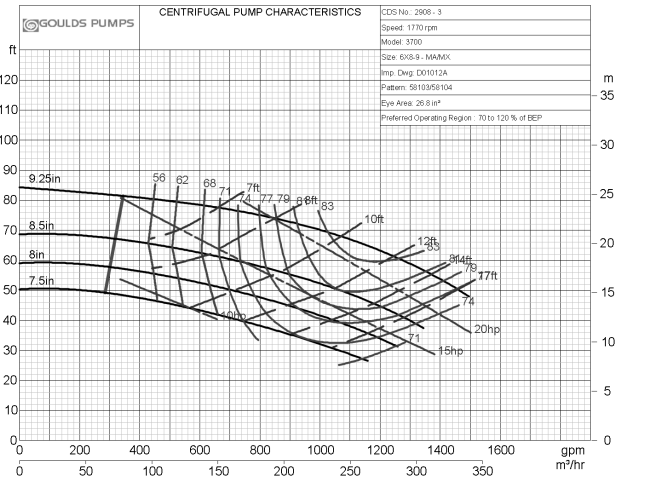


4x8-27D **1180rpm**

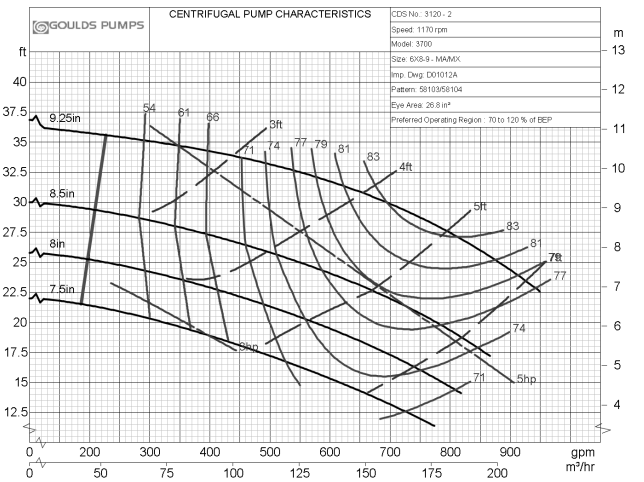
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



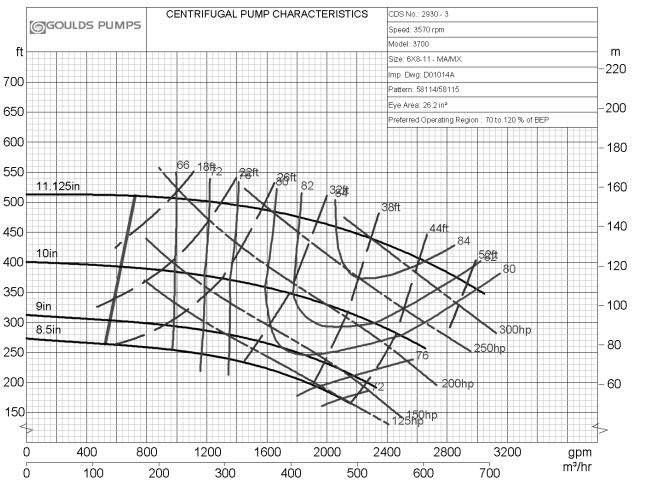
6X8-9 **3570rpm**



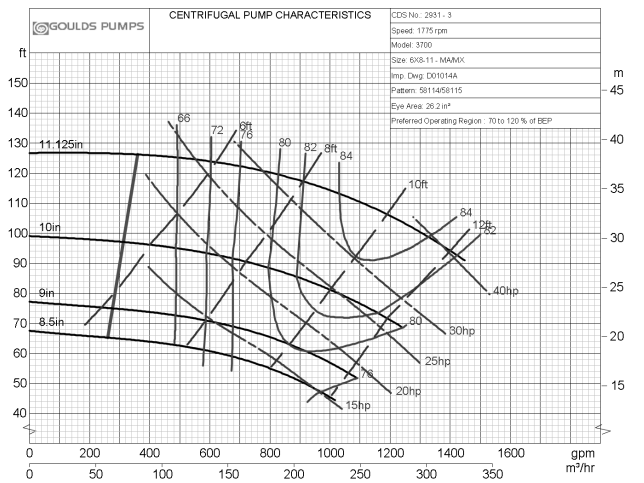
6X8-9 **1770rpm**



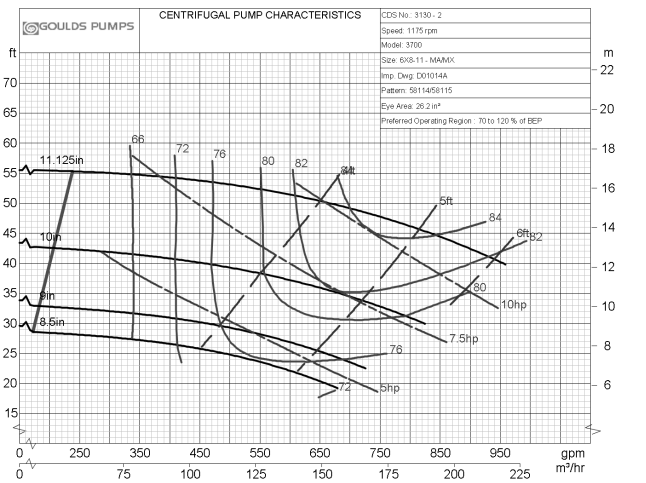
6X8-9 **1170rpm**



6X8-11 **3570rpm**



6X8-11 **1775rpm**

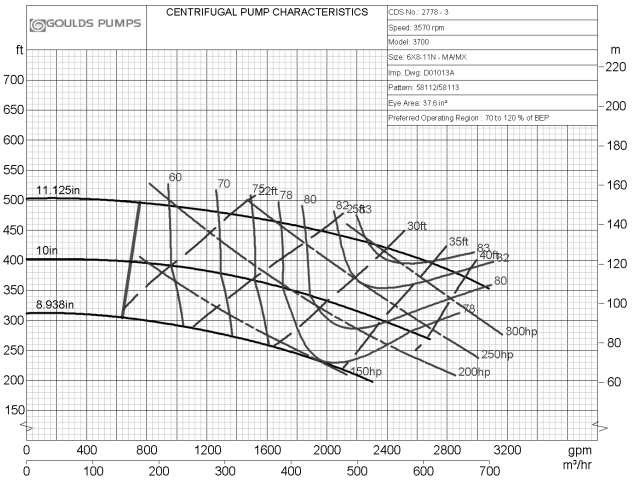


6X8-11 **1175rpm**

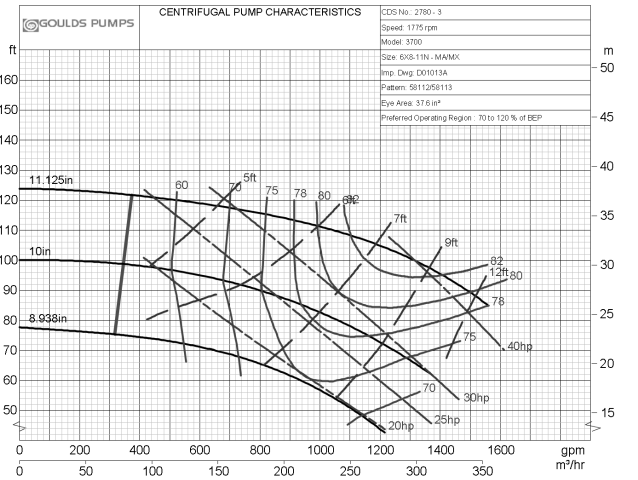
60Hz Curves

Model 3700

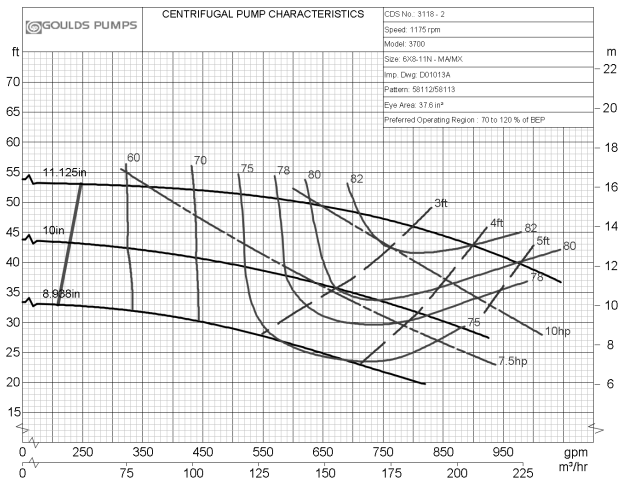
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



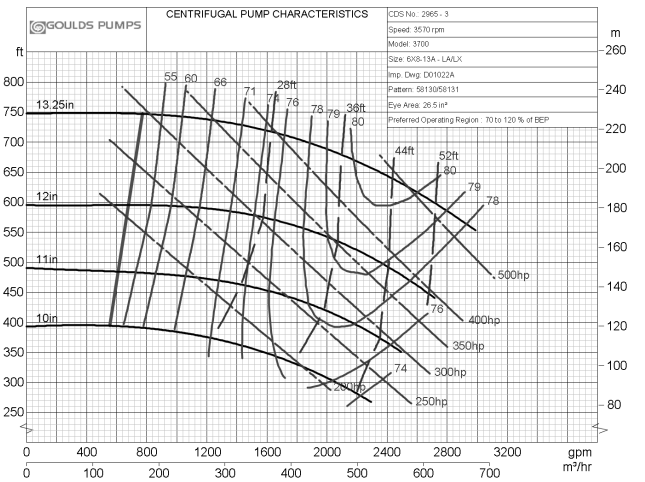
6X8-11N **3570rpm**



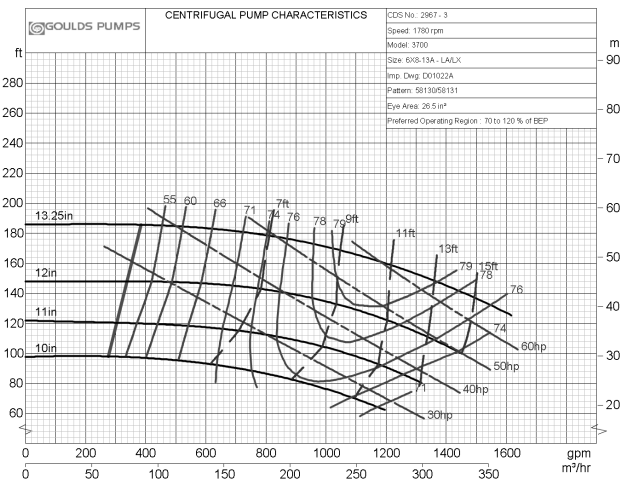
6X8-11N **1775rpm**



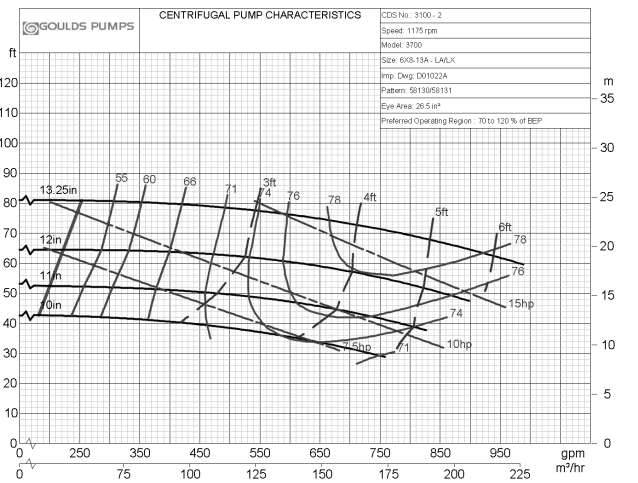
6X8-11N **1175rpm**



6X8-13A **3570rpm**

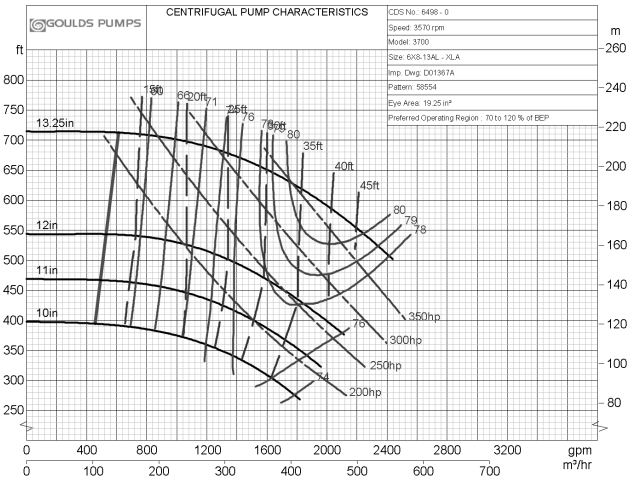


6X8-13A **1780rpm**

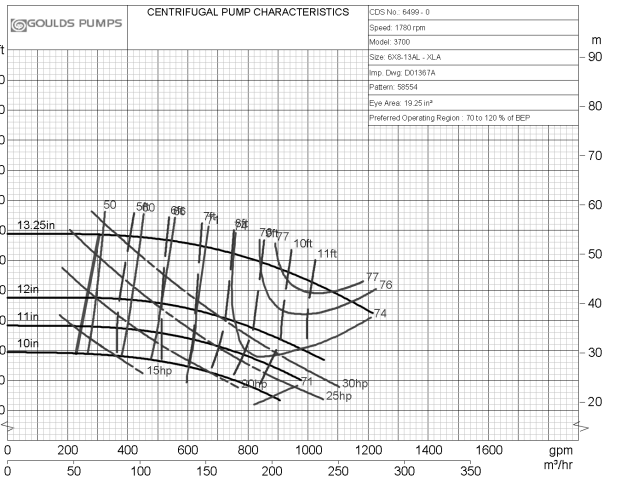


6X8-13A **1175rpm**

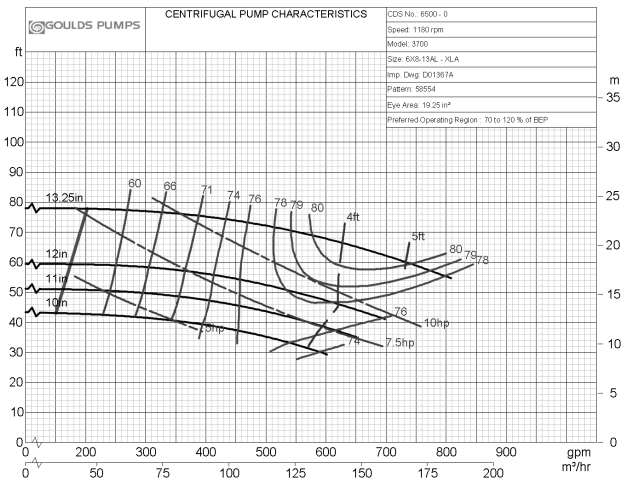
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



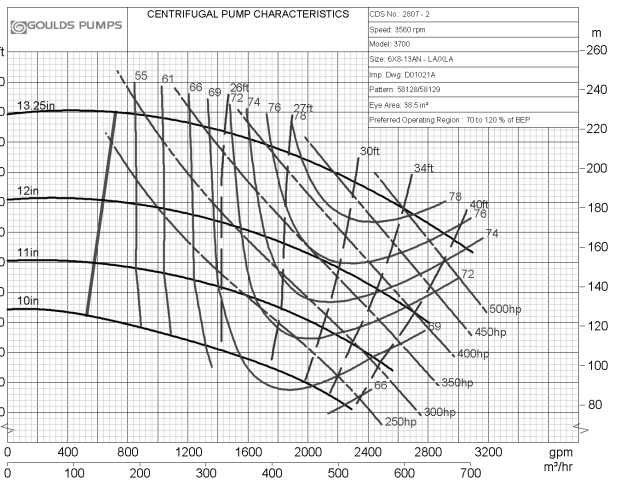
6X8-13AL **3570rpm**



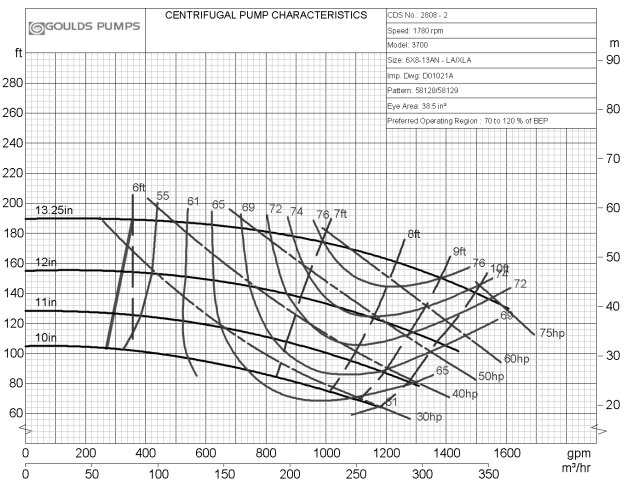
6X8-13AL **1780rpm**



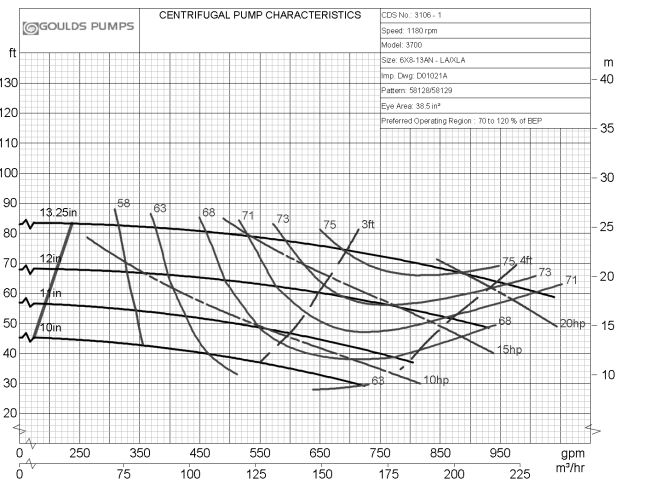
6X8-13AL **1180rpm**



6X8-13AN **3560rpm**



6X8-13AN **1780rpm**



6X8-13AN **1180rpm**

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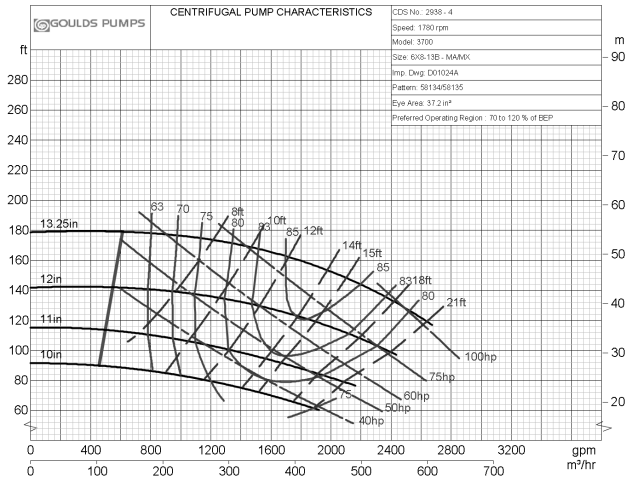
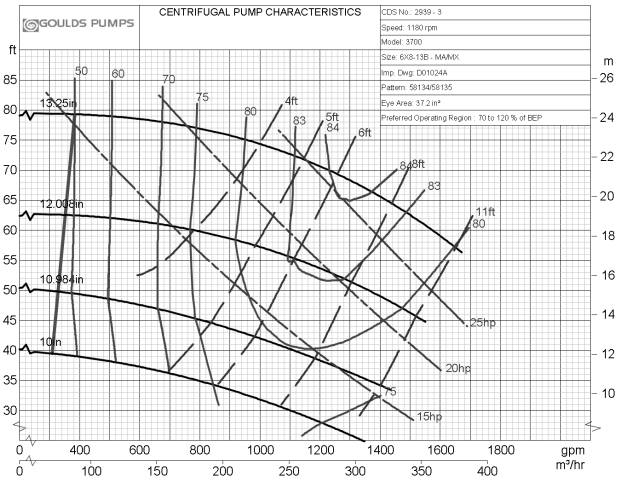
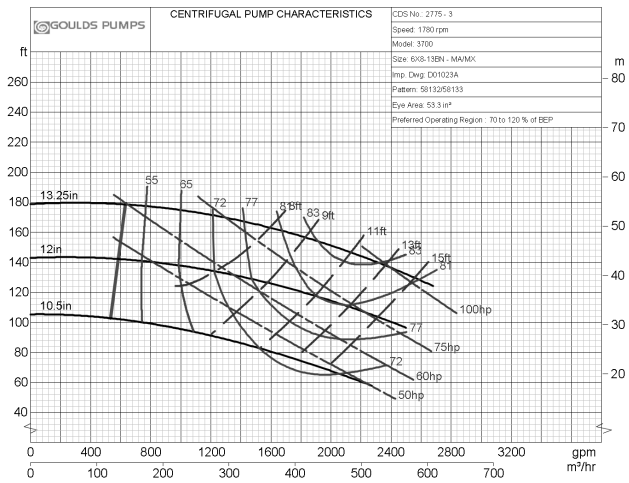


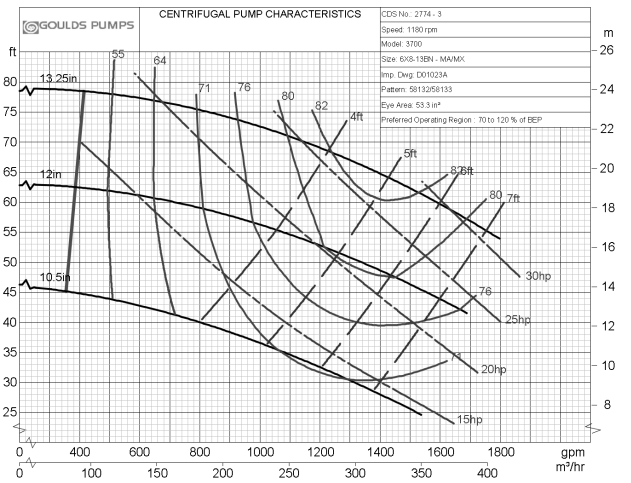
6X8-13B **1780rpm**



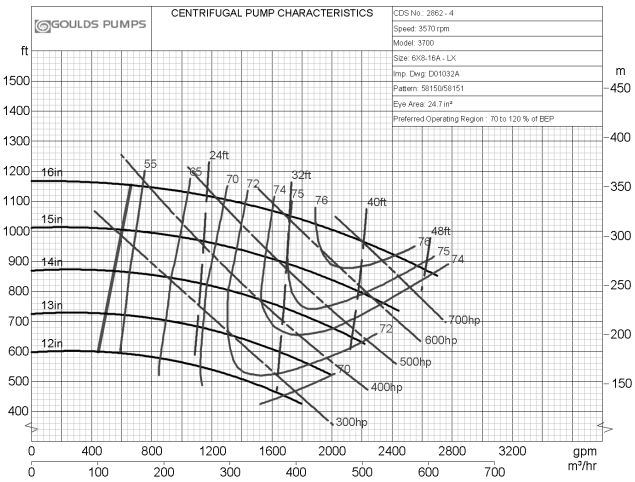
6X8-13B **1180rpm**



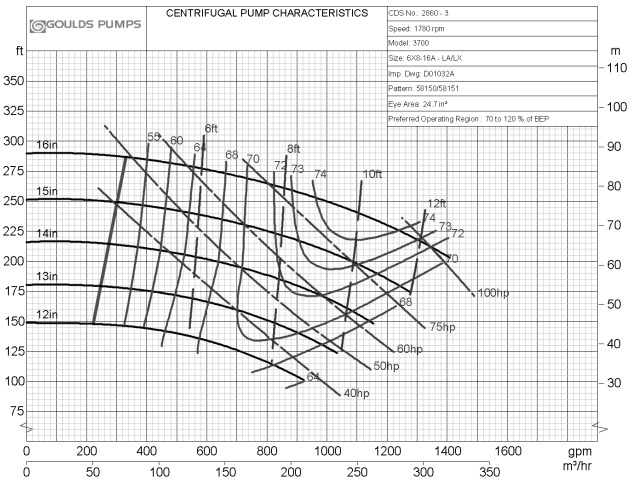
6X8-13BN **1780rpm**



6X8-13BN **1180rpm**



6X8-16A **3570rpm**



6X8-16A **1780rpm**

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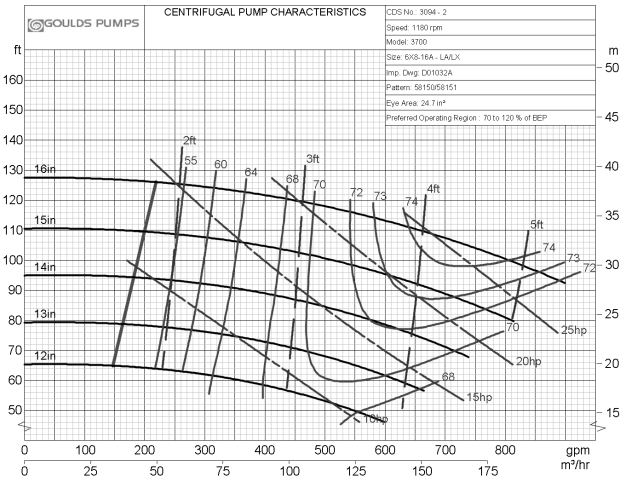
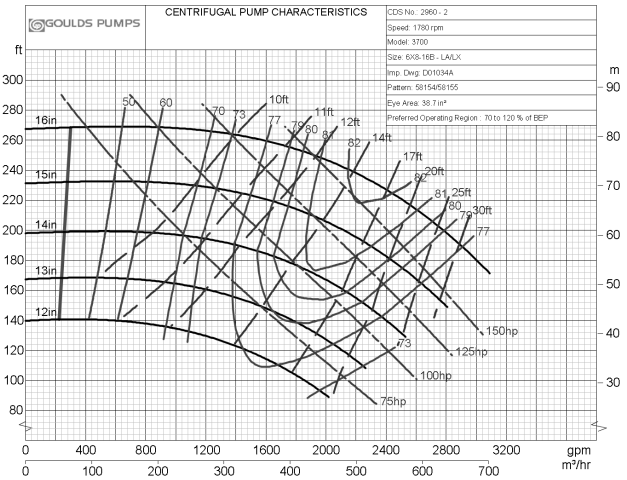
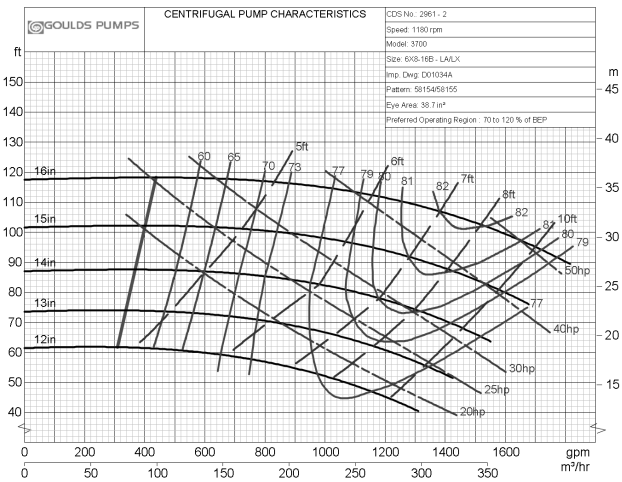


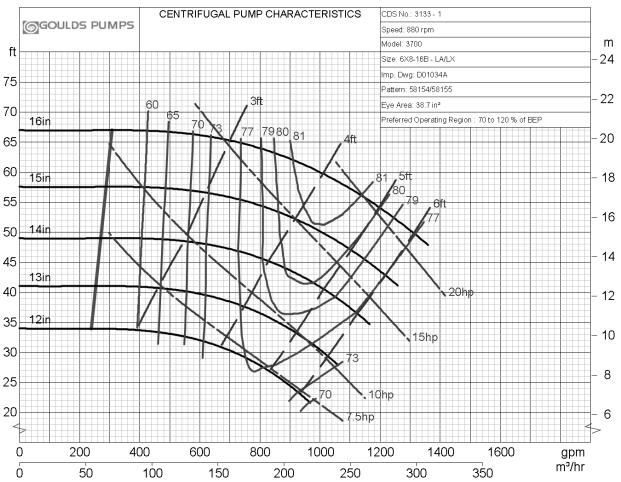
6X8-16A **1180rpm**



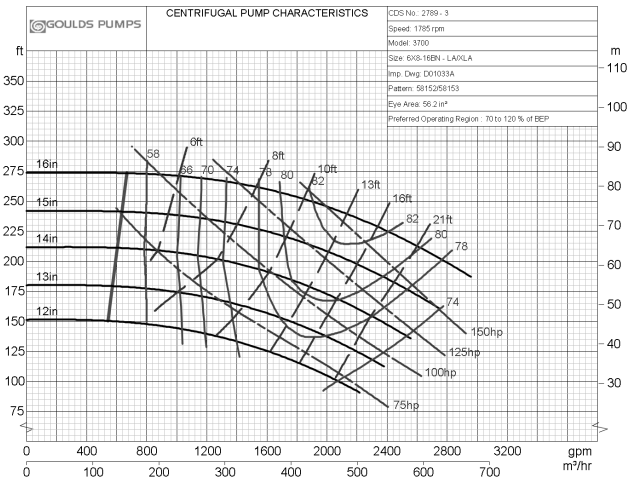
6X8-16B **1780rpm**



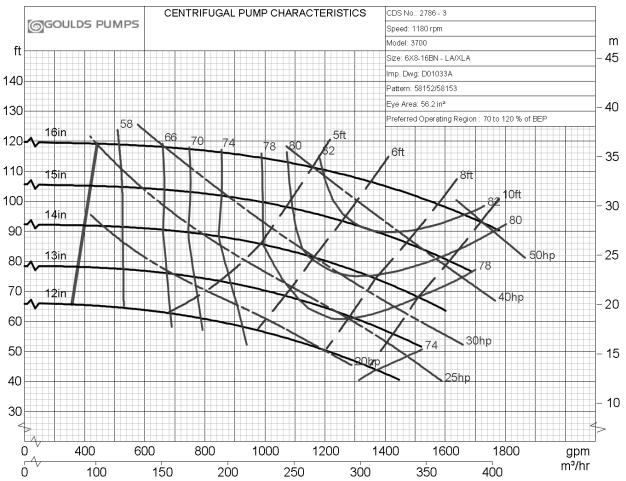
6X8-16B **1180rpm**



6X8-16B **880rpm**



6X8-16BN **1785rpm**



6X8-16BN **1180rpm**

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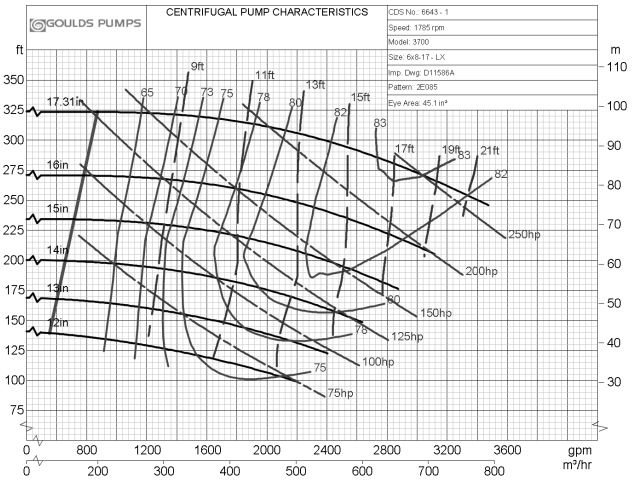
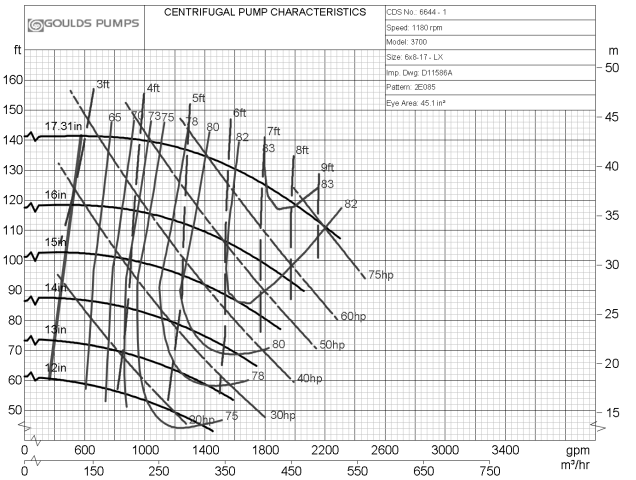
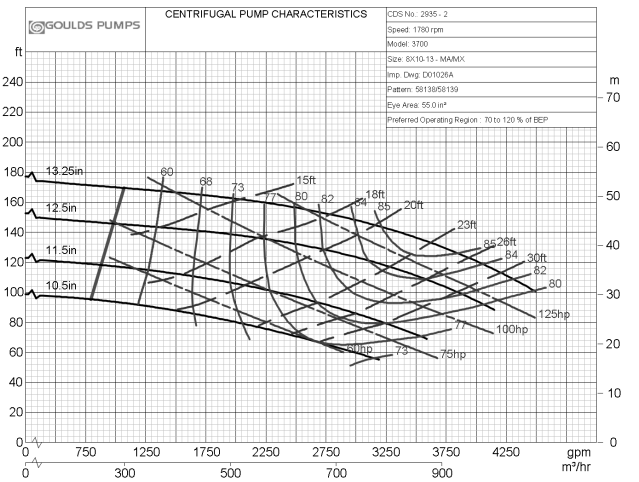


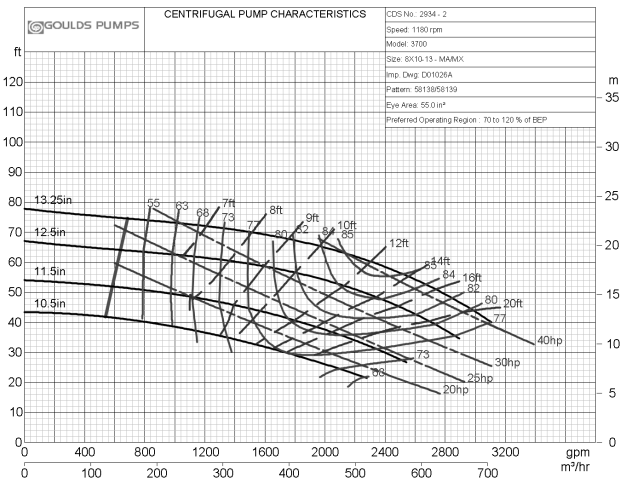
6x8-17 **1785rpm**



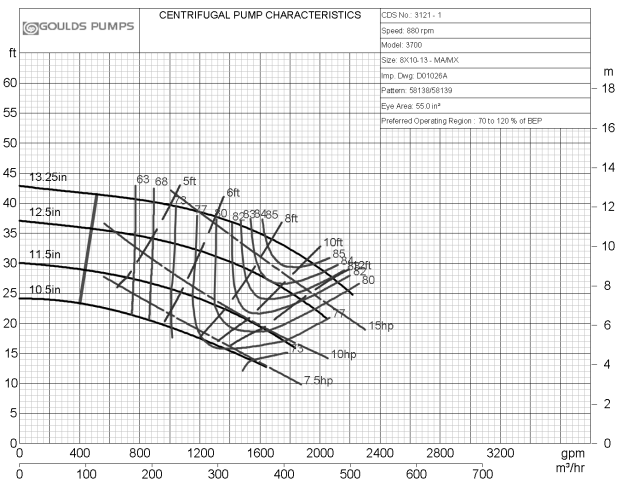
6x8-17 **1180rpm**



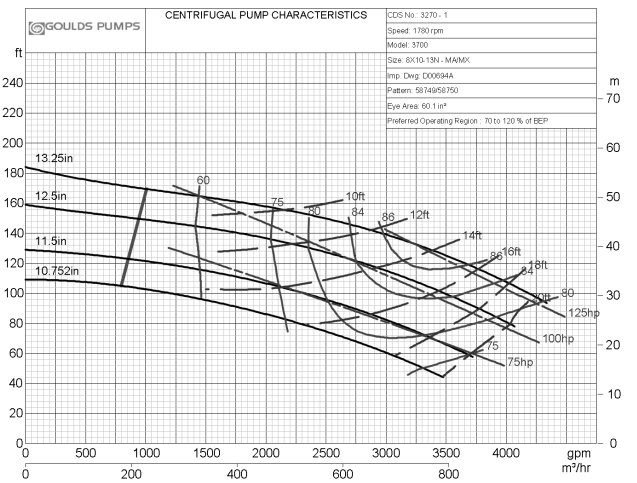
8X10-13 **1780rpm**



8X10-13 **1180rpm**

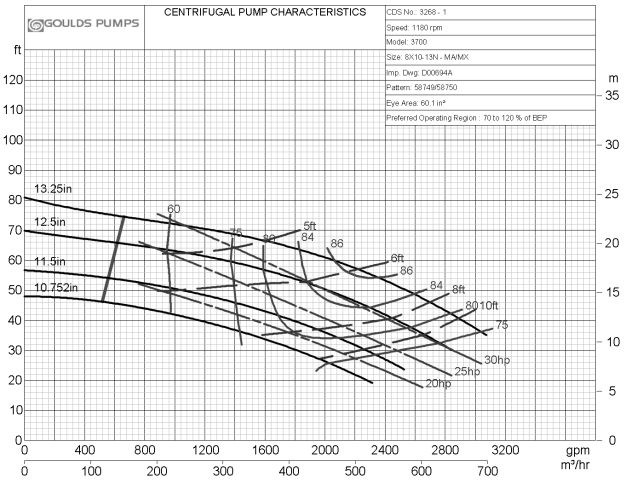


8X10-13 **880rpm**

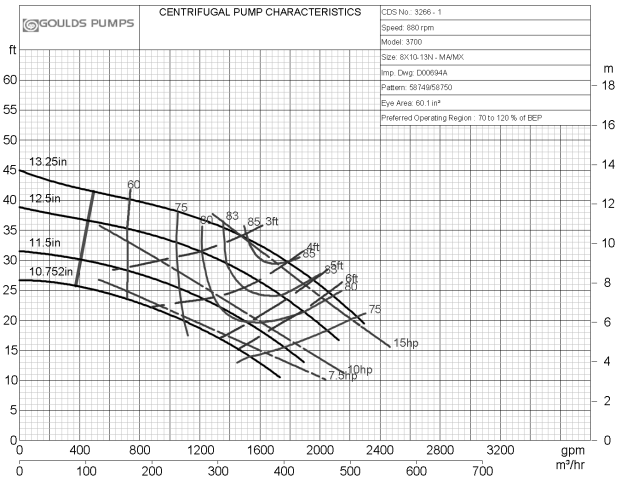


8X10-13N **1780rpm**

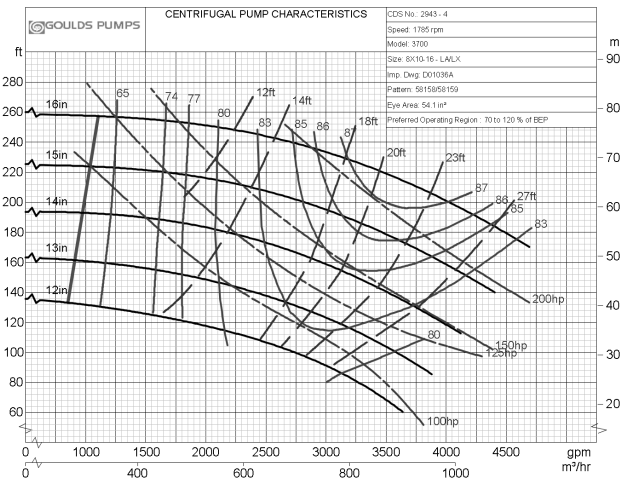
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



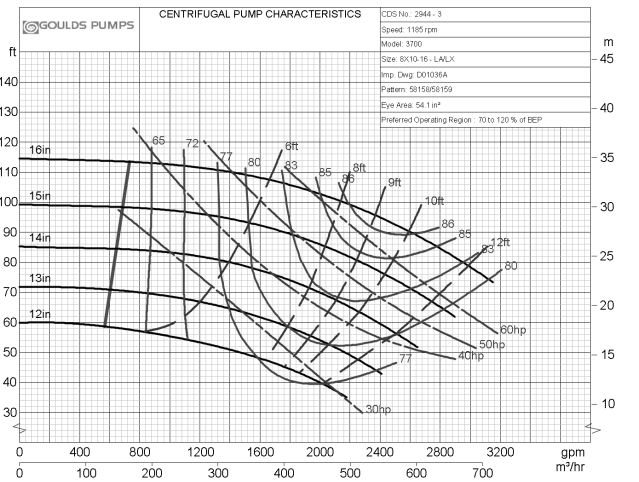
8X10-13N **1180rpm**



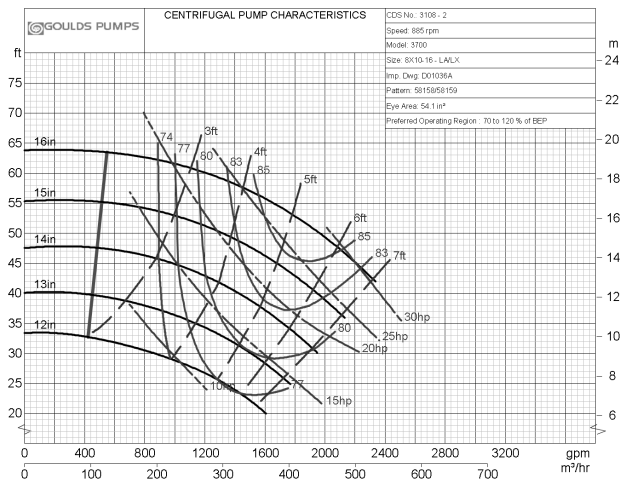
8X10-13N **880rpm**



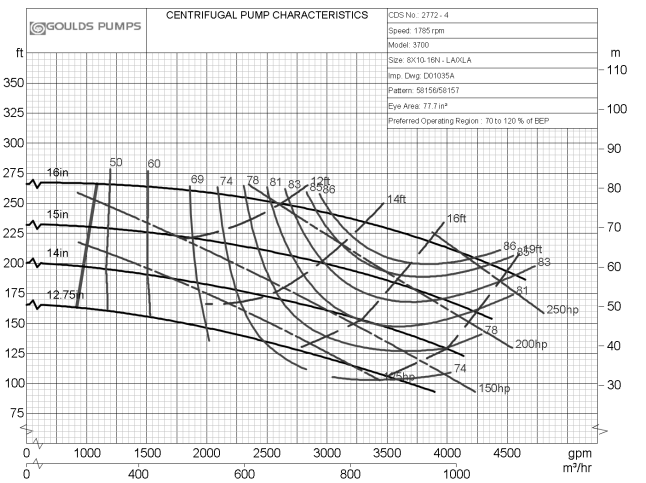
8X10-16 **1785rpm**



8X10-16 **1185rpm**



8X10-16 **885rpm**



8X10-16N **1785rpm**

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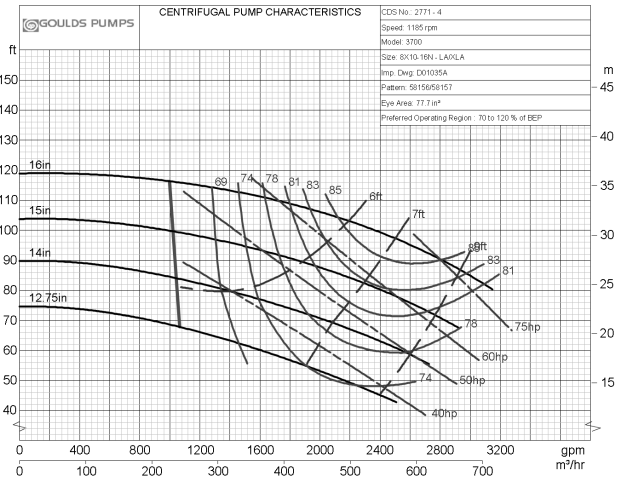
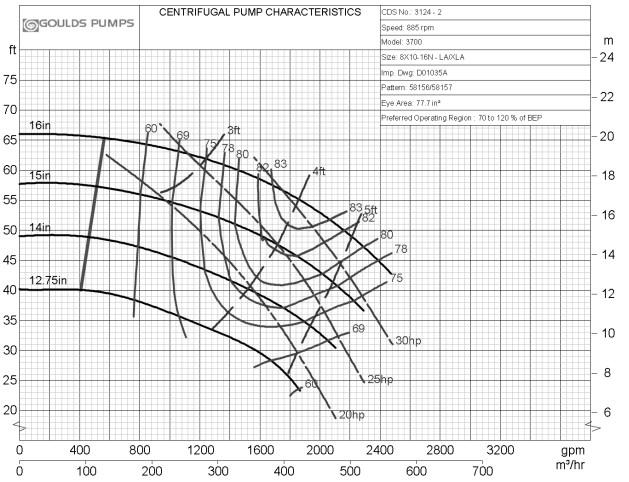
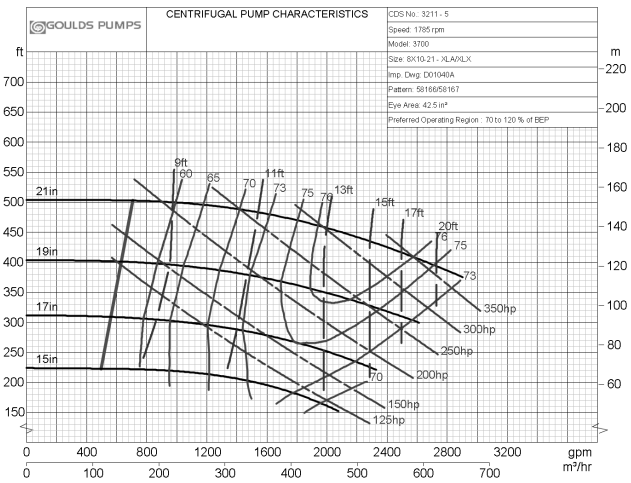


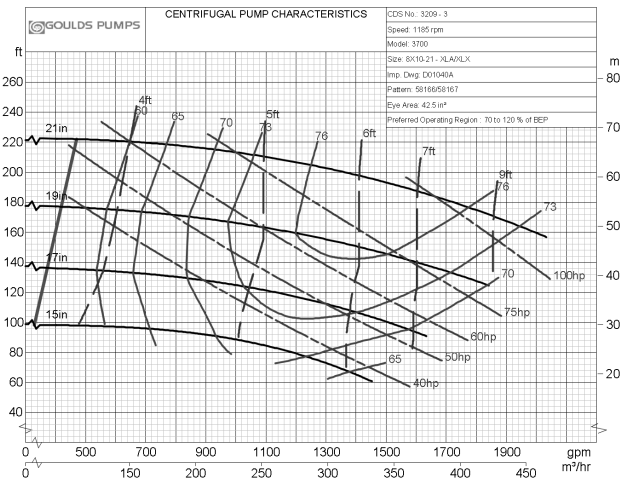
8X10-16N **1185rpm**



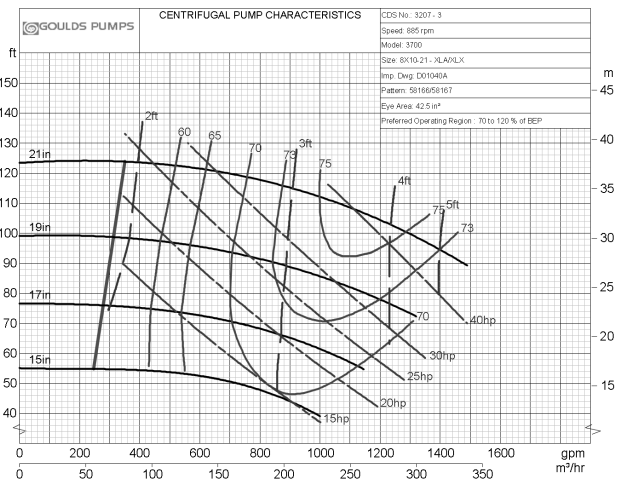
8X10-16N **885rpm**



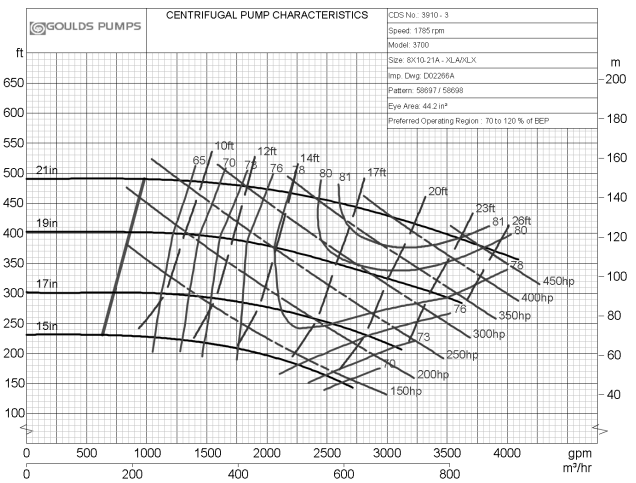
8X10-21 **1785rpm**



8X10-21 **1185rpm**

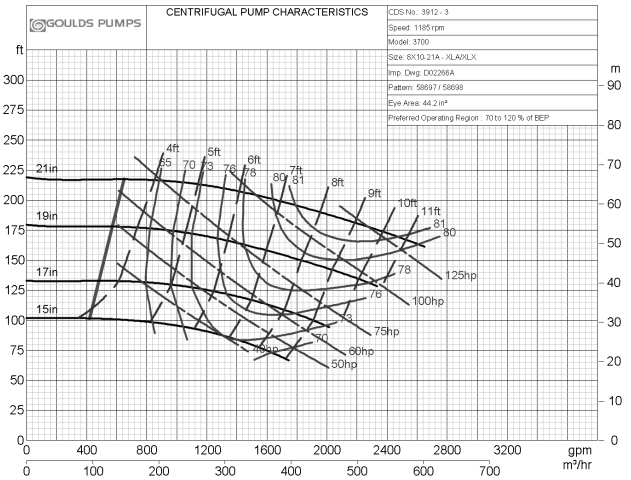


8X10-21 **885rpm**

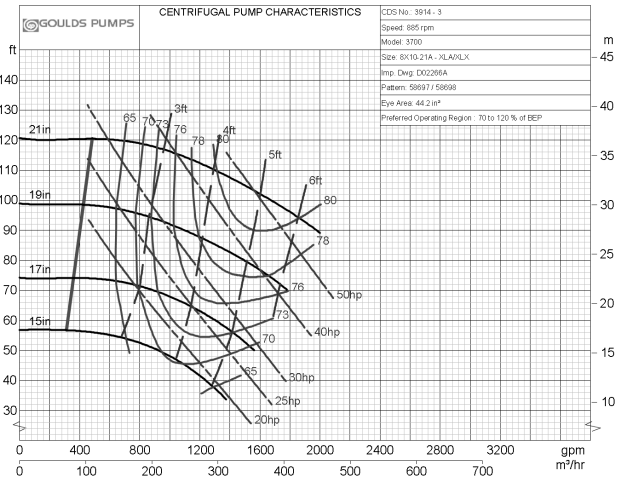


8X10-21A **1785rpm**

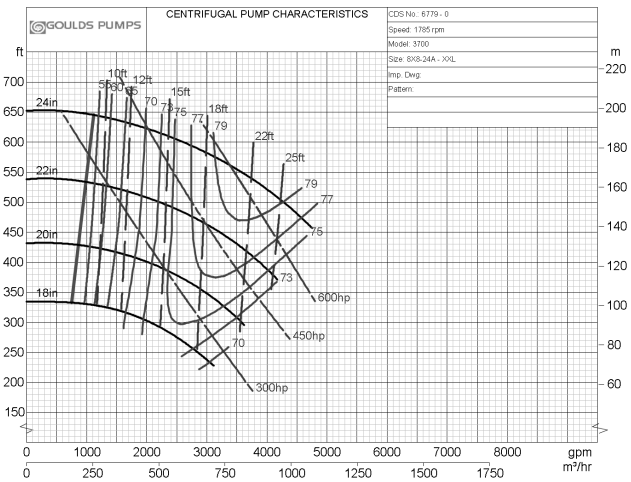
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



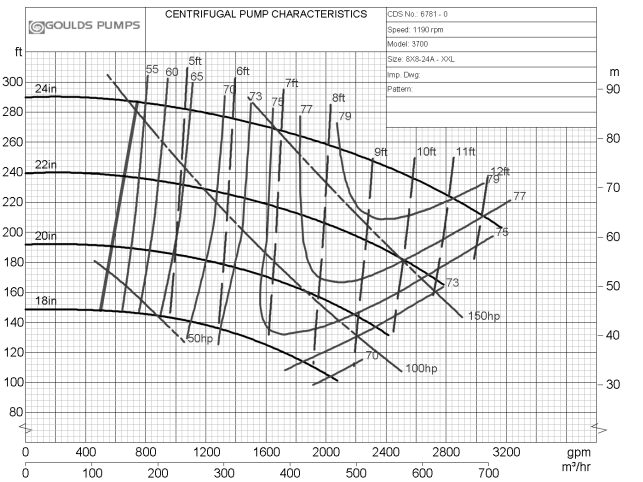
8X10-21A **1185rpm**



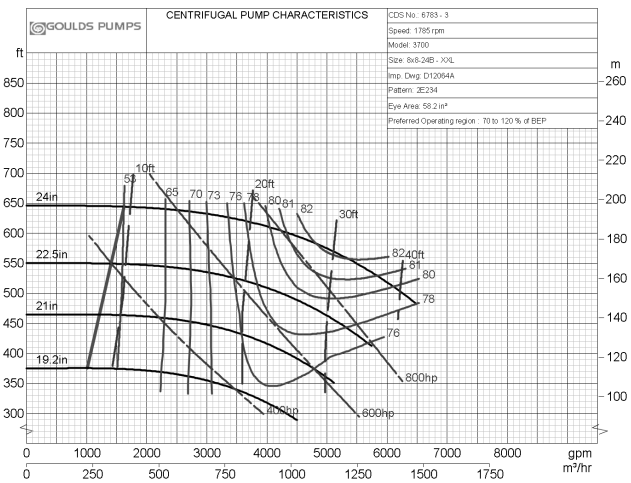
8X10-21A **885rpm**



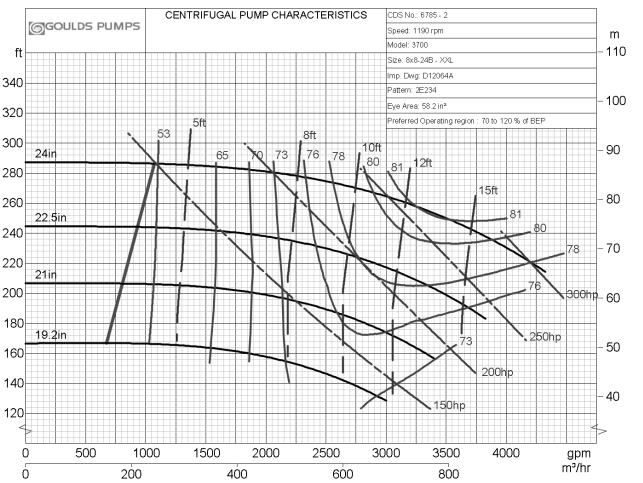
8X8-24A **1785rpm**



8X8-24A **1190rpm**



8x8-24B **1785rpm**

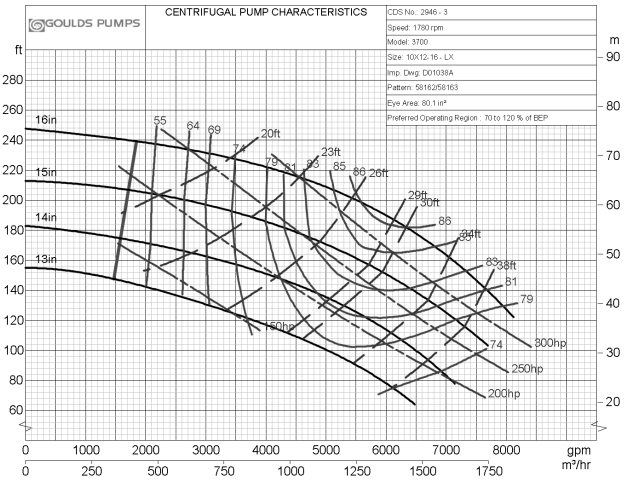


8x8-24B **1190rpm**

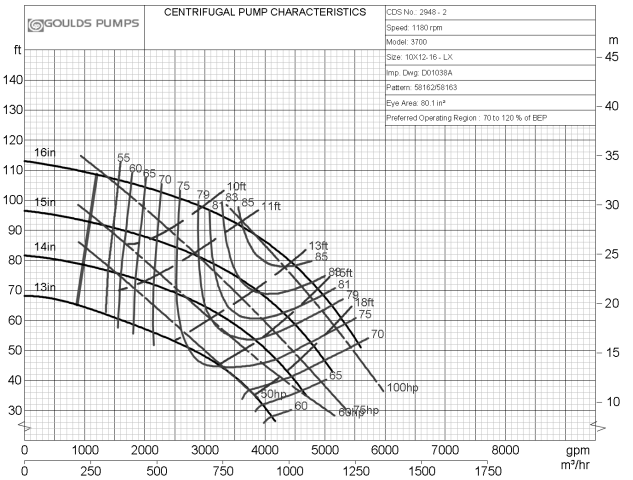
60Hz Curves

Model 3700

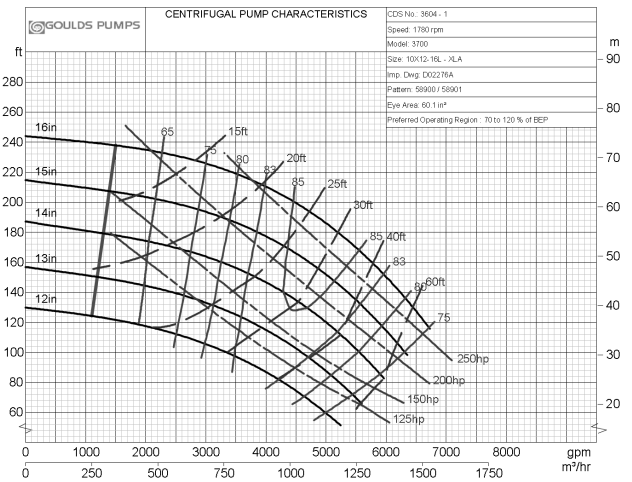
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



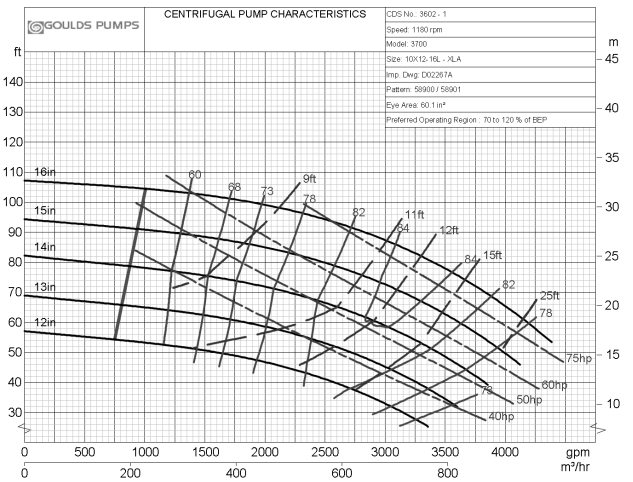
10X12-16 **1780rpm**



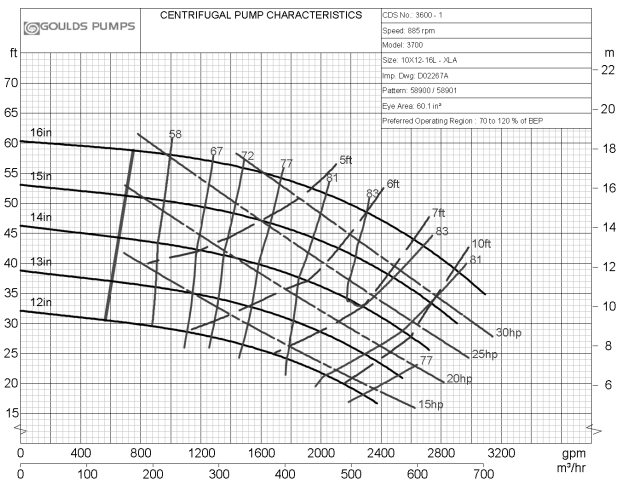
10X12-16 **1180rpm**



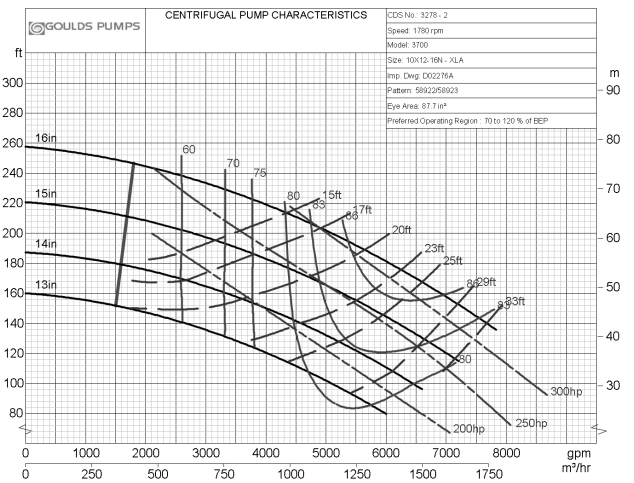
10X12-16L **1780rpm**



10X12-16L **1180rpm**



10X12-16L **885rpm**



10X12-16N **1780rpm**

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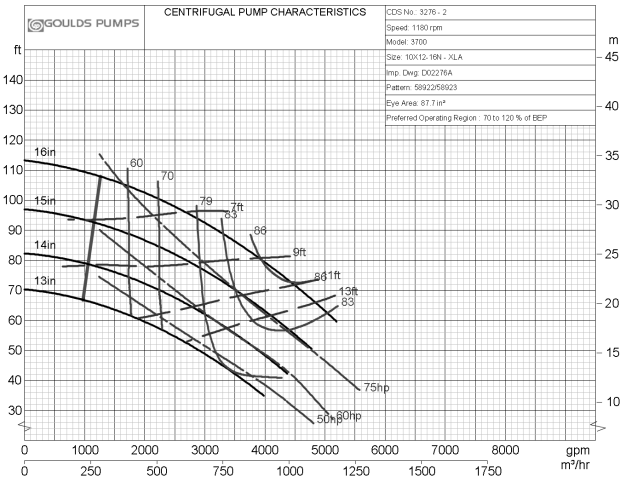
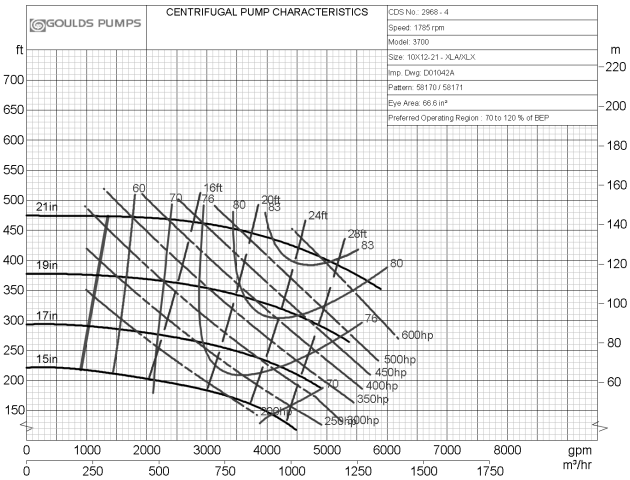
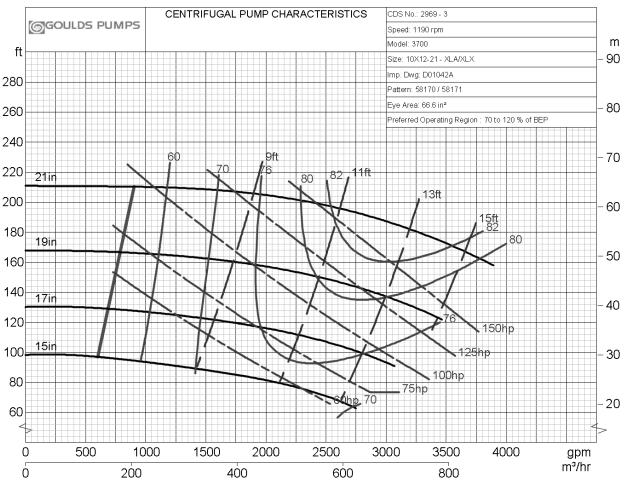


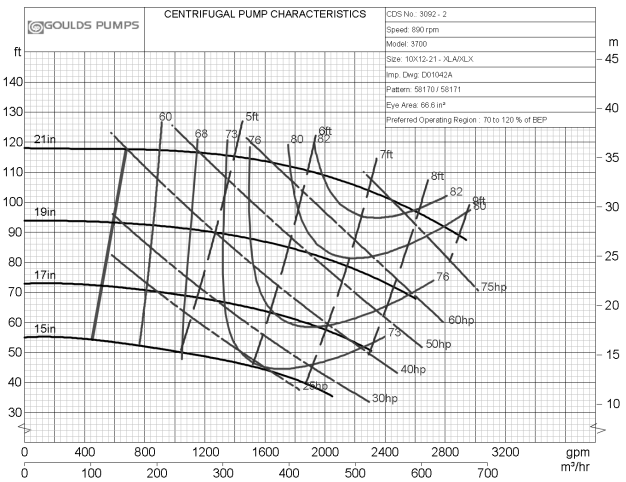
10X12-16N **1180rpm**



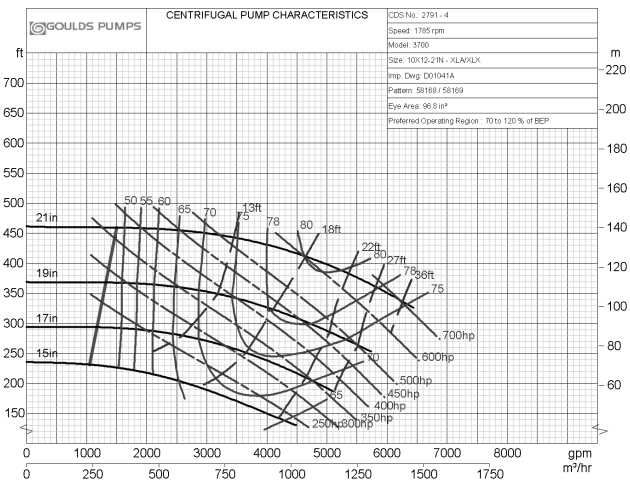
10X12-21 **1785rpm**



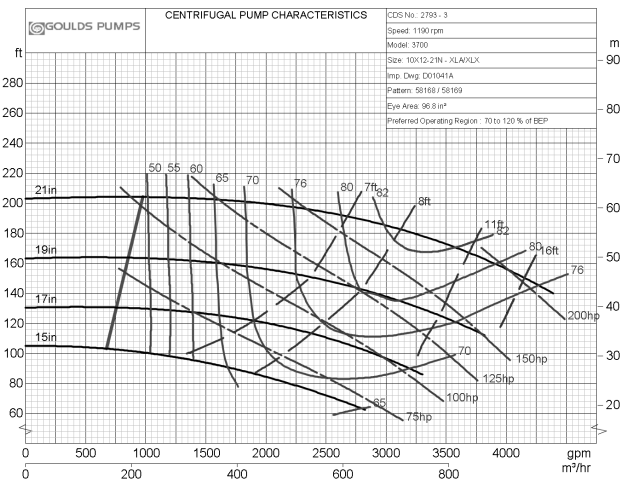
10X12-21 **1190rpm**



10X12-21 **890rpm**



10X12-21N **1785rpm**



10X12-21N **1190rpm**

60Hz Curves

Model 3700

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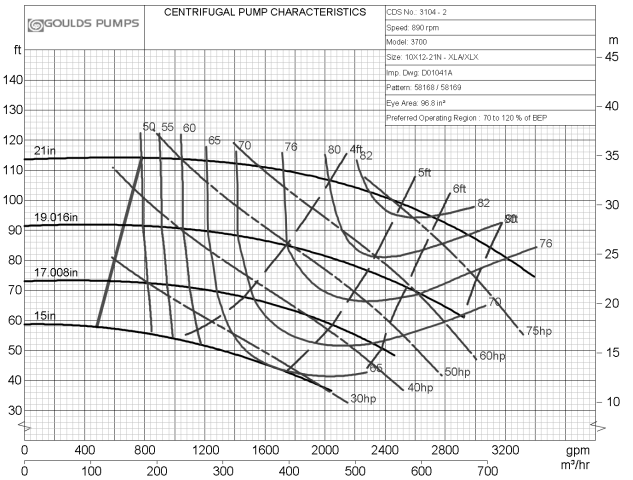
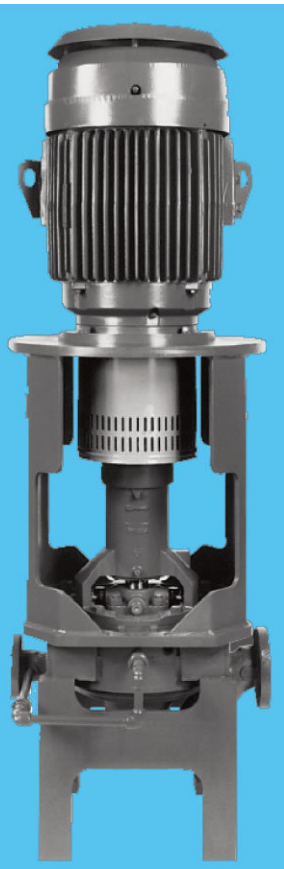


10X12-21N **890rpm**

NOTES

NOTES



Goulds Model 3910 provides the benefits of an in-line pump-low installation costs and space savings-without compromising reliability, maintainability, safety or hydraulic performance.

Goulds Model 3910 (API OH3)

Vertical In-Line Pumps Designed to Meet the Demanding Process Requirements of ISO 13709 and API 610 11th Edition

- Capacities to 6,000 GPM (1,360 m^3/h)
- Heads to 750 feet (230 m)
- Temperatures to 650° F (340° C)
- Pressures from full vacuum to 600 PSIG (42 bar)

Design Features

- **Hydraulic Coverage** – Line designed for full 50 / 60 Hz performance.
- **Back Pull-Out Construction** – Spacer-type coupling allows one-craft maintenance.
- **Centerline Supported** – High-temperature stability.
- **Labyrinth Seals** – Eliminate loss of lubricant, prevent lubricant contamination for maximum bearing life.
- **Maximum Interchangeability** – Power end and impellers completely interchangeable with Goulds Model 3180.
- **International Design** – Metric fasteners and fittings used throughout.

Typical Applications

- **Refinery Units** — Distillation, Flasher, CCU, Hydrotreater, MTBE, Alkylation, Reformer, Gas Plant, Isomerization
- **Petrochemical Plants** — Olefins, BTX Recovery, Ethylene Glycol, Vinyl Chloride, Styrene, Phenol, Propylene Glycol, Alcohols, Ketones, Acids, Acrylonitrile, Anhydrides.

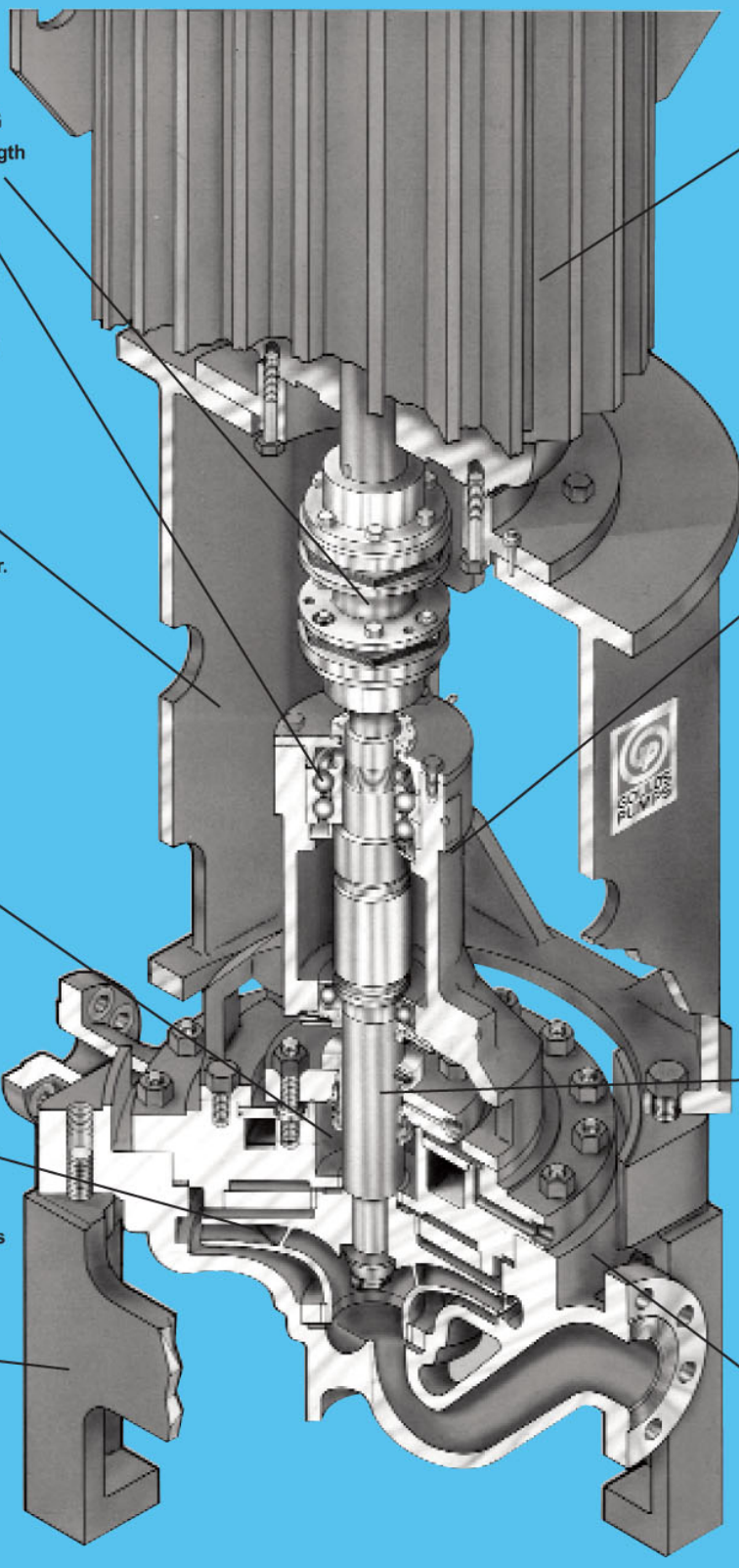
Typical Services

- Condensate
- Stabilizer Feed
- Reflux
- Stripper Feed
- Reactor Feed
- Scrubber Circulation
- Acid
- Fractionator Reflux
- Finishing Column Bottoms
- Caustic
- Stripper Overhead Product

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3910 API-610 *Bearing Frame* In-Line Pumps (API OH3)

Design Features for a Wide Range of Refinery & Petrochemical Services



SPACER COUPLING
With standard spacer length used for all applications.

PUMP BEARINGS
Carry all pump hydraulic loads. Duplex angular contact thrust bearings and deep groove Conrad radial bearing standard with grease lubrication. Oil mist optional.

RIGID MOTOR SUPPORT
Maintains alignment between pump and motor. Open on both sides for ventilation, ease of maintenance.

SEAL CHAMBER COVER
Conforms fully to API-610/ISO 13709. Designed to accept wide range of API 682/ISO 21049 cartridge seals.

IMPELLER
Impeller balanced to stringent ISO 1940 Grade 1.0 (exceeds API minimum). 3910LF pumps do not utilize impeller or casing wear rings.

OPTIONAL CASING SUPPORTS
Provide additional support and stability. One piece fabricated support available. Low-flow pumps utilize an open impeller.

STANDARD C-FACE VERTICAL MOTOR
Does not require special thrust bearings to carry pump loads. Other motor designs can be used.

MODEL 3700 INTER-CHANGEABILITY
Bearing frame, bearings, shaft, mechanical seal, impeller and wear rings completely interchangeable with Goulds Model 3700 horizontal process pumps.

HEAVY DUTY BEARING FRAME
Rabbited fits assure runout and concentricity within API-610/ISO 13709 specifications. Accessible monitoring locations. Frame machined for use of Goulds Framehook™ back pull-out removal device.

BACK PULL-OUT
Frame assembly, cover, impeller easily removed as a unit for maintenance using Goulds patented Framehook™ without disturbing piping or motor.

RIGID SHAFT ASSEMBLY
Limits deflection at seal faces to less than 0.002 in. (.05 mm) under the most severe operating conditions.

IN-LINE DESIGN
Simplifies installation, minimizes floor space requirements.

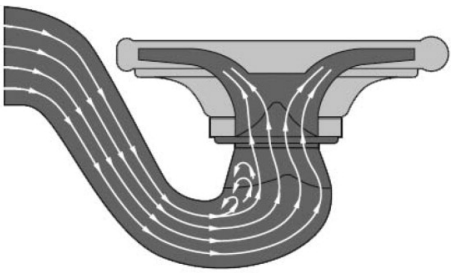
IN-LINE CASING
Rugged design, accepts two times API-610/ISO 13709 nozzle loads. 300 RF flanges standard. Proprietary suction device assures smooth, even flow into impeller eye.

Design Features for Optimum Reliability

Goulds Model 3910 utilizes proven design features to ensure reliable performance.

ROTATING ELEMENT

Shaft and bearings are same as used with Goulds Model 3700 horizontal process pump. Proven design preferred for toughest services.

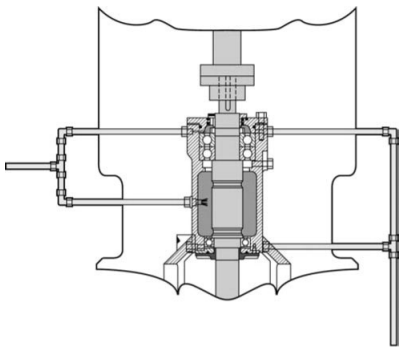


ENGINEERED IN-LINE SUCTION DESIGN

The 3910 suction design is the result of extensive model and full-scale testing. NPSH requirements are minimized. Design assures streamlined, even flow into impeller eye; reduces losses encountered in conventional suction designs.

High Temperature Capability

Standard grease lubrication limited to 350F (175C). Oil mist available to 650F (340C).



OIL MIST LUBRICATION

Pure oil mist available to meet customer requirements and to handle higher temperature pumpages.

Optional Features

Goulds offers users a range of options to meet specific plant and process requirements.

PUMP SUPPORTS

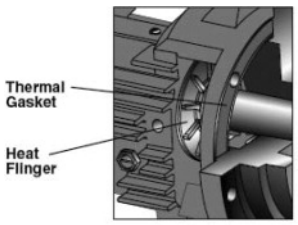
Provide additional support and stability of entire unit during installation and maintenance. Also available in one piece fabricated construction.

NON METALLIC RINGS

Non-metallic rings are available for increased efficiency and limited dry run capability.

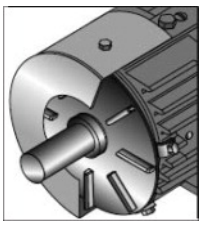
ABRASIVE SERVICES

Hardened coatings are available for services with abrasive solids.



HEAT FLINGER AND THERMAL BARRIER

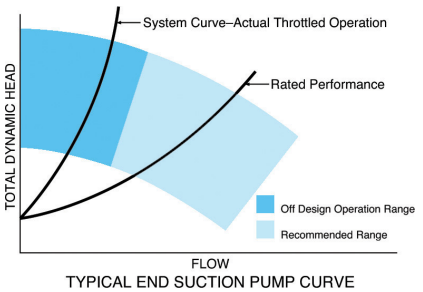
Thermal gasket creates heat barrier between seal chamber and bearing frame. Heat flinger dissipates shaft-conducted heat and circulates air to reduce heat build-up.



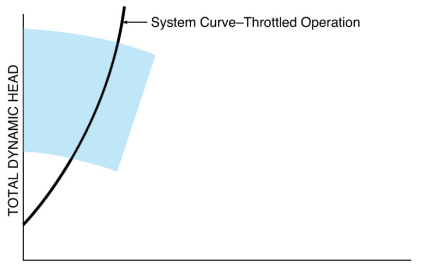
AIR COOLING

High capacity fan and shroud mounted on power end effectively reduce bearing frame temperature for cooler running bearings without using cooling water.

Designed for Low Flow Services



TYPICAL END SUCTION PUMP CURVE



3700 LF PUMP CURVE

Not All Pumps are Designed for Low Flows

Many users throttle pumps to attain low flow rates - yet create bearing and seal issues. The traditional enclosed impeller passage ways would be too small to properly manufacture at these low flow rates.

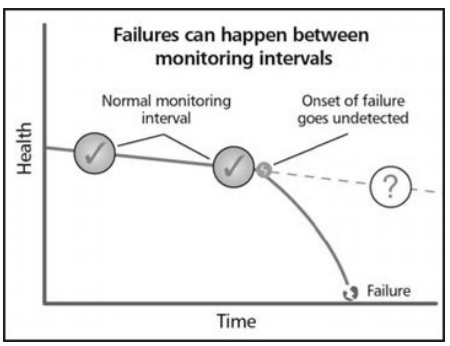
3910 LF Low Flow Solution

The 3910 LF semi-open radial vane impeller eliminates these enclosed impeller limitations. The unique circular volute casing eliminates competitor diffusers thus reducing the pump size, footprint and lifetime costs.

i-ALERT™ Condition Monitor

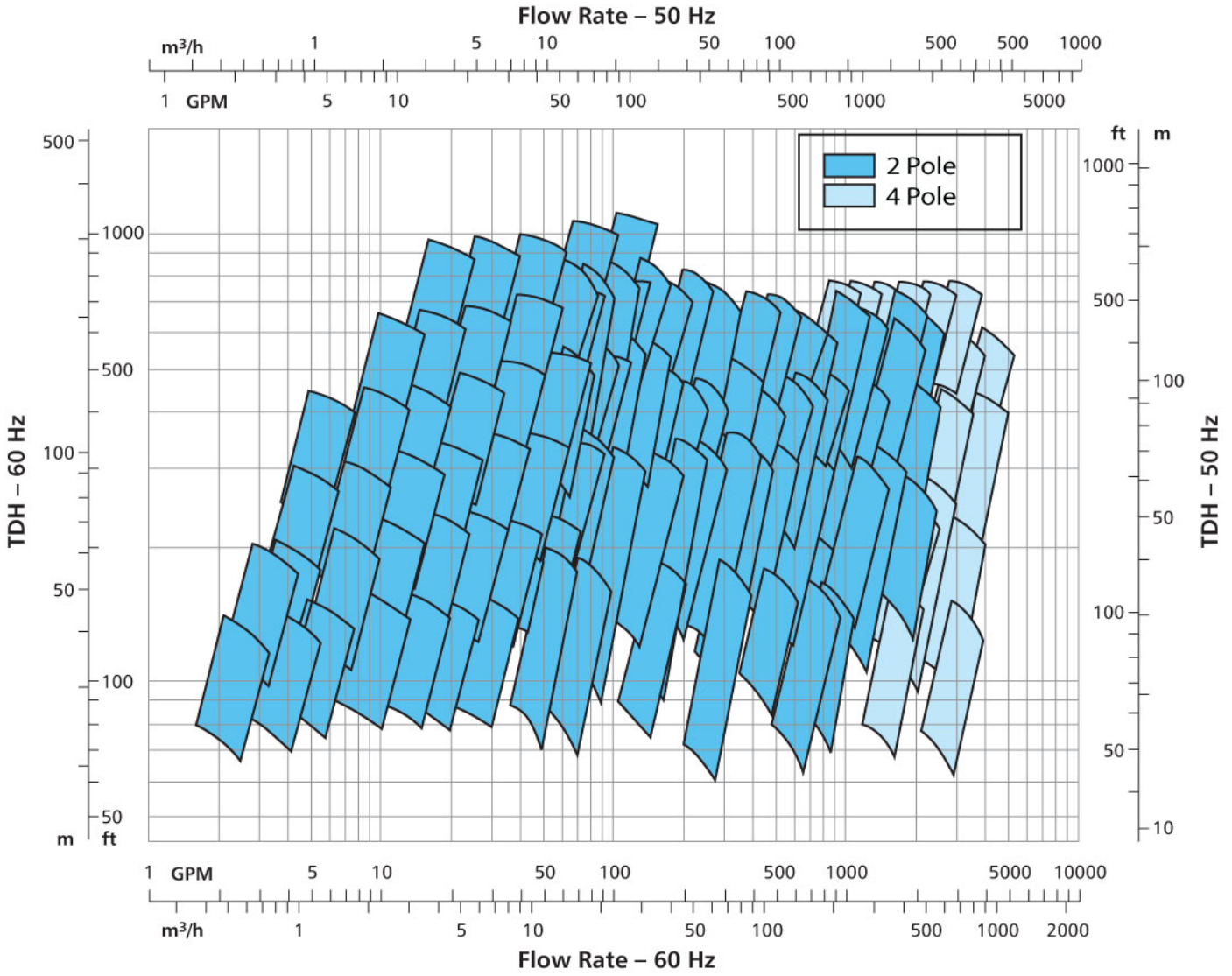
The heart of the *i*- FRAME, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

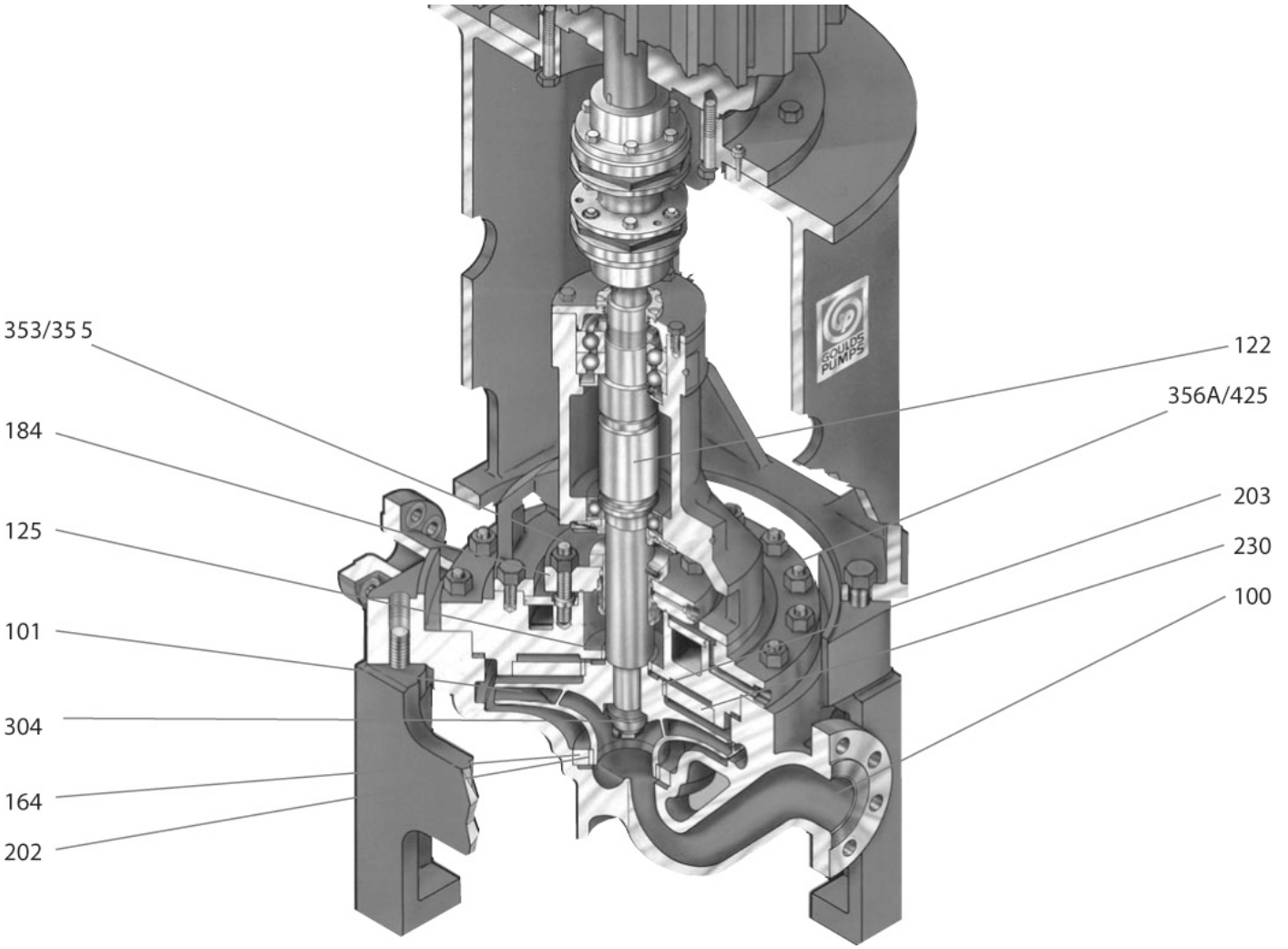
60 Hz Hydraulic Coverage **Model 3910**



For individual pump curves, please see Model 3700 section or visit www.GouldsPumps.com/PSS.html

Sectional View

Model 3910



Parts List and Materials of Construction

Item	Part Name	S-4	S-6	S-8	C-6	A-8	D-1	D-2
100	Casing	Carbon Steel			12% Chrome	316L SS	Duplex SS	S.Duplex SS
101	Impeller	Carbon Steel	12% Chrome	316L SS	12% Chrome	316L SS	Duplex SS	S.Duplex SS
122	Shaft	ANSI 4140 *		316L SS	410 SS	316L SS	Duplex SS	S.Duplex SS
125	Throat Bushing	Cast iron	410 SS	316L SS	410 SS	316L SS	Duplex SS	S.Duplex SS
164, 230	Wear Ring - Casing **	Cast iron	12% Chrome	316L SS	12% Chrome	316L SS	Duplex SS/ Stellite 12	S.Duplex SS/ Stellite 6
202, 203	Wear Ring - Impeller **	Cast iron	12% Chrome	Nitronic 60	12% Chrome	Nitronic 60	Duplex SS/ Stellite 12	S. Duplex SS/ Stellite 6
184	Seal Chamber Cover	Carbon Steel			12% Chrome	316L SS	Duplex SS	S.Duplex SS
304	Impeller Nut	Steel	316 SS				Duplex SS	S.Duplex SS
356A, 425	Casing studs / nuts	ANSI 4140						

* 410 SS on S-6 when temperature exceeds 350F (175C)
* Not utilized on 3700LF low flow pumps.

NOTES

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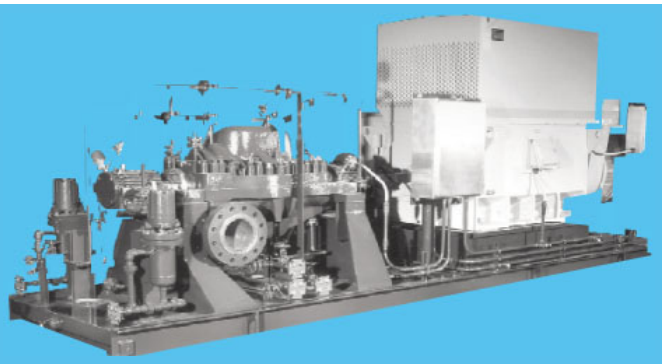


Proven API Leadership

ITT Goulds Pumps is a proven leader in multistage and API pumps with several thousand engineered multistage pumps sold and 40+ years of multistage pump expertise.

ITT Goulds Pumps offers proven engineering packaging expertise with highly complex specifications. We offer complex lube oil skids, seal flush piping plans, etc. to meet the toughest customer applications. Optional

Goulds Model 3600

Heavy Duty Multi-Stage Pumps Designed for High Head/High Capacity Services

- Capacities to 8,500 GPM (1930 m3/h)
- Heads to 9,000 feet (2740 m)
- Temperatures to 400°F (205°C)
- Pressures to 4,000 PSIG (275 kg/cm ^{2})
- API 610 11th edition / ISO 13709 compliance available (API BB3)

Design Features

- **Engineered Hydraulics -** Dense hydraulic coverage to better match your process for efficiency and reliability. Custom hydraulics are available.
- **Engineered Packaging** with a wide range of drivers, seals, piping, nozzle configurations, flanges, baseplates, and QC testing.
- **Axially Split Casing -** for ease of maintenance.
- **Dual Volute Design** balances hydraulic radial thrust at each stage for extended seal/bearing life.
- **Heavy Duty Single Row Bolting** prevents distortion and chance of interstage leakage.
- **Precision Cast Impellers:** smooth, dimensionally consistent hydraulic passages for maximum efficiency.
- **Compact Crossover** - for streamlined fluid flow, minimum friction loss, and maximum efficiencey.
- **Dynamically Balanced Impellers and Rotors** ensure smooth operation and increased reliability.

Applications

- The model 3600 is a robust solution for a variety of applications. This is an API pump for refineries, injection offshore platforms, pipeline, boiler feed, descaling, mine dewatering, process transfer, desalination, water injection, and CO^2 injection.
- ITT is experienced in higher discharge pressures and lower specific gravity than defined in API 610.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3600 Heavy Duty Multi-Stage Pumps

Design Features for High Head/High Capacity Services

OPPOSED IMPELLER ARRANGEMENT
Provides permanent hydraulic axial balance. Impellers staggered on shaft to minimize vibration due to vane pass.

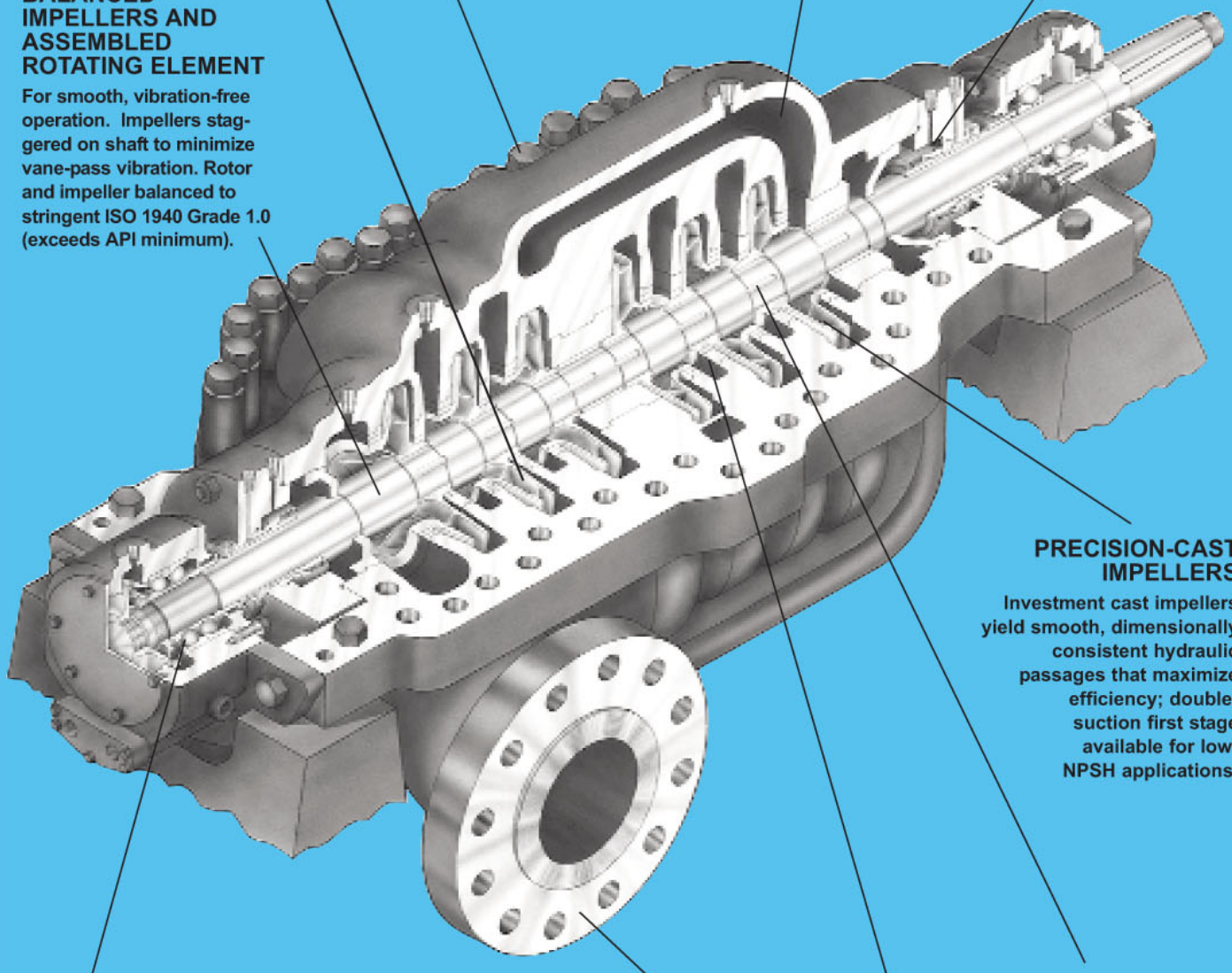
SINGLE ROW BOLTING
All nuts located on top for ease of maintenance.

DUAL VOLUTE CASING
Assures radial balance, minimum shaft deflection.

COMPACT CROSSOVERS
For streamlined fluid flow – minimum friction loss, maximum efficiency.

API-610/ISO 13709 SEAL CHAMBERS
Accept wide range of sealing options including seals conforming to API-610/ISO 13709, cartridge and conventional mechanical seals.

DYNAMICALLY BALANCED IMPELLERS AND ASSEMBLED ROTATING ELEMENT
For smooth, vibration-free operation. Impellers staggered on shaft to minimize vane-pass vibration. Rotor and impeller balanced to stringent ISO 1940 Grade 1.0 (exceeds API minimum).



PRECISION-CAST IMPELLERS
Investment cast impellers yield smooth, dimensionally consistent hydraulic passages that maximize efficiency; double-suction first stage available for low-NPSH applications.

HEAVY-DUTY BEARINGS
Oil-lubricated ball radial and duplex thrust standard; sleeve radial / ball thrust also available, or pressure-lubricated sleeve radial and tilt pad thrust.

DOUBLE SUCTION FIRST STAGE IMPELLER
Available for low NPSH service requirements.

ANSI B16.5 FLANGES
Class 900 RF standard on suction and discharge; other classes available as options.

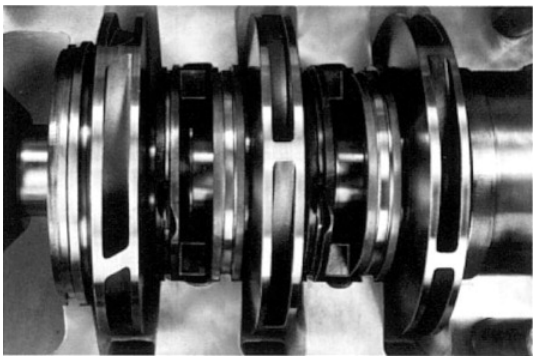
SPLIT STAGE PIECES AND CENTER BUSHING
Allow dynamic balancing of assembled rotating element.

POSITIVELY DRIVEN IMPELLERS
Key driven with shrink fit and secured against axial movement in both directions. Allows precise balancing of rotating element.

Design Features for Optimum Reliability

Low Vibration/Smooth Performance

- Individual impellers and complete rotor assembly dynamically balanced.
- Shrink fit of impellers to shaft assures precise balancing of rotating assembly.
- Precision cast impellers have equal volumes between vanes for reduced pressure pulsations.
- Impellers are mounted on shaft with vane tips staggered for reduced pressure pulsations.



Staggered impeller vane tips reduce pressure pulsations at vane passing frequency.

Serviceability

- Cartridge type mechanical seals for ease of assembly, proper installation.
- Single row bolting with stud nuts located on upper half for easy accessibility.

Split stage pieces and center case bushing can be removed for inspection of wear surfaces without disassembling rotor assembly.

Entire rotating assembly can be removed for maintenance without disturbing suction/discharge piping.

Single row bolting simplifies disassembly/reassembly.

Designed for API-610 11th Edition/ISO 13709 Services

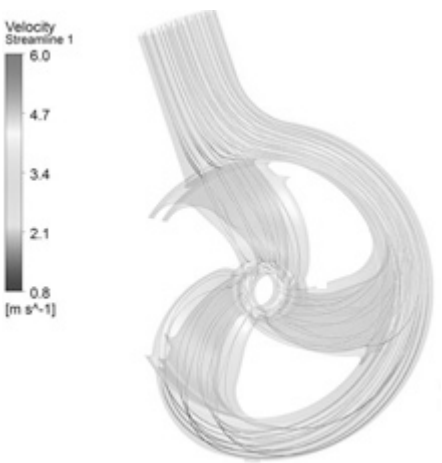
- Casing, nozzles and baseplate meet or exceed API 610/ ISO 13709 nozzle load requirements.
- Impellers are shrink-fit to shaft and independently secured against axial movement.
- Seal chambers meet dimensional requirements of API 610/ISO 13709 and can be fitted with single-, double- or tandem-cartridge mechanical seals.
- Non metallic Rings available for applications with low specific gravity, or for increased efficiency or ability to withstand short periods of dry running.
- Impellers and rotating equipment element dynamically balanced to API 610.

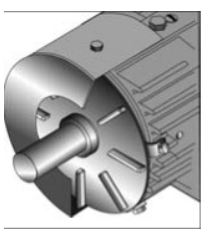
Design/Analysis Capabilities

Casing pressure capability and structural design developed and refined using advanced finite element analysis. Goulds engineering staff is fully equipped to perform the rotor lateral response analyses and residual unbalance checks necessary to assure stable operation and low vibration levels.

Thermal transient analysis using finite element models used to determine allowable casing temperature rise and assure mechanical reliability.

Hydraulic designs developed using dynamic flow models assure stable performance with consistent, high efficiency levels.





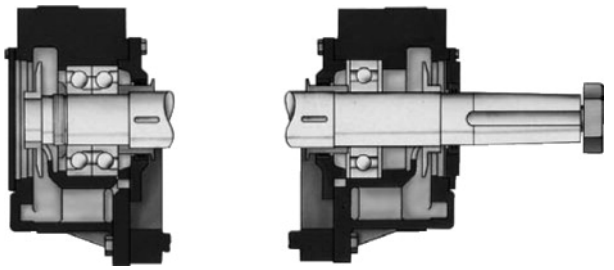
AIR COOLING

High capacity fan and shroud mounted on power end effectively reduce bearing frame temperature for cooler running bearings without using cooling water.

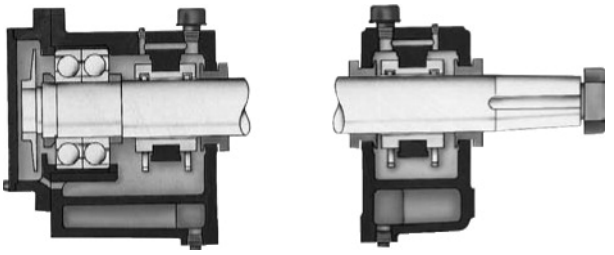
Optional Features for Application Flexibility

Bearing Arrangements

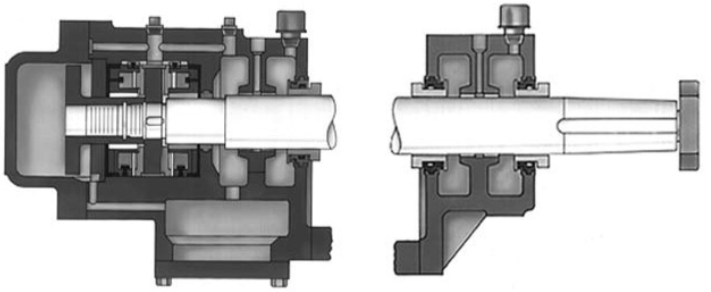
Oil lubricated ball radial and duplex thrust bearings are standard on the Model 3600.Ring oil lubricated sleeve radial and ball thrust or pressure lubricated sleeve radial and tilting pad thrust bearings can be furnished to meet customer or operating requirements. Hydrodynamic bearings offered with pressurized oil lube systems.



DUPLEX BALL THRUST/BALL RADIAL BEARINGS



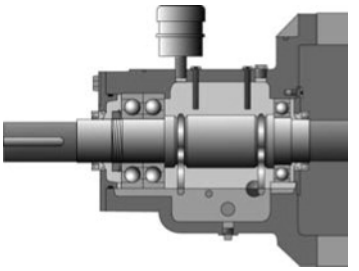
DUPLEX BALL THRUST/SLEEVE RADIAL BEARINGS



TILTING PAD THRUST/SLEEVE RADIAL BEARINGS

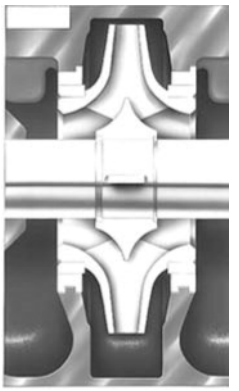
Oil Mist Lubrication System

Connections for pure or purge oil mist lubrication can be provided for immediate use or future requirements.



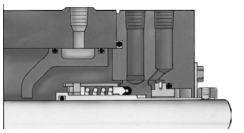
Double Suction First-Stage Impeller

Available on 4-inch and larger discharge size pumps for services where $NPSH_A$ is limited.



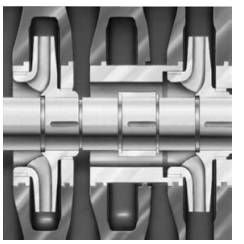
Shaft Sealing and Seal Chambers

Seal chambers meet API-610/ISO 13709 dimensional requirements. We offer any available seal and seal systems that are appropriate for your specific application including API 682 seals.



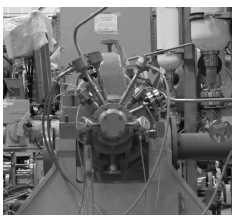
Destaging

Goulds Model 3600 can be supplied with one or more blank stages to meet existing head conditions, and allow for future increases. The shaft is protected by a sleeve to maintain the impeller fit. A by-pass cylinder assures smooth, even flow to the next impeller.



Instrumentation

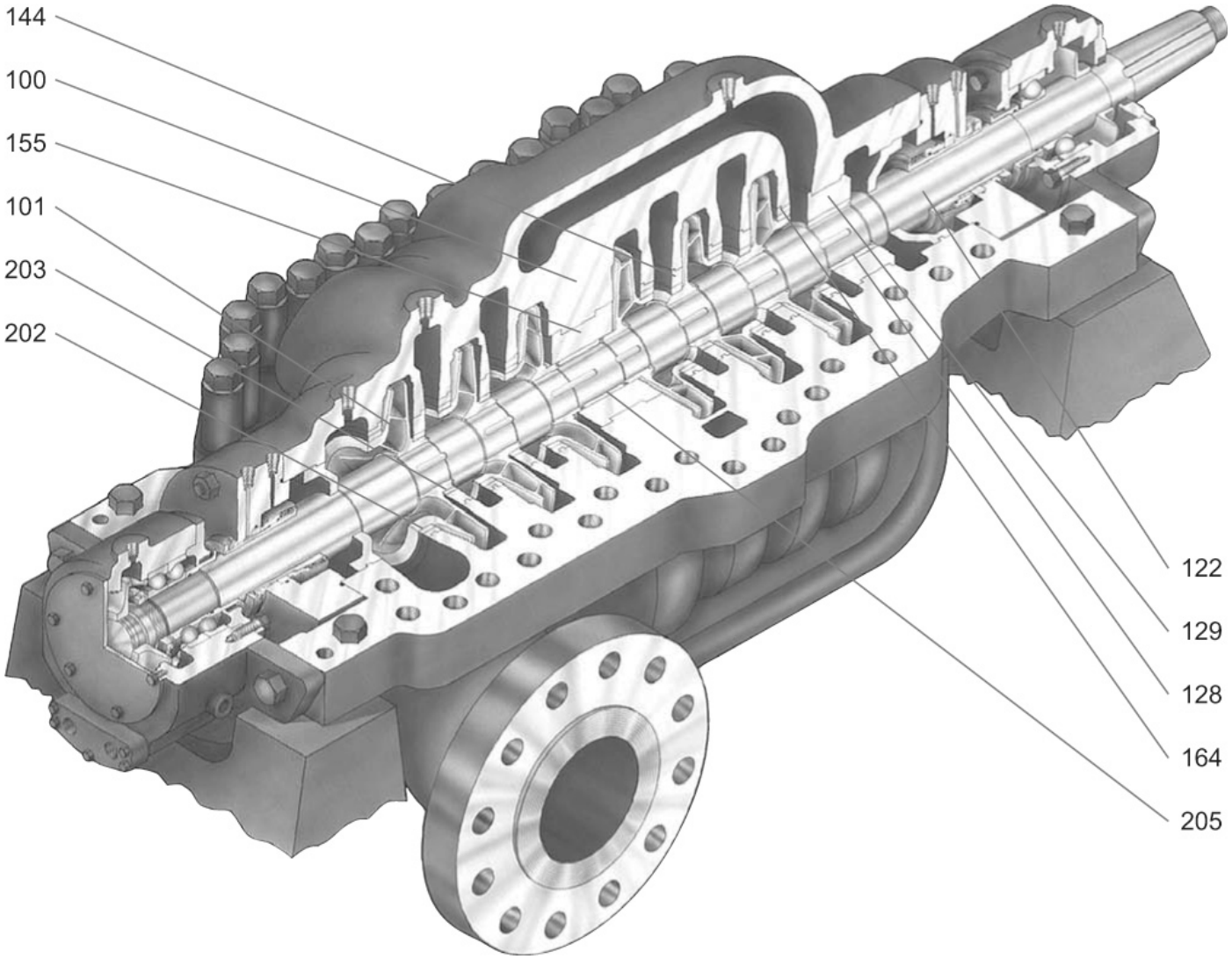
The 3600 can be furnished with instrumentation options to measure vibration and temperature. RTD's or thermocouples can be furnished to measure bearing temperatures and to monitor temperature rise in the casing. Bearing housing vibration can be monitored on pumps furnished with ball bearings. Pumps supplied with sleeve bearings can be furnished with non-contacting vibration probes to measure actual rotor vibration.



Interstage Bleedoff

Interstage bleedoff available for multiple discharge conditions.

Sectional View Model 3600



Parts List and Materials of Construction

Item	Part Name	S-6	S-8	C-6	A-8	D-1	D-2
100	Casing	Carbon Steel		12% Chrome	316L SS	Duplex SS	S.Duplex SS
101	Impeller	12% Chrome	316L SS	12% Chrome	316L SS	Duplex SS	S.Duplex SS
122	Shaft	17-4 ph	Nitronic 50	17-4 ph	Nitronic 50	Duplex SS	S.Duplex SS
202, 203	Wear Ring - Impeller **	17-4 ph	Nitronic 60	12% Chrome	Nitronic 60	Duplex SS/ Stellite 12	S. Duplex SS/ Stellite 6
128	Throttle Sleeve	Nitronic 60				Duplex SS	S.Duplex SS
205	Center Sleeve	Nitronic 60				Duplex SS	S.Duplex SS
164	Wear Ring - Casing **	420 SS	316L SS	420 SS	316L SS	Duplex SS	S.Duplex SS
129	Throttle Bushing	420 SS	316L SS	420 SS	316L SS	Duplex SS	S.Duplex SS
144	Stage Pieces (rings)	420 SS	316L SS	420 SS	316L SS	Duplex SS	S.Duplex SS
155	Center Bushing	420 SS	316L SS	420 SS	316L SS	Duplex SS	S.Duplex SS

* 410 SS on S-6 when temperature exceeds 350F (175C)
* Not utilized on 3700LF low flow pumps.

A Leader in API Engineered Pump Package Solutions...

Proven API Leadership

ITT Goulds Pumps is a proven leader in API Pumps

- Over 20,000 units installed
  - Over 17,000 OH2/OH3's
  - Over 3,000 BB1/BB2/BB3 pumps
- 40+ years of API expertise
- Participating member on API 610 and API 682 committees

Family of API Pumps

ITT Goulds Pumps has a family of proven API pumps

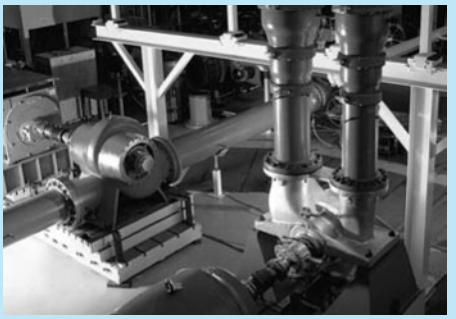
- Overhung pumps
- Single- and two-stage between-bearing pumps
- Multistage between-bearing pumps
- Vertical, double casing pumps
- Barrel multistage pumps
- Specialty pumps

Industry Leading Hydraulic Coverage

- We offer dense hydraulic coverage to meet your process needs.
- Better hydraulic fits can mean improved efficiency and long-term reliability and parts life.

8000 HP / 5960 kW Testing Capability

- Our test facilities can test your pump in the most demanding conditions.
- Optional complete train (or full string) test at 50 or 60 hz.
- Ability to test job motors at 5kv, 5.5kv, 6kv, 6.6kv, 7.2kv, 10kv, 11kv, 12.5kv, 13.2kv.



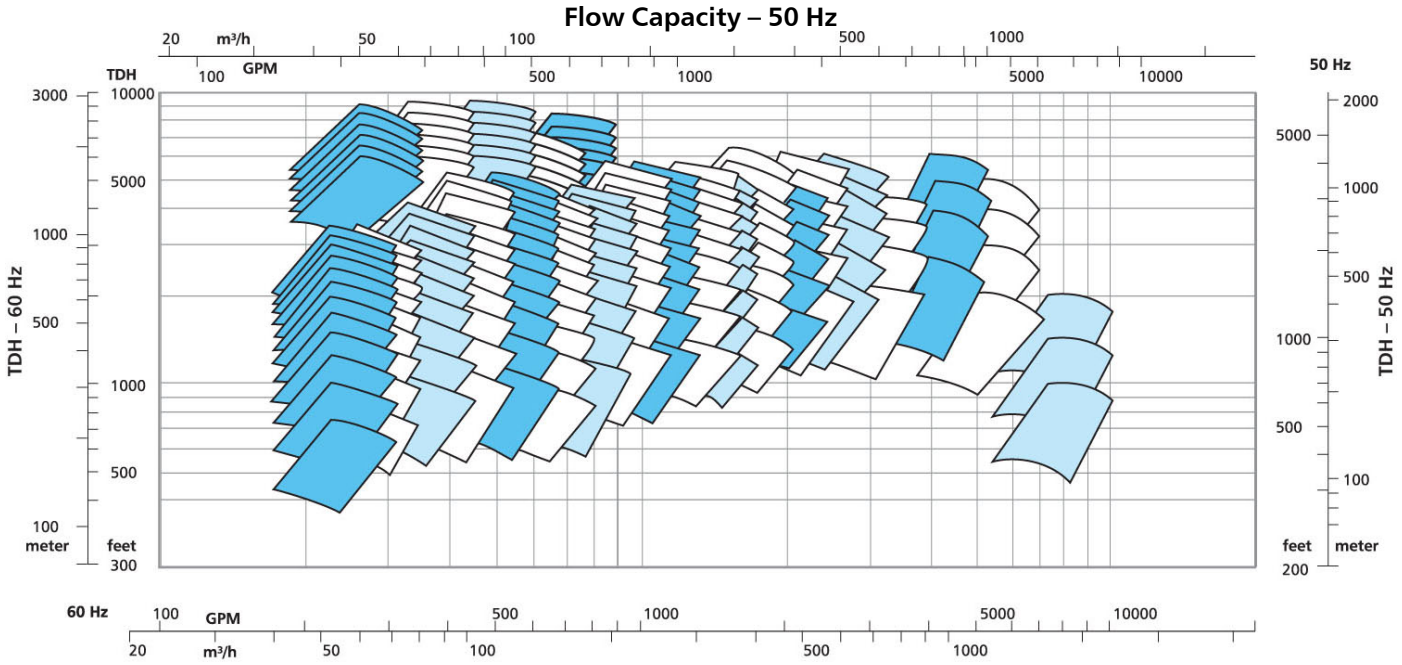
API Engineering Expertise

- We are experts in packaging engineered pumps that meet your demanding applications - with true conformance to the latest API specifications.
- We have extensive experience in nearly every type of driver, bearing, seal, piping configuration, nozzle configuration, flange and baseplate designs to meet your application needs.
- ITT is a world leader in technology and engineering including hydraulics, materials science, mechanical design, and fluid dynamics.

Broad Applications

- Petroleum refining, production, and distribution
- Petrochemical and demanding chemical processing
- High temperature applications including boiler circulation
- General industrial requiring high temperature or high pressures

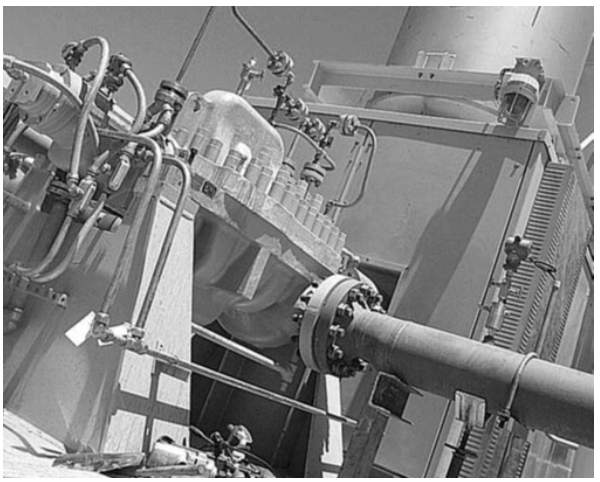
Hydraulic Coverage 60 Hz and 50 Hz



Hydraulics above represent 80% to 110% of best efficiency point (BEP).

Pump Installations

The Goulds Model 3600 is built to handle the toughest services in harsh environments. These pictures show demanding installations in the deserts of the Middle East and Australia.



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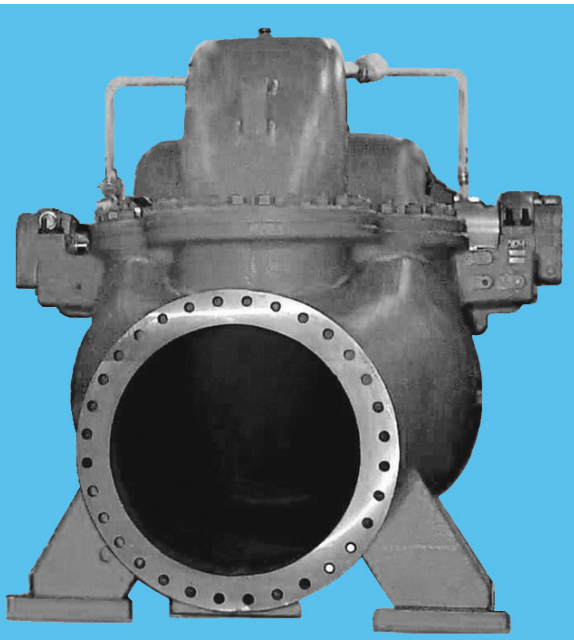
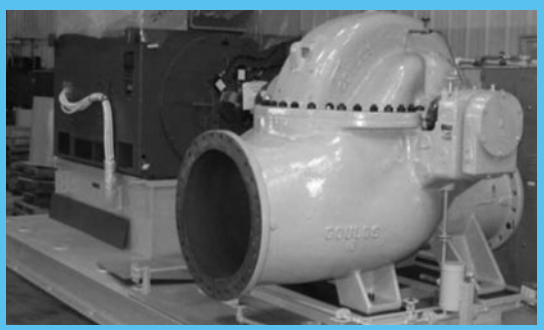


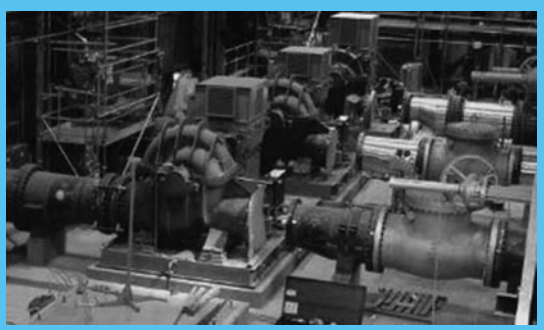
Model 3610

End Suction API-610/ISO 13709 Process Pump

- **Designed for optimum reliability**
- **State-of-the-art mechanical design features**
- **48 casing sizes-choice of impellers with most casings.**



Motor Driven Unit



Typical Installation

Goulds Model 3610

High-Temperature and -Pressure Process Pumps That Meet or Exceed 610 API 11th Edition and ISO 13709 2nd Edition

Safety, reliability, and versatility are they key words for our double suction API 610 between-bearing (BB1) pump.

Safety and Reliability

We provide engineered solutions with true conformance to the latest API specifications.

The result is a safe and rugged API process pump designed for a 20-year life.

Versatility

- Capacities to 50,000 GPM (11355 m^3/h)
- Total Dynamic Head to 700 feet (215 m)
- Temperatures to 300°F (149°C)
- Pressures vacuum to 300 PSIG (21 kg/cm^2)

Materials - Available in a wide range of materials including all API 610 constructions and custom applicaiton needs.

Engineered Hydraulics - Industry-leading hydrualic combinations to better match your process for efficiency and reliability. Custom hydraulics are available.

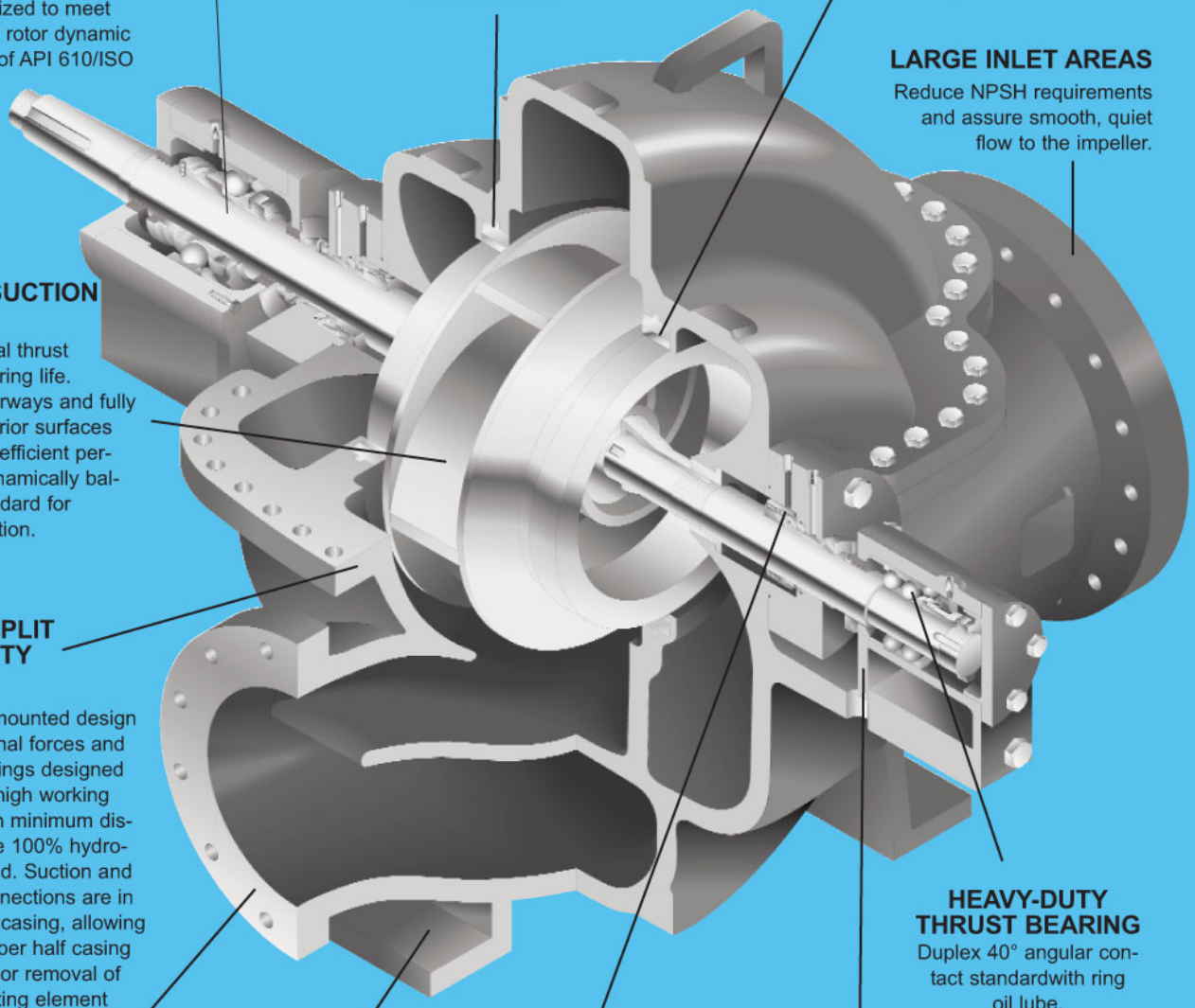
Engineered Packaging with a wide range of drivers, seals, piping, nozzle configurations, flanges, baseplates, and QC testing.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3610

API 610/ISO 13709

Axially-Split Between-Bearing (BB1) Pump



HEAVY DUTY SHAFTS
Minimum deflection in the toughest services means excellent shaft seal and bearing life. Sized to meet deflection and rotor dynamic requirements of API 610/ISO 13709.

RENEWABLE CASING WEAR RINGS
Positively locked on impeller hubs to permit easy renewal of API 610 / ISO 13709 running clearance and protect impeller hubs from wear.

RENEWABLE IMPELLER WEAR RINGS
Positively locked on impeller hubs permit easy renewal of API 610/ISO 13709 running clearance and protect impeller hubs from wear.

LARGE INLET AREAS
Reduce NPSH requirements and assure smooth, quiet flow to the impeller.

DOUBLE SUCTION IMPELLER
Minimizes axial thrust for longer bearing life. Polished waterways and fully machinedexterior surfaces assure highly efficient performance. Dynamically balanced as standard for smooth operation.

AXIALLY-SPLIT HEAVY-DUTY CASINGS
Rugged foot-mounted design to resist external forces and vibration. Casings designed to with-stand high working pressures with minimum distortion and are 100% hydrostatically tested. Suction and discharge connections are in the lower half casing, allowing removal of upper half casing for inspection or removal of complete rotating element without disturbing piping or driver.

HEAVY-DUTY THRUST BEARING
Duplex 40° angular contact standardwith ring oil lube.

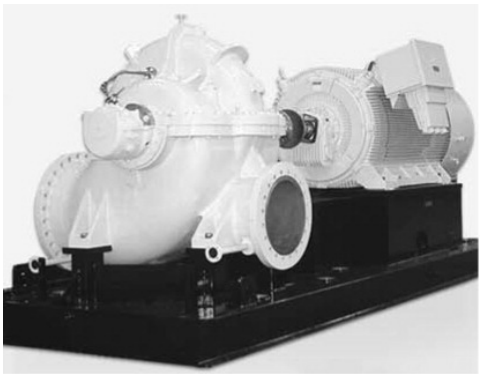
CLASS 300 RF FLANGES STANDARD

FOOT-MOUNTED CASINGS
Heavy-duty mounting to accept API 610/ISO13709 nozzle loads and maintain pump alignment.

ENLARGED SEAL CHAMBERS
Conforms to API 610/13709 dimensional requirements. Allows use of a wide varietyof API 610/ISO13709 cartridge mechanical seals.

LABYRINTH BEARING PROTECTION
Standard on all 3610 pumps. Significantly reduces the chance for bearing contamination and greatly improves mean time between failure.

Materials of Construction



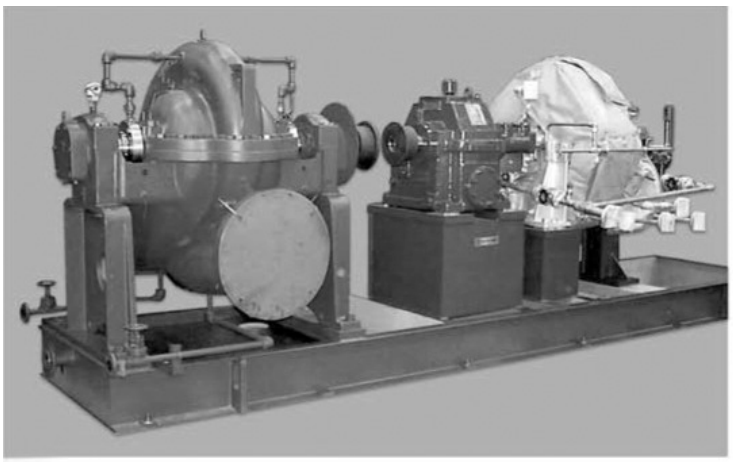
Model 20 x 30-40 1500 HP

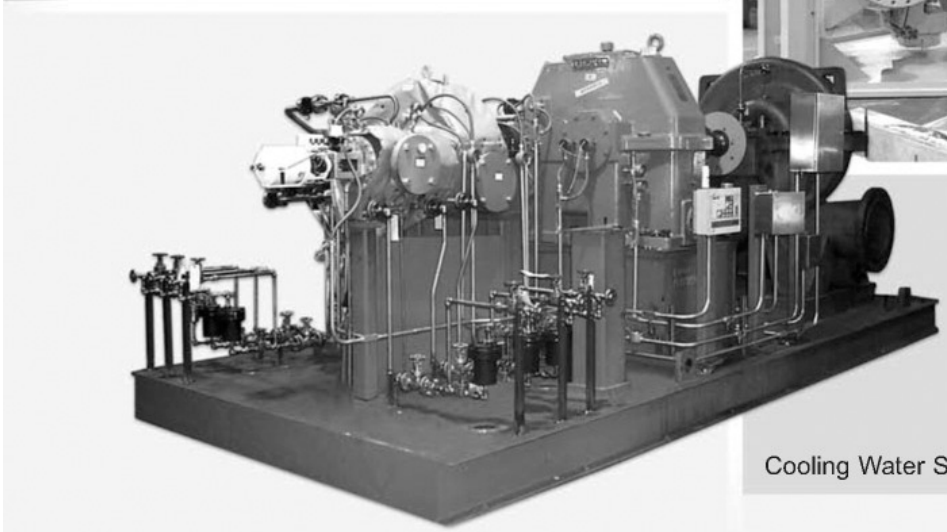
Part Description	S-4	S-6	C-4	A-8
Casing	Carbon Steel	Carbon Steel	12% Chrome	316 SS
Impeller	Carbon Steel	12% Chrome	12% Chrome	316 SS
Shaft	Carbon Steel	Carbon Steel	12% Chrome	316 SS
Shaft Sleeve[1]	C1	12% Chrome Hard	12% Chrome Hard	316 SS Hard
Casing Wear Ring[1]	C1	12% Chrome Hard	12% Chrome Hard	316 SS Hard
Bearing Housings	Carbon Steel			
Impeller Wear Ring[1]	C1	12% Chrome Hard	12% Chrome Hard	316 SS Hard

[1] Also available in hardened/hard metal coated materials.

Refinery Crude Oil Service (Middle East)

Refinery Cooling Tower Service (South America)





Offshore Platform Service (Gulf of Mexico)

Cooling Water Service (Canadian Oil Sands)

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  - Over 17,000 OH2/OH3's
  - Over 3,000 BB1/BB2/BB3 pumps
- 40+ years of API expertise
- Participating member on API 610 and API 682 committees

Family of API Pumps

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- Overhung pumps
- Single- and two-stage between-bearing pumps
- Multistage between-bearing pumps
- Vertical, double casing pumps
- Barrel multistage pumps
- Specialty pumps

Industry Leading Hydraulic Coverage

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- Better hydraulic fits can mean improved efficiency and long-term reliability and parts life.

8000 HP / 5960 kW Testing Capability

- Our test facilities can test your pump in the most demanding conditions.
- Optional complete train (or full string) test at 50 or 60 hz.
- Ability to test job motors at 5kv, 5.5kv, 6kv, 6.6kv, 7.2kv, 10kv, 11kv, 12.5kv, 13.2kv.

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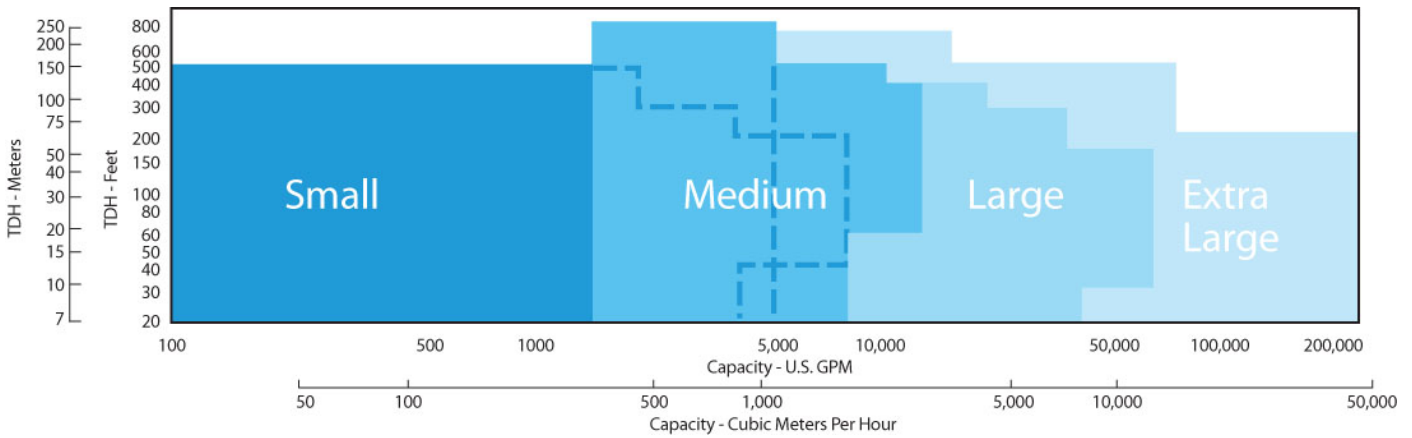
- We have extensive experience in nearly every type of driver, bearing, seal, piping configuration, nozzle configuration, flange and baseplate designs to meet your application needs.
- ITT is a world leader in technology and engineering including hydraulics, materials science, mechanical design, and fluid dynamics.

Broad Applications

- Petroleum refining, production, and distribution
- Petrochemical and demanding chemical processing
- High temperature applications including boiler circulation
- General industrial requiring high temperature or high pressures

Hydraulic Coverage Model 3610



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

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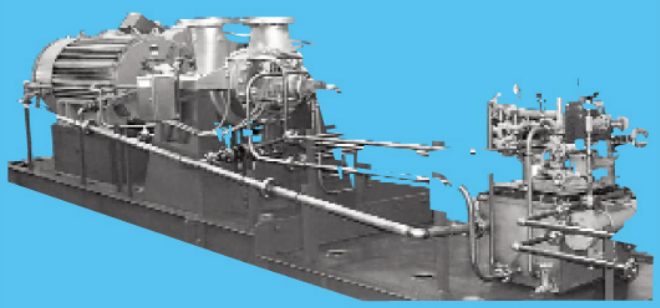
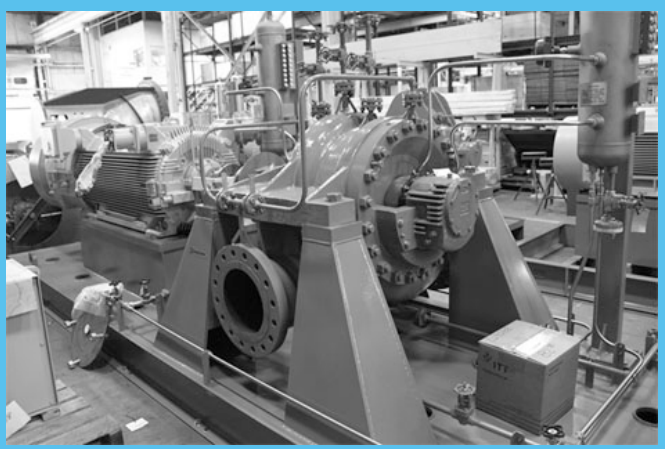


Goulds Model 3620 between bearings radially split process pumps are designed for smooth, reliable operation and fully meet the specification requirements of API-610/ISO 13709 to assure extended service life.



Custom nozzle orientation available including in-line (picture above) and side-top configuration.

Goulds Model 3620

High-Temperature and -Pressure Process Pumps That Meet or Exceed 610 API 11th Edition/ISO 13709 2nd Edition

Safety, realibility, and versatility are the key words for our single stage, centerline mounted, between-bearing, radially split API 610 process pump (API BB2) .

Safety and Reliability

We provide engineered solutions with true conformance to the latest API specifications including the stringent emissions containment per API 682.

The result is a safe and rugged API process pump designed for a 20-year life.

Versatility

- Capacities to 20,000 GPM (4540 m^3/h)
- Heads to 1,500 feet (455m)
- Temperatures to 850° F (455° C)
- Pressures to 1,000 PSIG (70 bar)

Materials - Available in a wide range of materials including all API 610 constructions and custom applicaiton needs.

Engineered Hydraulics - Dense hydraulic coverage to better match your process for efficiency and reliability. Custom hydraulics are available.

Engineered Packaging with a wide range of drivers, seals, piping, nozzle configurations, flanges, base-plates, and QC testing.

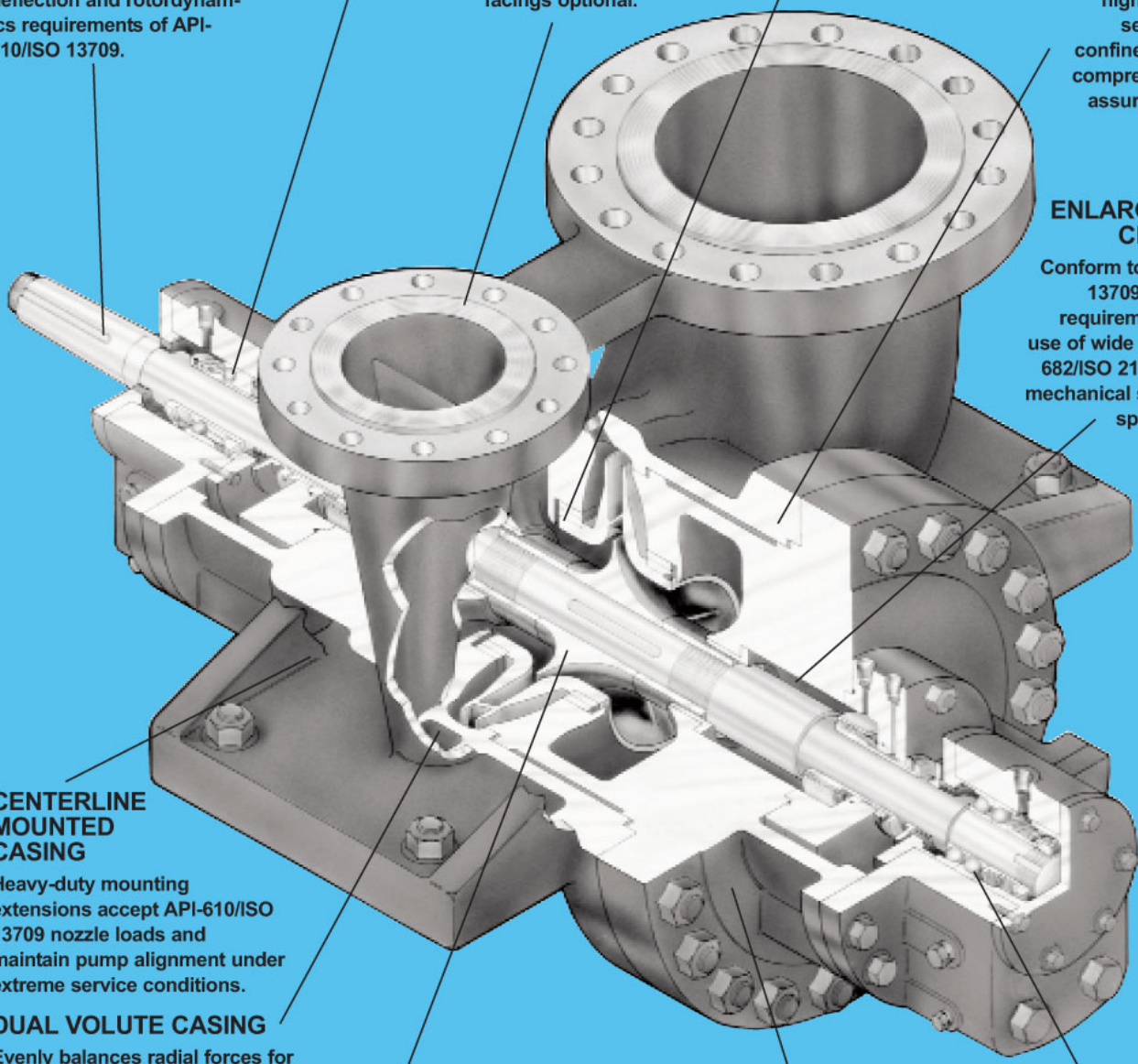
Applications

- **Refinery** : Tower bottoms, process feed, column reflux, circulation and pump around, process booster
- **Power Plant**: Boiler feed booster, boiler circulation, ash sluice

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3620 High Temperature/High Pressure Double Suction Pumps (API BB2)

Heavy Duty Design Features for Refinery, Petrochemical and Power Generation Services



HEAVY DUTY SHAFT
Minimum shaft deflection for extended seal and bearing life. Sized to meet deflection and rotordynamics requirements of API-610/ISO 13709.

HEAVY DUTY RADIAL BEARINGS STANDARD

CLASS 300 RF FLANGES STANDARD
Other classes and facings optional.

RENEWABLE WEAR RINGS
API 610 / ISO 13709 clearances. Positively locked. Standard feature.

RADIALLY SPLIT CASING
Designed specifically for high pressure / high temperature services. Fully confined controlled compression gasket assures leak-proof sealing.

ENLARGED SEAL CHAMBERS
Conform to API-610/ISO 13709 dimensional requirements. Allows use of wide range of API-682/ISO 21049 cartridge mechanical seals to meet specific service conditions.

CENTERLINE MOUNTED CASING
Heavy-duty mounting extensions accept API-610/ISO 13709 nozzle loads and maintain pump alignment under extreme service conditions.

DUAL VOLUTE CASING
Evenly balances radial forces for minimum shaft deflection, increased bearing and seal life.

DOUBLE SUCTION IMPELLER
Designed for low NPSH services. Hydraulically designed to balance axial loads for increased bearing life. Rotor and impeller balanced to stringent ISO 1940 Grade 1.0 (exceeds API minimum).

CASING HEAD ON OUTBOARD END
Allows removal of rotor without disturbing suction or discharge piping. Single head standard. Double head design optional.

HEAVY DUTY THRUST BEARING
Duplex 40° angular contact thrust bearings and deep-groove (Conrad) radial bearings sized for minimum three-year bearing life under most severe operating conditions. Exceeds API 610/ISO 13709 requirements.

A Leader in API Engineered Pump Package Solutions...

Proven API Leadership

ITT Goulds Pumps is a proven leader in API Pumps

- Over 20,000 units installed
  - Over 17,000 OH2/OH3's
  - Over 3,000 BB1/BB2/BB3 pumps
- 40+ years of API expertise
- Participating member on API 610 and API 682 committees

Family of API Pumps

ITT Goulds Pumps has a family of proven API pumps

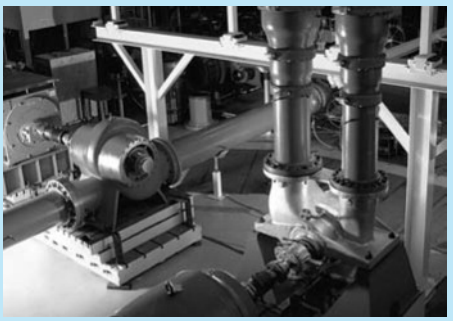
- Overhung pumps
- Single- and two-stage between-bearing pumps
- Multistage between-bearing pumps
- Vertical, double casing pumps
- Barrel multistage pumps
- Specialty pumps

Industry Leading Hydraulic Coverage

- We offer dense hydraulic coverage to meet your process needs.
- Better hydraulic fits can mean improved efficiency and long-term reliability and parts life.

8000 HP / 5960 kW Testing Capability

- Our test facilities can test your pump in the most demanding conditions.
- Optional complete train (or full string) test at 50 or 60 hz.
- Ability to test job motors at 5kv, 5.5kv, 6kv, 6.6kv, 7.2kv, 10kv, 11kv, 12.5kv, 13.2kv.



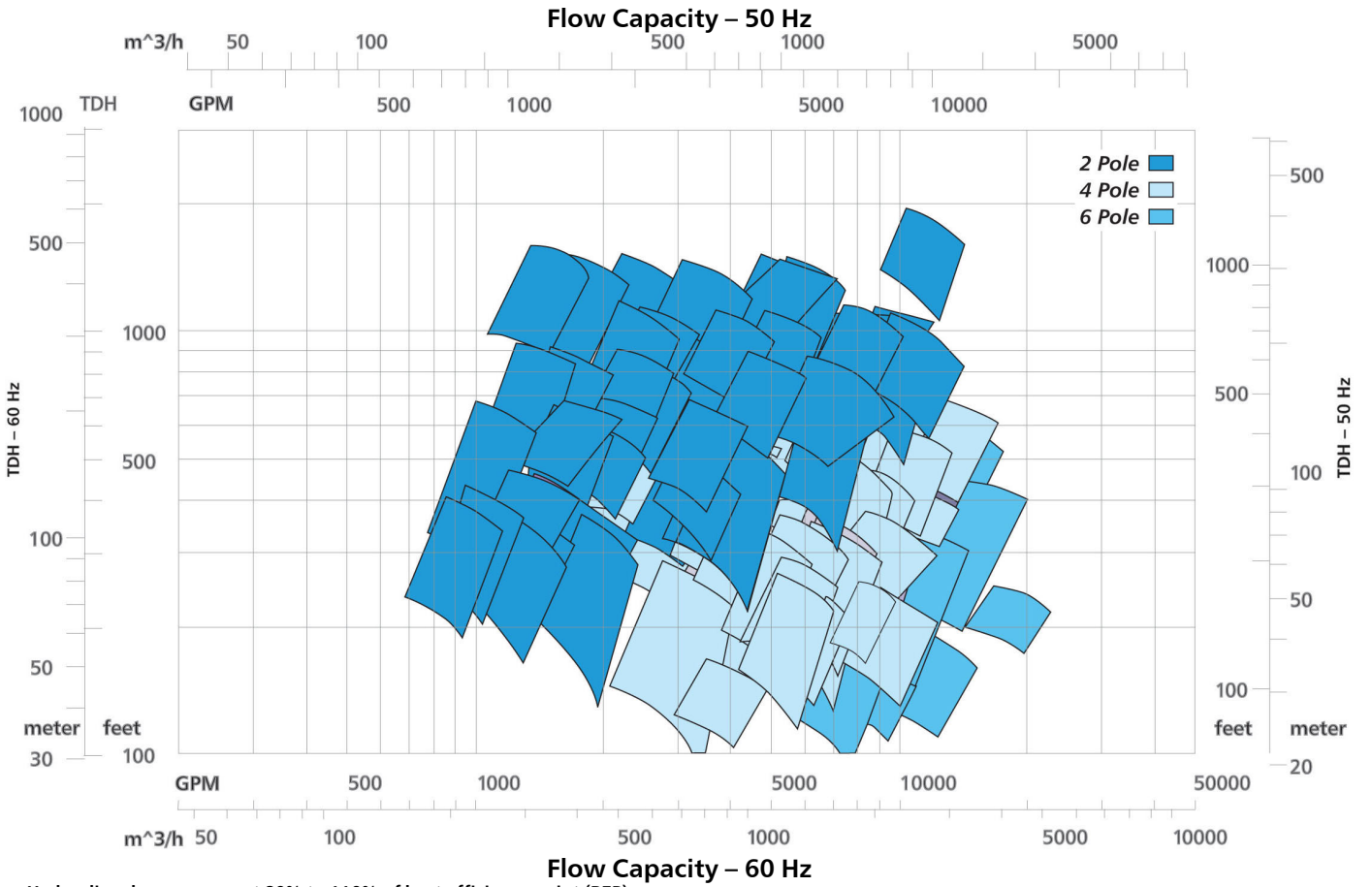
API Engineering Expertise

- We are experts in packaging engineered pumps that meet your demanding applications - with true conformance to the latest API specifications.
- We have extensive experience in nearly every type of driver, bearing, seal, piping configuration, nozzle configuration, flange and baseplate designs to meet your application needs.
- ITT is a world leader in technology and engineering including hydraulics, materials science, mechanical design, and fluid dynamics.

Broad Applications

- Petroleum refining, production, and distribution
- Petrochemical and demanding chemical processing
- High temperature applications including boiler circulation
- General industrial requiring high temperature or high pressures

Hydraulic Coverage



Hydraulics above represent 80% to 110% of best efficiency point (BEP).

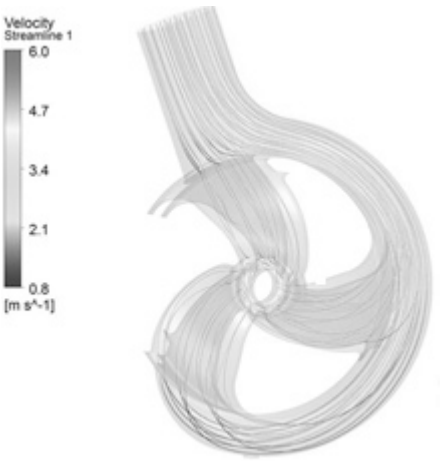
Design Features for Optimum Reliability

Designed for API-610 11th Edition/ISO 13709 Services

- Casing, nozzles and baseplate meet or exceed API 610/ ISO 13709 nozzle load requirements.
- Impellers are shrink-fit to shaft and independently secured against axial movement.
- Seal chambers meet dimensional requirements of API 610/ISO 13709 and can be fitted with single-, double- or tandem-cartridge mechanical seals.
- Steel bearing frame is standard for maximum structural integrity.
- Impellers and rotating equipment element dynamically balanced to API 610 / ISO 13709 requirements.
- Separation margins between operating speeds and critical speeds meet or exceed API 610 / ISO 13709 requirements.

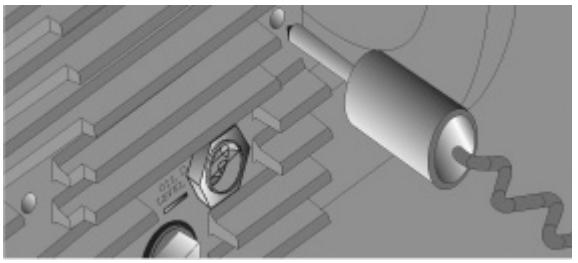
Design/Analysis Capabilities

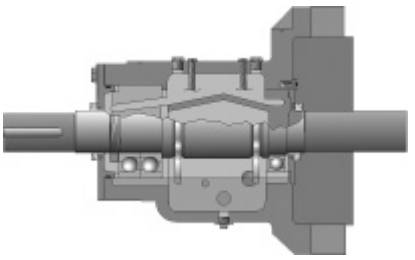
Casing pressure capability and structural design developed and refined using advanced finite element analysis. Goulds engineering staff is fully equipped to perform the rotor lateral response analysis and residual unbalance checks necessary to ensure stable operation and low vibration levels. Thermal transient analysis using finite element models used to determine allowable casing temperature rise and ensure mechanical reliability. Hydraulic designs developed using dynamic flow models ensure stable performance with consistent, high efficiency levels.



Improved Bearing environment

- Bearing frame fins provide optimum heat dissipation.
- Condition monitoring sites allow easy and consistent monitoring of temperature and vibration. Provision for instrumentation mounting per API 670 available.
- Large oil sight glass allows viewing of the condition and level of oil, critical for bearing life.
- Extra large oil sump provides cooler running bearings.
- Proven channeled oil lubrication system ensures flow-through of cooled oil to thrust and radial bearings.
- Standard dual oil rings, positively located, provide oil flow to channeled oil lubrication system and prevent oil foaming.

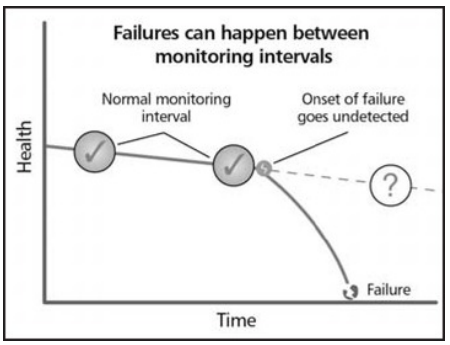




i-ALERT™ Condition Monitor

The heart of the *i*- FRAME, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



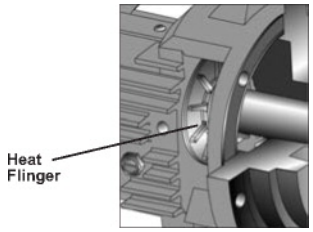
A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

Optional Features for Application Flexibility

Goulds offers users a range of options to meet specific plant and process requirements.

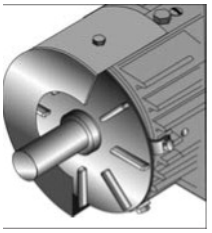
High Temperature Capability

For high temperature applications, these options are available.



HEAT FLINGER

Heat flinger dissipates shaft-conducted heat and circulates air to reduce heat build-up.



AIR COOLING

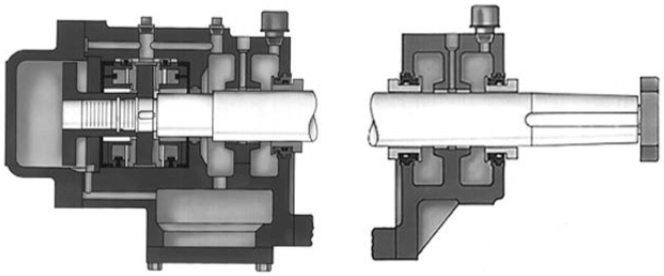
High capacity fan and shroud mounted on power end effectively reduce bearing frame temperature for cooler running bearings without using cooling water.

WATER COOLING

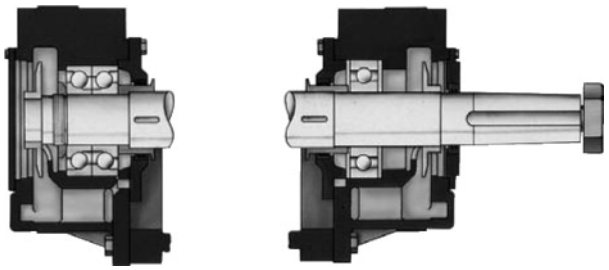
Finned cooler for maintaining oil/bearing temperature. Corrosion resistant material.

Bearing Arrangements

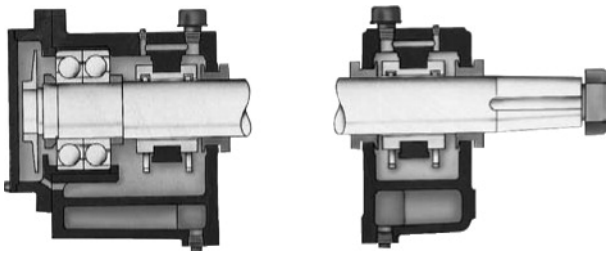
Oil lubricated ball radial and duplex thrust bearings are standard on the Model 3620. Ring oil lubricated sleeve radial and ball thrust or pressure lubricated sleeve radial and tilting pad thrust bearings can be furnished to meet customer or operating requirements. Hydrodynamic bearings offered with pressurized oil lube systems.



TILTING PAD THRUST/SLEEVE RADIAL BEARINGS

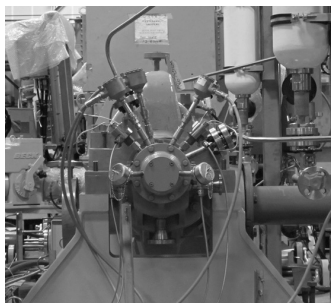


DUPLEX BALL THRUST/BALL RADIAL BEARINGS



DUPLEX BALL THRUST/SLEEVE RADIAL BEARINGS

Instrumentation



The 3620 can be furnished with instrumentation options to measure vibration and temperature. RTDs or thermocouples can be furnished to measure bearing temperatures and to monitor temperature rise in the casing. Bearing housing vibration can be monitored on pumps furnished with ball bearings. Pumps supplied with sleeve bearings can be furnished with non-contacting vibration probes to measure actual rotor vibration.

NOTES

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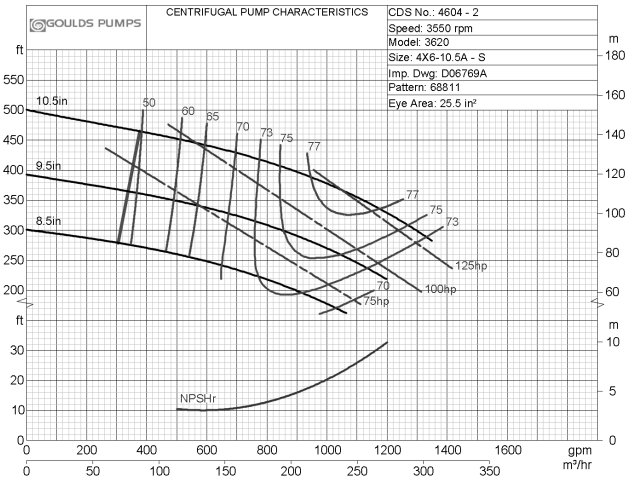
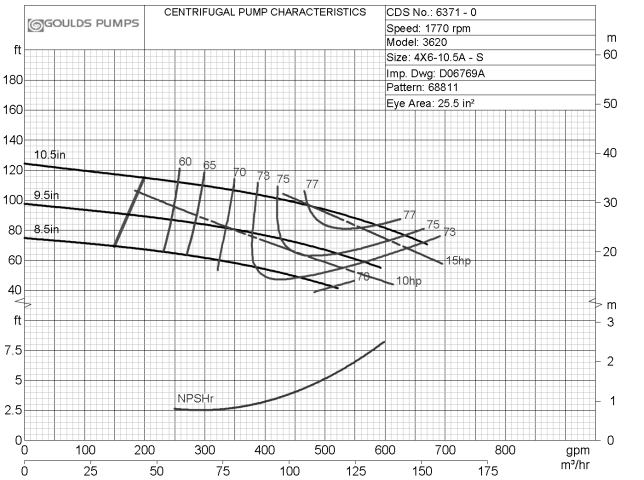
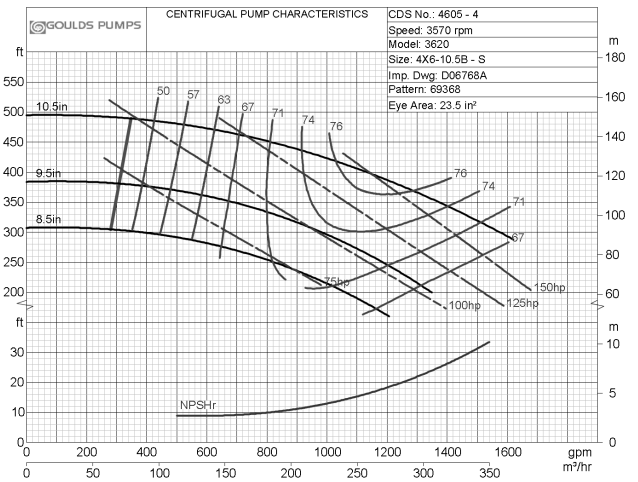


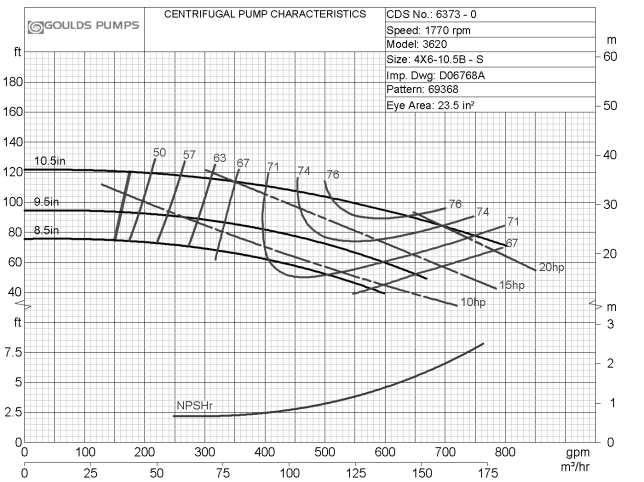
4X6-10.5A **3550rpm**



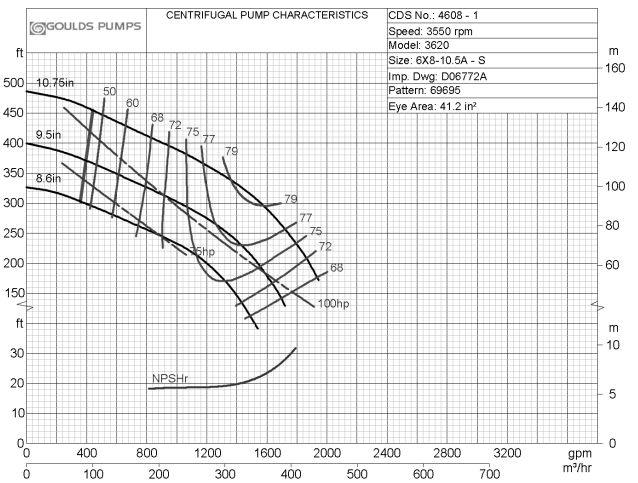
4X6-10.5A **1770rpm**



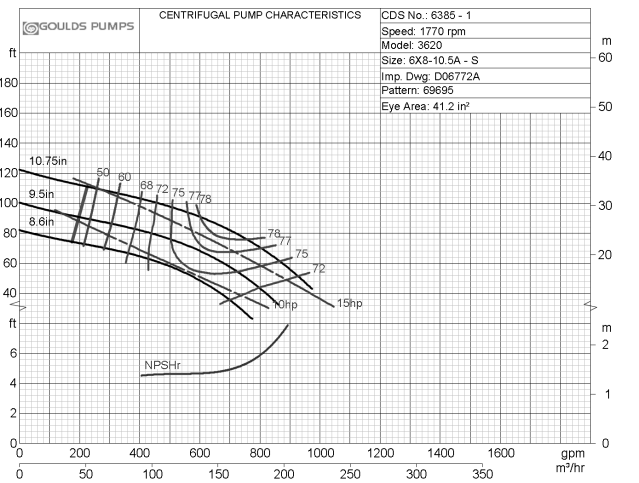
4X6-10.5B **3570rpm**



4X6-10.5B **1770rpm**

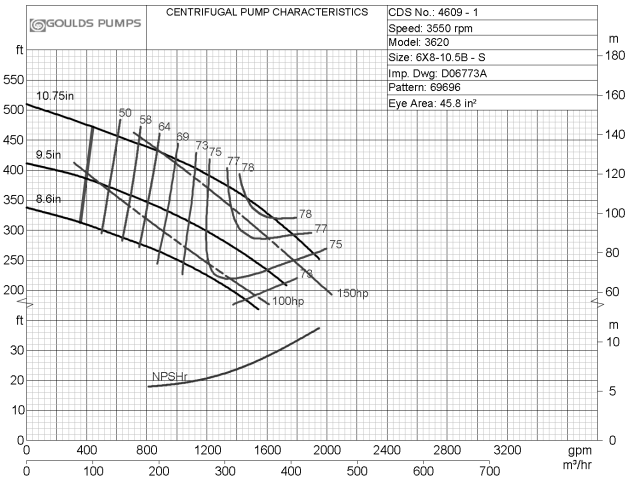


6X8-10.5A **3550rpm**

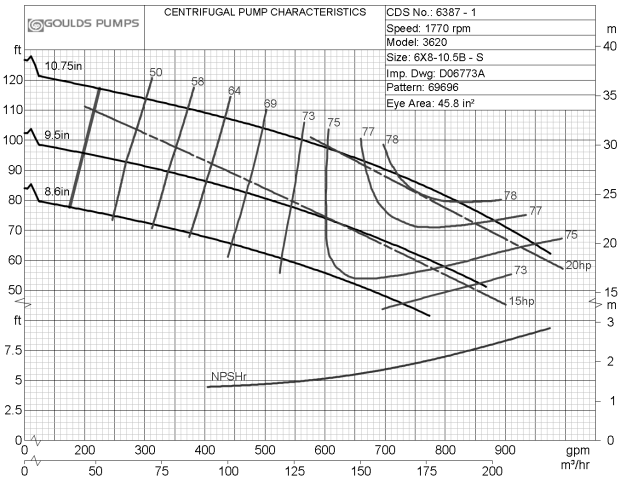


6X8-10.5A **1770rpm**

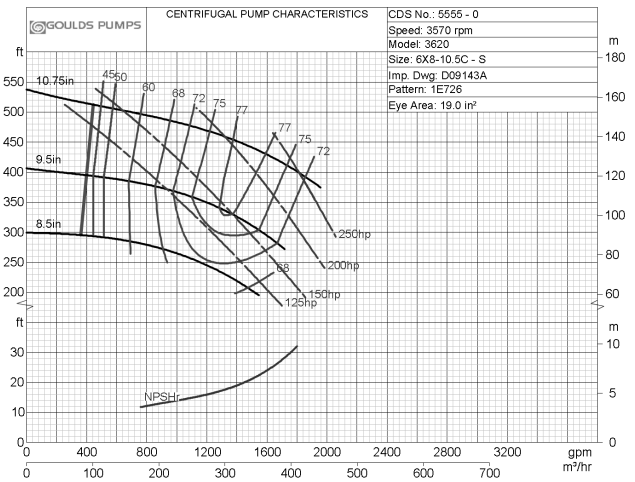
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



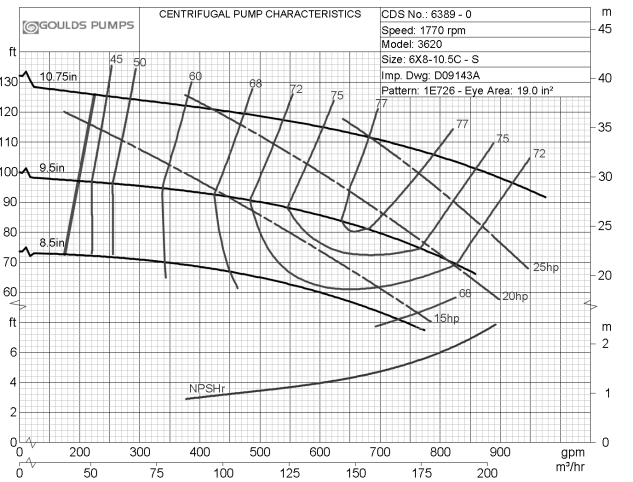
6X8-10.5B **3550rpm**



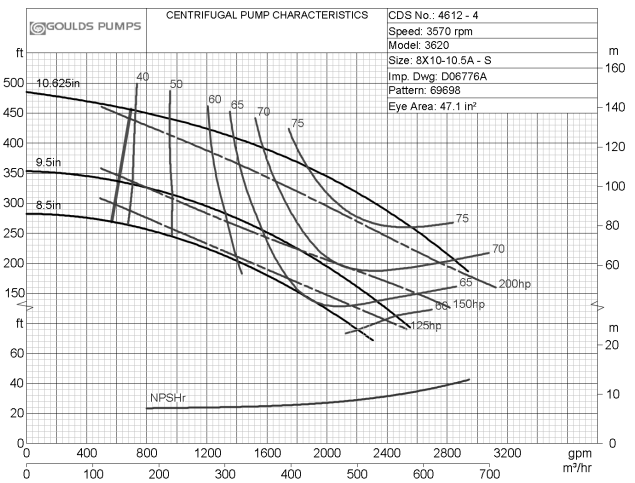
6X8-10.5B **1770rpm**



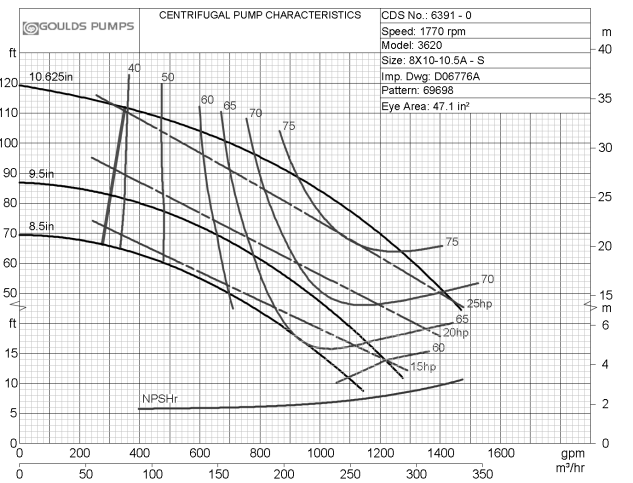
6X8-10.5C **3570rpm**



6X8-10.5C **1770rpm**

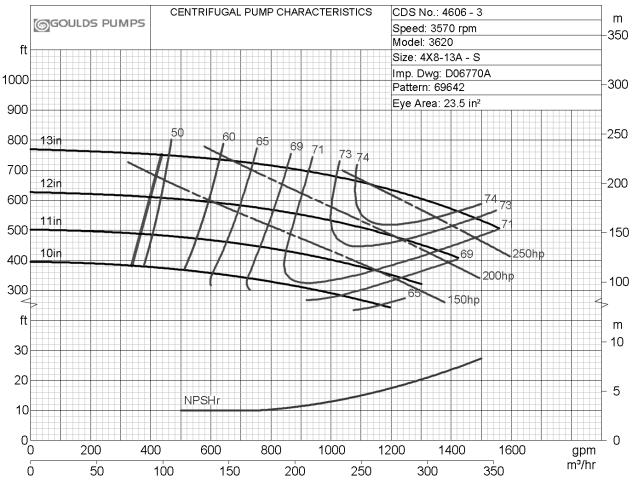


8X10-10.5A **3570rpm**

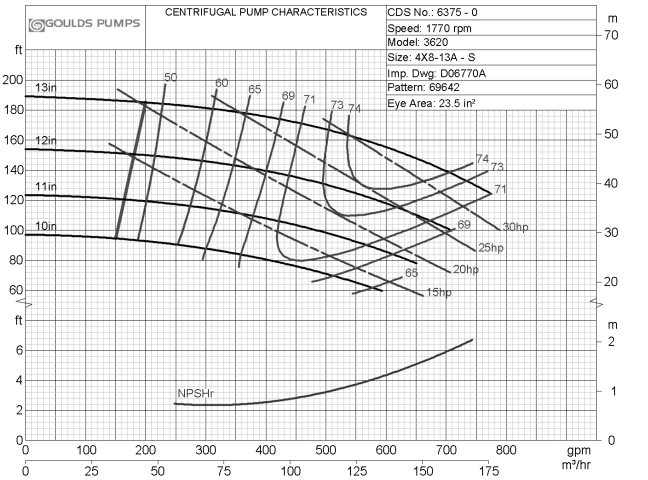


8X10-10.5A **1770rpm**

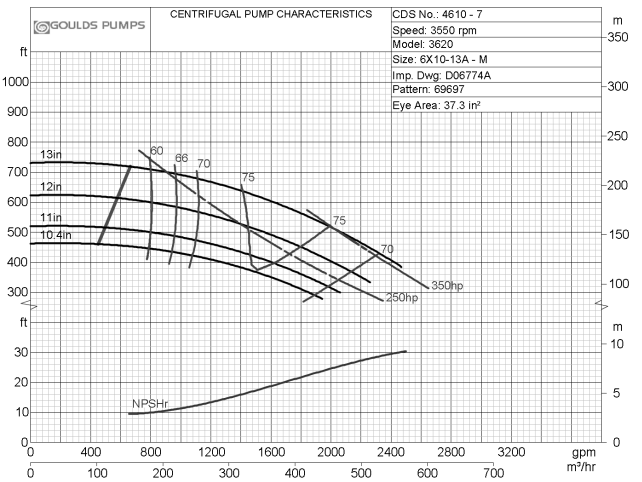
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



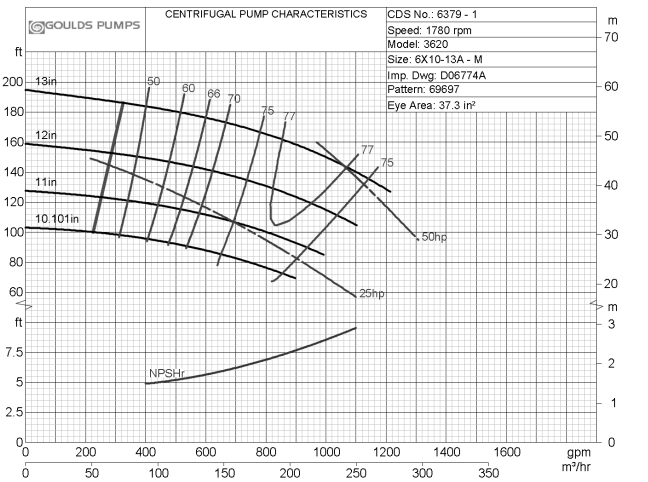
4X8-13A **3570rpm**



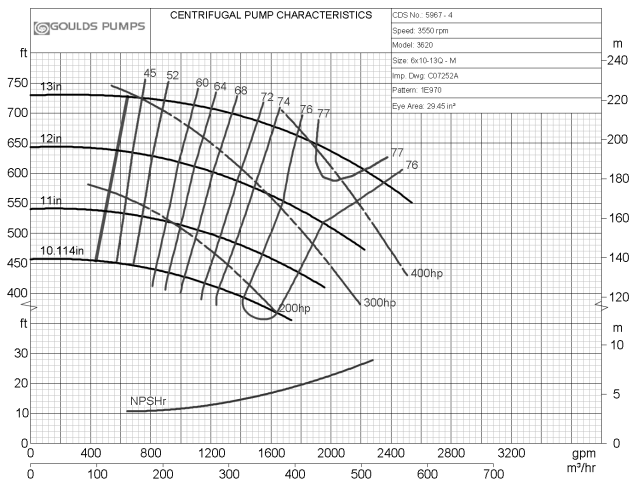
4X8-13A **1770rpm**



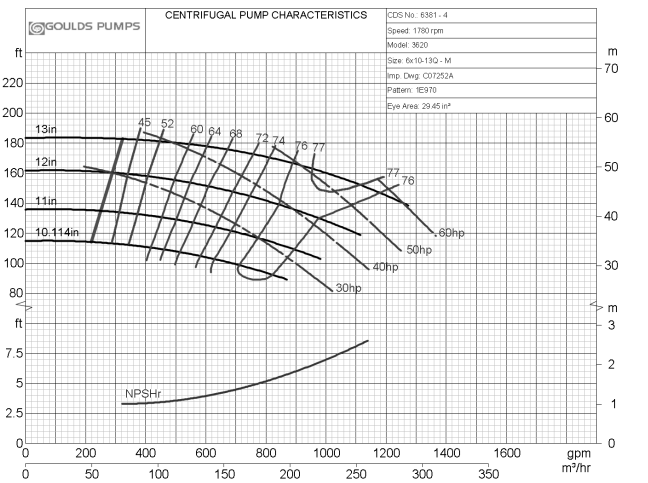
6X10-13A **3550rpm**



6X10-13A **1780rpm**



6x10-13Q **3550rpm**

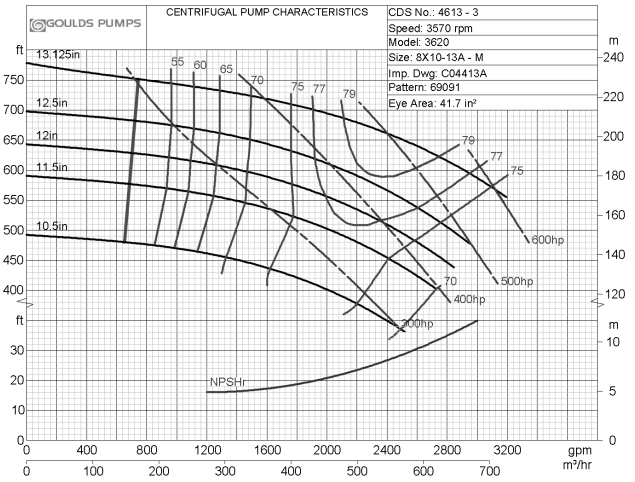


6x10-13Q **1780rpm**

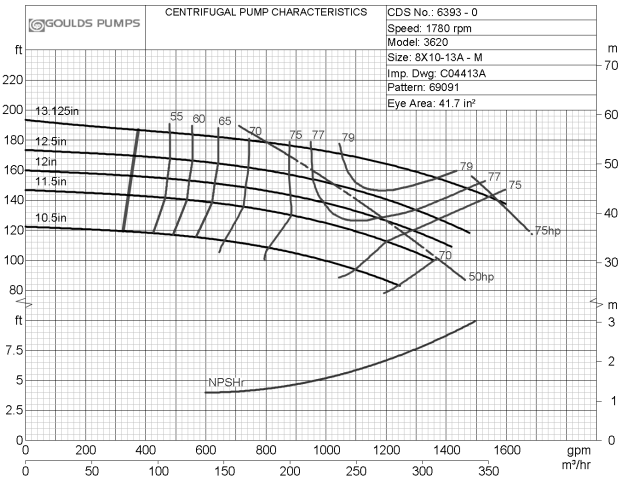
60Hz Curves

Model 3620

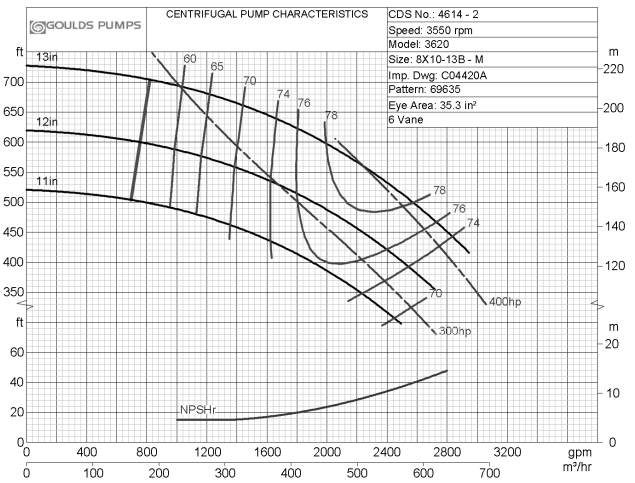
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



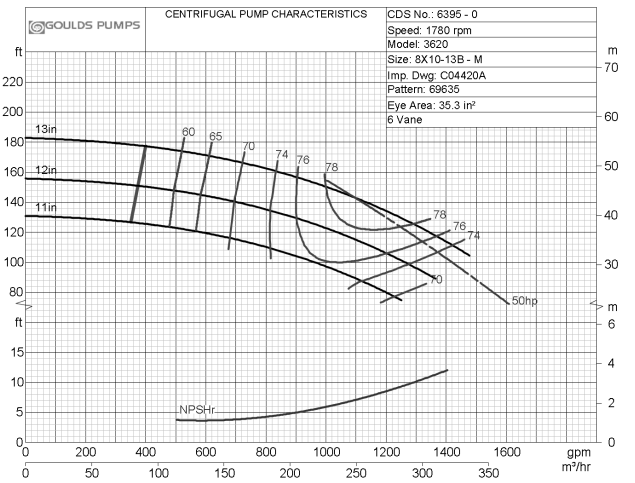
8X10-13A **3570rpm**



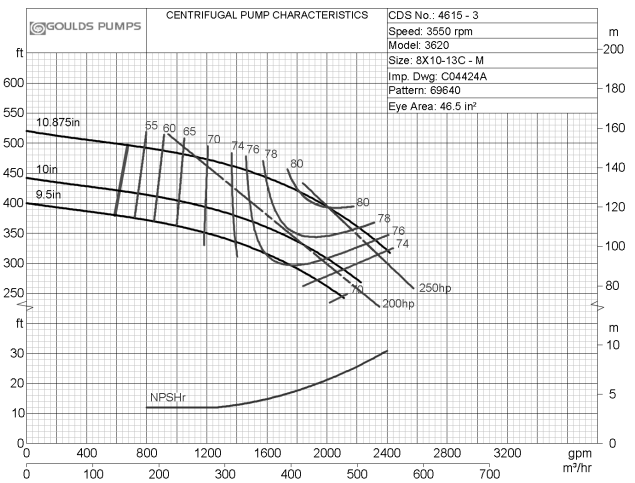
8X10-13A **1780rpm**



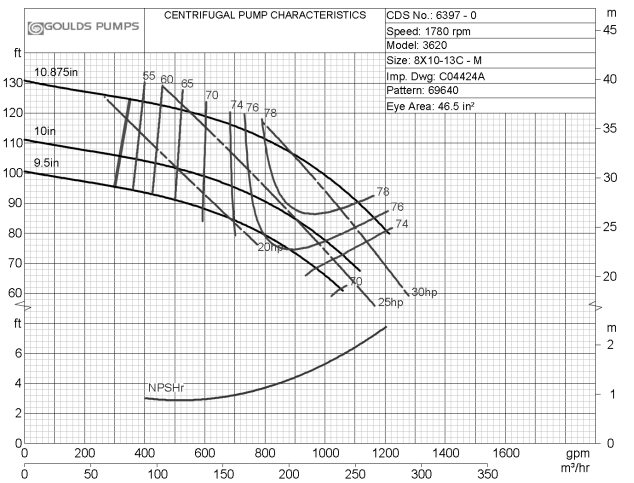
8X10-13B **3550rpm**



8X10-13B **1780rpm**



8X10-13C **3550rpm**



8X10-13C **1780rpm**

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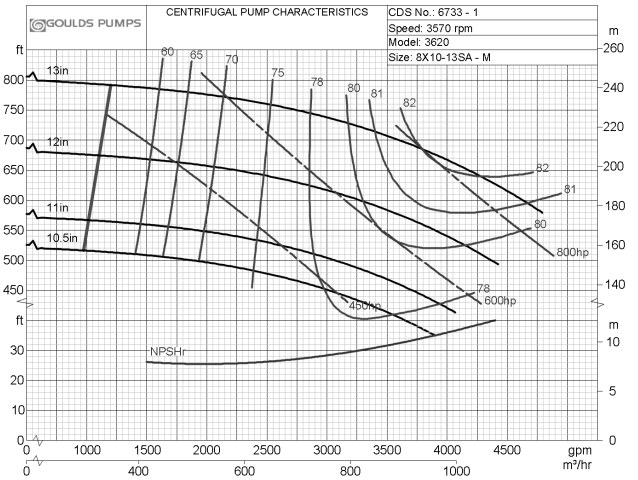
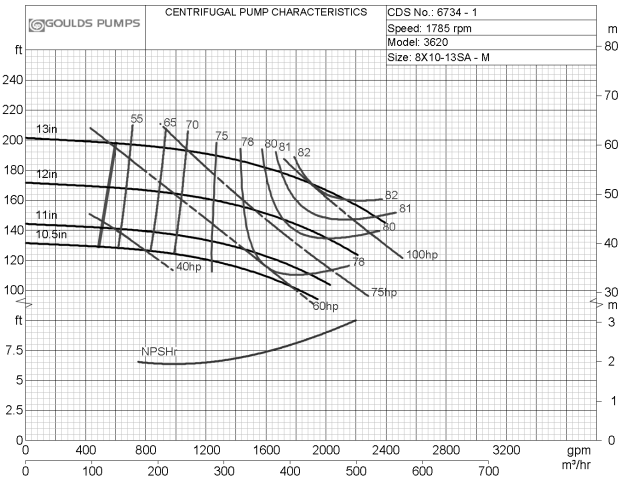
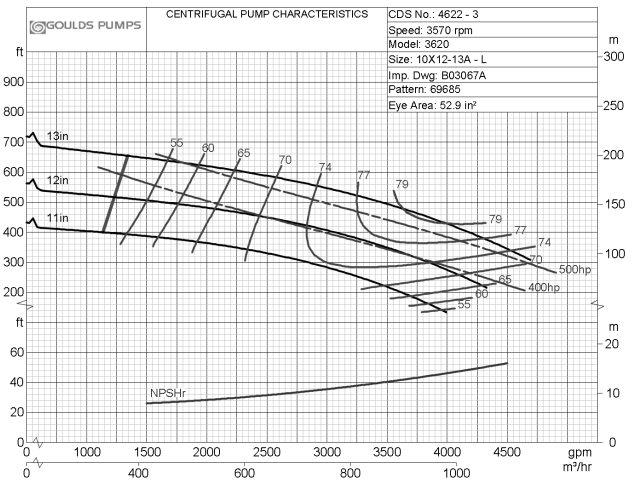


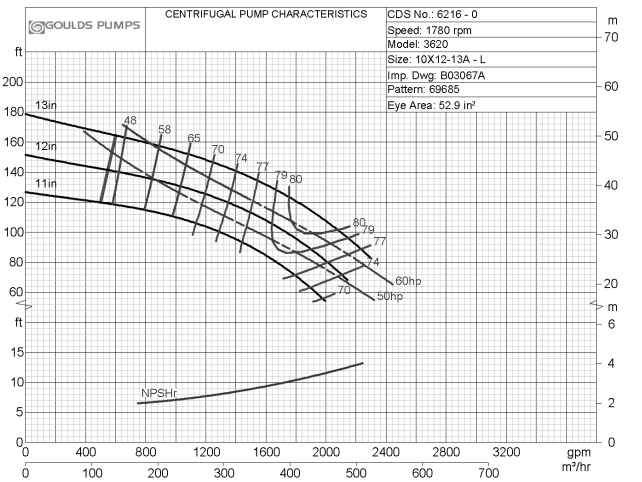
8X10-13SA **3570rpm**



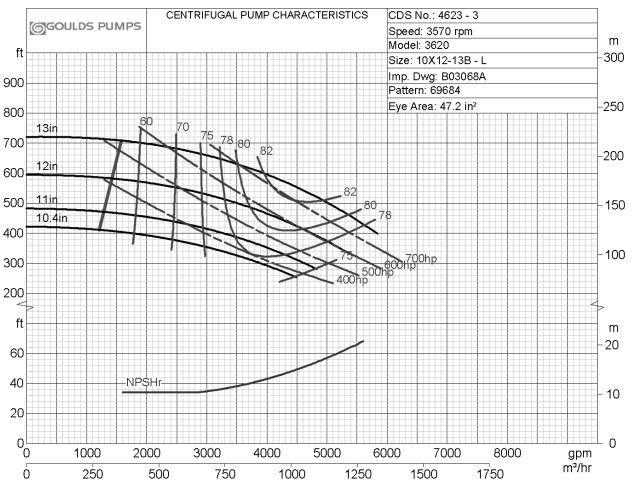
8X10-13SA **1785rpm**



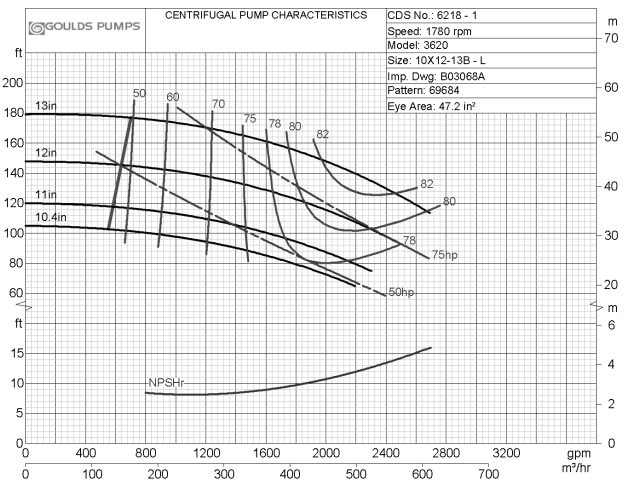
10X12-13A **3570rpm**



10X12-13A **1780rpm**



10X12-13B **3570rpm**

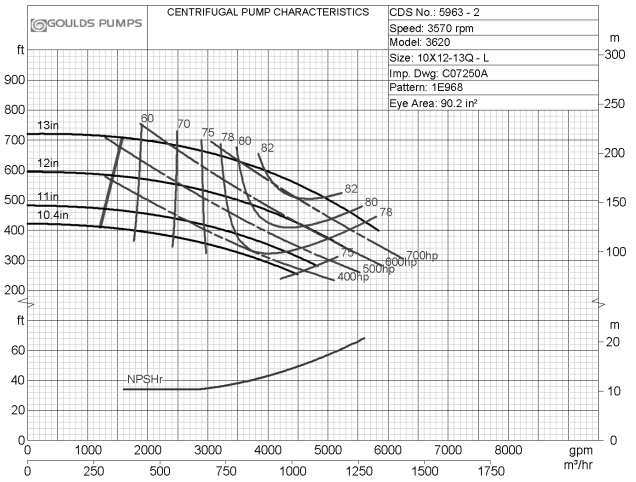


10X12-13B **1780rpm**

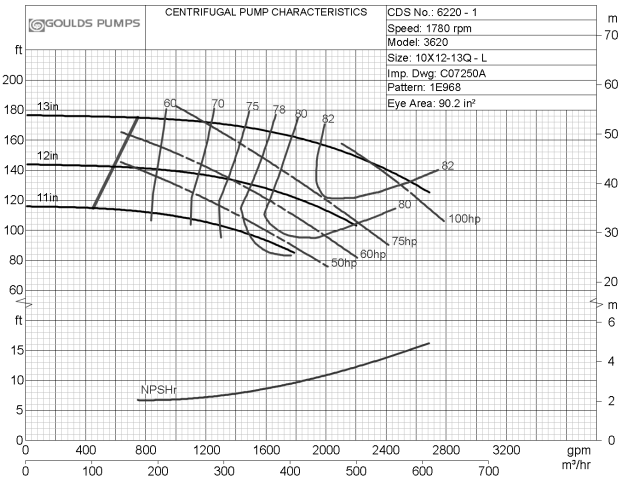
60Hz Curves

Model 3620

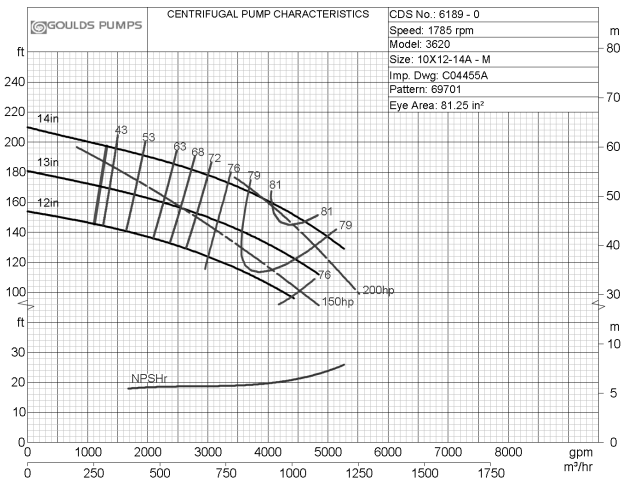
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



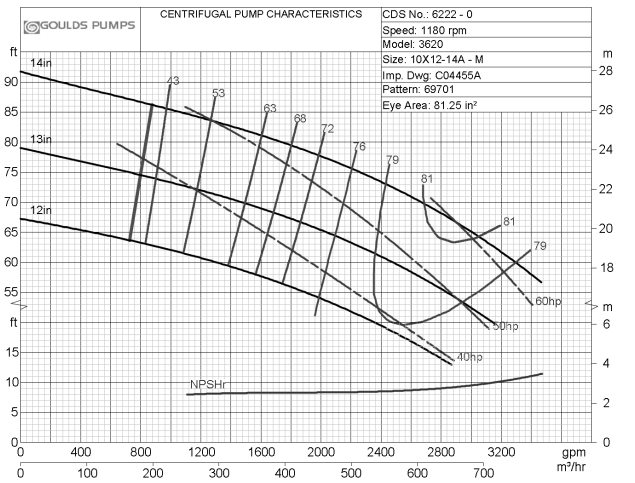
10X12-13Q **3570rpm**



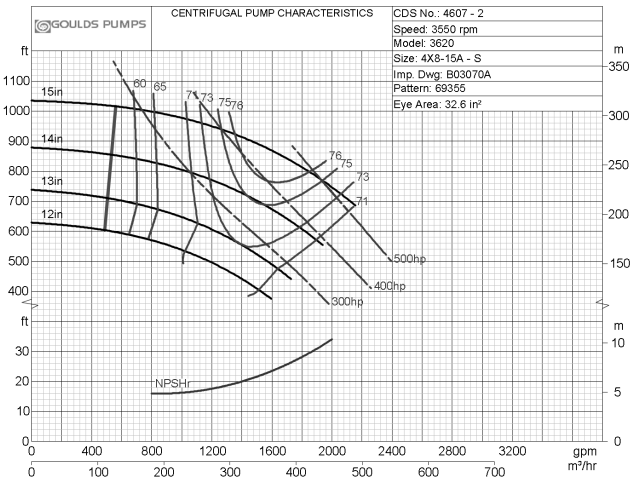
10X12-13Q **1780rpm**



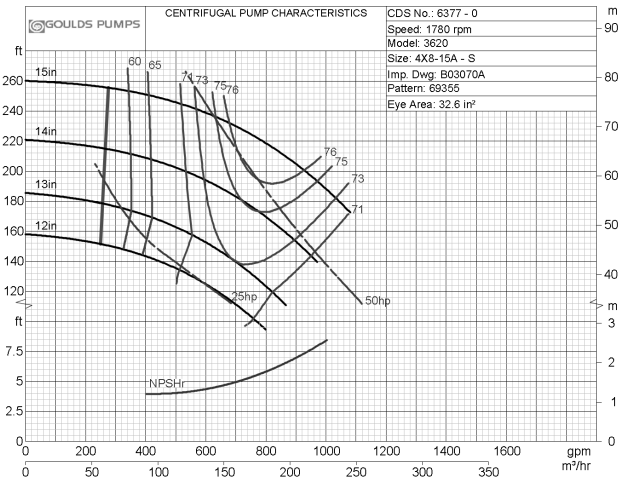
10X12-14A **1785rpm**



10X12-14A **1180rpm**

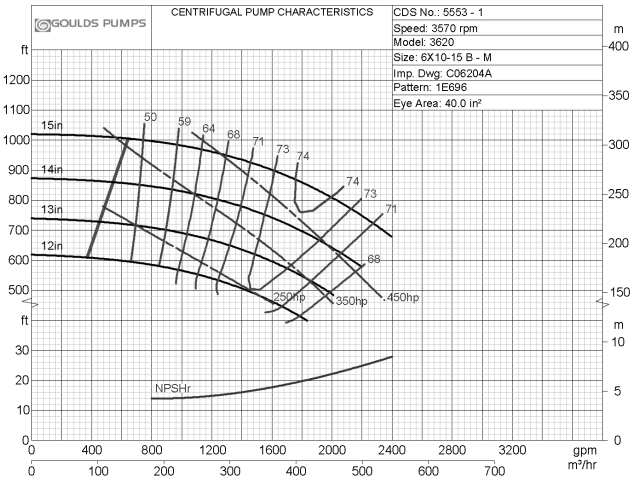


4X8-15A **3550rpm**

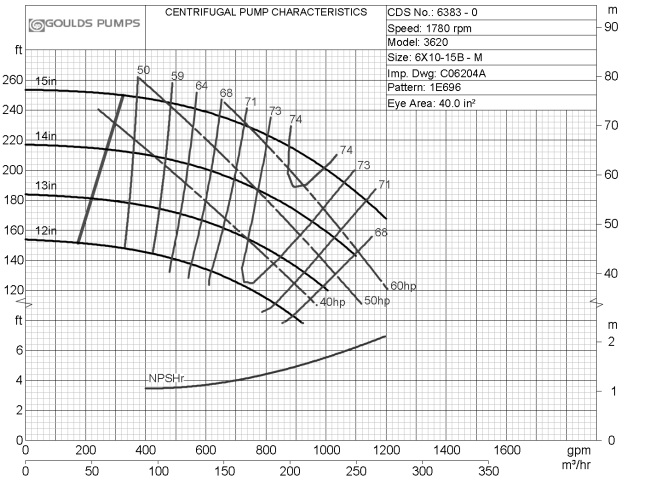


4X8-15A **1780rpm**

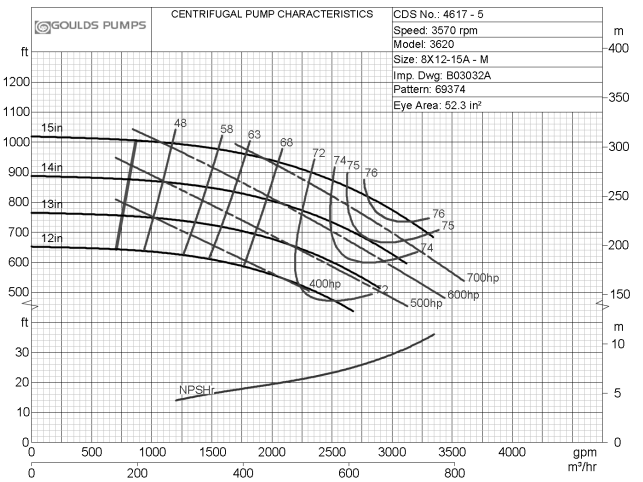
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



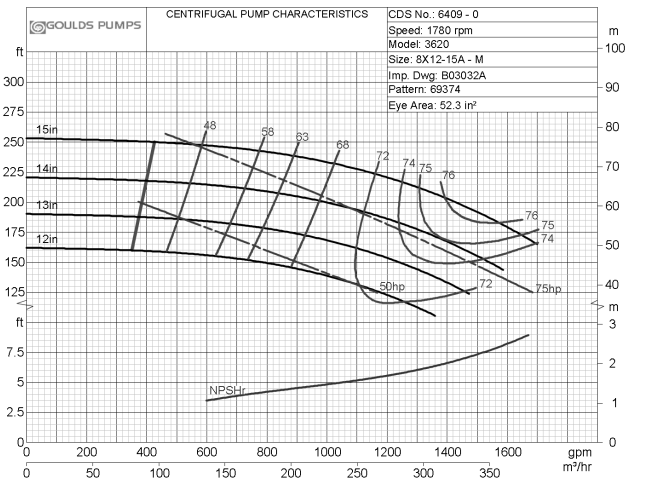
6X10-15 B **3570rpm**



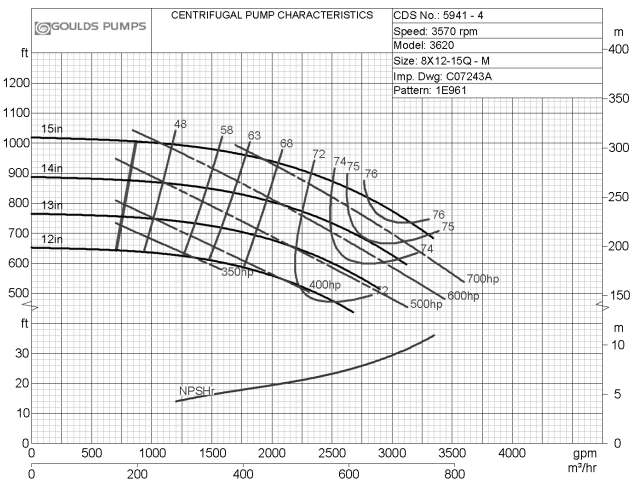
6X10-15B **1780rpm**



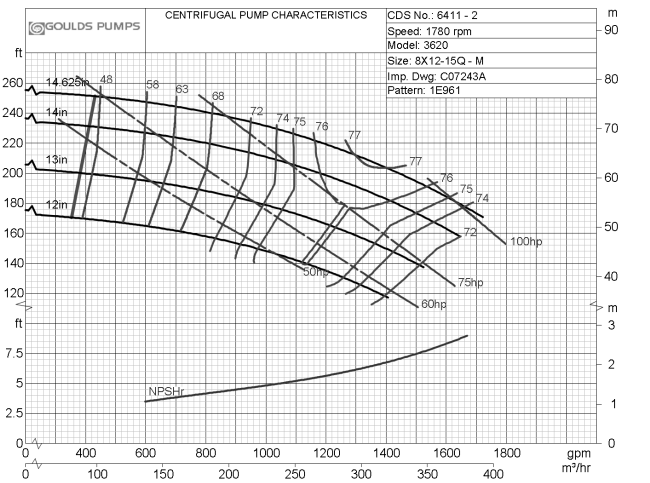
8X12-15A **3570rpm**



8X12-15A **1780rpm**



8X12-15Q **3570rpm**

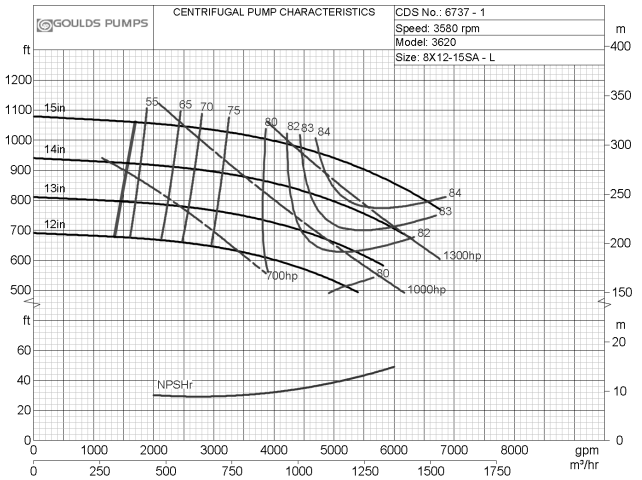


8X12-15Q **1780rpm**

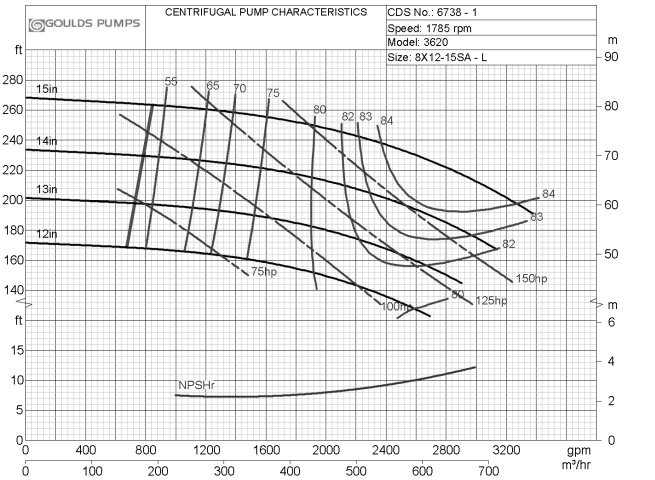
60Hz Curves

Model 3620

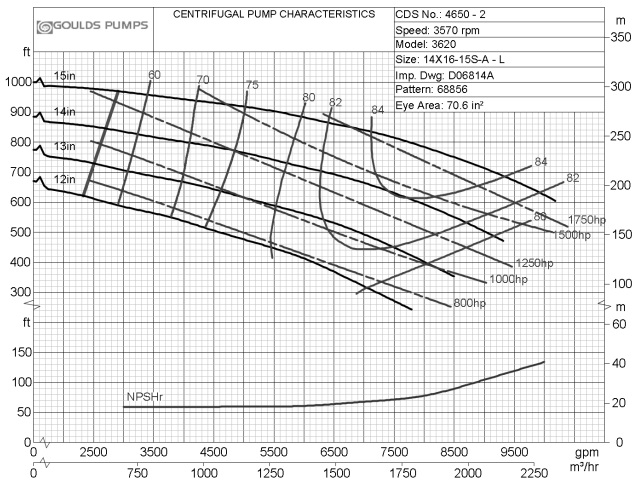
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



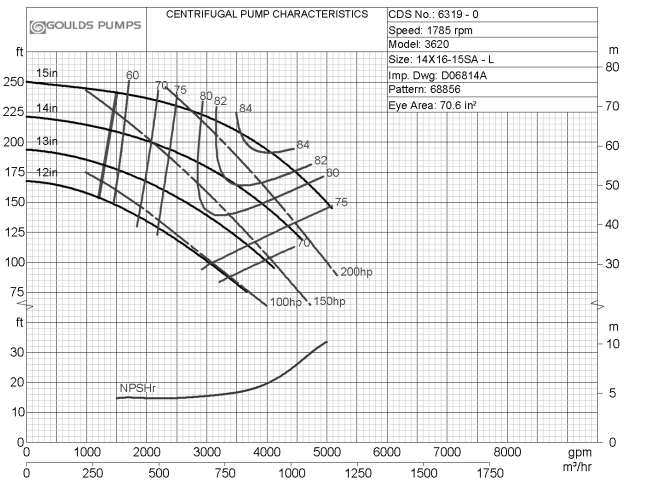
8X12-15SA **3580rpm**



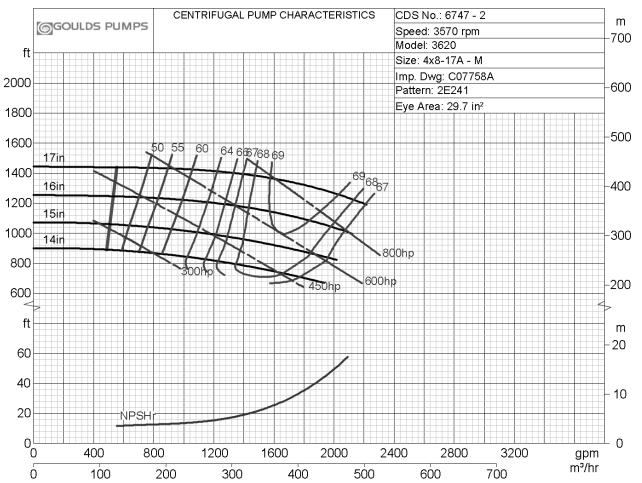
8X12-15SA **1785rpm**



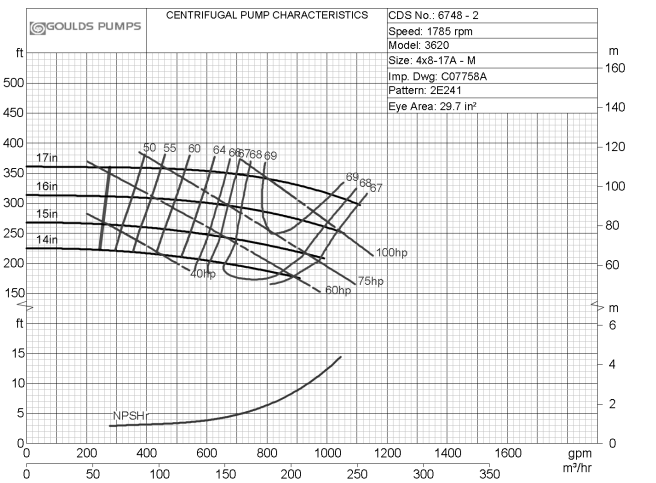
14X16-15S-A **3570rpm**



14X16-15SA **1785rpm**

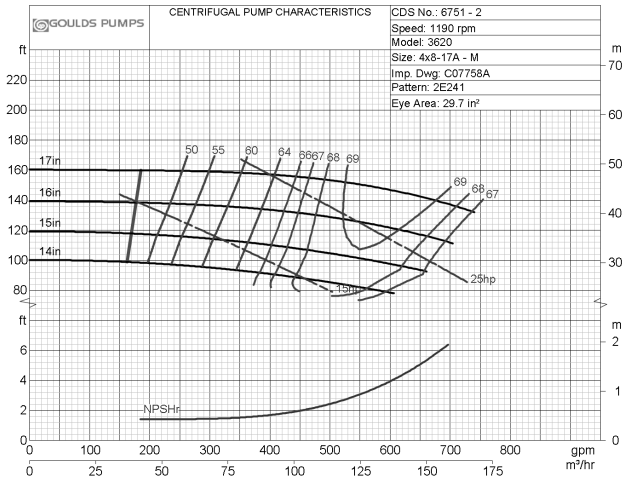


4x8-17A **3570rpm**

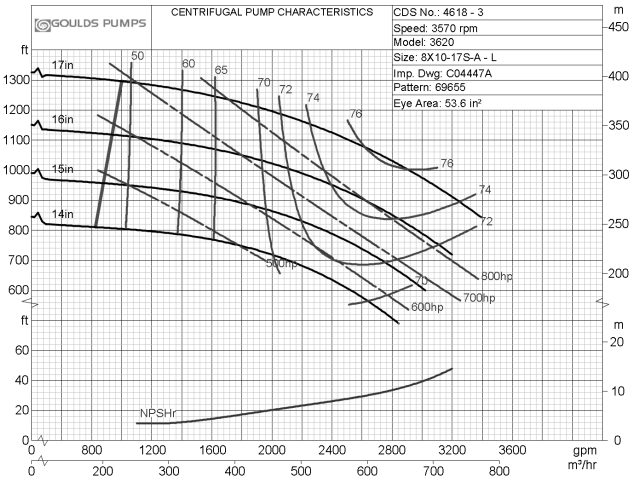


4x8-17A **1785rpm**

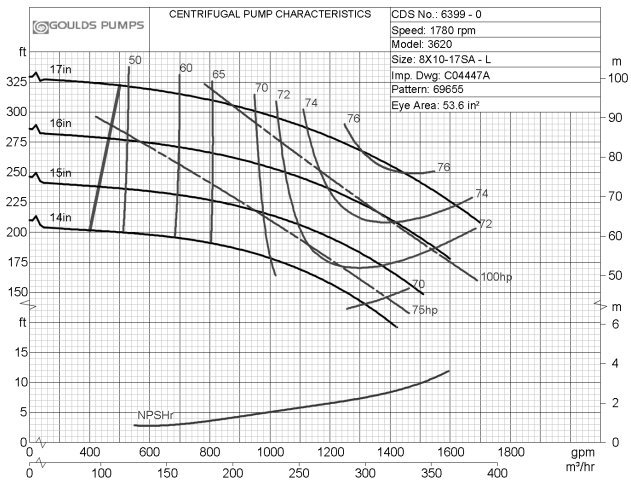
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



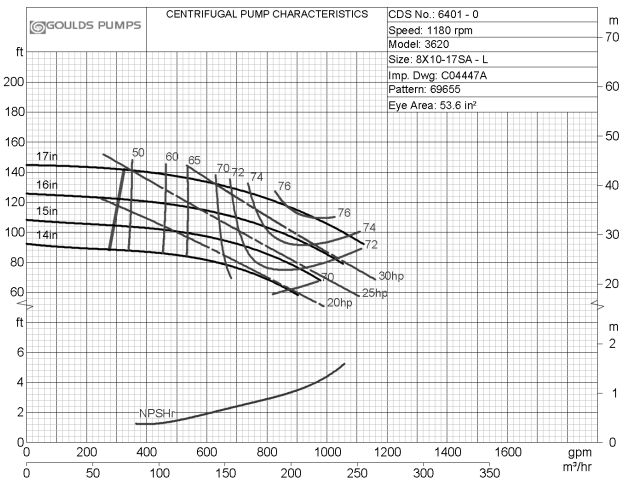
4x8-17A **1190rpm**



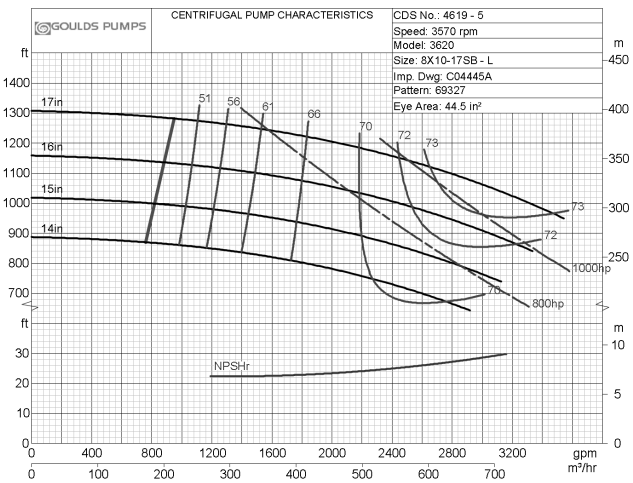
8X10-17S-A **3570rpm**



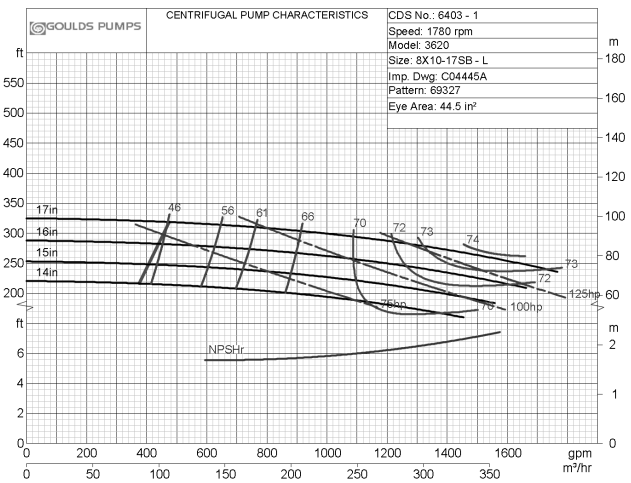
8X10-17SA **1780rpm**



8X10-17SA **1180rpm**



8X10-17SB **3570rpm**

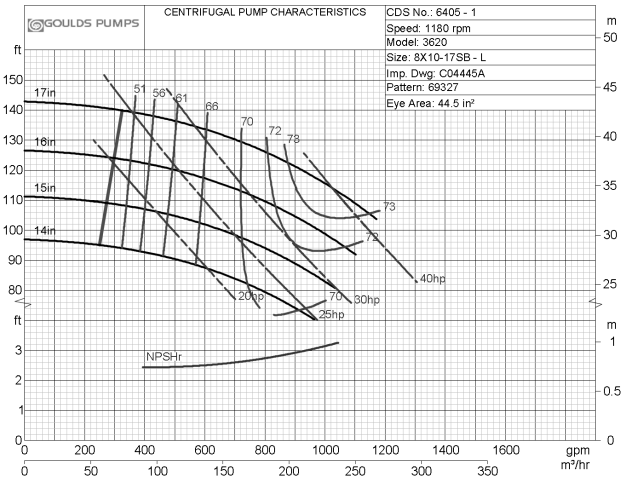


8X10-17SB **1780rpm**

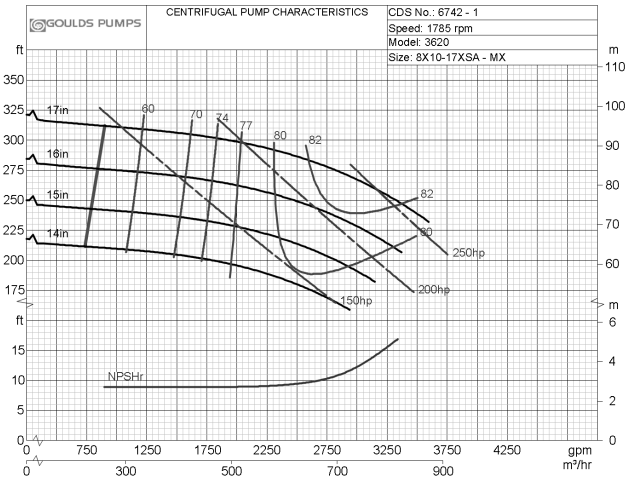
60Hz Curves

Model 3620

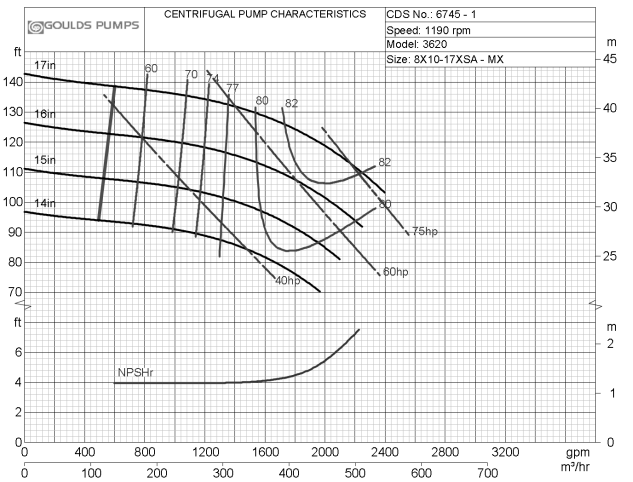
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



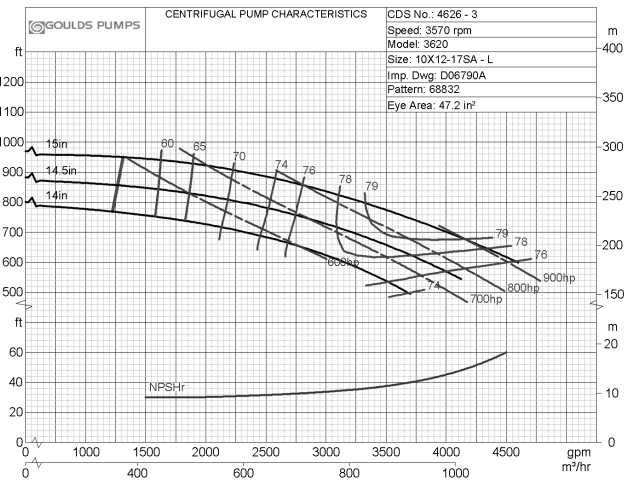
8X10-17SB **1180rpm**



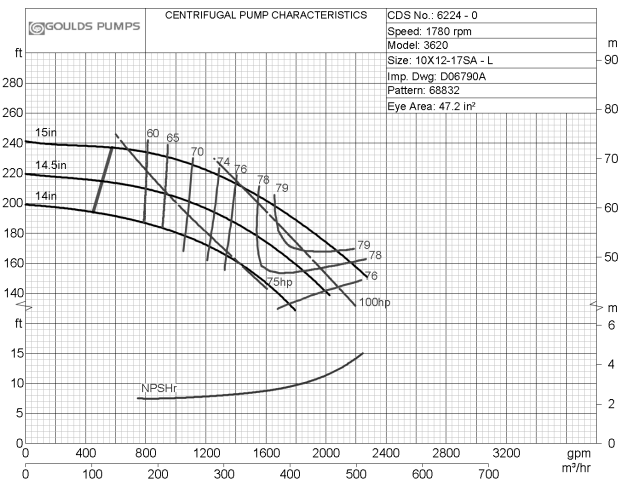
8X10-17XSA **1785rpm**



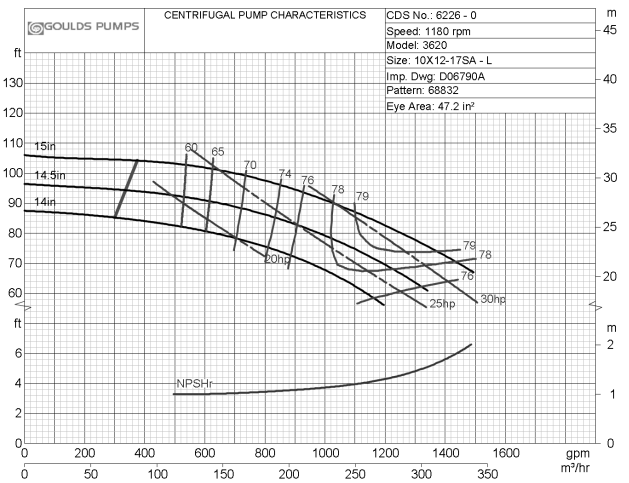
8X10-17XSA **1190rpm**



10X12-17SA **3570rpm**

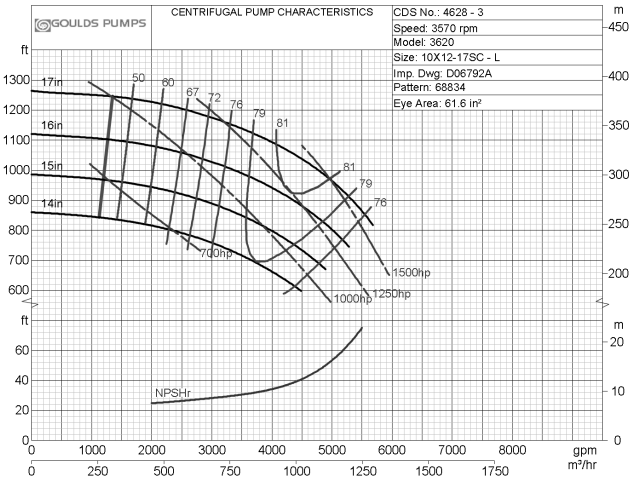


10X12-17SA **1780rpm**

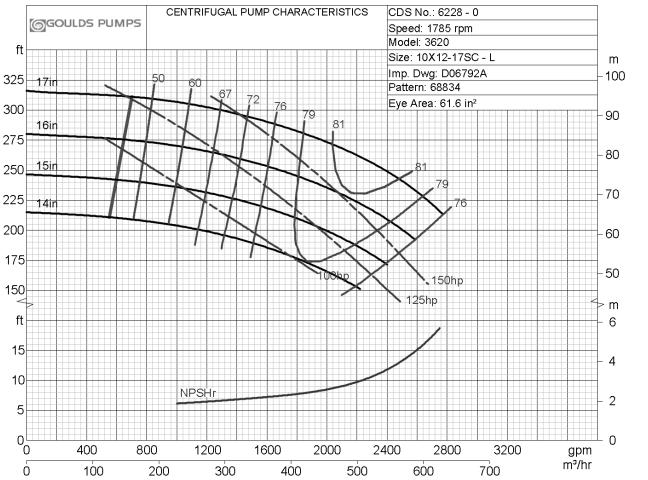


10X12-17SA **1180rpm**

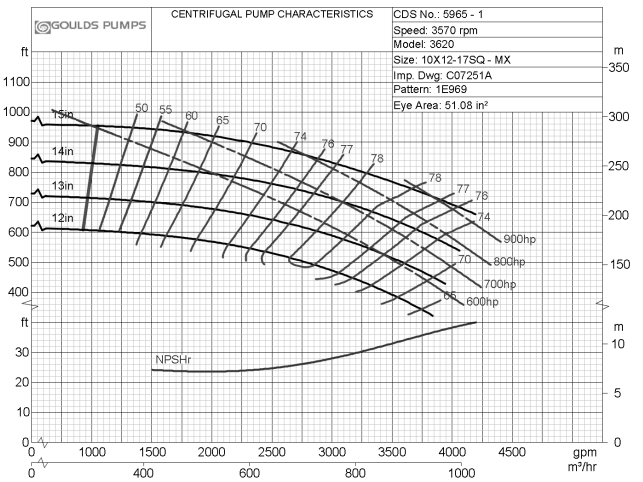
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



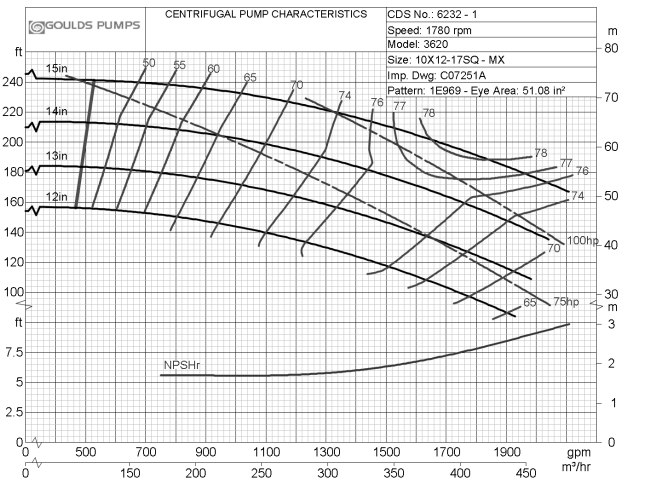
10X12-17SC **3570rpm**



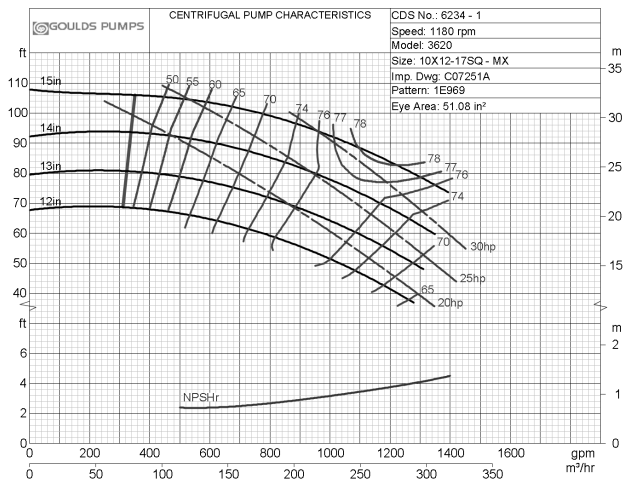
10X12-17SC **1785rpm**



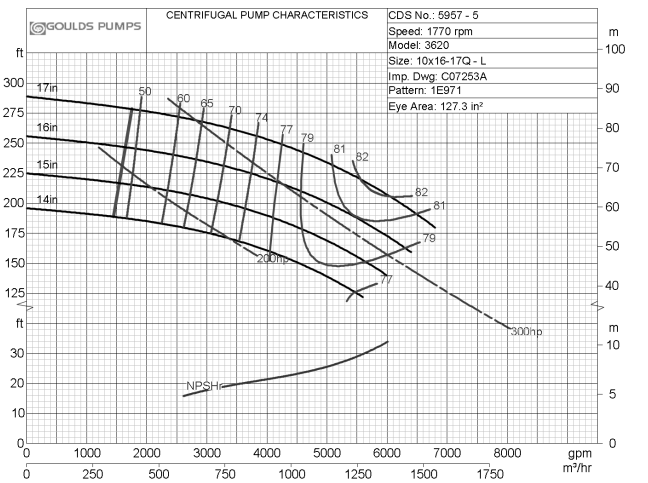
10X12-17SQ **3570rpm**



10X12-17SQ **1780rpm**



10X12-17SQ **1180rpm**

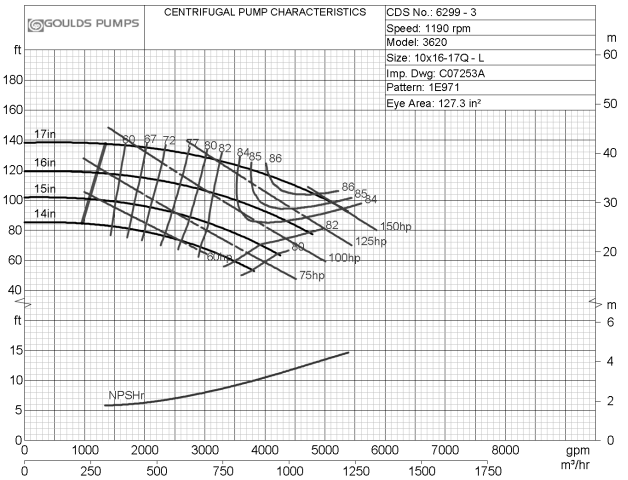


10x16-17Q **1770rpm**

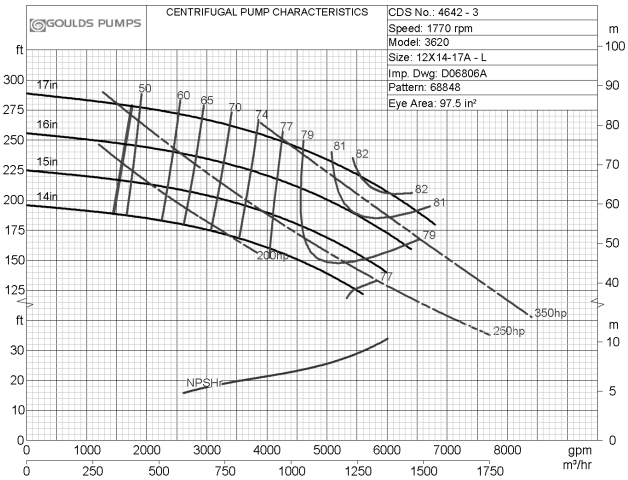
60Hz Curves

Model 3620

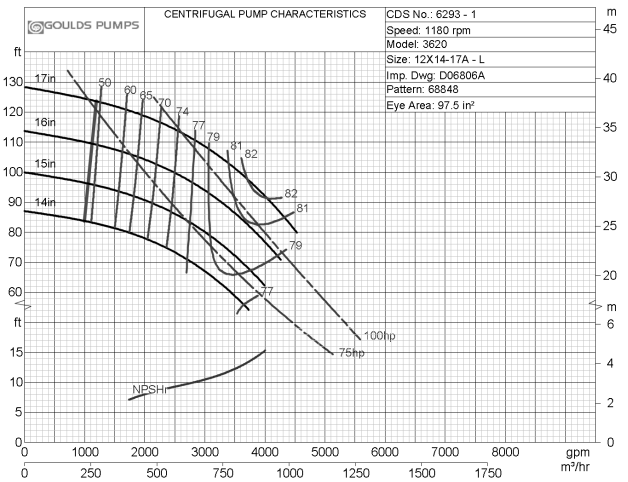
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



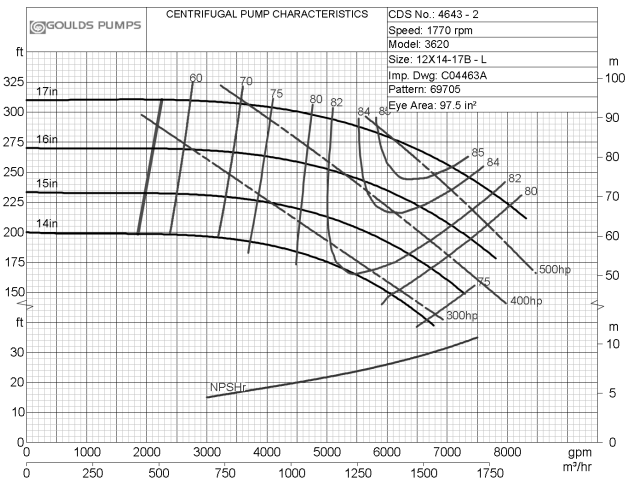
10x16-17Q **1190rpm**



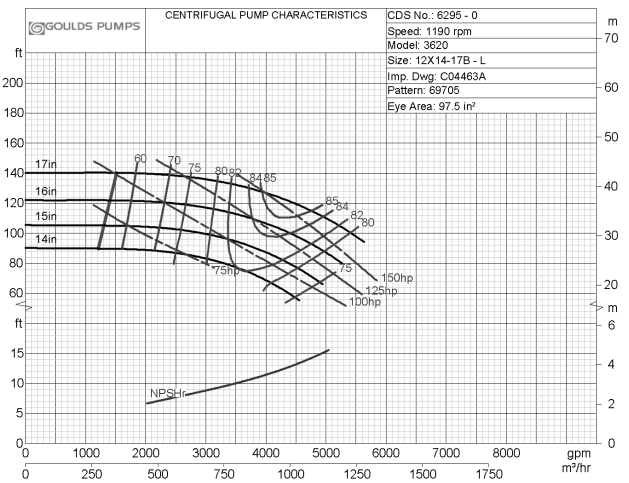
12X14-17A **1770rpm**



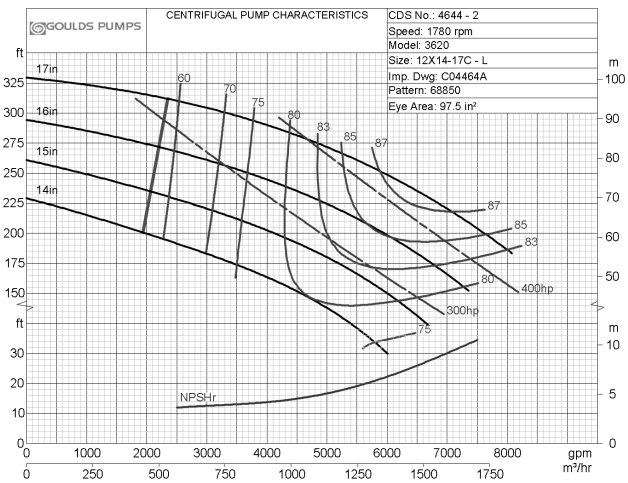
12X14-17A **1180rpm**



12X14-17B **1770rpm**

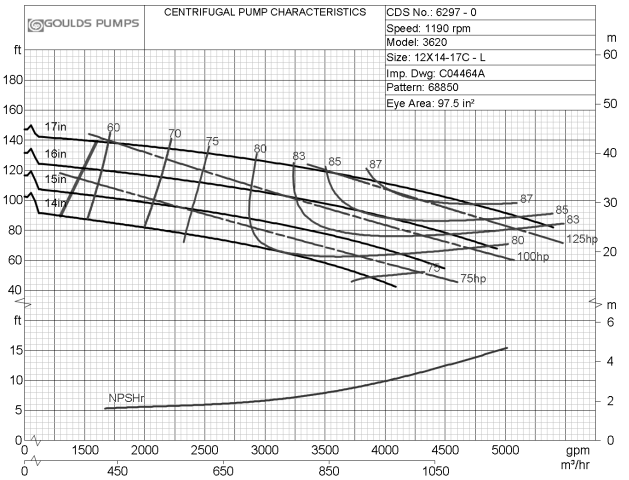


12X14-17B **1190rpm**

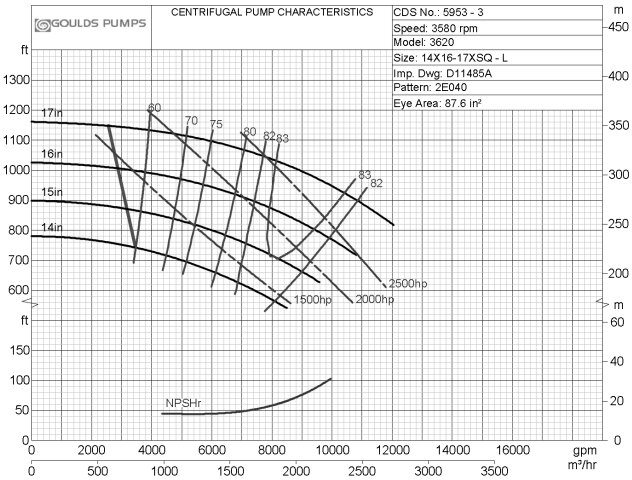


12X14-17C **1780rpm**

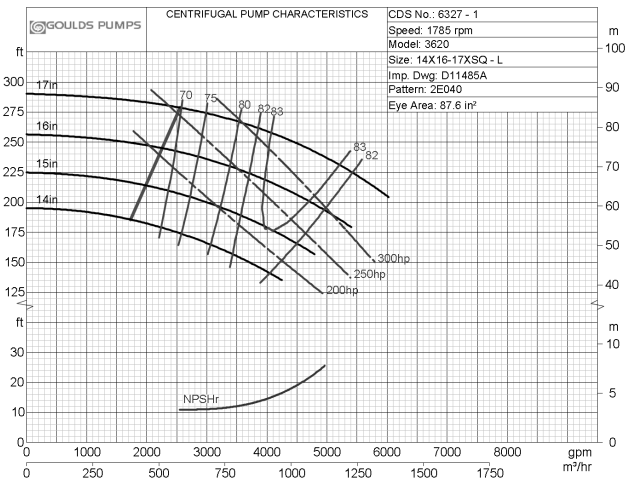
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



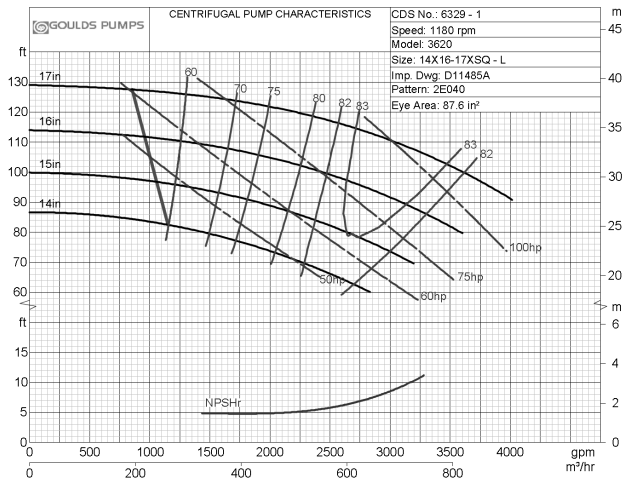
12X14-17C **1190rpm**



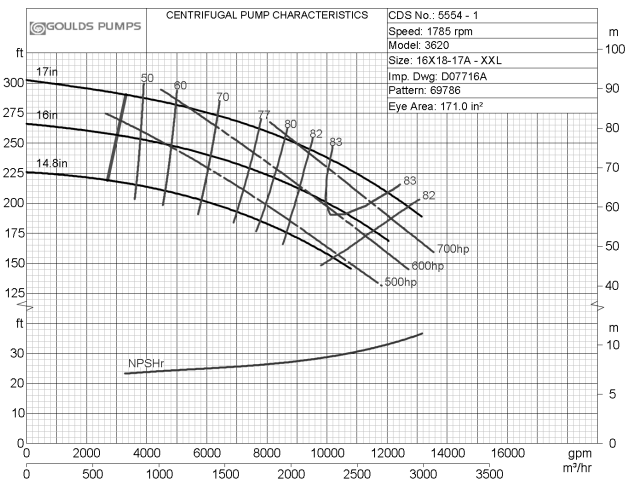
14X16-17XSQ **3580rpm**



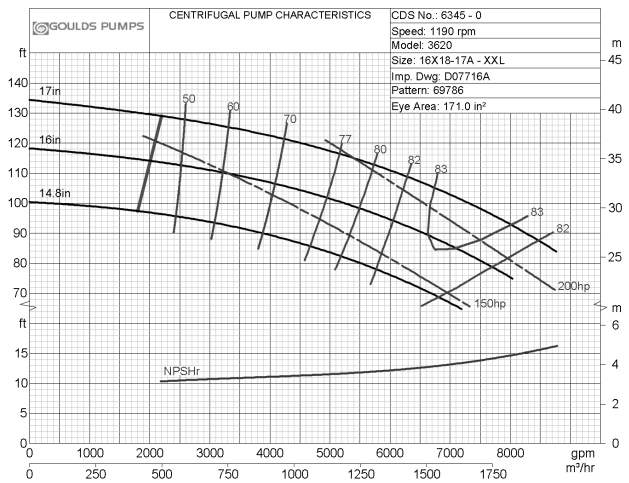
14X16-17XSQ **1785rpm**



14X16-17XSQ **1180rpm**

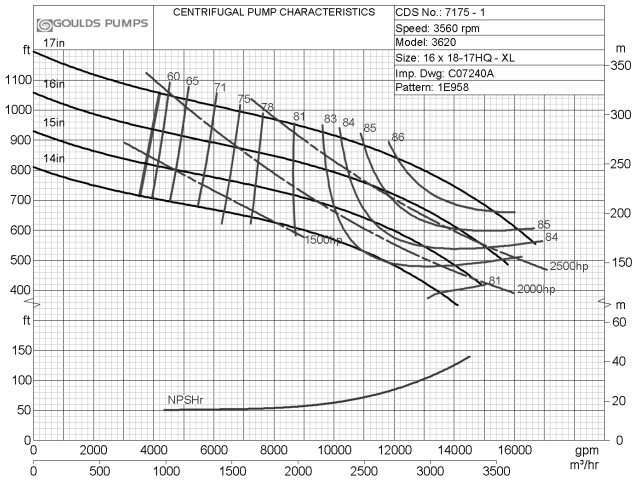


16X18-17A **1785rpm**

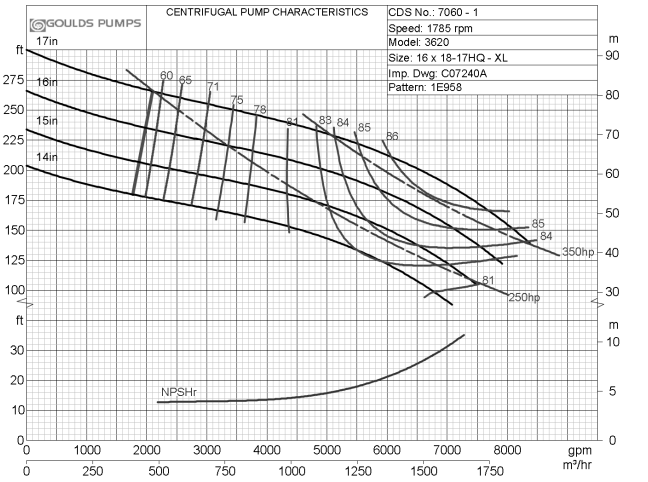


16X18-17A **1190rpm**

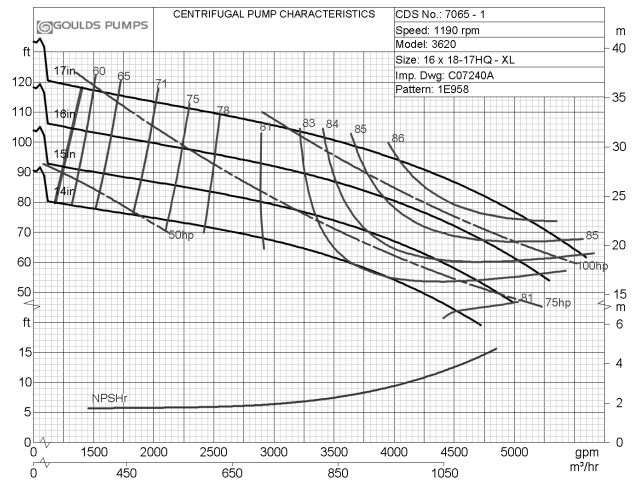
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



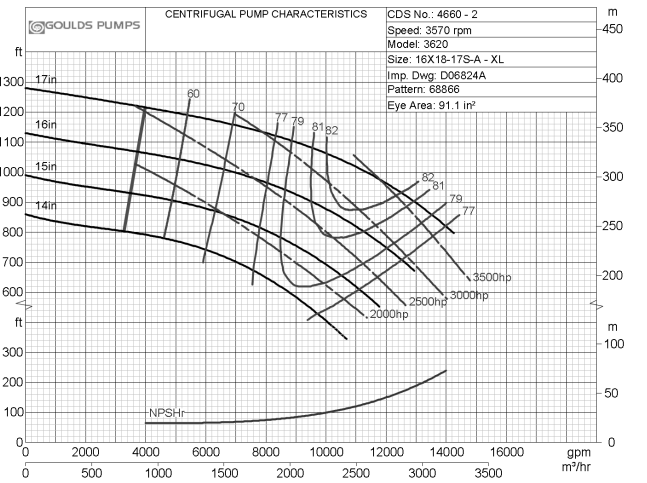
16 x 18-17HQ **3560rpm**



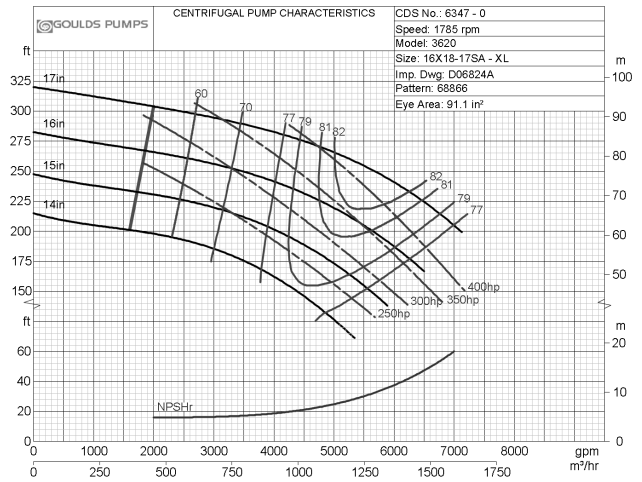
16 x 18-17HQ **1785rpm**



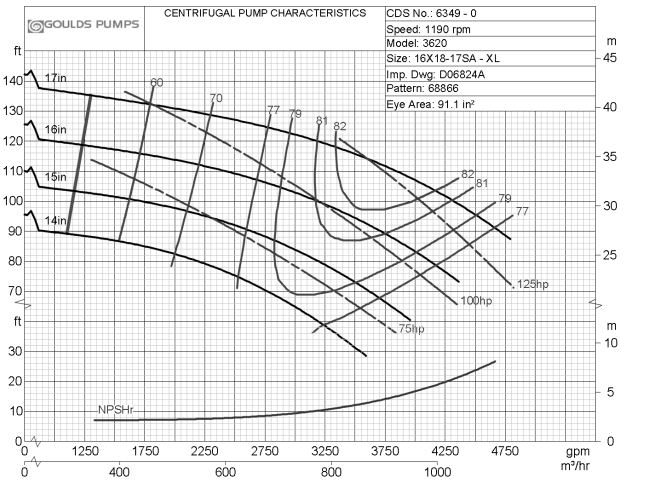
16 x 18-17HQ **1190rpm**



16X18-17S-A **3570rpm**

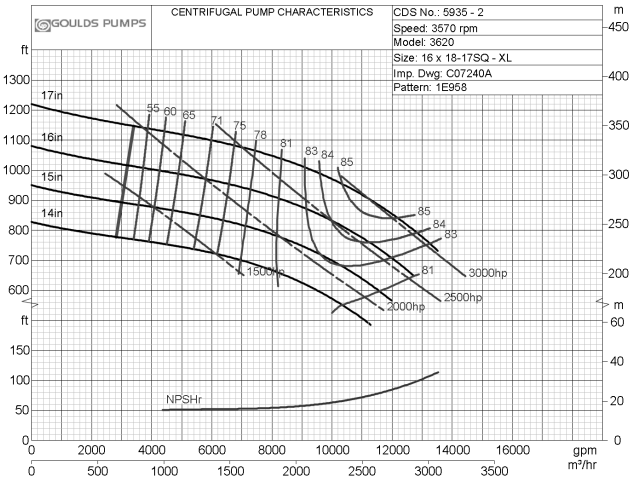


16X18-17SA **1785rpm**

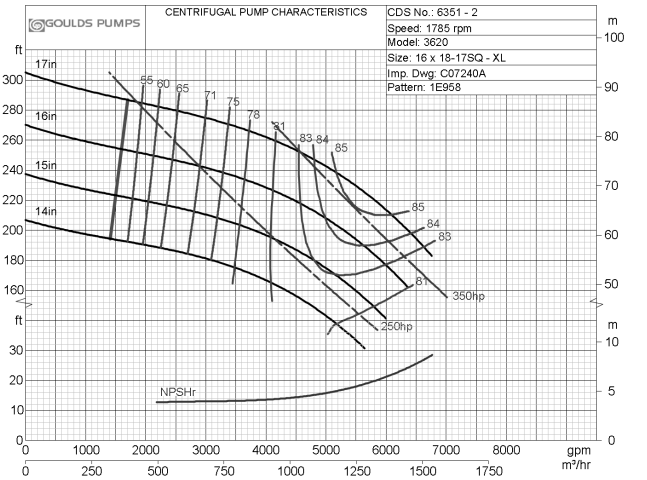


16X18-17SA **1190rpm**

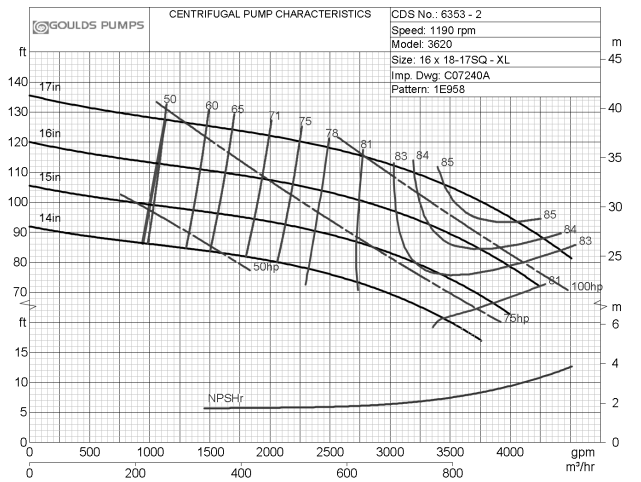
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



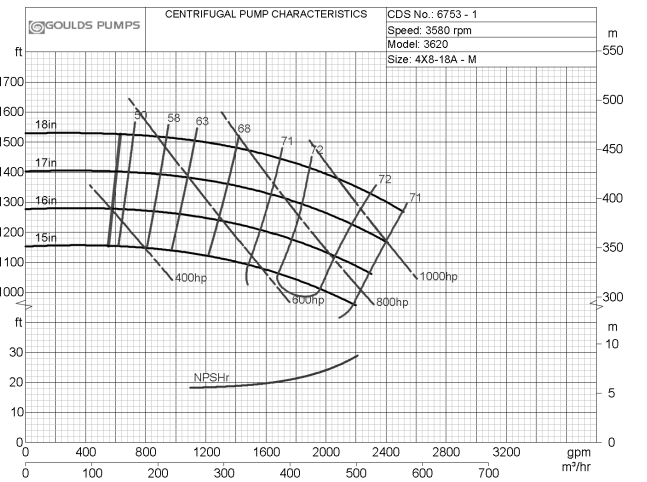
16 x 18-17SQ **3570rpm**



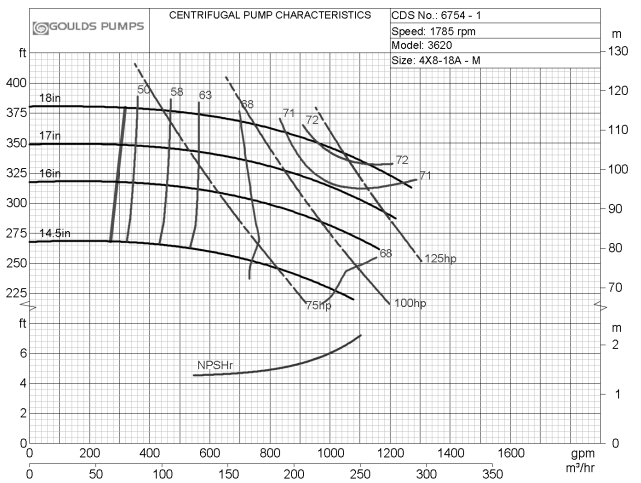
16 x 18-17SQ **1785rpm**



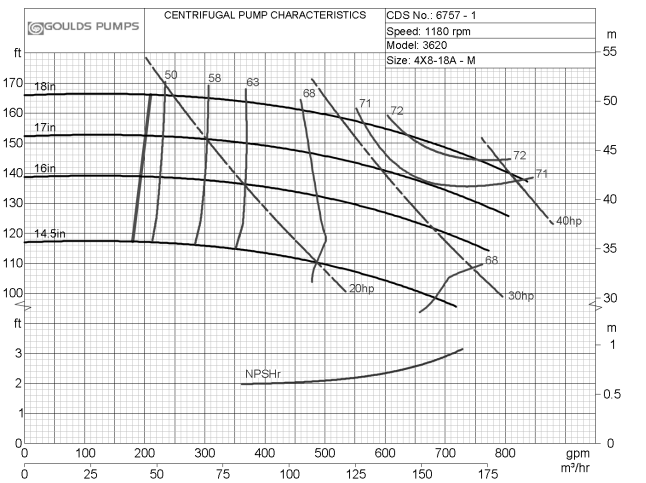
16 x 18-17SQ **1190rpm**



4X8-18A **3580rpm**



4X8-18A **1785rpm**

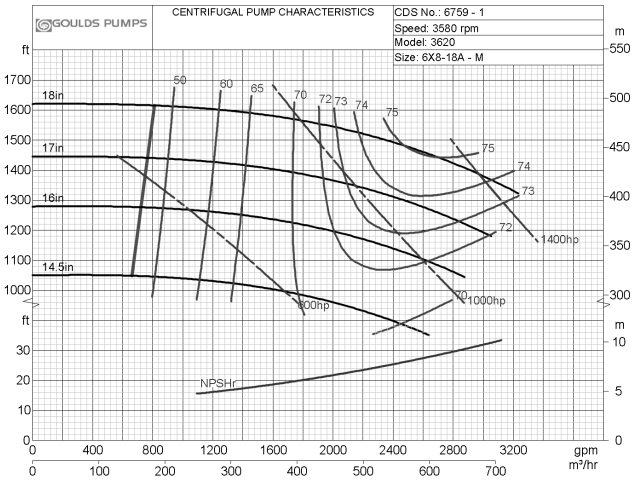


4X8-18A **1180rpm**

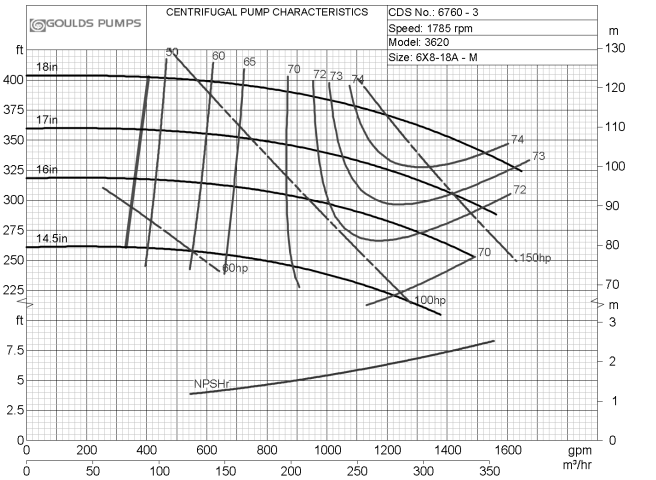
60Hz Curves

Model 3620

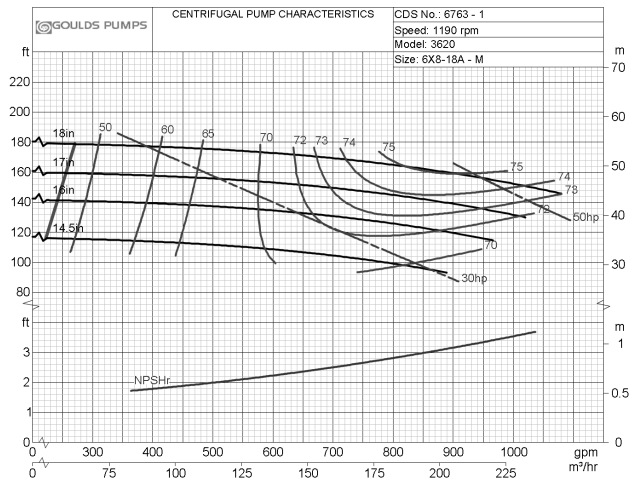
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



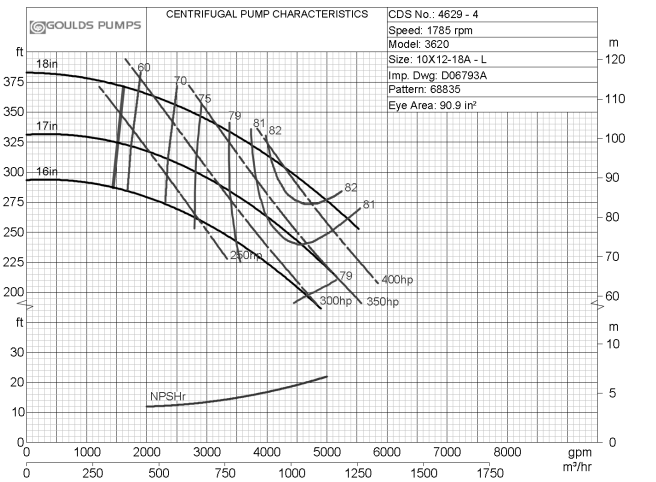
6X8-18A **3580rpm**



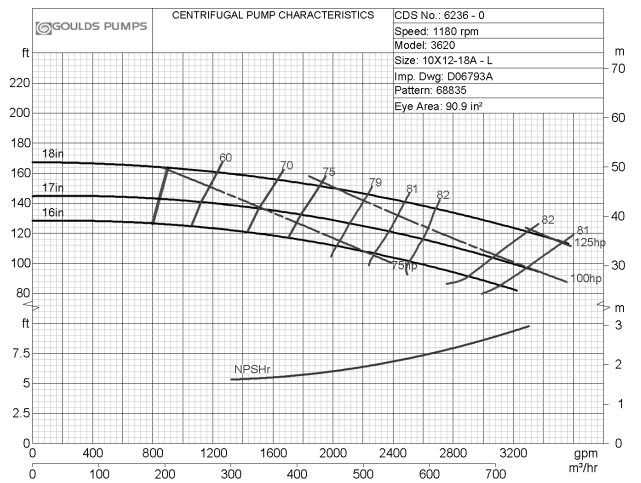
6X8-18A **1785rpm**



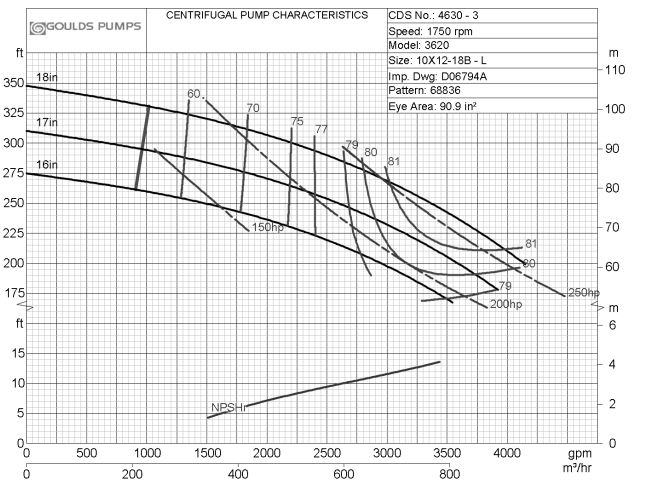
6X8-18A **1190rpm**



10X12-18A **1785rpm**

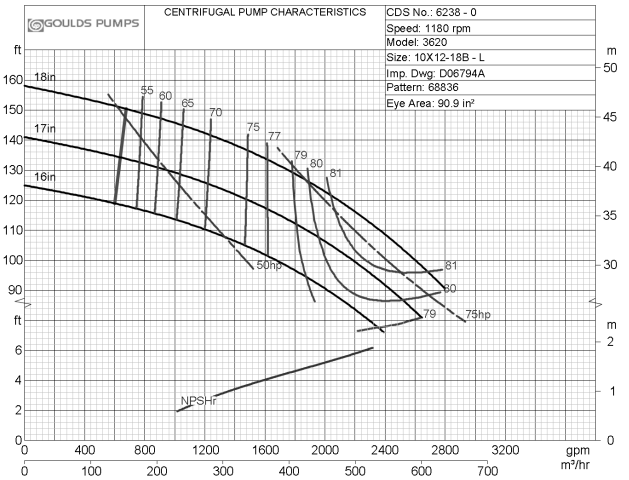


10X12-18A **1180rpm**

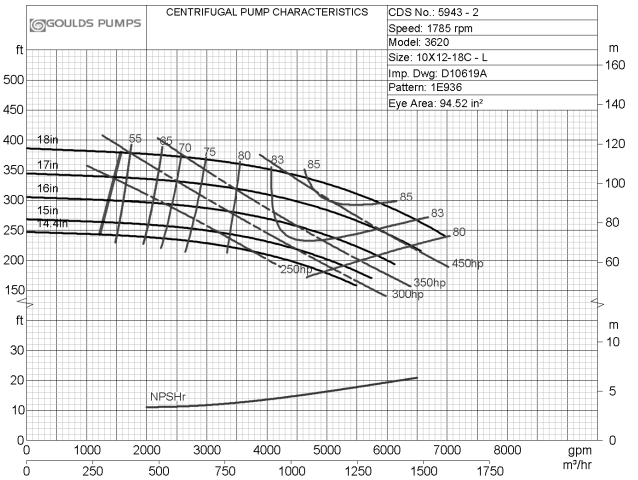


10X12-18B **1750rpm**

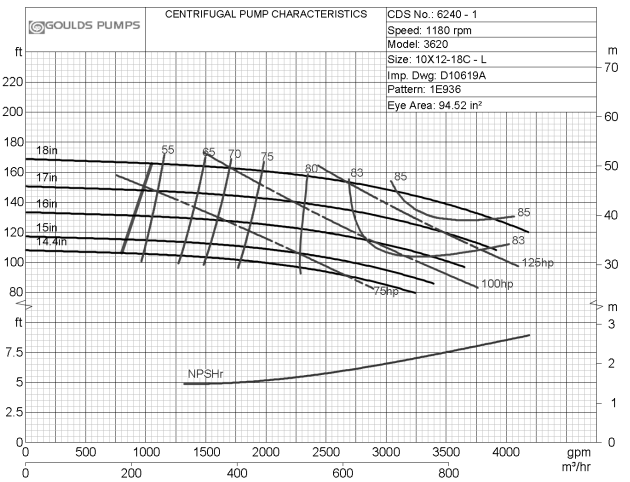
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



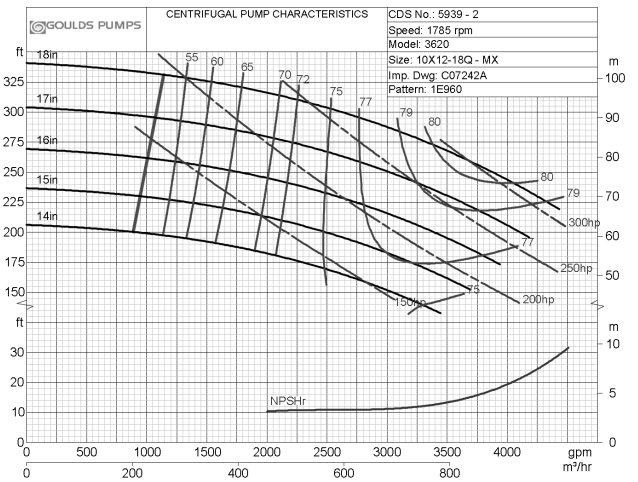
10X12-18B **1180rpm**



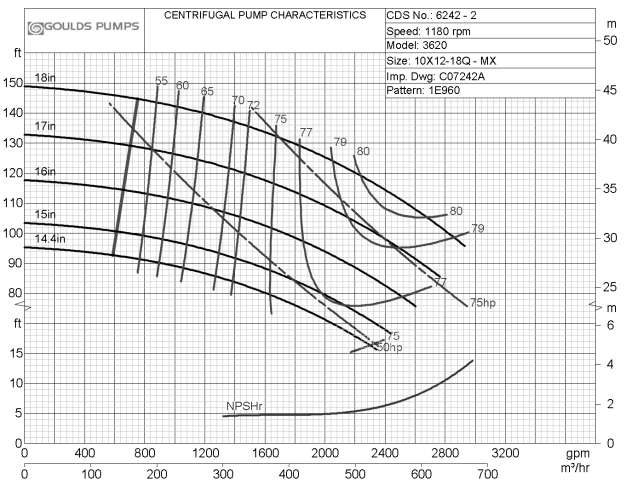
10X12-18C **1785rpm**



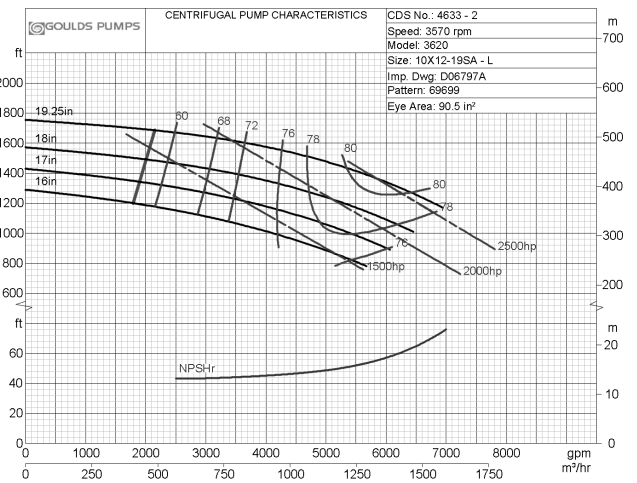
10X12-18C **1180rpm**



10X12-18Q **1785rpm**

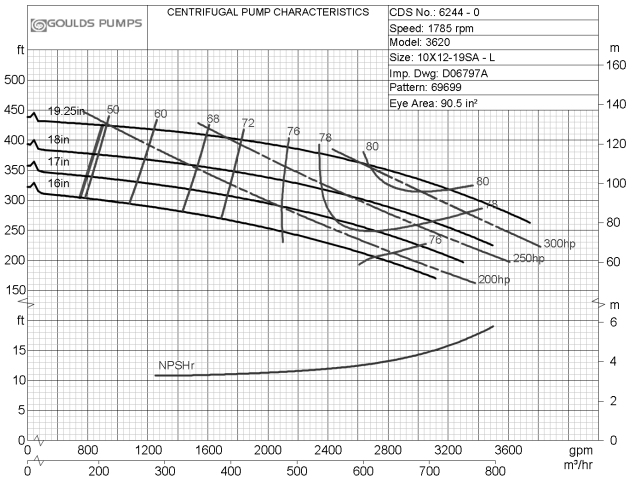


10X12-18Q **1180rpm**

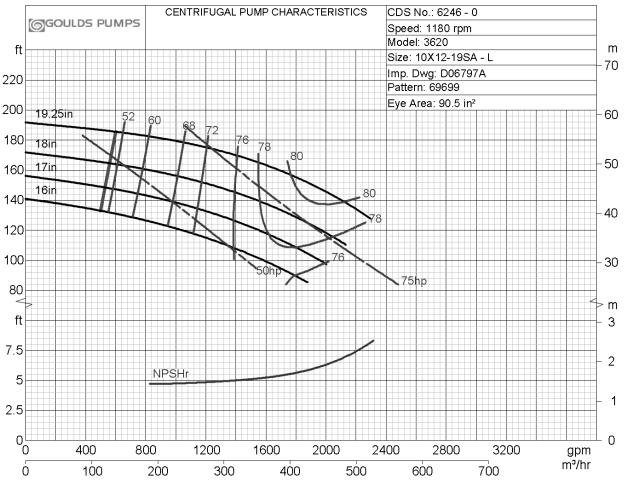


10X12-19SA **3570rpm**

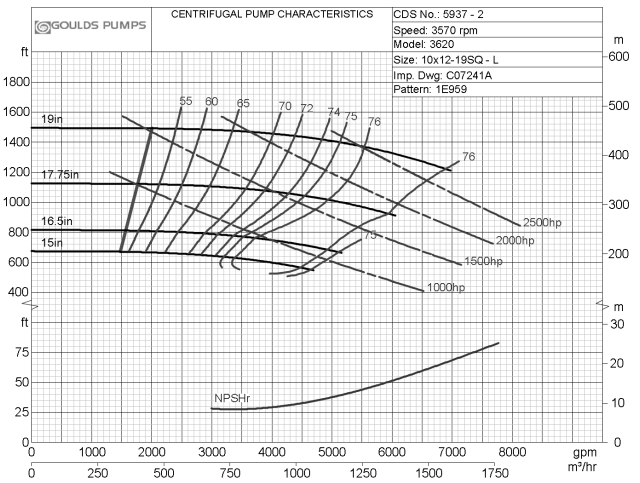
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



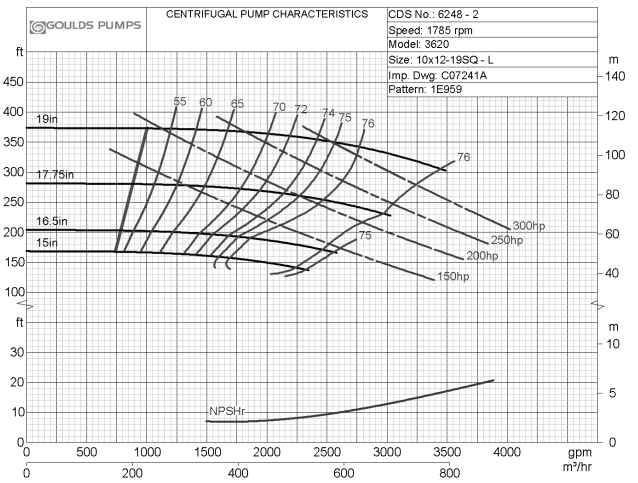
10X12-19SA **1785rpm**



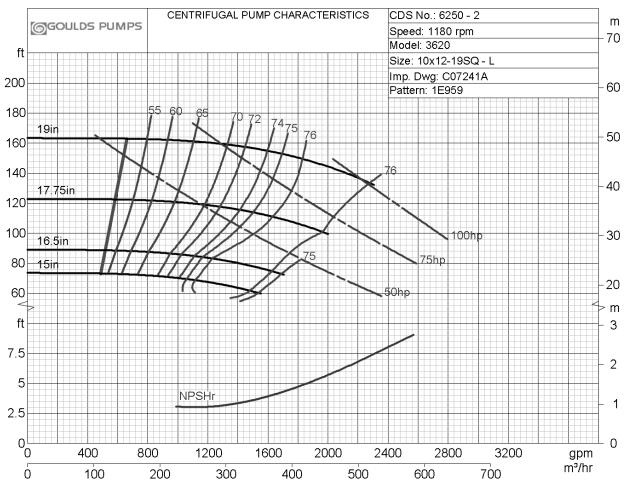
10X12-19SA **1180rpm**



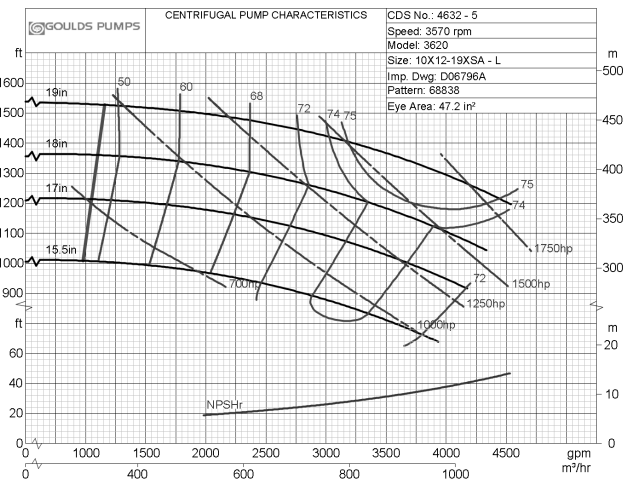
10x12-19SQ **3570rpm**



10x12-19SQ **1785rpm**



10x12-19SQ **1180rpm**



10X12-19XSA **3570rpm**

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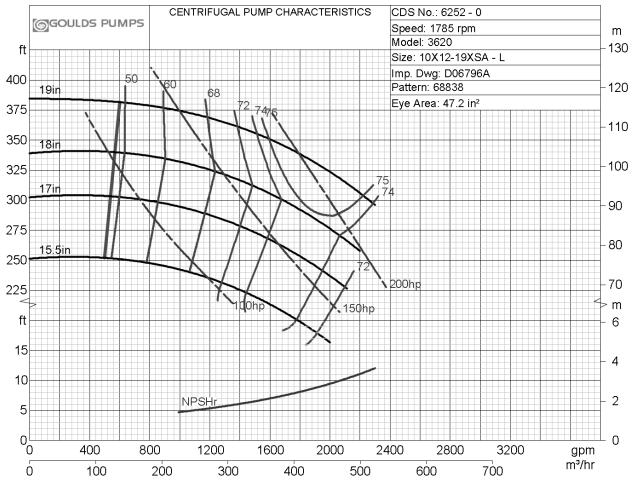
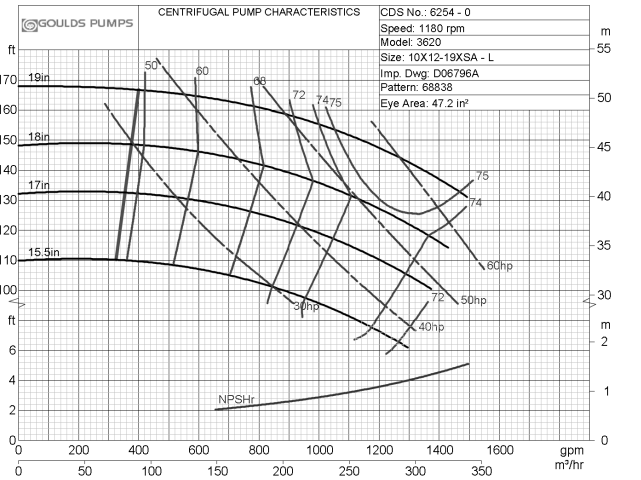
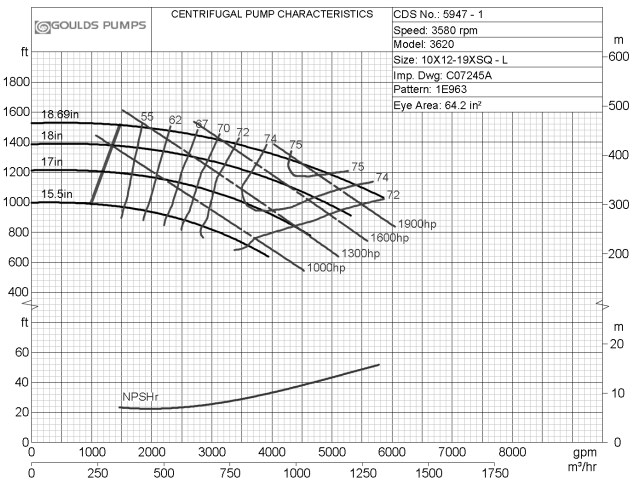


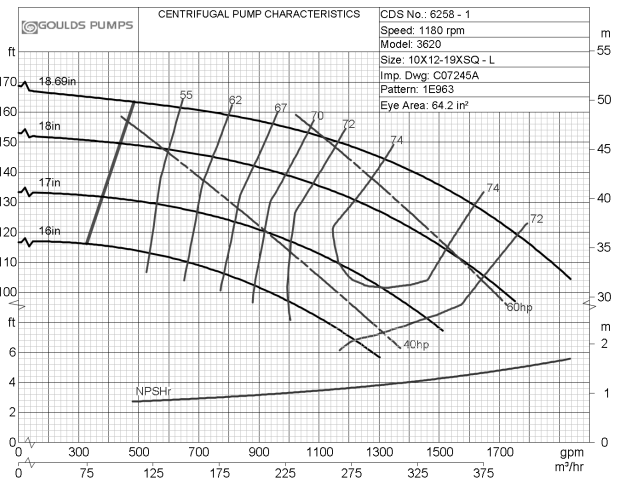
10X12-19XSA **1785rpm**



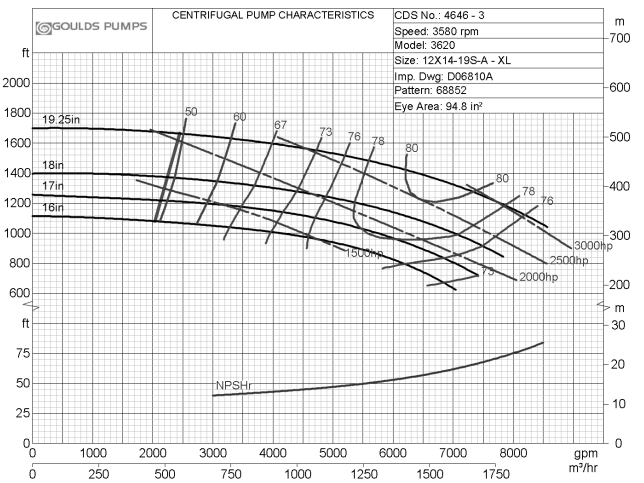
10X12-19XSA **1180rpm**



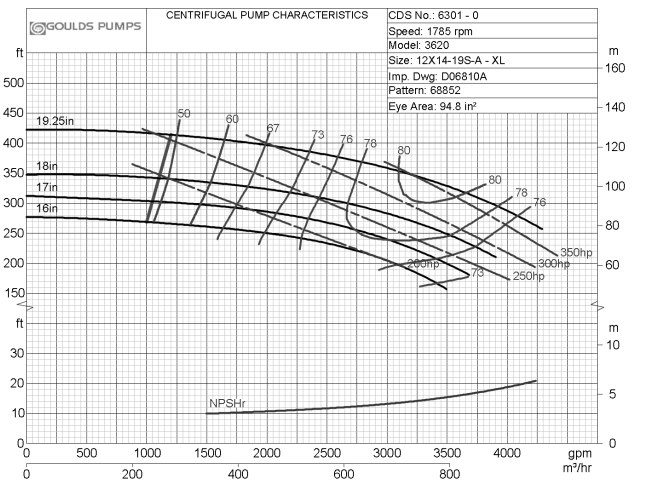
10X12-19XSQ **3580rpm**



10X12-19XSQ **1180rpm**



12X14-19S-A **3580rpm**



12X14-19S-A **1785rpm**

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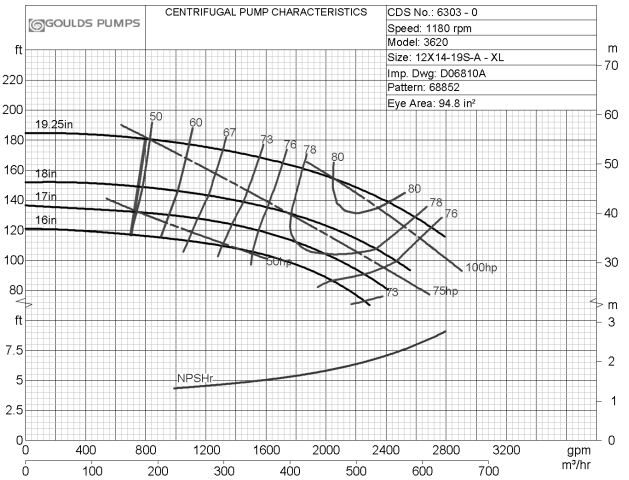
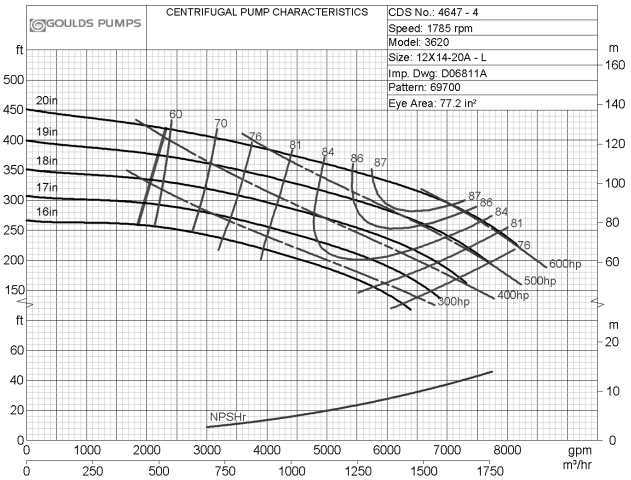
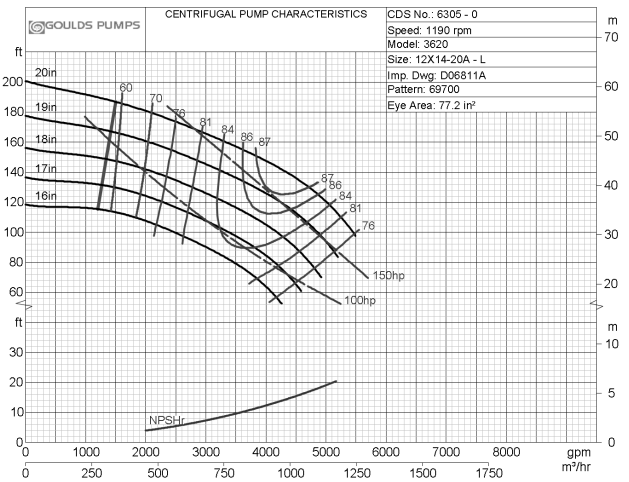


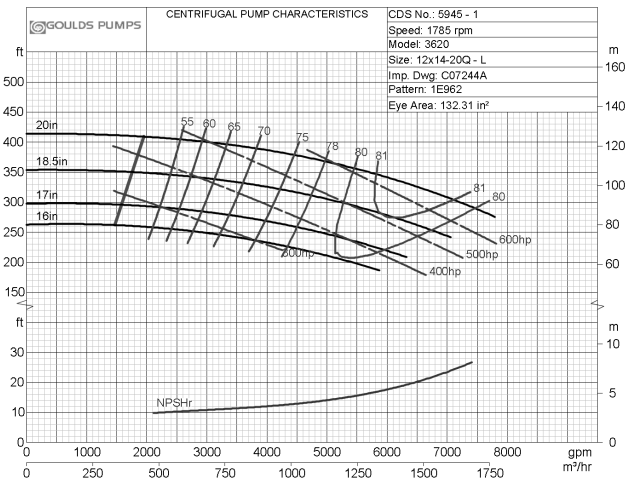
12X14-19S-A **1180rpm**



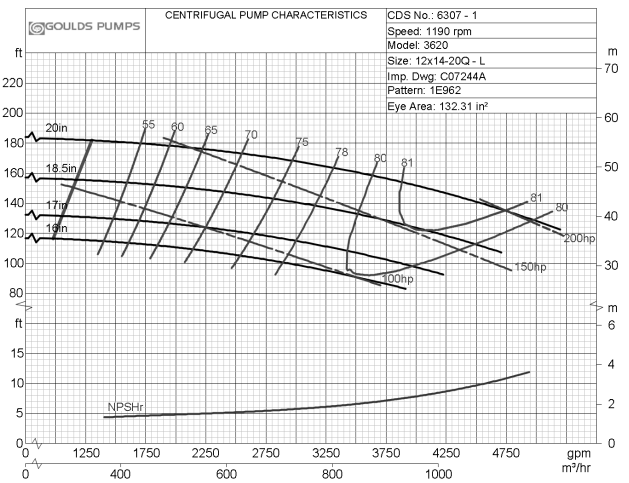
12X14-20A **1785rpm**



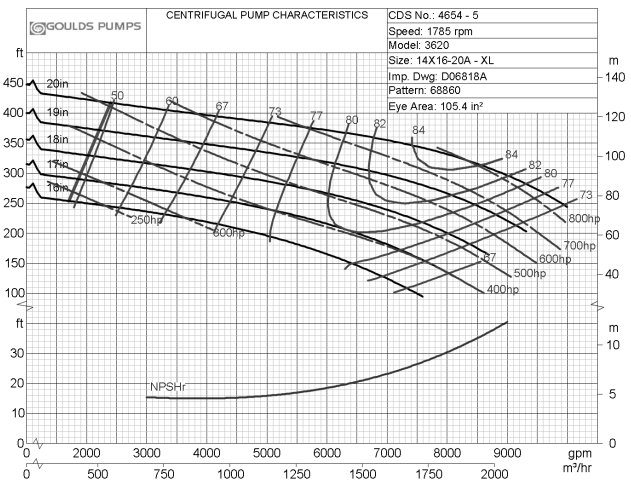
12X14-20A **1190rpm**



12x14-20Q **1785rpm**



12x14-20Q **1190rpm**



14X16-20A **1785rpm**

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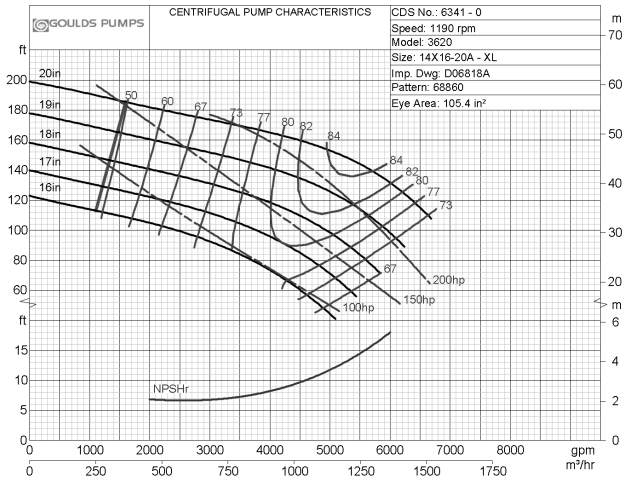
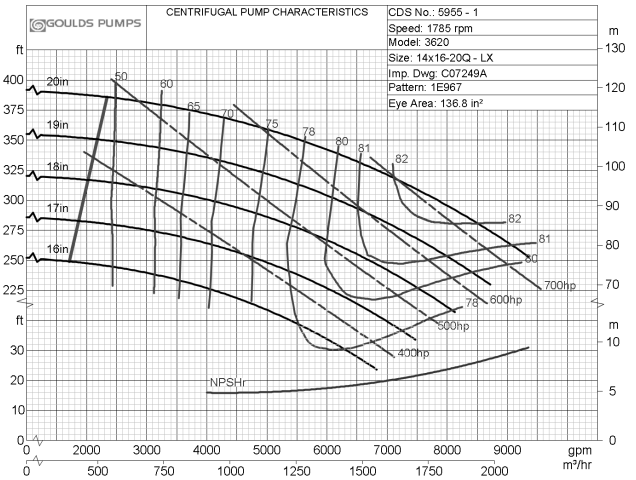
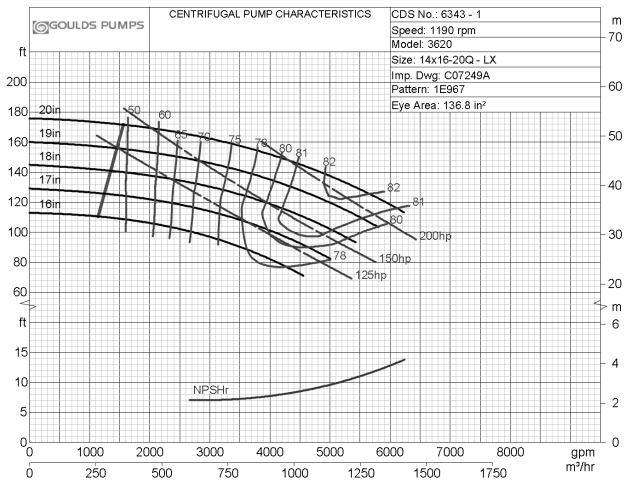


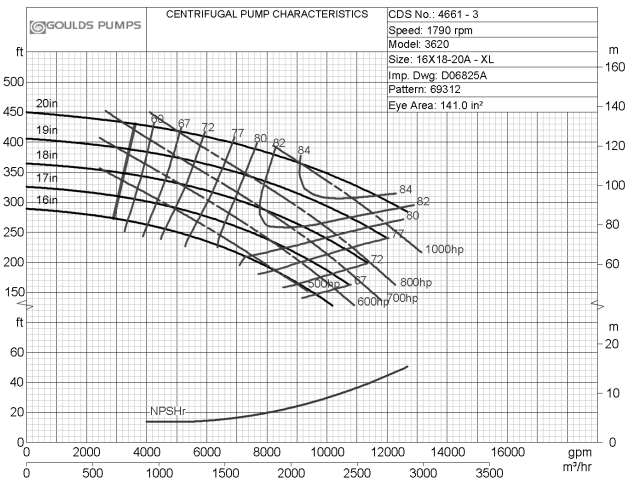
14X16-20A **1190rpm**



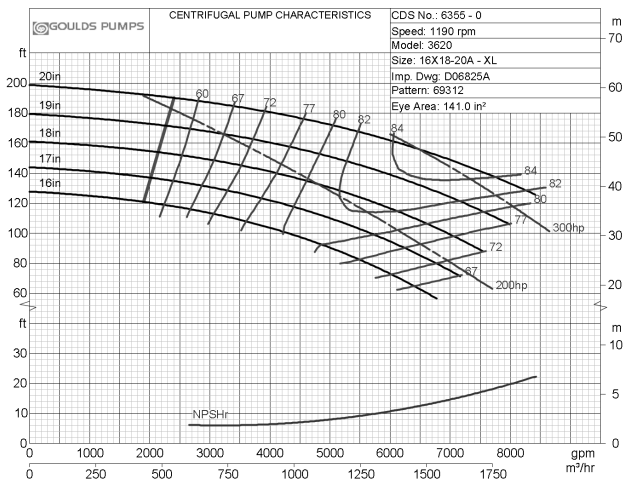
14x16-20Q **1785rpm**



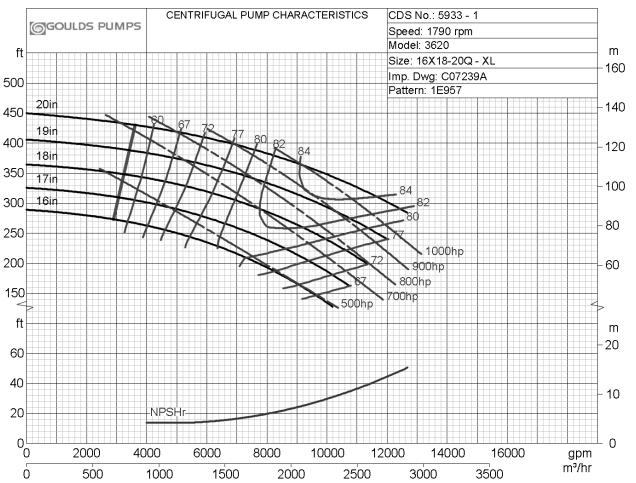
14x16-20Q **1190rpm**



16X18-20A **1790rpm**



16X18-20A **1190rpm**

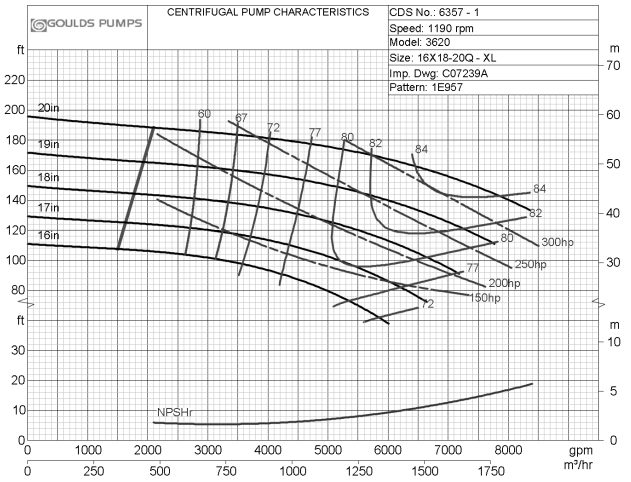


16X18-20Q **1790rpm**

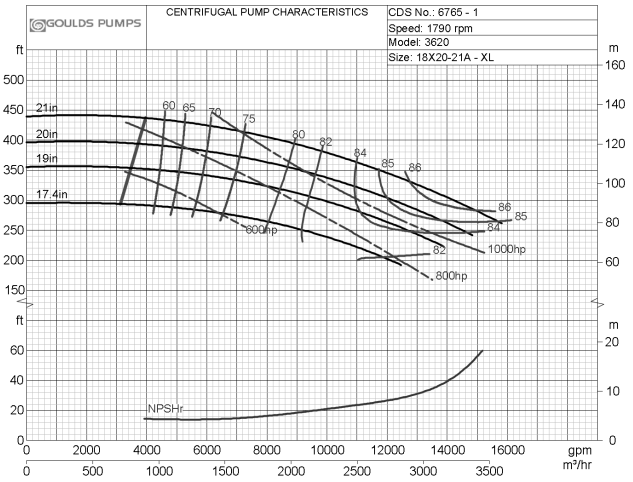
60Hz Curves

Model 3620

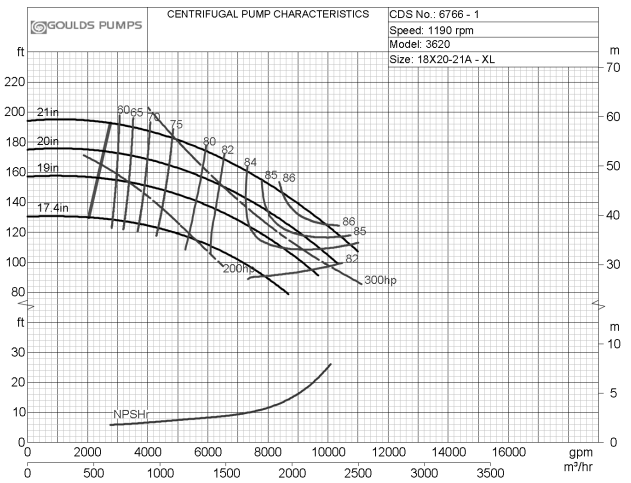
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



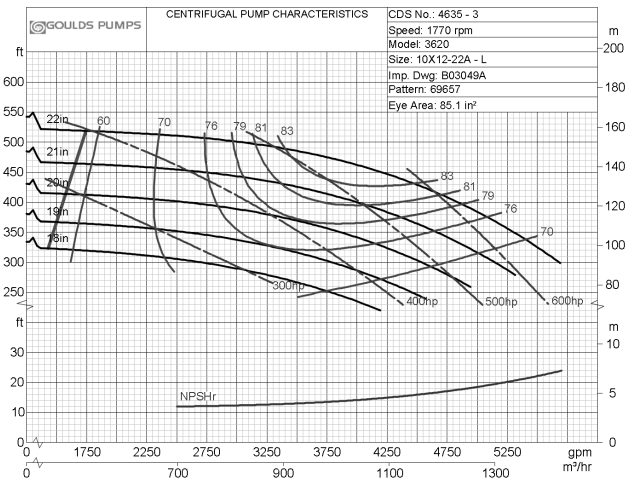
16X18-20Q **1190rpm**



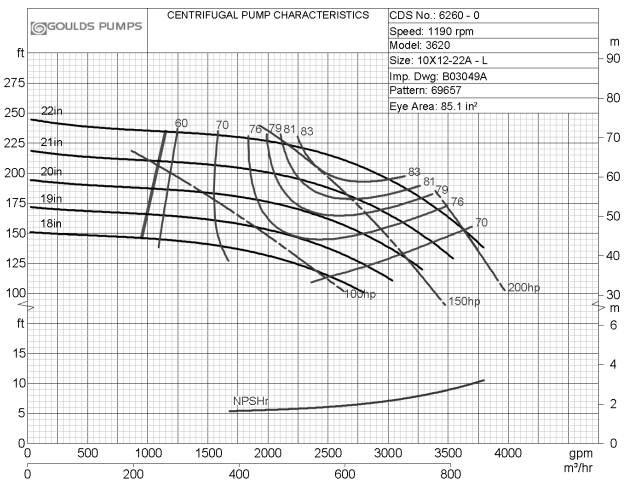
18X20-21A **1790rpm**



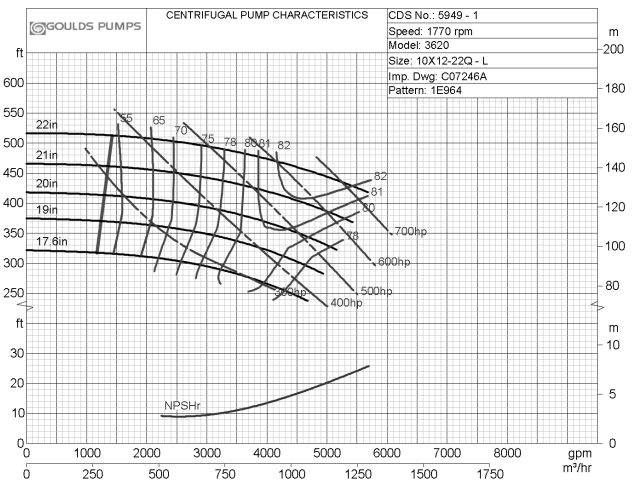
18X20-21A **1190rpm**



10X12-22A **1770rpm**

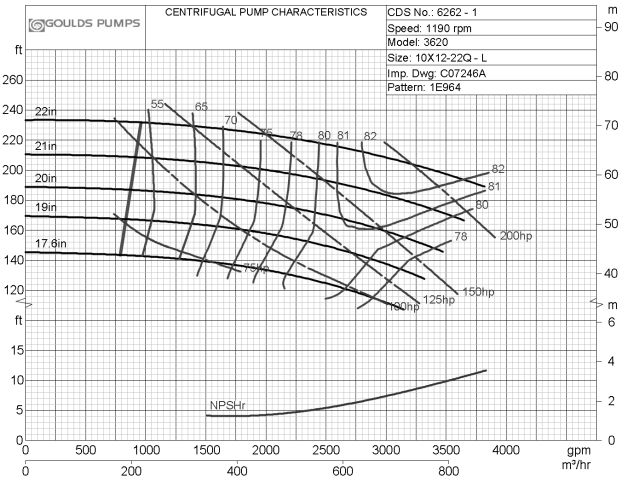


10X12-22A **1190rpm**

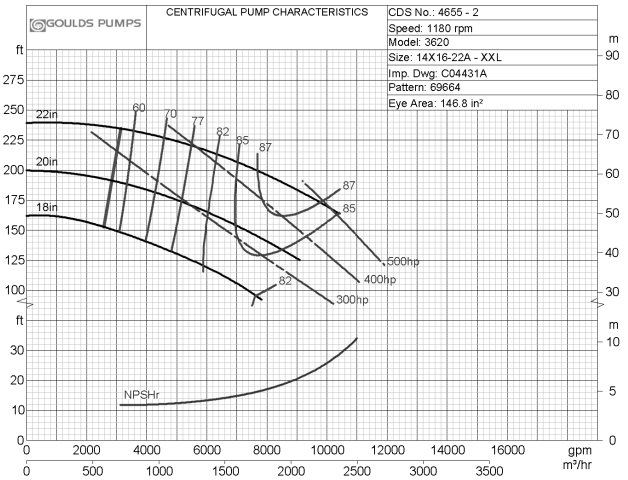


10X12-22Q **1770rpm**

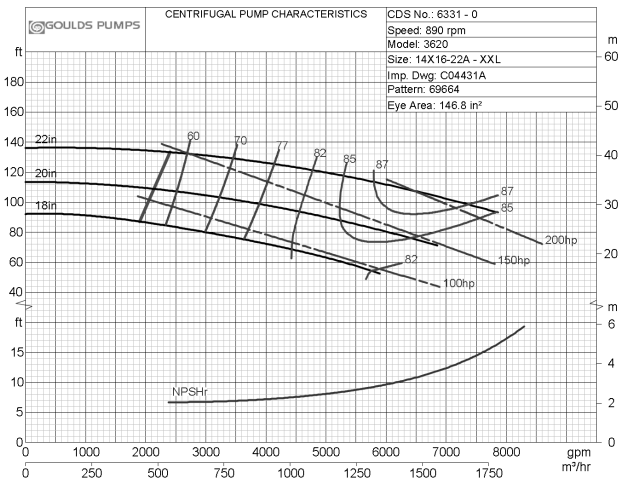
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



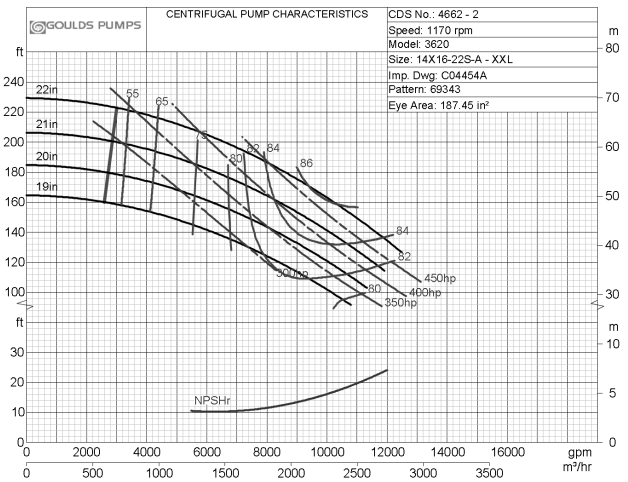
10X12-22Q **1190rpm**



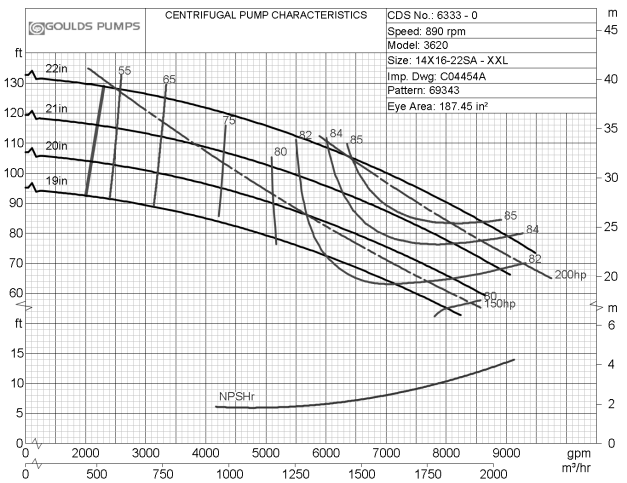
14X16-22A **1180rpm**



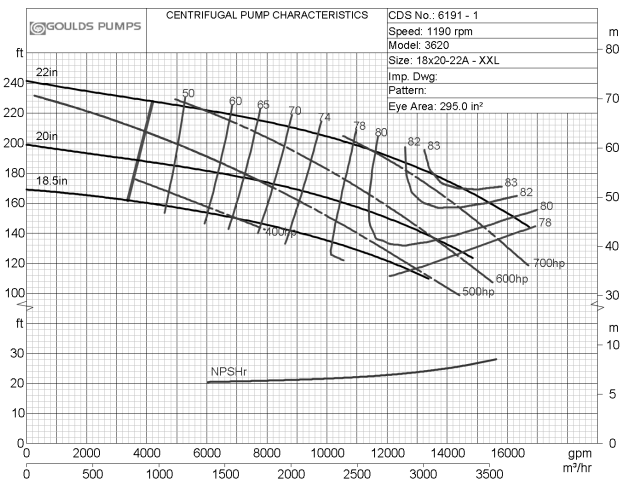
14X16-22A **890rpm**



14X16-22S-A **1170rpm**



14X16-22SA **890rpm**

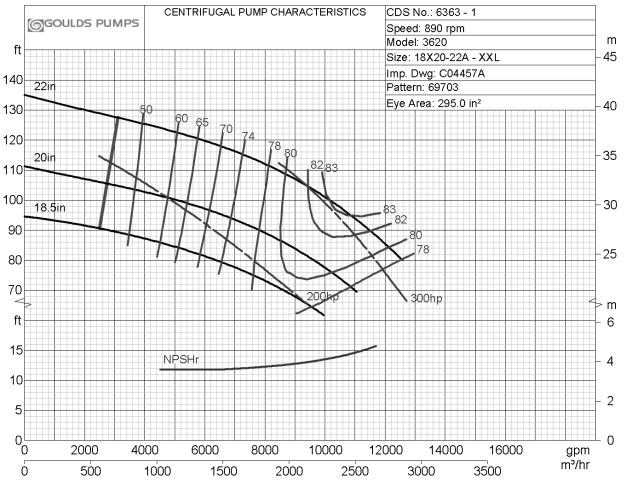


18x20-22A **1190rpm**

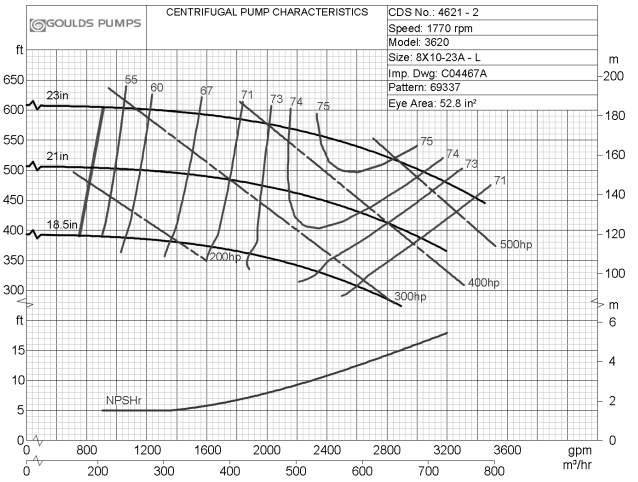
60Hz Curves

Model 3620

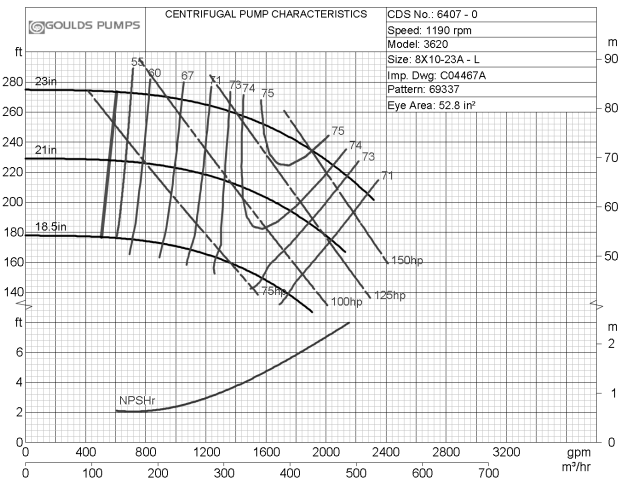
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



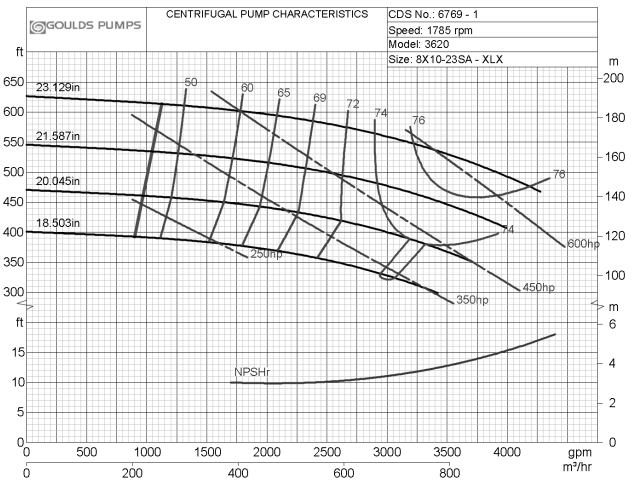
18X20-22A **890rpm**



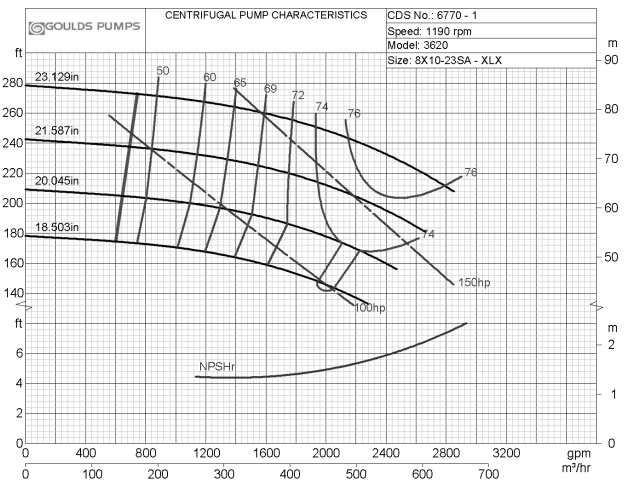
8X10-23A **1770rpm**



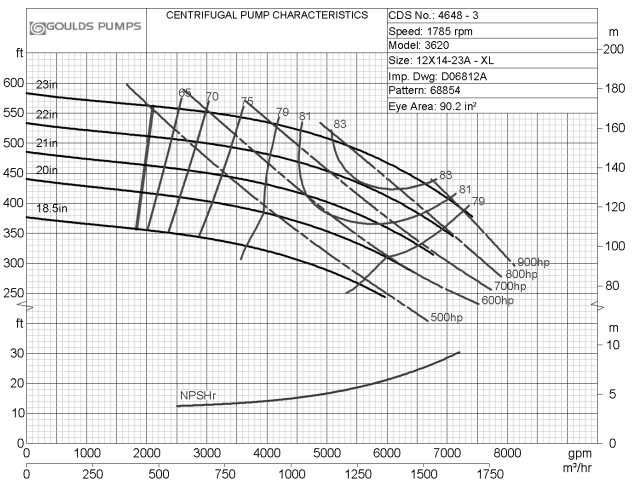
8X10-23A **1190rpm**



8X10-23SA **1785rpm**

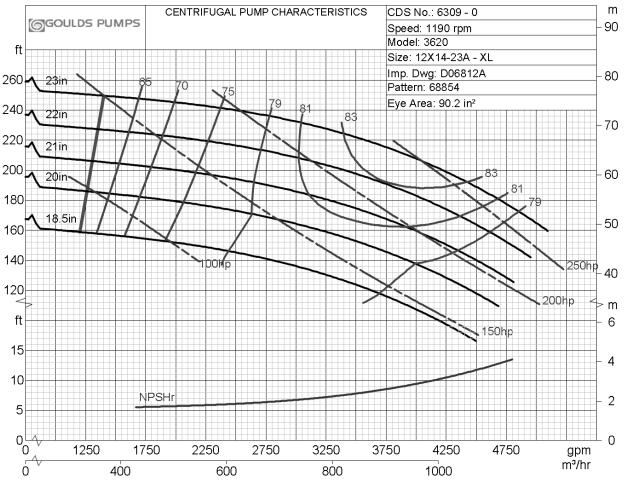


8X10-23SA **1190rpm**

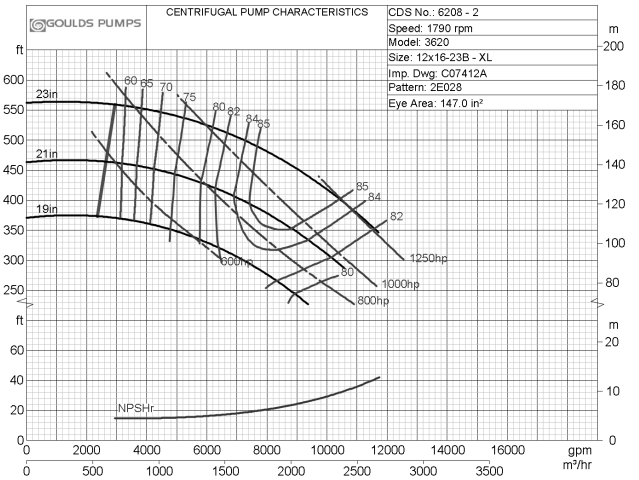


12X14-23A **1785rpm**

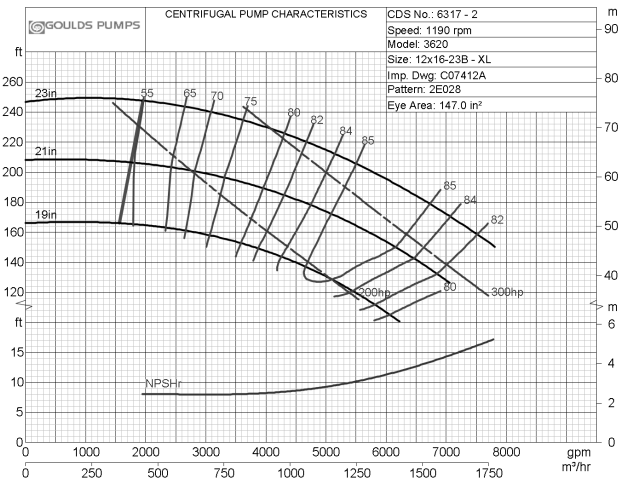
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



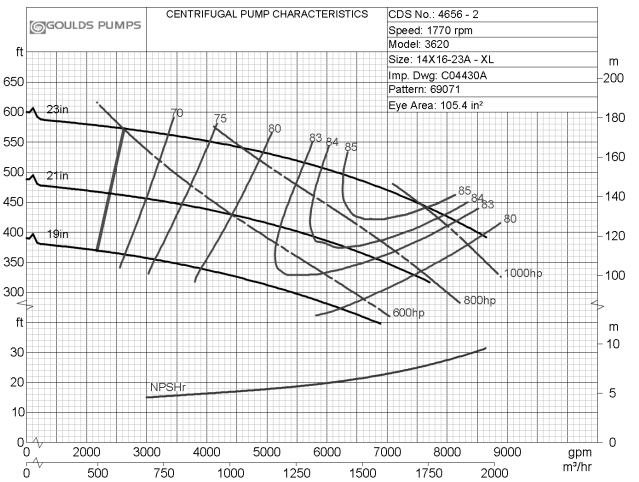
12X14-23A **1190rpm**



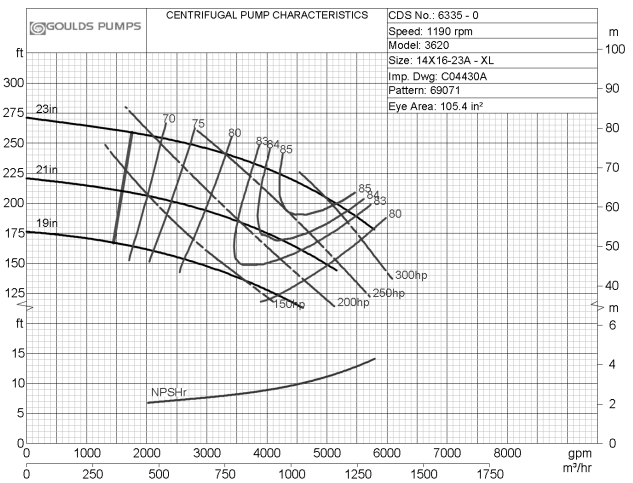
12x16-23B **1790rpm**



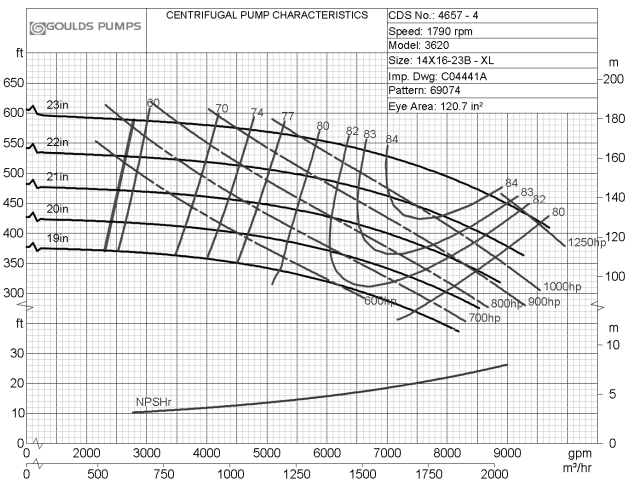
12x16-23B **1190rpm**



14X16-23A **1770rpm**



14X16-23A **1190rpm**

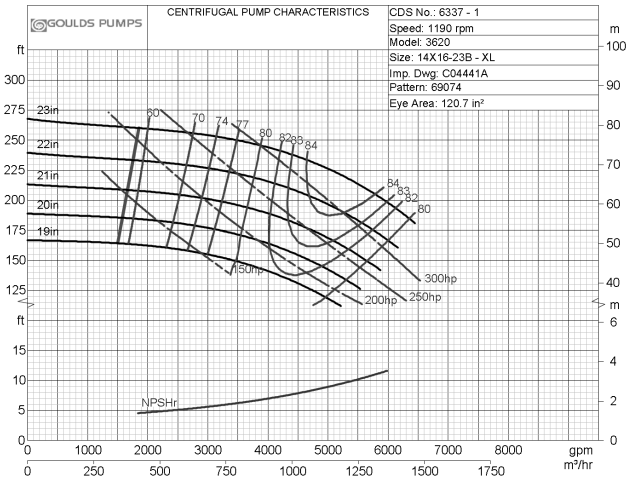


14X16-23B **1790rpm**

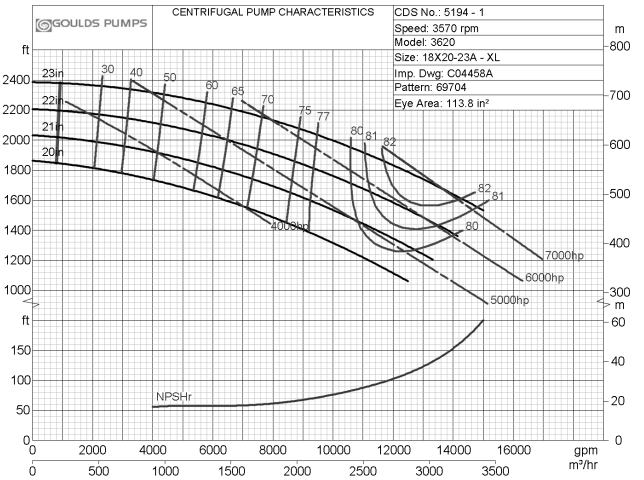
60Hz Curves

Model 3620

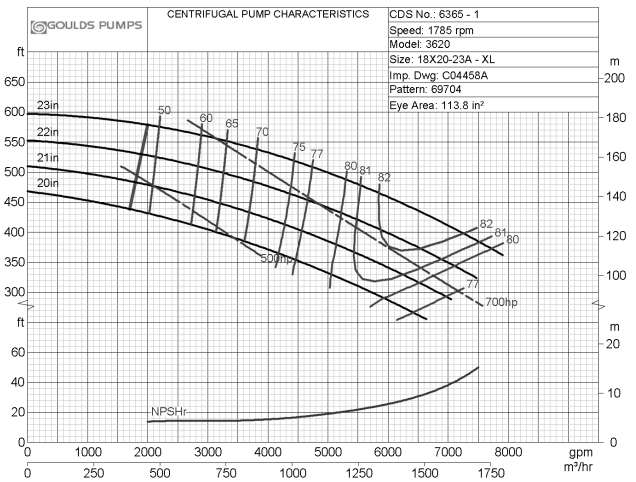
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



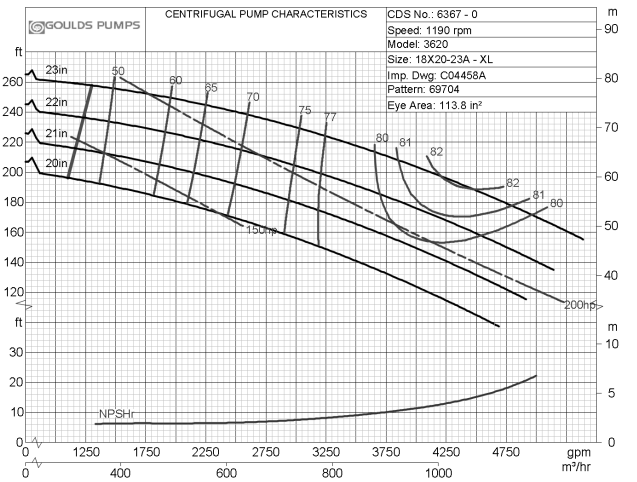
14X16-23B **1190rpm**



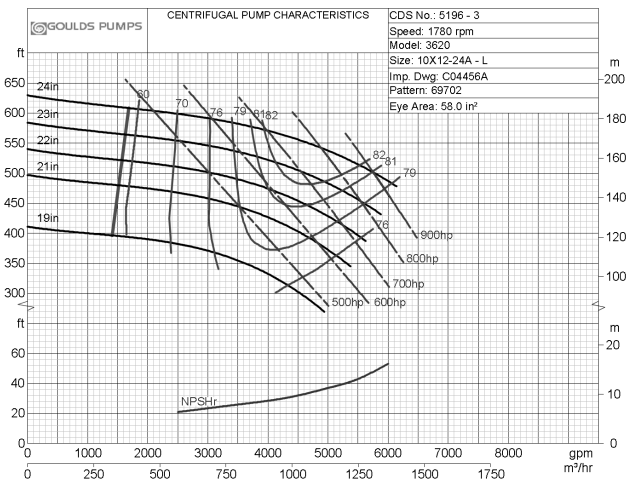
18X20-23A **3570rpm**



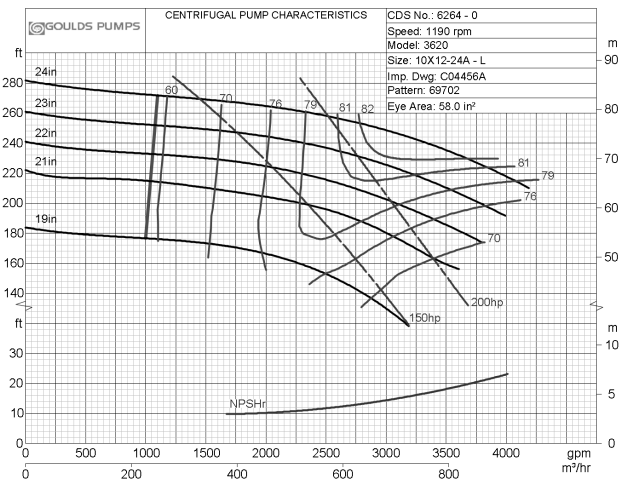
18X20-23A **1785rpm**



18X20-23A **1190rpm**

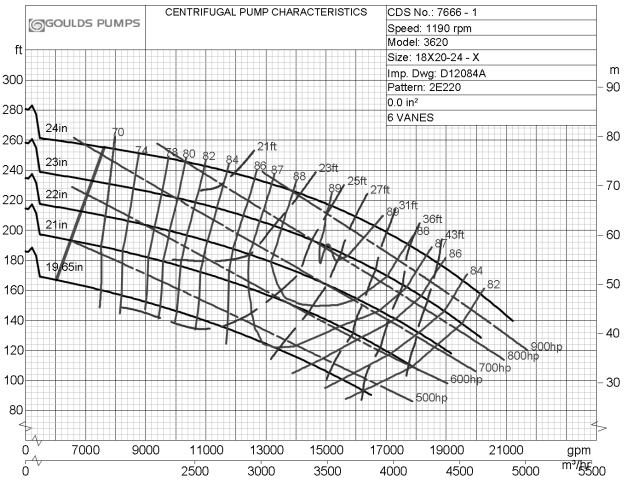


10X12-24A **1780rpm**

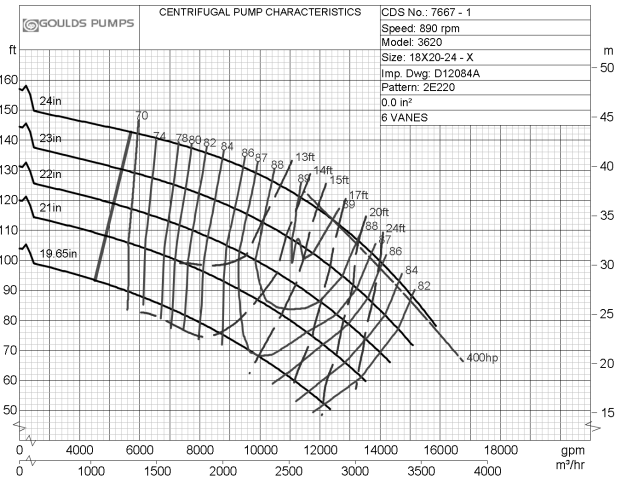


10X12-24A **1190rpm**

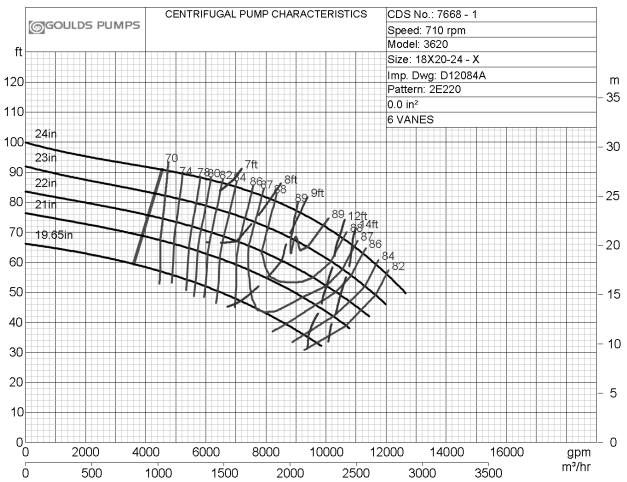
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



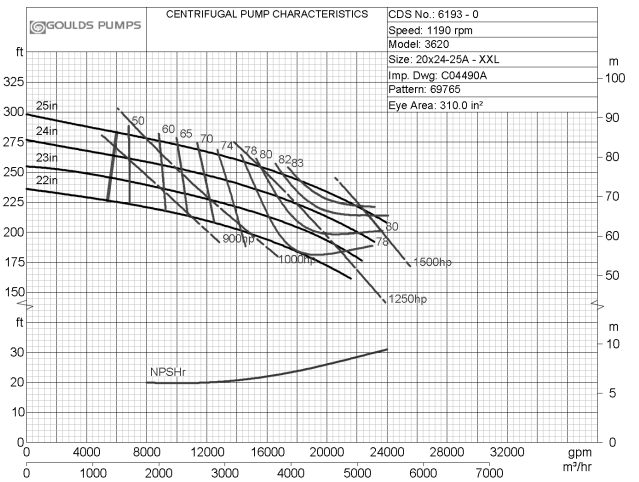
18X20-24 **1190rpm**



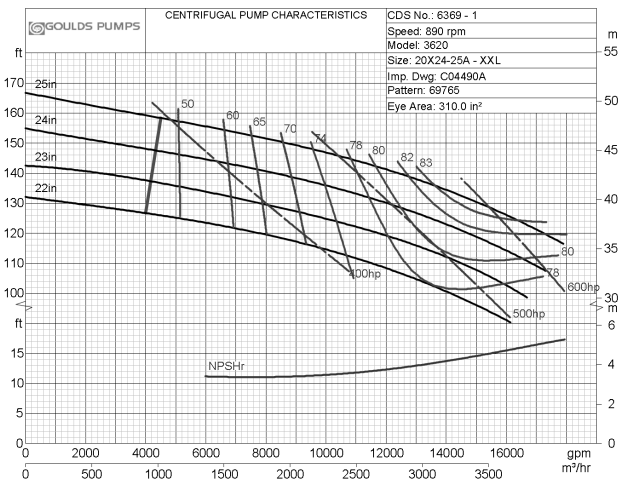
18X20-24 **890rpm**



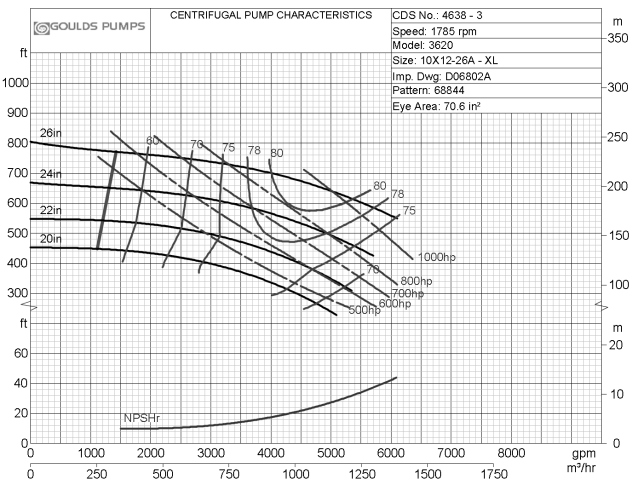
18X20-24 **710rpm**



20x24-25A **1190rpm**

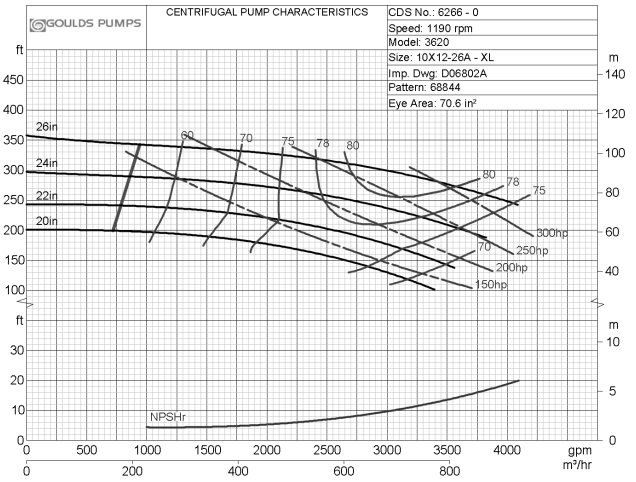


20X24-25A **890rpm**

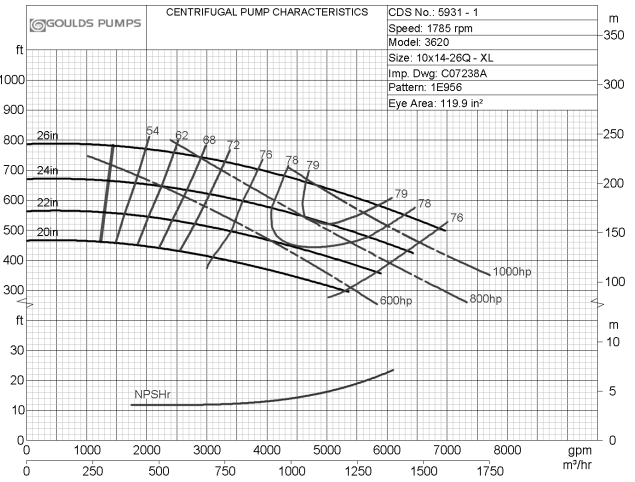


10X12-26A **1785rpm**

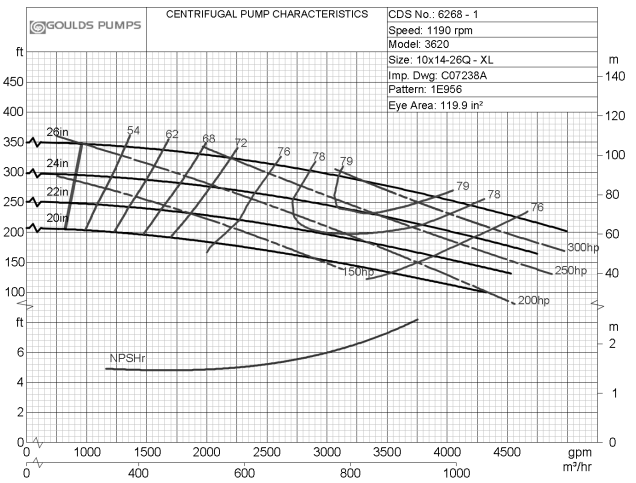
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



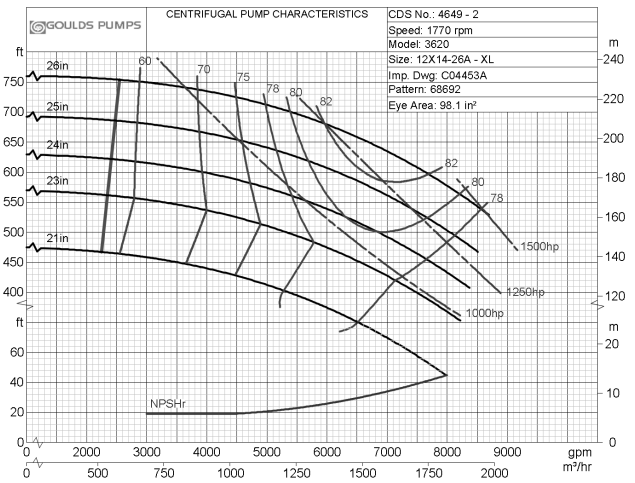
10X12-26A **1190rpm**



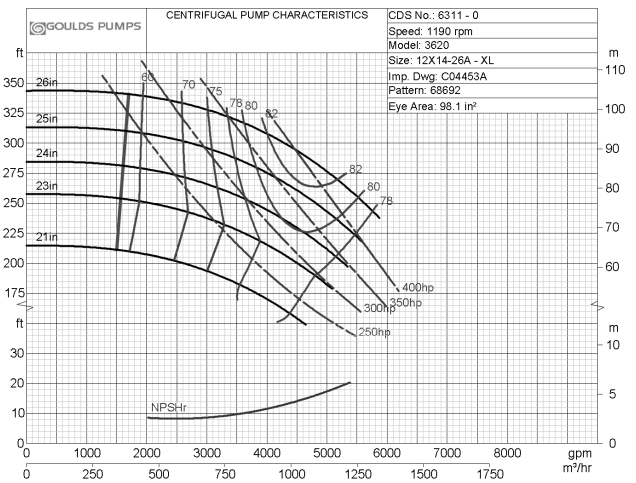
10x14-26Q **1785rpm**



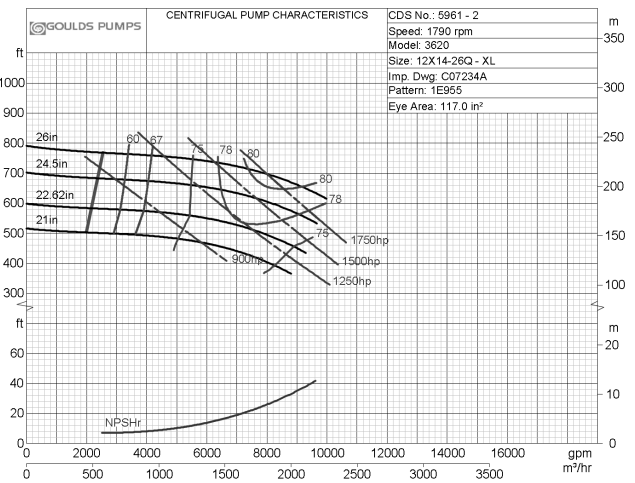
10x14-26Q **1190rpm**



12X14-26A **1770rpm**

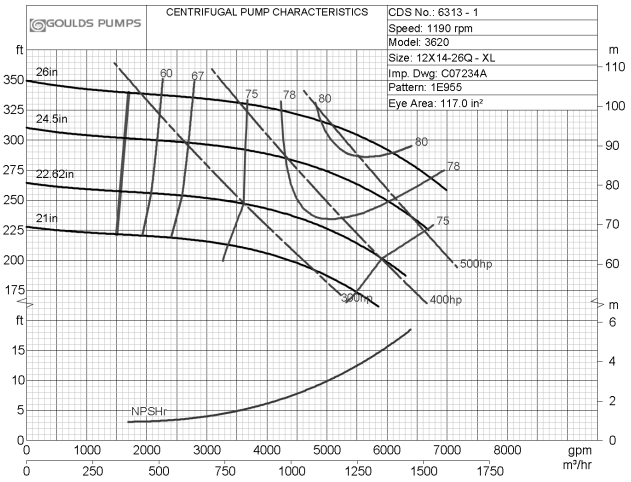


12X14-26A **1190rpm**

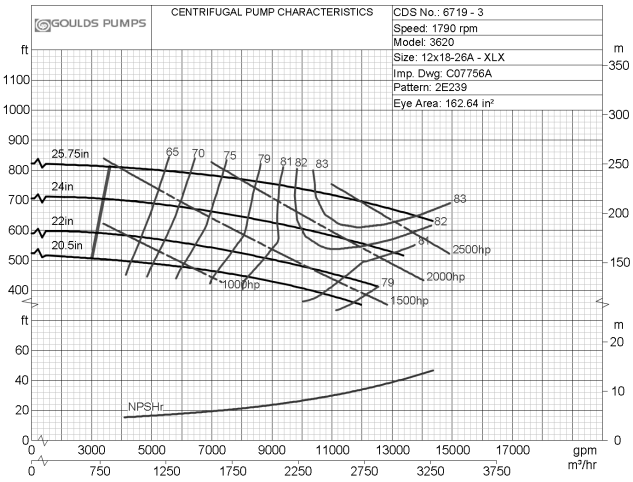


12X14-26Q **1790rpm**

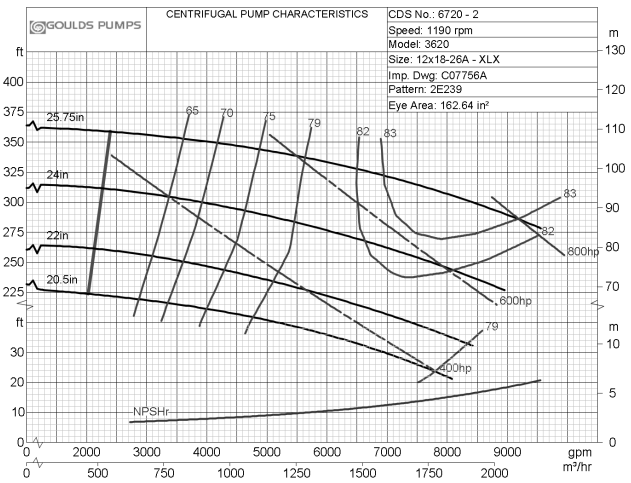
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



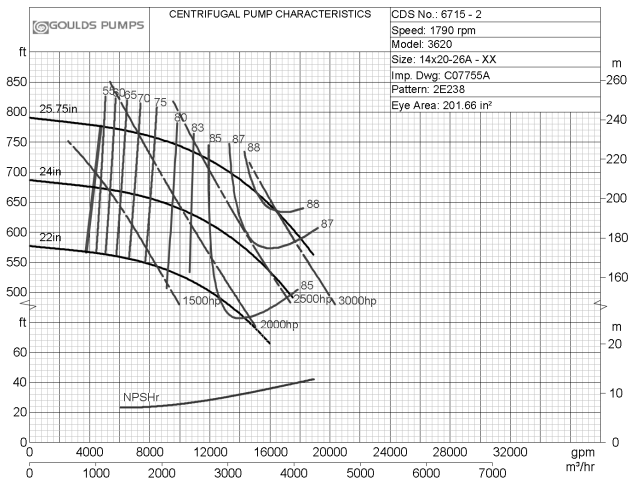
12X14-26Q **1190rpm**



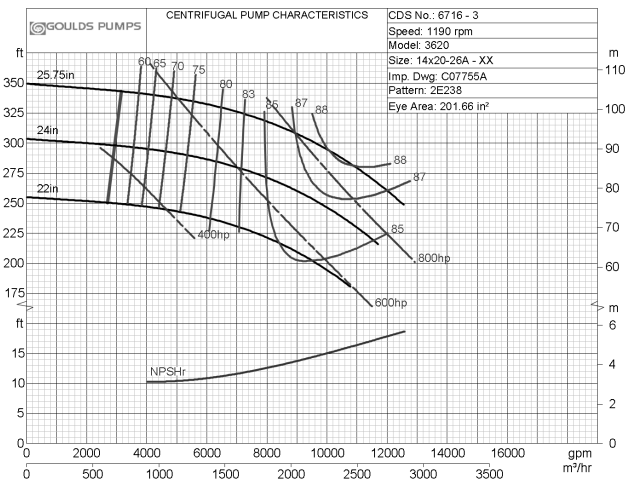
12x18-26A **1790rpm**



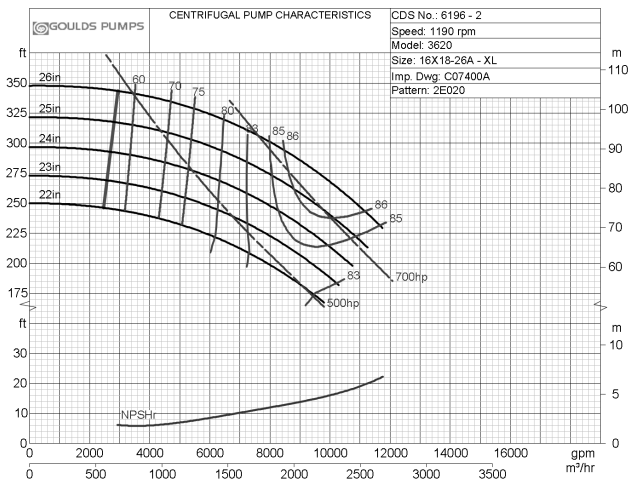
12x18-26A **1190rpm**



14x20-26A **1790rpm**



14x20-26A **1190rpm**

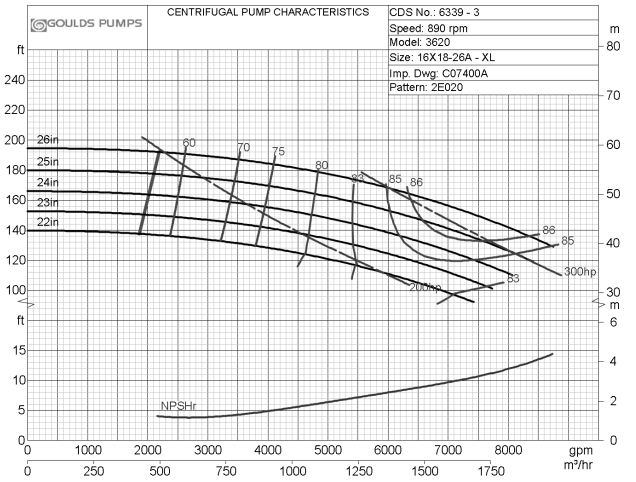


16X18-26A **1190rpm**

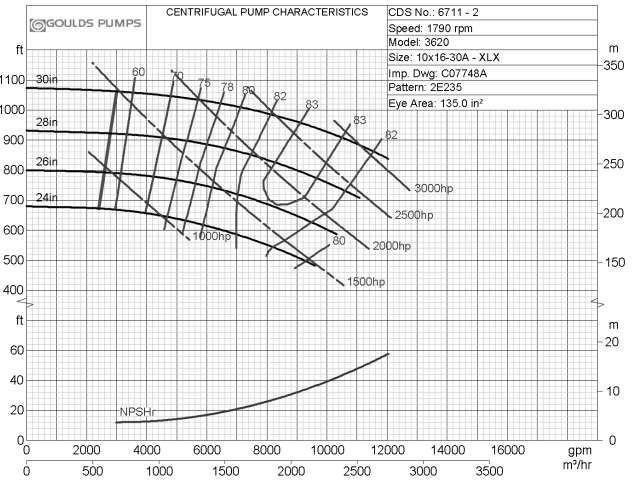
60Hz Curves

Model 3620

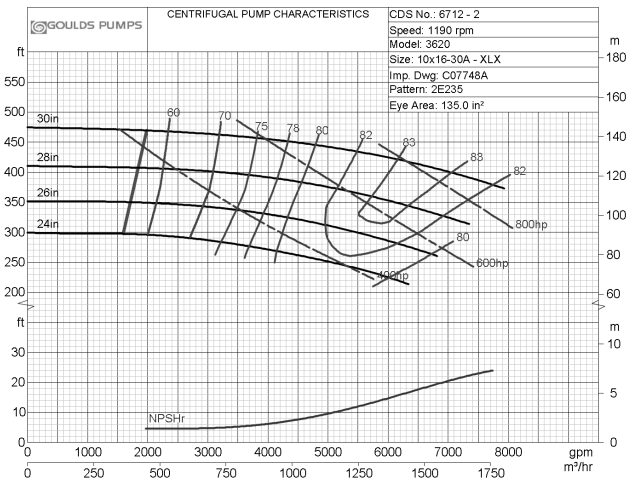
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



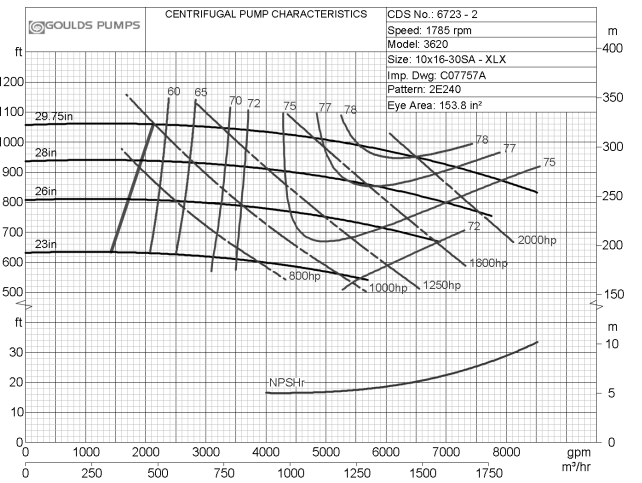
16X18-26A **890rpm**



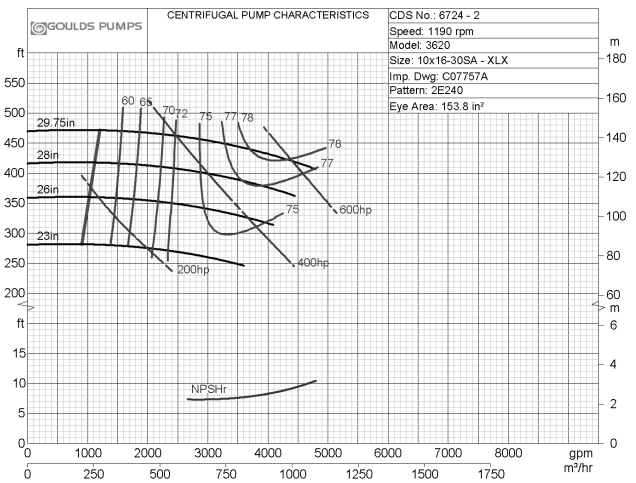
10x16-30A **1790rpm**



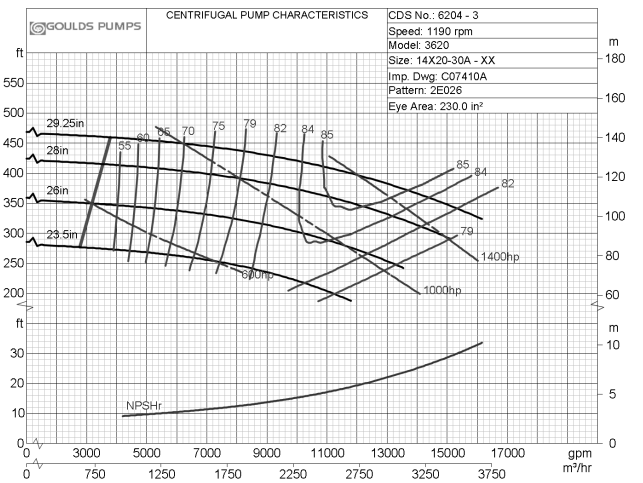
10x16-30A **1190rpm**



10x16-30SA **1785rpm**

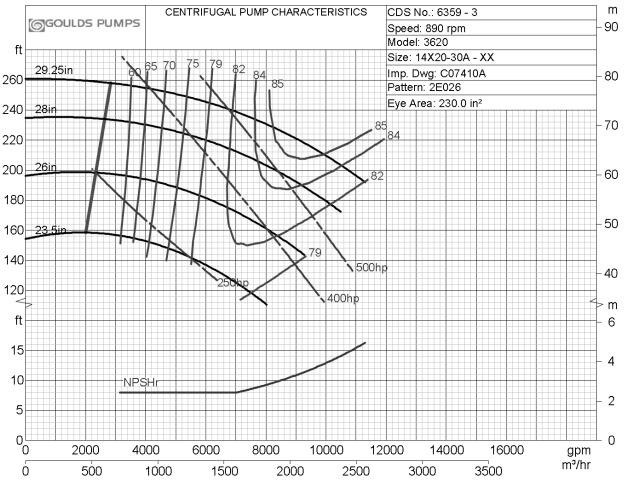


10x16-30SA **1190rpm**

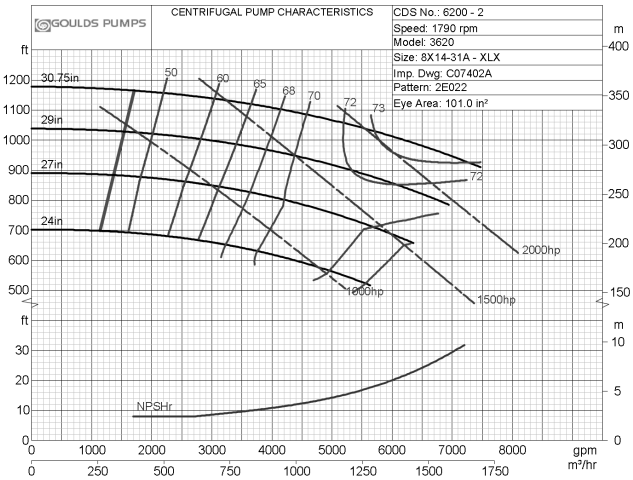


14X20-30A **1190rpm**

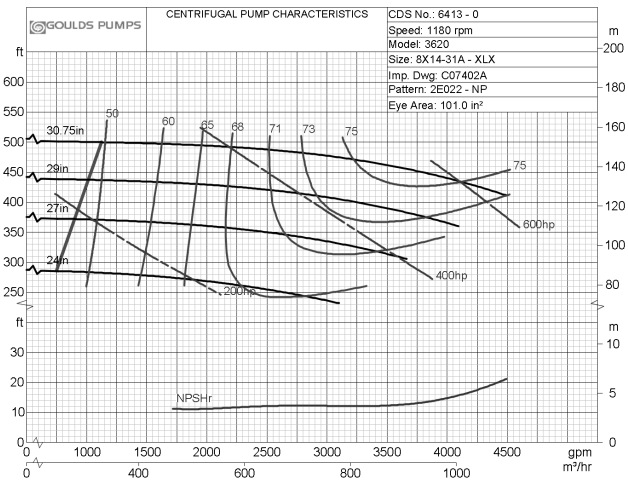
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



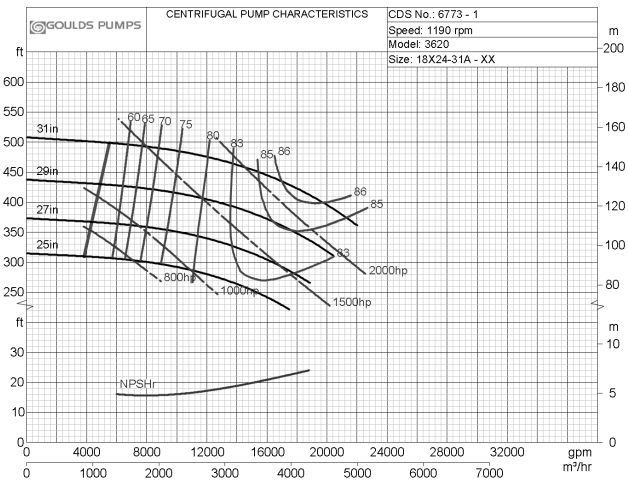
14X20-30A **890rpm**



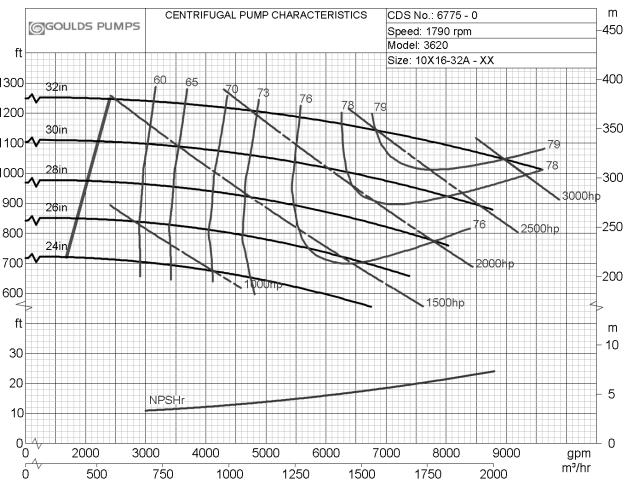
8X14-31A **1790rpm**



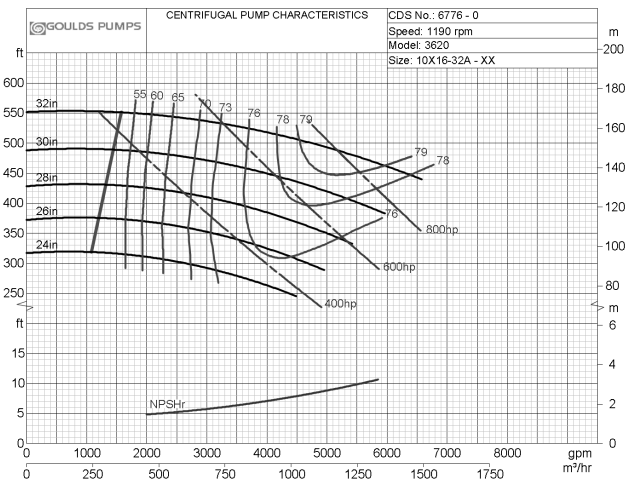
8X14-31A **1180rpm**



18X24-31A **1190rpm**



10X16-32A **1790rpm**

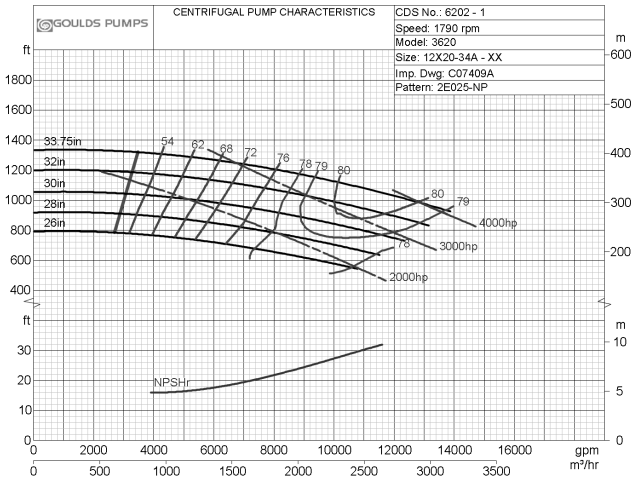


10X16-32A **1190rpm**

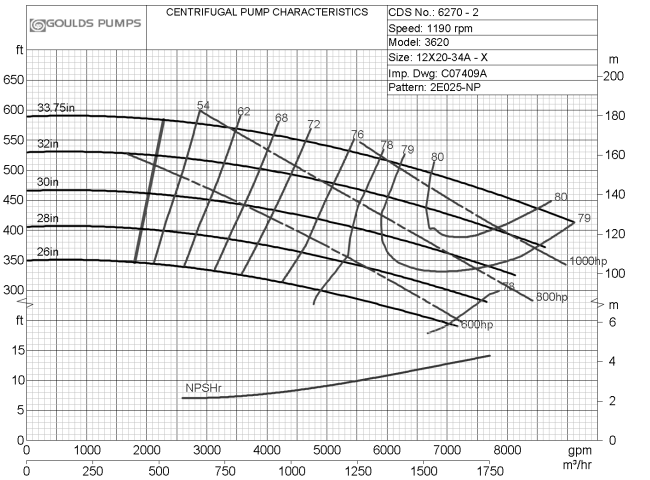
60Hz Curves

Model 3620

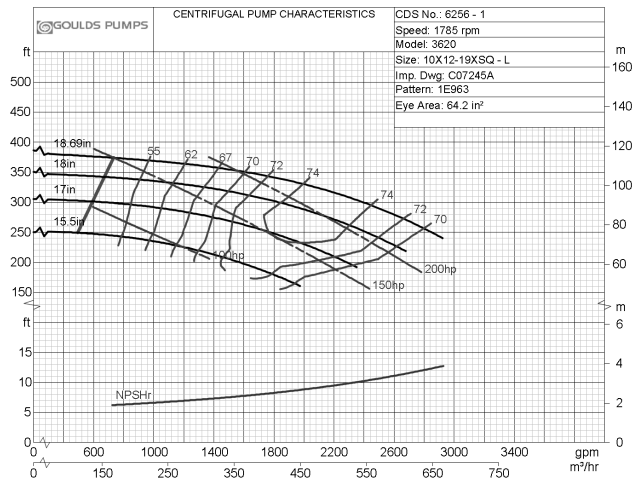
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



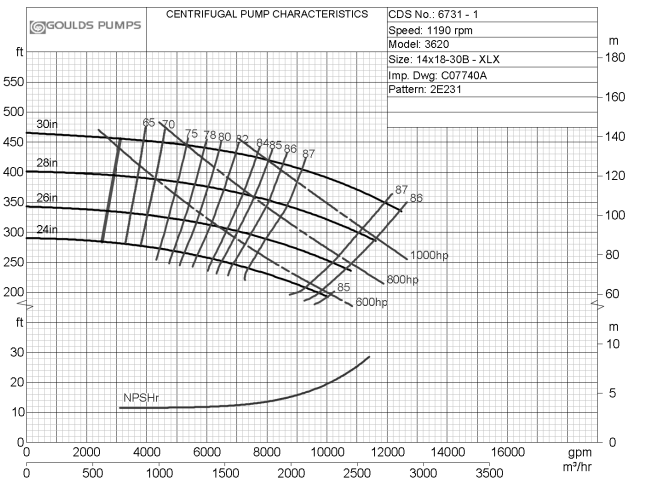
12X20-34A **1790rpm**



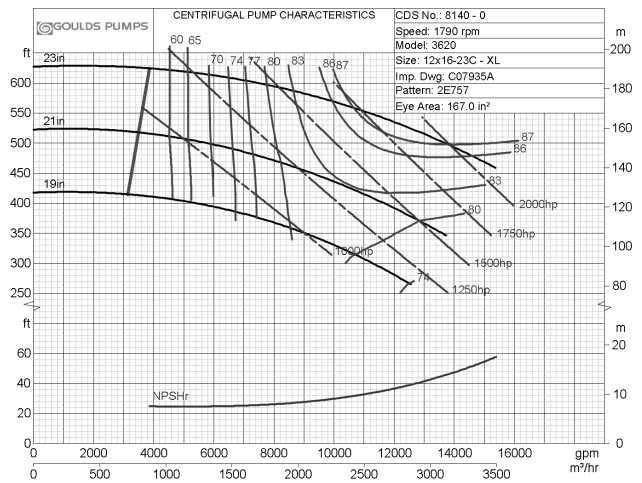
12X20-34A **1190rpm**



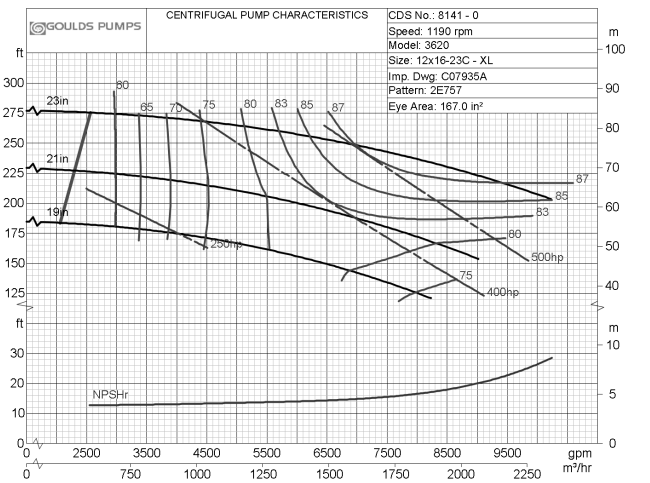
10X12-19XSQ **1785rpm**



14x18-30B **1190rpm**

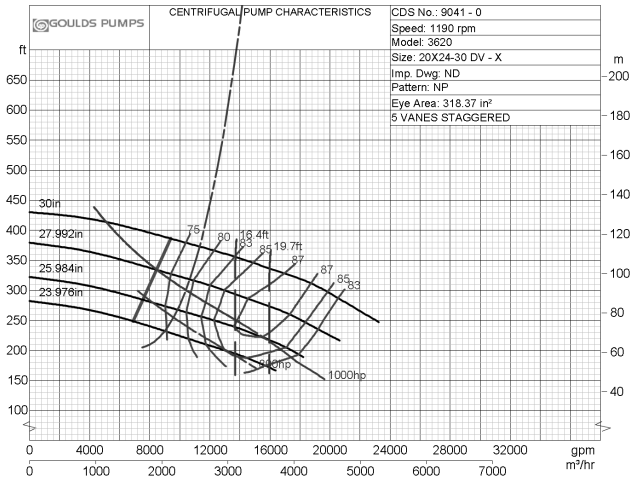


12x16-23C **1790rpm**

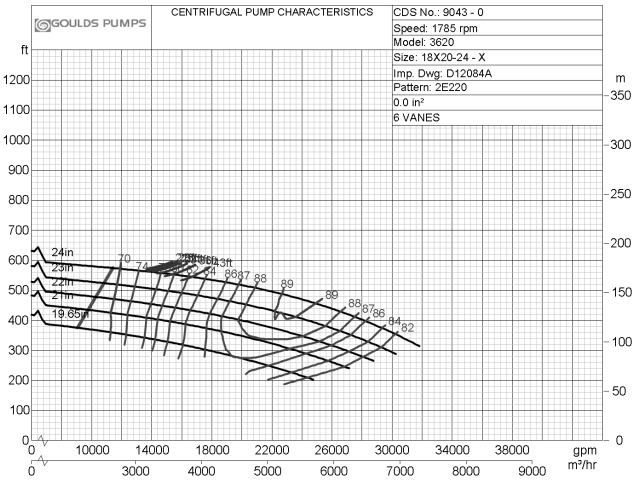


12x16-23C **1190rpm**

The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.

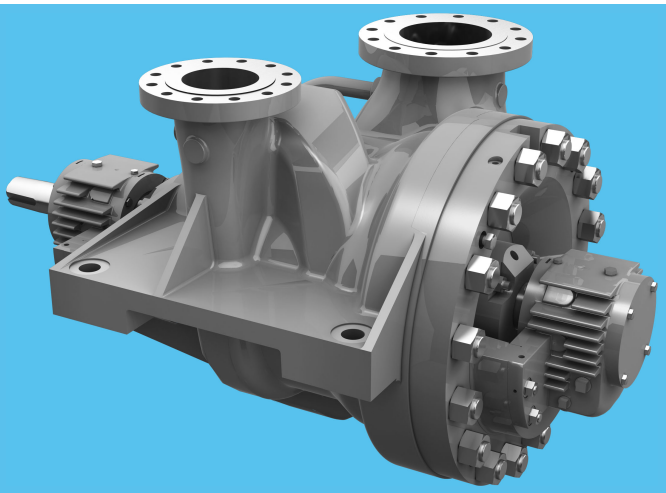


20X24-30 DV **1190rpm**



18X20-24 **1785rpm**

NOTES



Goulds Model 3640 between-bearings radially split process pumps are designed for smooth, reliable operation, and meet the toughest specification requirements of API-610/ISO 13709 to assure extended service life.

Goulds Model 3640

High-Temperature and -Pressure Process Pumps That Meet or Exceed API 610 11th Edition/ISO 13709 2nd Edition

Safety, relability and versatility are the key words for our 2 stage, centerline mounted, between-bearing (BB2) API 610 process pumps.

Safety and Reliability

We provide engineered solutions with true conformance to the latest API specifications including the stringent emissions containment per API 682.

The result is a safe and rugged between-bearing API process pump designed for a 20-year life.

Versatility

- Capacities to 7,500 GPM (1700 m^3/h)
- Total Dynamic Head to 2,500 feet (760 m)
- Temperature to 850°F (455°C)
- Pressures vaccum to 1,130 PSIG (75 kg/cm^2)

Materials - Available in a wide range of materials including all API 610 constructions and custom application needs.

Engineered Hydraulics - Dense hydraulic coverage to better match your process for efficiency and reliability. Custom hydraulics are available.

Engineered Packaging with a wide range of drivers, seals, piping, nozzle configurations, flanges, base plates, and QC testing.

Applications

- **Refinery -** Process feed, reflux, splitter bottoms, high-pressure process transfer

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3640 High Pressure/High Temperature Two-Stage Process Pumps

Heavy Duty Design Features for Refinery and Petrochemical Services

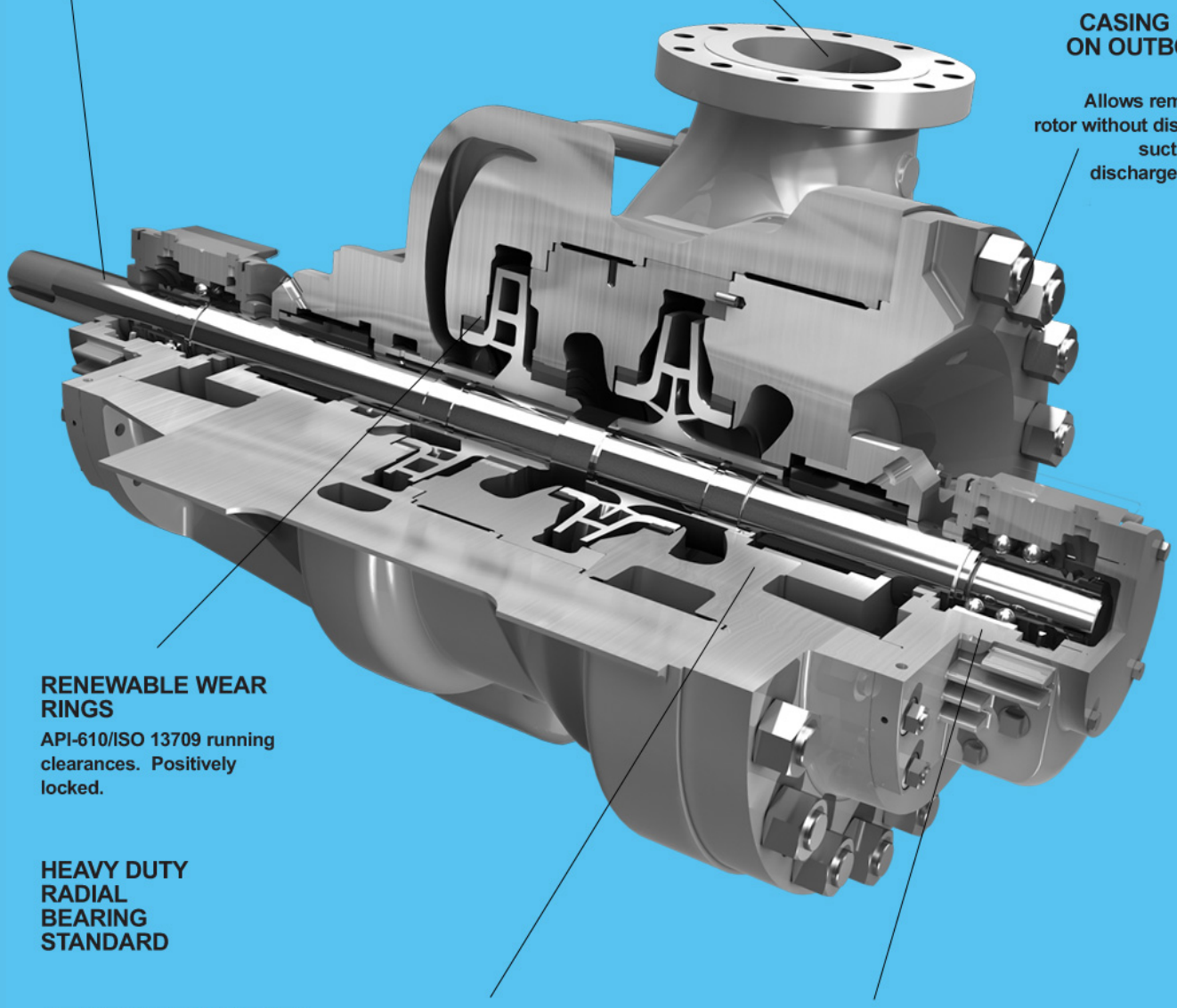
HEAVY DUTY SHAFT
Minimum shaft deflection for extended seal bearing life. Sized to meet deflection and rotor dynamics requirements of API-610/ISO 13709.

RADIALLY SPLIT CASING
Designed specifically for high pressure/high temperature services. Fully confined controlled compression gaskets assure leak-proof sealing.

CLASS 300 RF FLANGES STANDARD
Other classes and facings optional.

OPPOSED IMPELLERS ARRANGEMENT
Reduced axial forces for maximum bearing life. Impellers are driven by individual keys and positioned on shaft by dual locknuts. Staggered impeller vane tips for reduced pressure pulsations at vane passing frequency.

CASING HEAD ON OUTBOARD END
Allows removal of rotor without disturbing suction and discharge piping.



RENEWABLE WEAR RINGS
API-610/ISO 13709 running clearances. Positively locked.

HEAVY DUTY RADIAL BEARING STANDARD

CENTERLINE MOUNTED CASING
Heavy duty mounting extensions accept API-610/ISO 13709 nozzle loads and maintain pump alignment under extreme service conditions.

ENLARGED SEAL CHAMBERS
Conform to API-682/ISO 13709 dimensional requirements. Allows use of wide range of cartridge mechanical seals to meet specific service conditions.

HEAVY DUTY THRUST BEARING
Duplex 40° angular contact standard. Ring oil lubricated. Other bearing configurations available to meet specific service requirements.

A Leader in API Engineered Pump Package Solutions...

Proven API Leadership

ITT Goulds Pumps is a proven leader in API Pumps

- Over 20,000 units installed
  - Over 17,000 OH2/OH3's
  - Over 3,000 BB1/BB2/BB3 pumps
- 40+ years of API expertise
- Participating member on API 610 and API 682 committees

Family of API Pumps

ITT Goulds Pumps has a family of proven API pumps

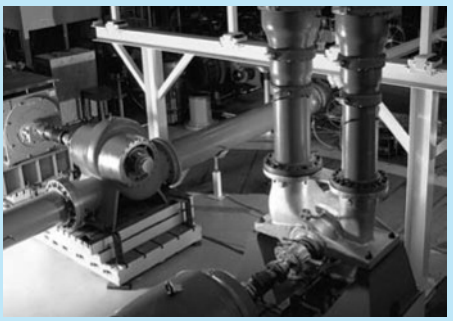
- Overhung pumps
- Single- and two-stage between-bearing pumps
- Multistage between-bearing pumps
- Vertical, double casing pumps
- Barrel multistage pumps
- Specialty pumps

Industry Leading Hydraulic Coverage

- We offer dense hydraulic coverage to meet your process needs.
- Better hydraulic fits can mean improved efficiency and long-term reliability and parts life.

8000 HP / 5960 kW Testing Capability

- Our test facilities can test your pump in the most demanding conditions.
- Optional complete train (or full string) test at 50 or 60 hz.
- Ability to test job motors at 5kv, 5.5kv, 6kv, 6.6kv, 7.2kv, 10kv, 11kv, 12.5kv, 13.2kv.



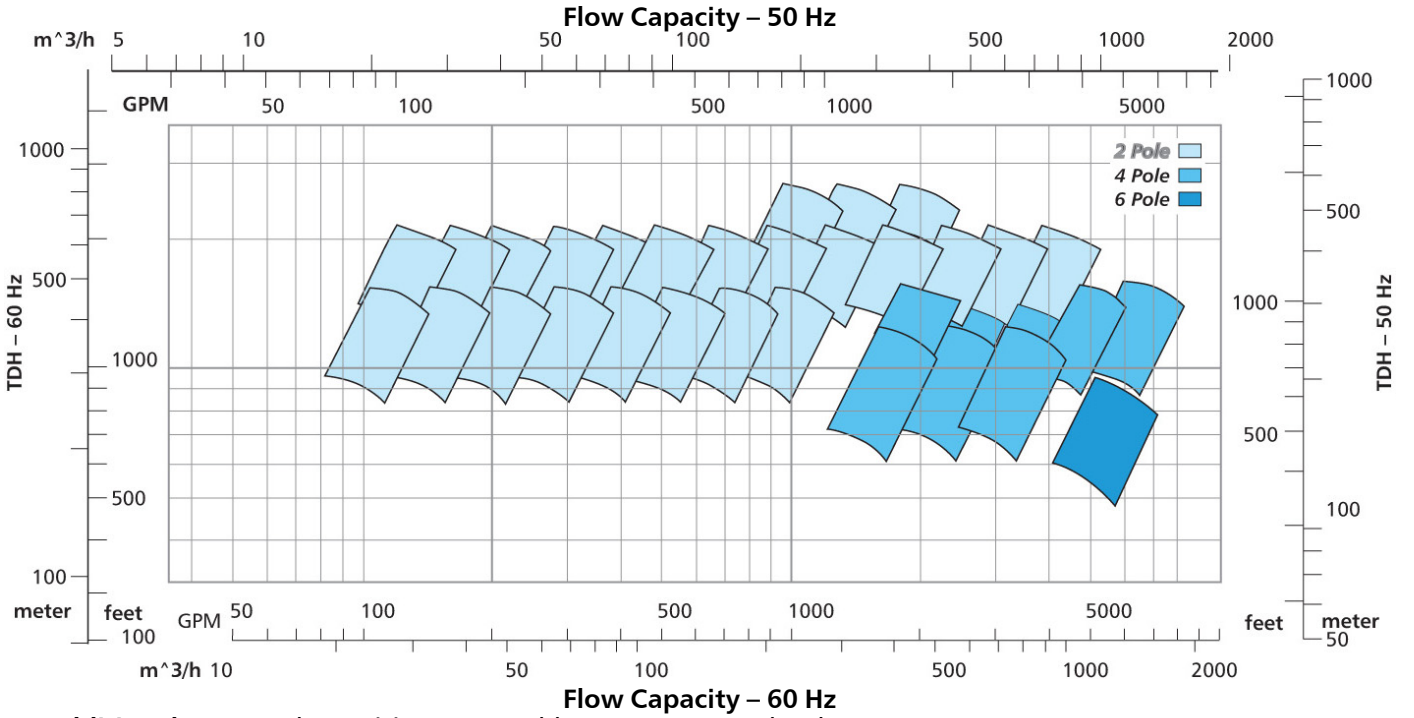
API Engineering Expertise

- We are experts in packaging engineered pumps that meet your demanding applications - with true conformance to the latest API specifications.
- We have extensive experience in nearly every type of driver, bearing, seal, piping configuration, nozzle configuration, flange and baseplate designs to meet your application needs.
- ITT is a world leader in technology and engineering including hydraulics, materials science, mechanical design, and fluid dynamics.

Broad Applications

- Petroleum refining, production, and distribution
- Petrochemical and demanding chemical processing
- High temperature applications including boiler circulation
- General industrial requiring high temperature or high pressures

Hydraulic Coverage

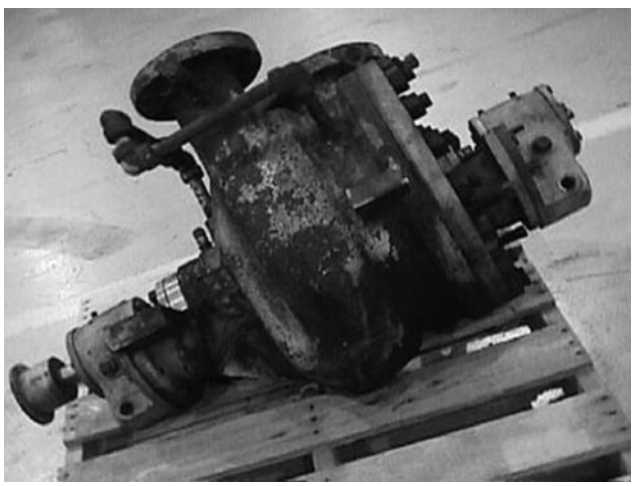


For **additional curves**, please visit www.GouldsPumps.com/PSS.html.

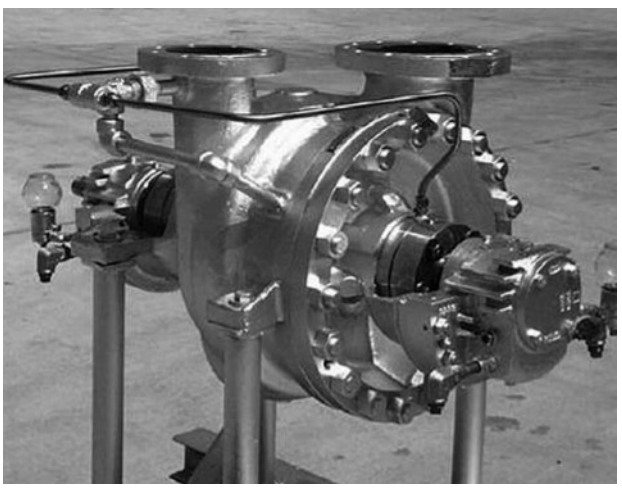
PRO Services® Engineered Upgrade

The following two-stage API BB2 Model 3640 was upgraded from an old edition of API 610 to the latest (10th) edition of API.

Original Pump



10th Edition Upgrade



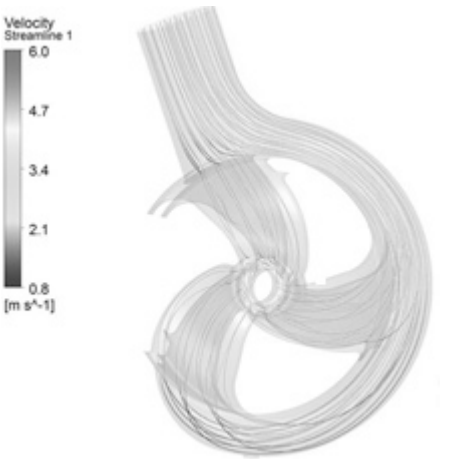
Design Features for Optimum Reliability

Designed for API-610 11th Edition/ISO 13709 Services

- Casing, nozzles and baseplate meet or exceed API 610/ ISO 13709 nozzle load requirements.
- Impellers are shrink-fit to shaft and independently secured against axial movement.
- Seal chambers meet dimensional requirements of API 610/ISO 13709 and can be fitted with single-, double- or tandem-cartridge mechanical seals.
- Steel bearing frame is standard for maximum structural integrity.
- Impellers and rotating equipment element dynamically balanced to API 610 / ISO 13709 requirements.
- Separation margins between operating speeds and critical speeds meet or exceed API 610 / ISO 13709 requirements.

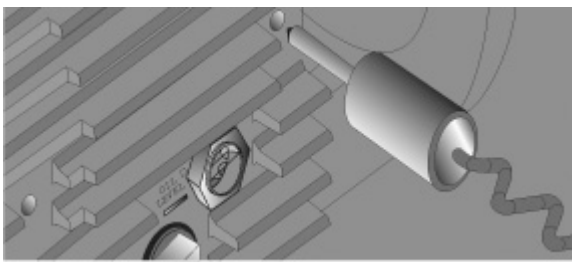
Design/Analysis Capabilities

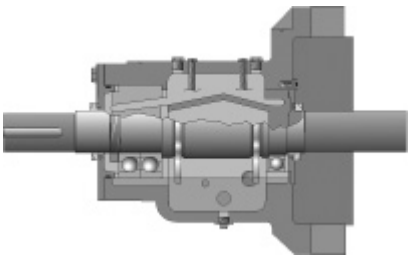
Casing pressure capability and structural design developed and refined using advanced finite element analysis. Goulds engineering staff is fully equipped to perform the rotor lateral response analysis and residual unbalance checks necessary to ensure stable operation and low vibration levels. Thermal transient analysis using finite element models used to determine allowable casing temperature rise and ensure mechanical reliability. Hydraulic designs developed using dynamic flow models ensure stable performance with consistent, high efficiency levels.



Improved Bearing environment

- Bearing frame fins provide optimum heat dissipation.
- Condition monitoring sites allow easy and consistent monitoring of temperature and vibration. Provision for instrumentation mounting per API 670 available.
- Large oil sight glass allows viewing of the condition and level of oil, critical for bearing life. • Extra large oil sump provides cooler running bearings.
- Proven channeled oil lubrication system ensures flow-through of cooled oil to thrust and radial bearings.
- Standard dual oil rings, positively located, provide oil flow to channeled oil lubrication system and prevent oil foaming.

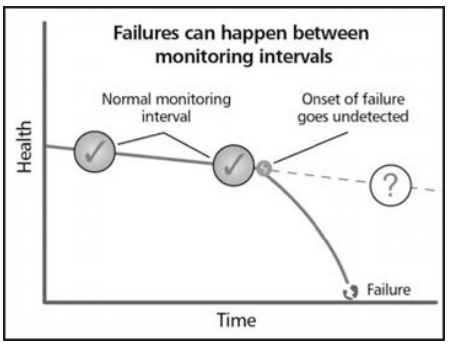




i-ALERT™ Condition Monitor

The heart of the *i*- FRAME, the condition monitor unit continuously measures vibration and temperature at the thrust bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes to the process or machine can be made before failure occurs.

A visual indication of pump health makes walk-around inspections more efficient and accurate. The result is a more robust process to monitor and maintain all your ANSI pumps so that your plant profitability is maximized.



A reliablility program centered around walk-arounds captures equipment condition on average once a month; the faliure process, however, can begin and end quite frequently within this time period.

Optional Features for Application Flexibility

Goulds offers users a range of options to meet specific plant and process requirements.

High Temperature Capability

For high temperature applications, these options are available.

EXTRA WIDE BASEPLATE

Provided for seal systems with auxiliary components to improve maintenance access.

HEAVY DUTY PEDESTAL

Unique trapezoidal design provides superior resistance to deflections from flange loads.

ABRASIVE SERVICES

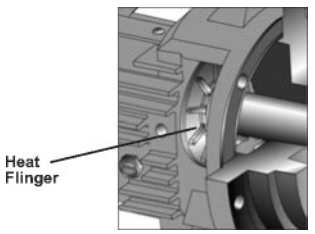
Hardened coatings are available for services with abrasive solids.

HIGH SUCTION PRESSURE

Applications requiring high suction pressure can be accommodated with minor design modifications..

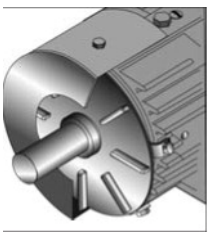
NON METALLIC RINGS

Non-metallic rings are available for increased efficiency and limited dry run capability.



HEAT FLINGER

Heat flinger dissipates shaft-conducted heat and circulates air to reduce heat build-up.



AIR COOLING

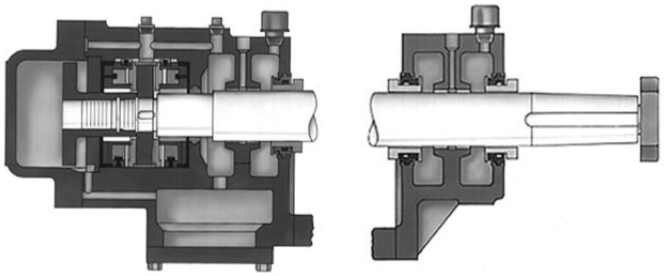
High capacity fan and shroud mounted on power end effectively reduce bearing frame temperature for cooler running bearings without using cooling water.

WATER COOLING

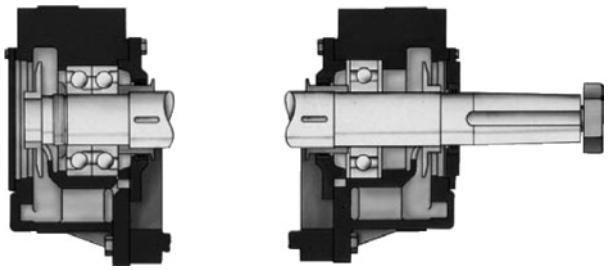
Finned cooler for maintaining oil/bearing temperature. Corrosion resistant material.

Bearing Arrangements

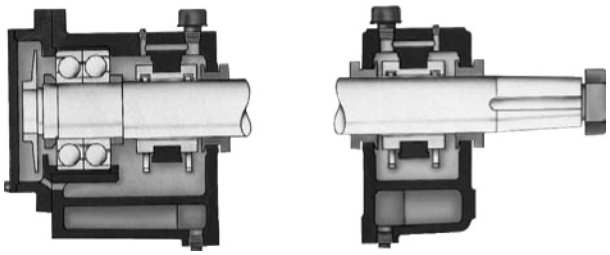
Oil lubricated ball radial and duplex thrust bearings are standard on the Model 3640. Ring oil lubricated sleeve radial and ball thrust or pressure lubricated sleeve radial and tilting pad thrust bearings can be furnished to meet customer or operating requirements. Hydrodynamic bearings offered with pressurized oil lube systems.



TILTING PAD THRUST/SLEEVE RADIAL BEARINGS

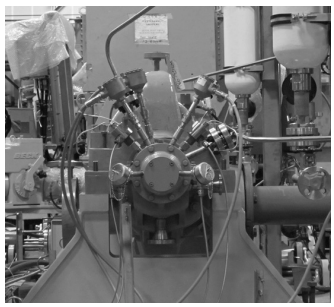


DUPLEX BALL THRUST/BALL RADIAL BEARINGS



DUPLEX BALL THRUST/SLEEVE RADIAL BEARINGS

Instrumentation



The 3640 can be furnished with instrumentation options to measure vibration and temperature. RTDs or thermocouples can be furnished to measure bearing temperatures and to monitor temperature rise in the casing. Bearing housing vibration can be monitored on pumps furnished with ball bearings. Pumps supplied with sleeve bearings can be furnished with non-contacting vibration probes to measure actual rotor vibration.

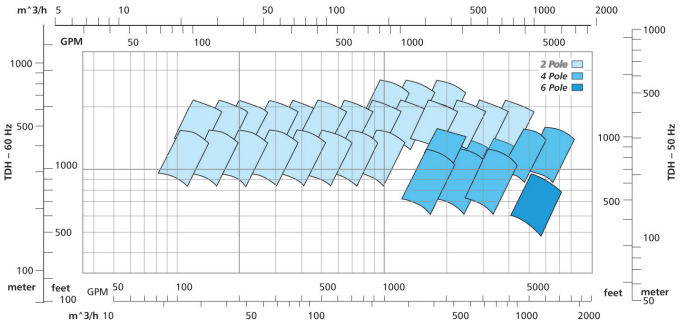
Upgrade Your Older Style API Process Pump

Need an economical alternative to high maintenance costs? Goulds PRO Services® Centers are experienced with reconditioning all types of pumps and rotating equipment, restoring equipment to original specification.

Users continually utilize PRO Services Centers for economical repair versus replacement, decreased downtime, reduced inventory of replacement parts, and the advantage of updated engineering technology.

BENEFITS

Years of experience allow PRO Services Centers to easily handle any rotating equipment, including pumps, drivers, gear boxes, centrifuges, blowers, fans and compressors.



Profit from these exclusive quality services:

- Quality rebuilds/repairs ensure maximum reliability from your rotating equipment.
- One-year warranty on all rebuilds/repairs.
- Upgrade old designs to latest technology to maximize reliability.

Your local PRO Services Center offers solutions for lowering Total Cost of Ownership of your pumping systems. This can be achieved by upgrading your older style API process pumps to today's high performance API standard.

The question of whether to replace or upgrade existing equipment is a challenge faced by most end users today. When casing, piping and foundation are in good shape, upgrading your existing pump to comply with current API standards usually is economically attractive compared to new pump installation. By exploring all options, a better decision can be made.

Upgrades may involve hydraulic modifications, drop-in replacements, and/or power end conversions. PRO Services Centers are experienced with all pump manufacturers.

NOTES

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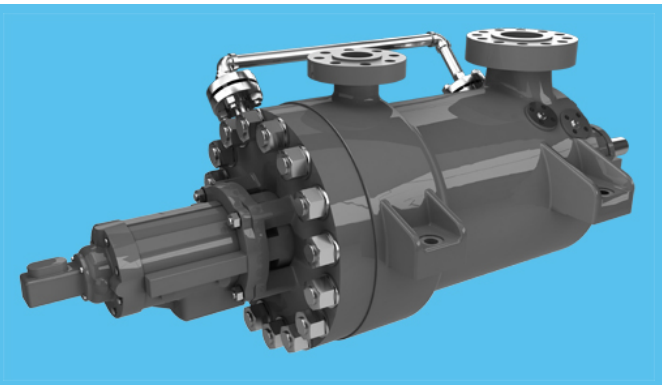


BB5 Multi-stage Barrel Pump

Goulds Model 7200CB

High-temperature, high-pressure low specific gravity BB5 barrel pumps for critical services

Safety and Reliability

Safety, reliability, and versatility are the key words for our radially-split, multi-stage, in-line diffuser type API 610 BB5 barrel pump. We provide engineered solutions with true conformance to the latest API specifications including the stringent emissions containment per API 682. The result is a safe and rugged API 610 process pump designed for a 20-year life.

Versatility

- Capacity to 4,000 GPM (910 m^3/h)
- Total dynamic head to 9,000 feet (2740 m)
- Temperatures to 800° F (425° C)
- Pressure to 4,000 PSIG (275 bar)
- Operating speeds to 6,000 RPM

Features

- **Impeller Arrangements** - In-line diffuser type design.
- **Diffusers / Impellers** - Metal to metal stage casing fits. Key driven and shrink fit impellers secured against axial movement in both directions.
- **Pull-Out Cartridge Assembly** - Stage casings sealed by discharge pressure. Cartridge removed on larger pumps with cartridge assembled.
- **Barrel Outer Casing** - Centerline mount, radial split, full design pressure. Cast barrel and nozzles. Custom nozzle locations / orientation available.
- **Balance Drum** - Designed over allowable flow range and clearances to reliability balance axial forces.
- **Rigid 360° Bearing Bracket** - For heavy duty service and low vibration levels.
- **Integral Wear Parts** - Variety of API metallic and API non-metallic materials and coatings available.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

A Leader in API Engineered Pump Package Solutions...

Proven API Leadership

ITT Goulds Pumps is a proven leader in API Pumps

- Over 20,000 units installed
  - Over 17,000 OH2/OH3's
  - Over 3,000 BB1/BB2/BB3 pumps
- 40+ years of API expertise
- Participating member on API 610 and API 682 committees

Family of API Pumps

ITT Goulds Pumps has a family of proven API pumps

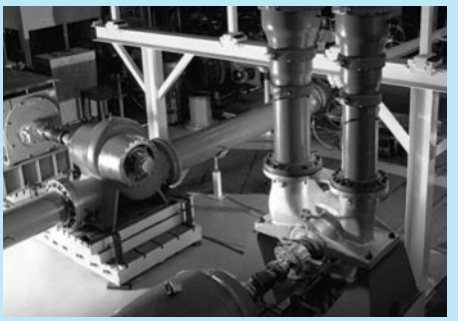
- Overhung pumps
- Single- and two-stage between-bearing pumps
- Multistage between-bearing pumps
- Vertical, double casing pumps
- Barrel multistage pumps
- Specialty pumps

Industry Leading Hydraulic Coverage

- We offer dense hydraulic coverage to meet your process needs.
- Better hydraulic fits can mean improved efficiency and long-term reliability and parts life.

8000 HP / 5960 kW Testing Capability

- Our test facilities can test your pump in the most demanding conditions.
- Optional complete train (or full string) test at 50 or 60 hz.
- Ability to test job motors at 5kv, 5.5kv, 6kv, 6.6kv, 7.2kv, 10kv, 11kv, 12.5kv, 13.2kv.



API Engineering Expertise

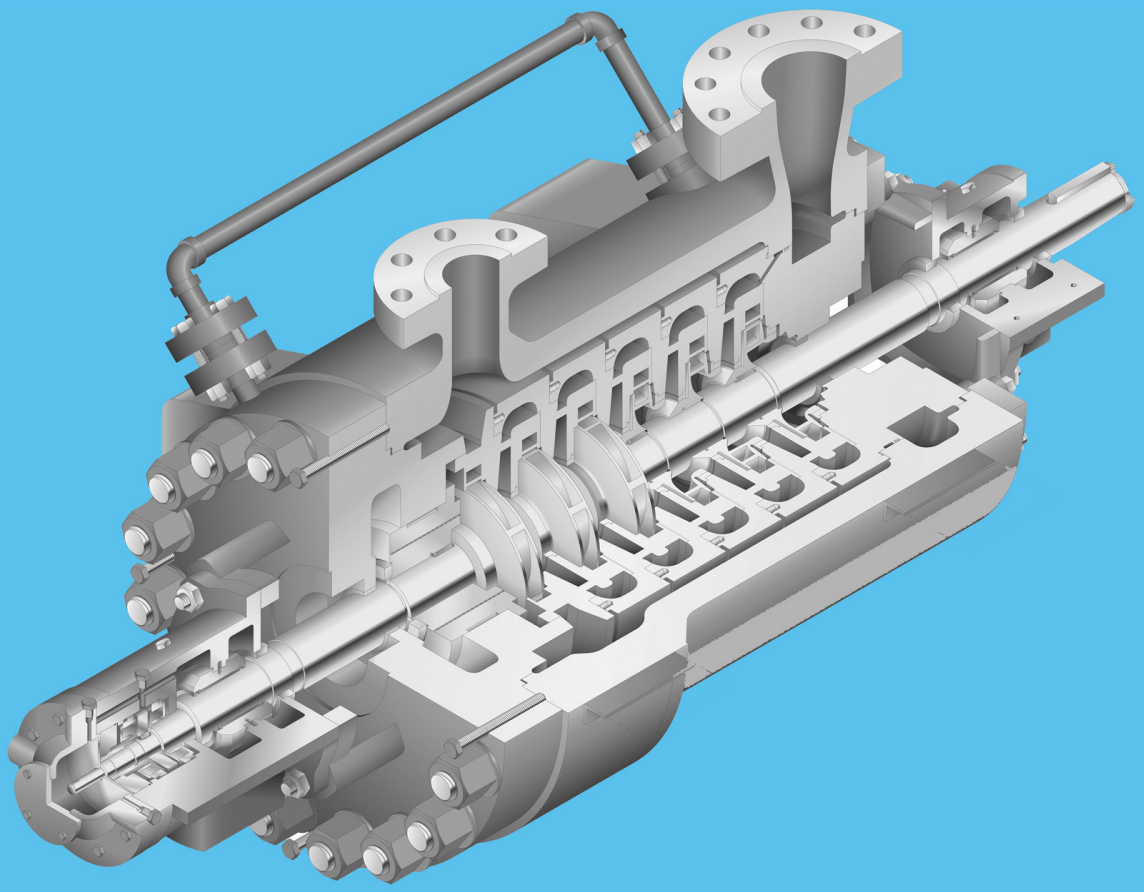
- We are experts in packaging engineered pumps that meet your demanding applications - with true conformance to the latest API specifications.
- We have extensive experience in nearly every type of driver, bearing, seal, piping configuration, nozzle configuration, flange and baseplate designs to meet your application needs.
- ITT is a world leader in technology and engineering including hydraulics, materials science, mechanical design, and fluid dynamics.

Broad Applications

- Petroleum refining, production, and distribution
- Petrochemical and demanding chemical processing
- High temperature applications including boiler circulation
- General industrial requiring high temperature or high pressures

Model 7200CB API 610 11th Edition/ISO 13709 2nd Edition

Design Features for Wide Range of High Temperature/High Pressure Services



Impeller Arrangements
In-line diffuser type design.

Diffusers/Impellers
Metal-to-metal stage casing fits. Key-driven and shrink-fit impellers secured against axial movement in both directions.

Fully Shrouded Diffuser Standard
Increases reliability by nearly eliminating diffuser fatigue.

Low-Vibration Design
Precision investment impeller castings and dynamically balanced rotor for low vibration.

Robust Rotor Design
With large stepped shaft and higher L3 / D4 ratios.

Pull-Out Cartridge Assembly
Stage casings sealed by discharge pressure. Cartridge removed on larger pumps with cartridge assembled.

Barrel Outer Casing
Centerline-mount, radial-split, full design pressure. Cast barrel and nozzles. Custom nozzle locations / orientation available.

Balanced Drum
Designed over allowable flow range and clearances to reliably balance axial forces.

Rigid 360° Bearing Bracket
Ball radial and duplex thrust. Pressure lubricated sleeve radial / tilting pad thrust. INPRO™ isolators.

Flanges
Heavy-duty class 900#, 1500#, and 2500# RF or RTJ flanges. 600# and 900# available on suction flange.

API 682 Seals
Accept a wide variety of seals, seal options and flush plans per API 610 and API 682.

Integral Wear Parts
Variety of API metallic and API non-metallic materials and coatings available.

Trusted Technology

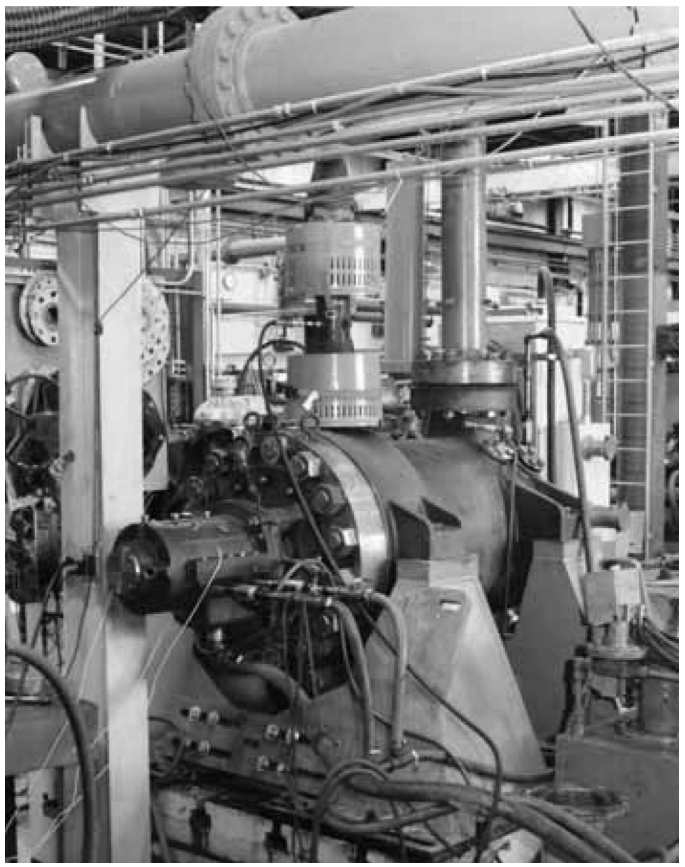
Model CB upgraded to 11th edition. Over 30 years of successful installations.

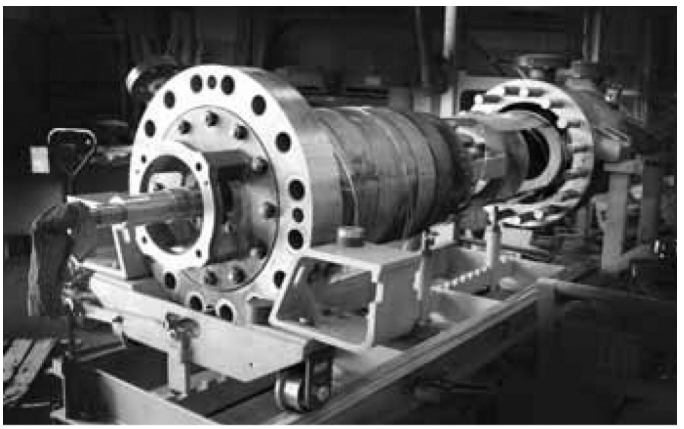
Proven Reliability

Properly designed balance drums are critical to a BB5 pump´s reliable control of axial thrust forces. We exhaustively test the pumps over the allowable wear clearances (1x to 2x clearances) to determine the range of axial thrust forces to properly size the balance drum. The result is reliable operation over the range of allowable conditions

Easy Maintenance

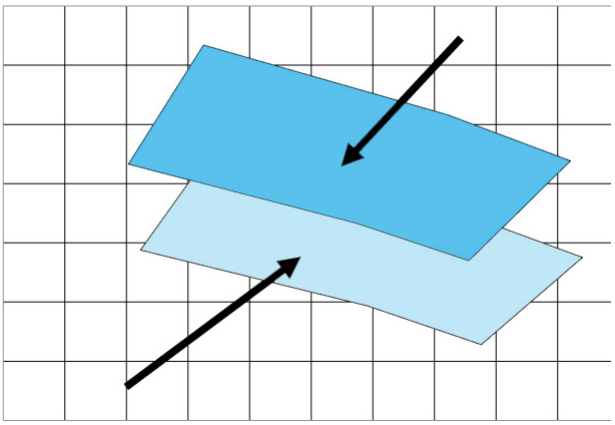
For Model 7200CB pumps, customers can quickly dismantle and remove the complete cartridge using our BB5 cradle tool. The pump casing and nozzles remain connected to speed removal



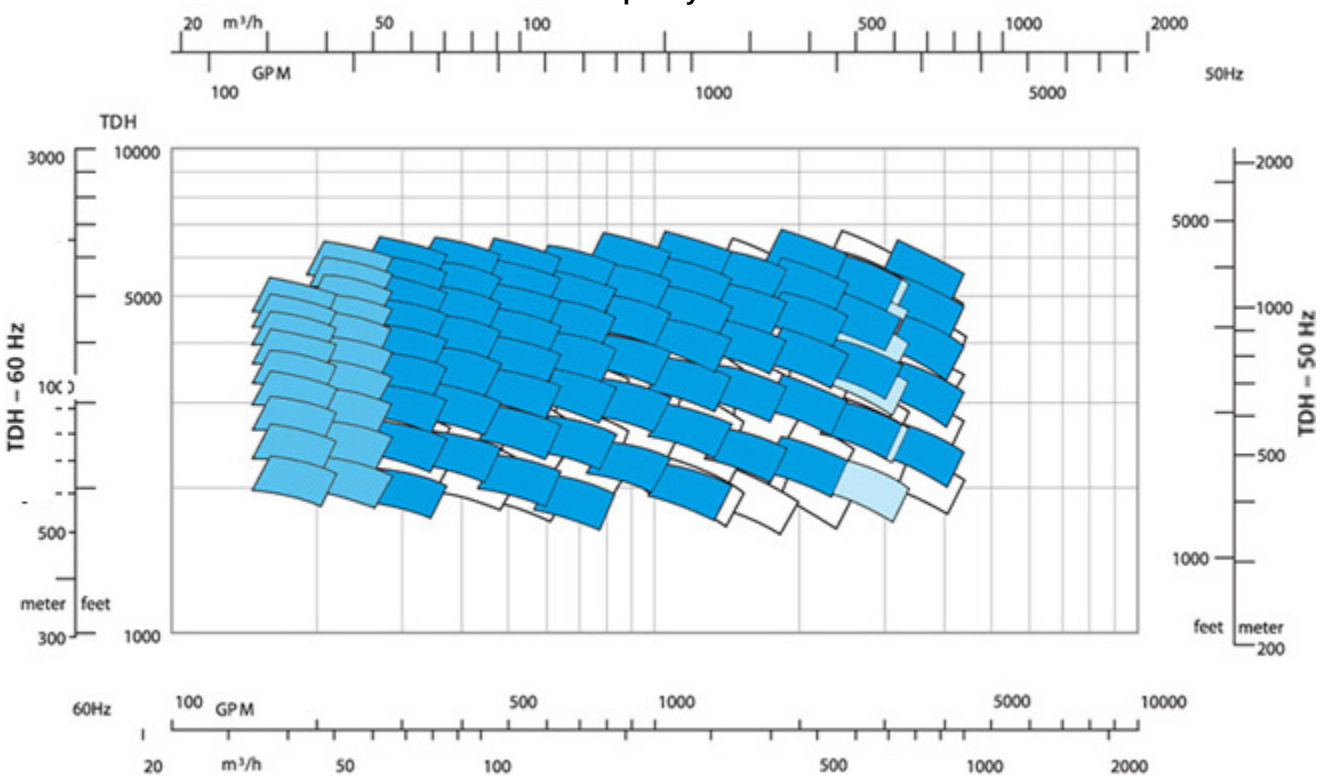


World Class Hydraulics

There are two sets of curves available. One set is optimized for maximum head-per-sage while a second set is optimized for maximum efficiency



Flow Capacity – 50 Hz



Flow Capacity – 60 Hz

Proven Service Experience

Hydraulic Rerates

Processes often change over time - causing pumps to run far from best efficiency point (BEP) with the associated reduction in reliability (MTBF).

We can perform a "hydraulic rerate" to your existing BB5 pump - moving the BEP to the left without any hydraulic changes. The modified pump's operation is closer to the BEP with increased efficiency and reliability.

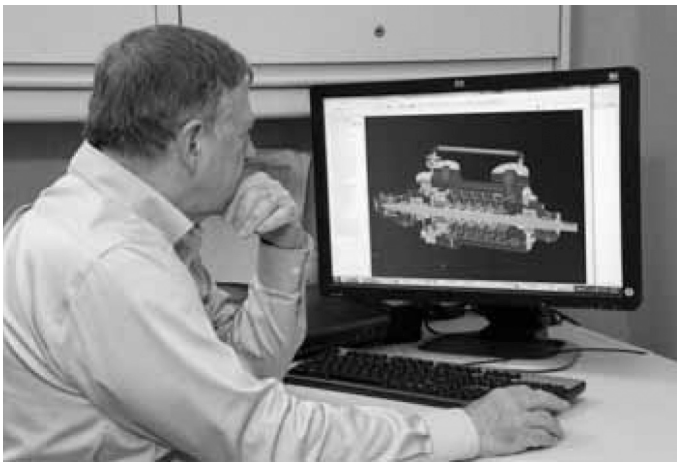
Drop-In Replacements

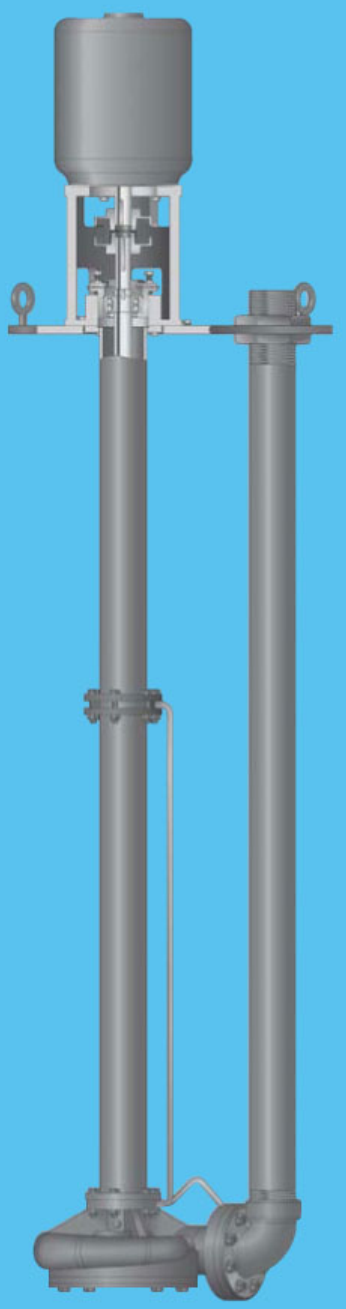
Our drop-in replacements allow you to get a new BB5 pump without replacing your existing piping and baseplate - saving you $10,000s in site costs while reducing emissions and improving MTBF.

We customize our BB5 casing nozzles and/or foot locations, offering you the best of both worlds - new pump with existing piping and site work.

Engineered Upgrades for All Brands

Older pumps don't comply with the more stringent latest editions of API. This causes many issues ranging from limited use of latest seal designs (API 682), potential seal emissions issues, poor reliability and MTBF, OEM parts becoming obsolete, and more. We perform engineered upgrades to your existing API Pump (any brand) - upgrading the power end, casing cover, shaft and seals to the latest API standards.





API 3171—The reliable performer for all API sump services

Goulds Model API 3171

API 610 Compliant VS4 Vertical Sump Pumps

- Capacities to 3180 GPM (722 m^3/h)
- Heads to 525 feet (160 m)
- Temperatures to 450° F (232° C)
- Pit Depths to 20 feet (6 m)

Design Features

- **Compliant Thrust Bearing Arrangement**
  - Grease or oil mist compatible
  - Duplex single row with machined brass cages
  - INPRO® bronze labyrinth seals
- **Compliant Disc Coupling Balanced to AGMA 9**
- **Fully Compliant Bearing Spans**
- **300# Discharge Flanges as Standard**
- **1/2" Diameter Lubelines for Steady Bearings**
- **Integral Lifting Eyes**
- **Many Interchangeable Parts with Model 3171**

Please Refer to Section CHEM-4C

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model VIT

API 610 Compliant VS1 Vertical Industrial Turbine Pump (For higher flows refer to high capacity section.)

- Flows to 70,000 GPM (15,900 m^3/Hr)
- Heads to 3,500 feet (1,067 m)
- Pressures to 2,500 psi (176 kg/cm^2)
- Bowl sizes from 6" to 55" (152.4 mm to 1,400 mm)
- Temperatures to 500° F (260°C)
- Horsepower to 5,000 HP (3,730 KW)

Design Advantages

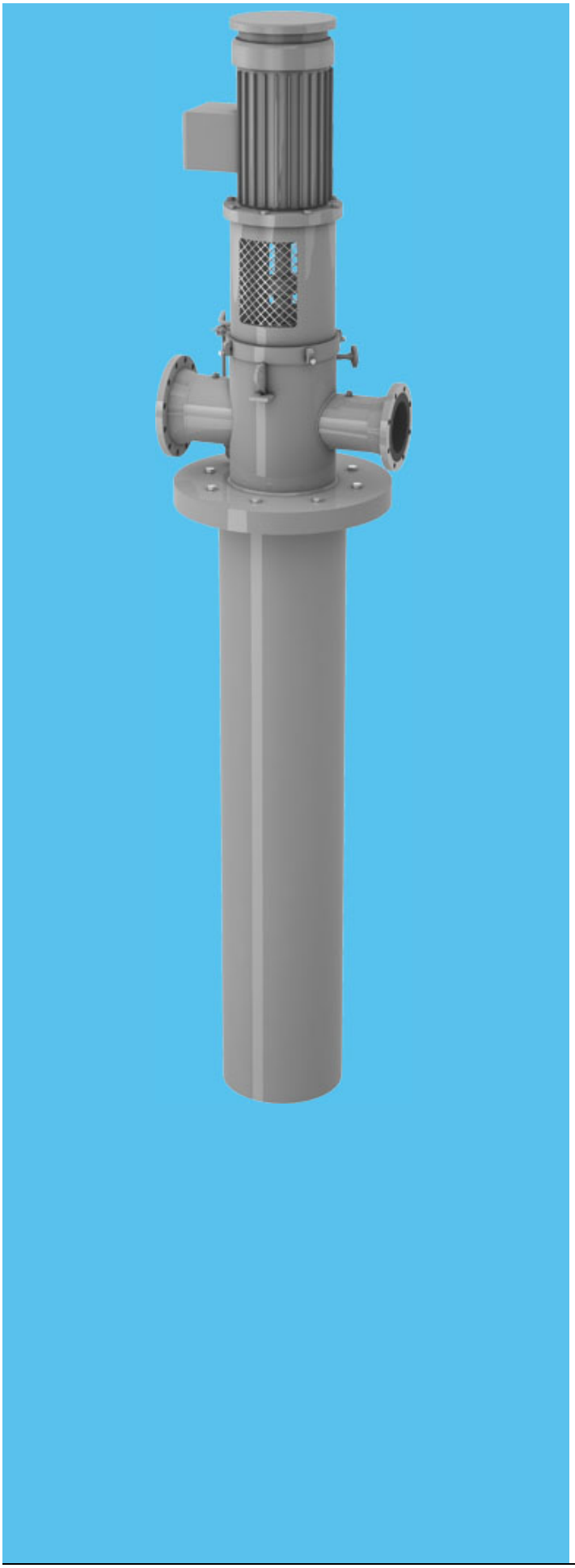
- Fabricated discharge head and flanged column
- Flanged bowl construction
- 416SS shafting
- Alloy construction with external flush of critical wear areas available for corrosive / abrasive services
- Built-in alignment and simple piping for less costly installation and ease of maintenance/ reduced downtime

Typical Services

- Cooling Water
- Seawater and River Water Intake
- Industrial Process Pumps
- Utility Circulating Water
- Condenser Circulating Water Pumps
- Fire Service
- Reclaimed Water

Please Refer to Section VT-1A

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.



Model VIC

API 610 Compliant VS6 Vertical Industrial Can-Type Pump

- Flows to 70,000 GPM (15,900 m^3/Hr)
- Heads to 3,500 feet (1,067 m)
- Pressures to 2500 psi (176 kg/cm^2)
- Bowl sizes from 6" to 55" (152.4 mm to 1,400 mm)
- Temperatures to 500° F (260°C)
- Horsepower to 5000 HP (3730 KW)

Design Advantages

- Fabricated discharge head and flanged column
- Flanged bowl construction
- 416SS shafting
- In-line suction and discharge simplifies installation
- Optional suction in can for site piping flexibility
- Inherent design features on Model VIC allow efficient operation at any NPSH available
- Alloy construction for corrosive / abrasive services

Typical Services

- Pipeline Booster
- Product Transfer, Refinery Blending
- Injection-Secondary Recovery
- Chemical Transfer
- Boiler Feed
- Condensate
- Cryogenics
- LNG Transfer
- Light Hydrocarbons
- Water Services

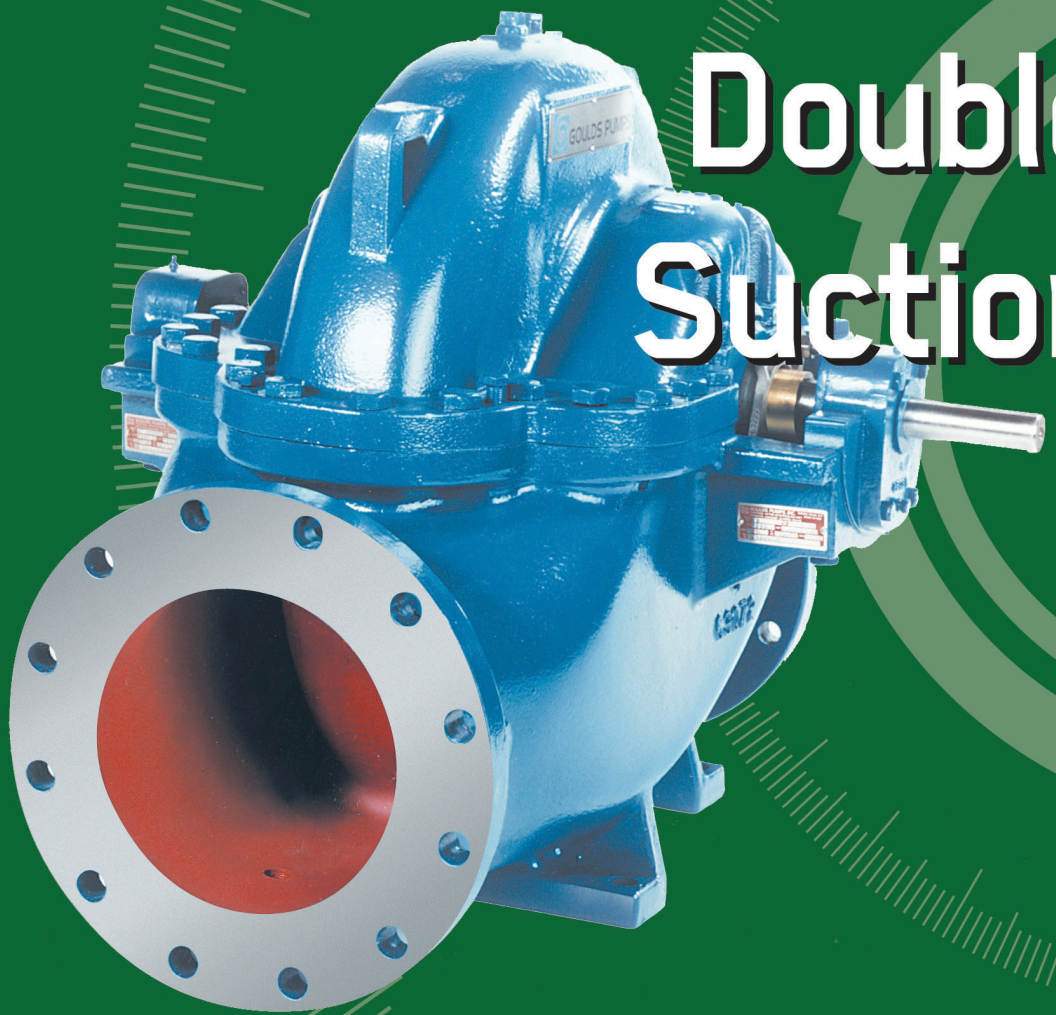
Please Refer to Section VT-1A

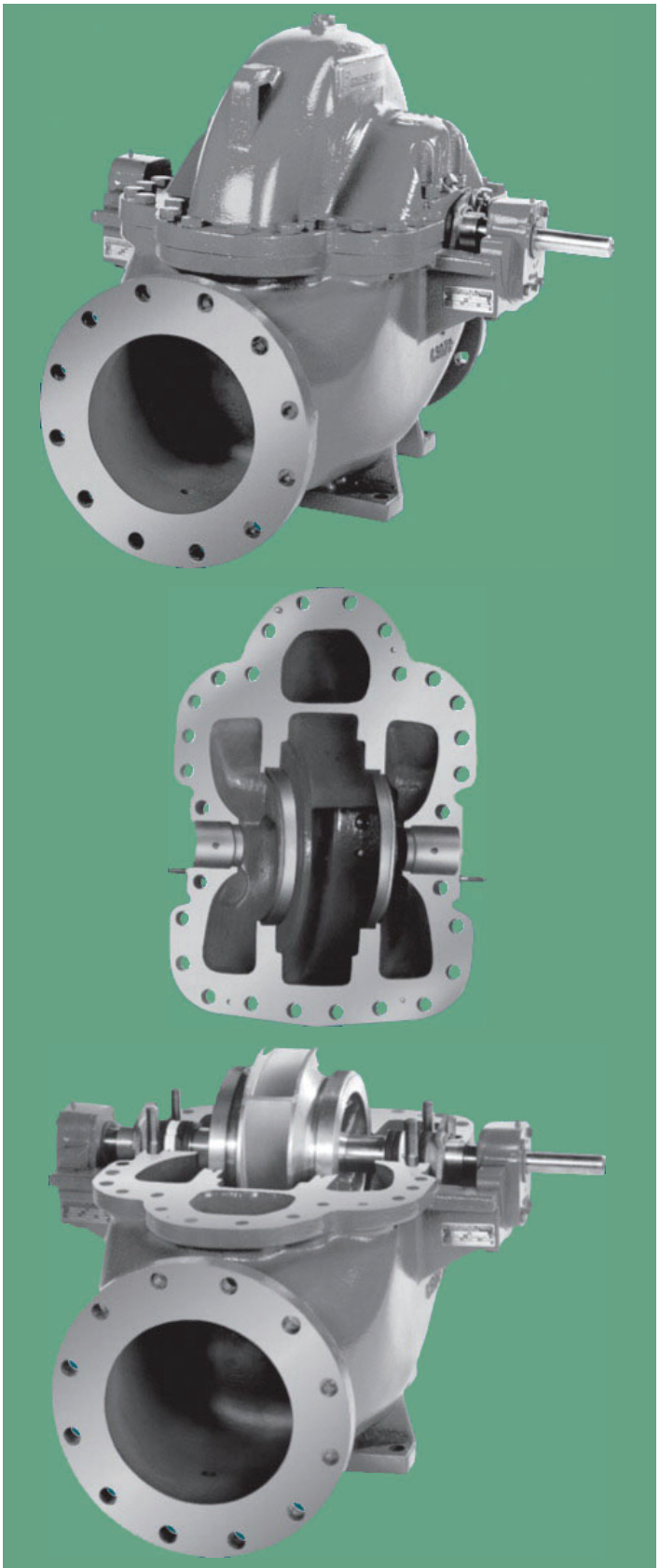
Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

NOTES

4

Double Suction





Goulds 3410

Double Suction Pumps Designed for a Wide Range of Industrial, Municipal, and Marine Services.

- Capacities to 8,000 GPM (1,817 m ^{3}/h)
- Heads to 570 feet (174 m)
- Temperatures to 350° F (177° C)
- Pressures to 250 PSIG (1,724 kPa)

Design Features

- **Double Suction/Dual Volute** Design assures axial and radial balance for long life, low maintenance.
- **Horizontally Split Casing** Suction and discharge nozzles in lower half casing for ease of inspection/maintenance.
- **Wear Rings** Easily replaceable wear rings protect against impeller, casing wear.
- **Sealing Flexibility** Choice of packing or wide range of mechanical seals.
- **Maximum Parts Interchangeability** Entire line uses just four rotating assemblies (exclusive of impellers and wear rings).

Applications

- **Process** — Quench water, stripper bottoms, reboiler circulation, cooling tower
- **Pulp & Paper** — Primary and secondary cleaner, filtrate, mill water supply shower, fan pump
- **Primary Metals** — Cooling water, quench and leaching
- **Municipal** — High lift, low lift, wash water, waste water, raw water
- **Utilities** — Cooling tower, component cooling, service water
- **Marine** — Bilge and ballast, cargo, cooling water, fire pump

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

3410 Single Stage, Double Suction Pumps

Standard Design Features for Wide Range of Heavy Duty Industrial, Municipal and Process Services

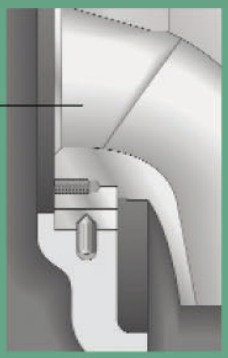
DOUBLE SUCTION IMPELLER
Minimizes axial thrust. Polished waterways and fully machined exterior surfaces assure highly efficient, smooth performance.

RENEWABLE CASE WEARING RINGS
Permits easy maintenance of proper running clearances. Locked in place by anti-rotation pins.

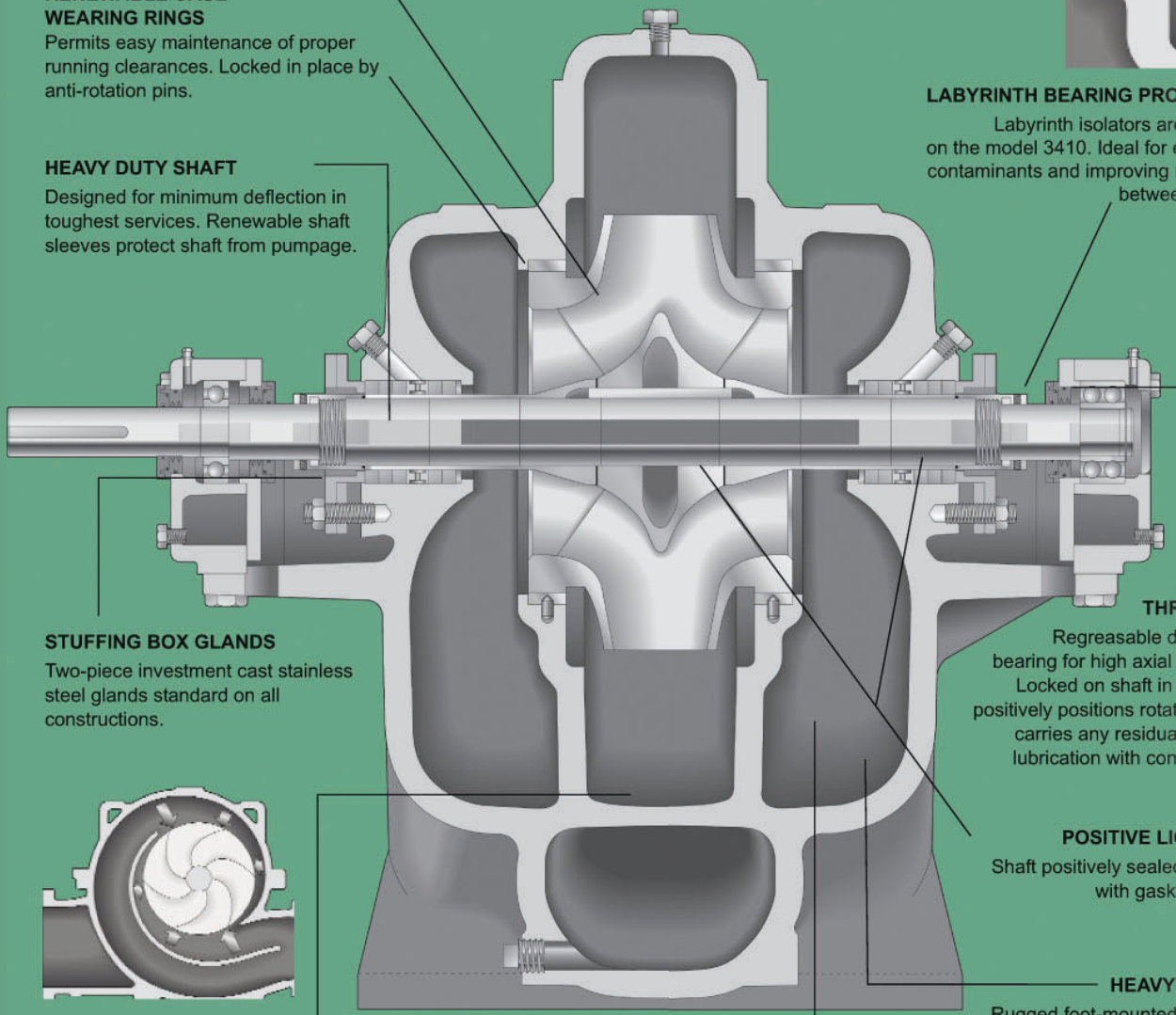
HEAVY DUTY SHAFT
Designed for minimum deflection in toughest services. Renewable shaft sleeves protect shaft from pumpage.

STUFFING BOX GLANDS
Two-piece investment cast stainless steel glands standard on all constructions.

RENEWABLE IMPELLER WEARING RINGS
Available as an option on all sizes. Locked on impeller hub with set screws.



LABYRINTH BEARING PROTECTION
Labyrinth isolators are standard on the model 3410. Ideal for eliminating contaminants and improving mean time between failures.



DOUBLE ROW THRUST BEARING
Regreasable double row thrust bearing for high axial thrust capability. Locked on shaft in bearing housing positively positions rotating element and carries any residual axial thrust. Oil lubrication with constant level oilers optional.

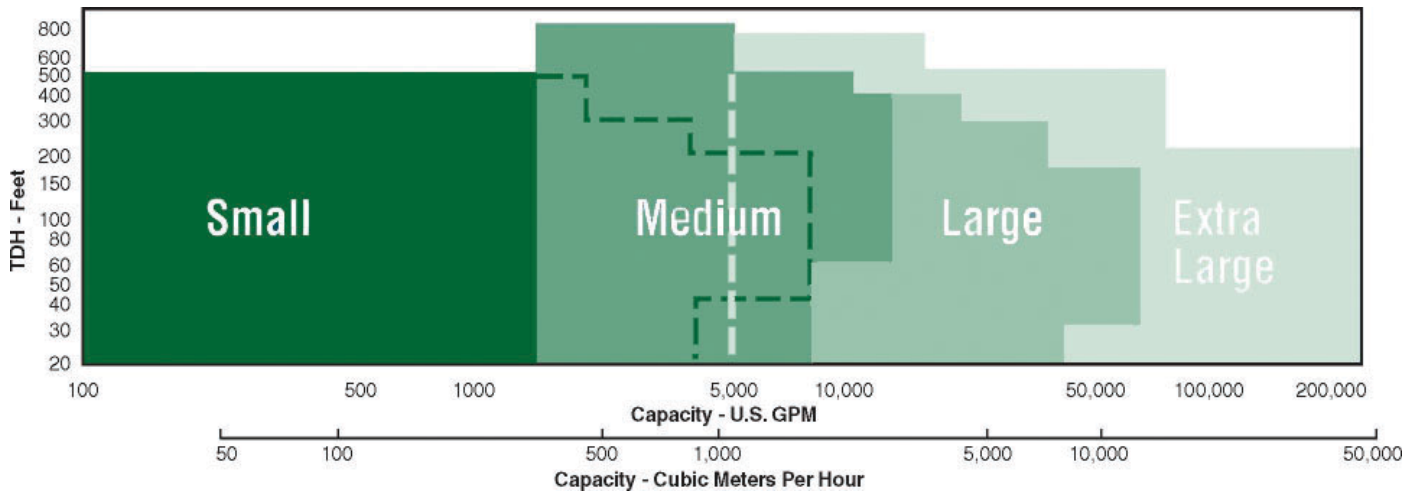
POSITIVE LIQUID SEALING
Shaft positively sealed from pumpage with gaskets and O-rings.

BALANCED DESIGN
Dual volute casing design equalizes radial forces and lessens radial reaction of shaft and bearings — assures smooth, vibration-free performance.Ideal when pumps must periodically operate at capacities above or below design capacity or at interrupted high head. Combined with double suction impeller for axial balance, the 3410 is designed for long life, low maintenance.(Dual volute casing not available on all sizes.)

LARGE INLET AREAS
Reduce NPSH requirement and assure smooth flow to impeller eye for efficient, quiet operation.

HEAVY DUTY CASING
Rugged foot-mounted design to resist external forces and vibration. Casing wall designed to withstand high working pressures with minimum distortion. Both suction and discharge connections in lower half, allowing removal of upper half casing for inspection or removal of complete rotating element without disturbing piping or driver.

The Most Complete Line of Double Suction Pumps In The Industry



Small Capacity

Flows to 8,000 GPM

3408

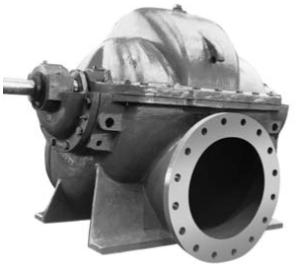
- Capacities to 6,000 GPM (1363 m^3/h)
- Heads to 570 Ft. TDH (174 m) Temperatures to 250° F (120° C) Working Press. to 400 PSI (2758 kPa)

3410

- Capacities to 8,000 GPM (1817 m^3/h)
- Heads to 570 Ft. TDH (174 m) Temperatures to 350° F (177° C)
- Working Press. to 250 PSI (1724 kPa)

Large Capacity

Flows to 65,000 GPM



3420

- Capacities to 65,000 GPM (14,762 m^3/h)
- Heads to 400 Ft. TDH (122 m)
- Temperatures to 275° F (135° C)
- Working Press. to 200 PSI (1379 kPa)

Medium Capacity

Flows to 12,000 GPM

3409

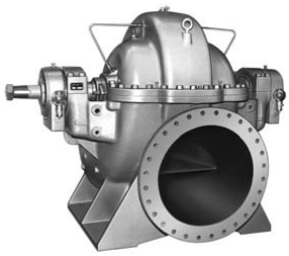
- Capacities to 12,000 GPM (2725 m^3/h)
- Heads to 850 Ft. TDH (259 m)
- Temperatures to 250° F (120° C)
- Working Press. to 400 PSI (2758 kPa)

Extra Large Capacity

Flows to 225,000 GPM

3498

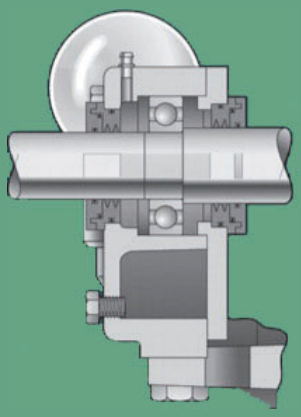
- Capacities to 225,000 GPM (51,098 m^3/h)
- Heads to 800 Ft. TDH (244 m)
- Temperatures to 275° F (135° C) Working Press. to 250 PSI (1724 kPa)



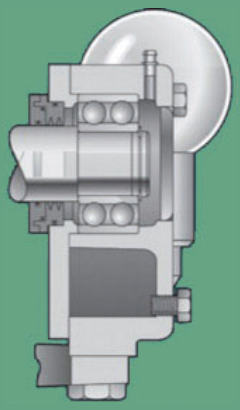
Other Features/Application Flexibility

Optional Oil Lubrication

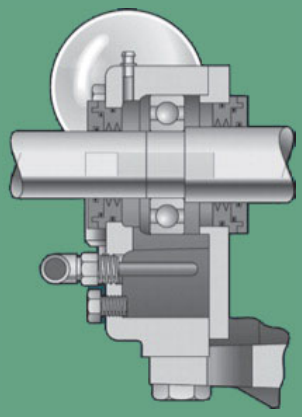
Field convertible with no remachining required.



Oil Lubricated Coupling End Bearings



Oil Lubricated Thrust End Bearings

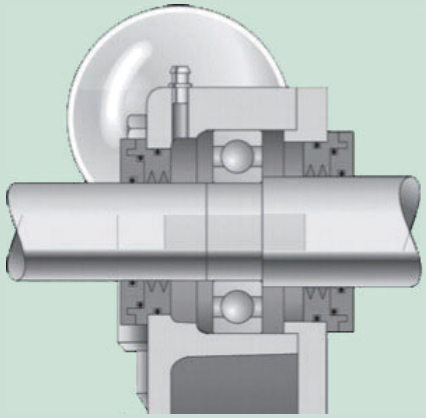


Water Cooled Bearings

Bearing Protection

Labyrinth Seals Supplied As Standard

Labyrinth seals are ideal for eliminating contaminants and providing long life with no shaft wear or heat generation.

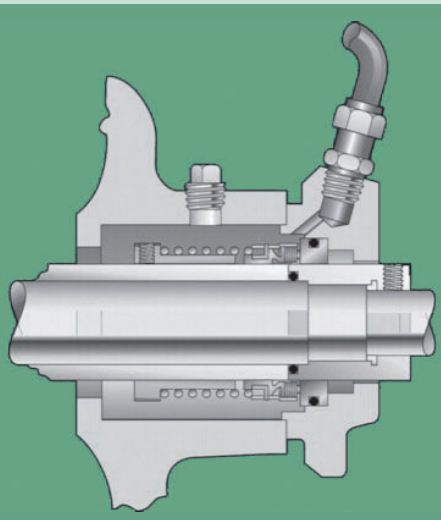


Labyrinth Oil Seals

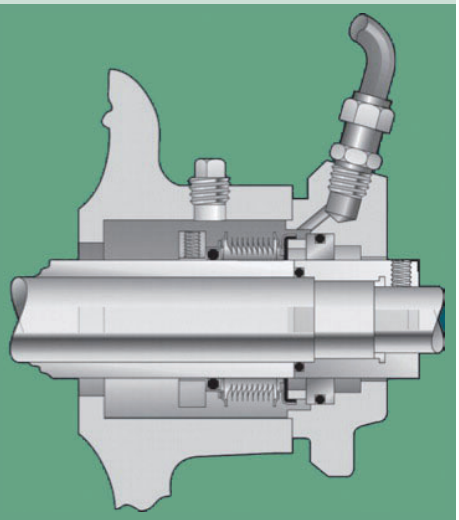
Optional Mechanical Seals

A wide variety of mechanical seals (including cartridge and split type) are readily available for maximum sealing flexibility.

Factory installed mechanical seals feature enlarged stuffing box bores for improved seal lubrication and cooling; extended seal life.

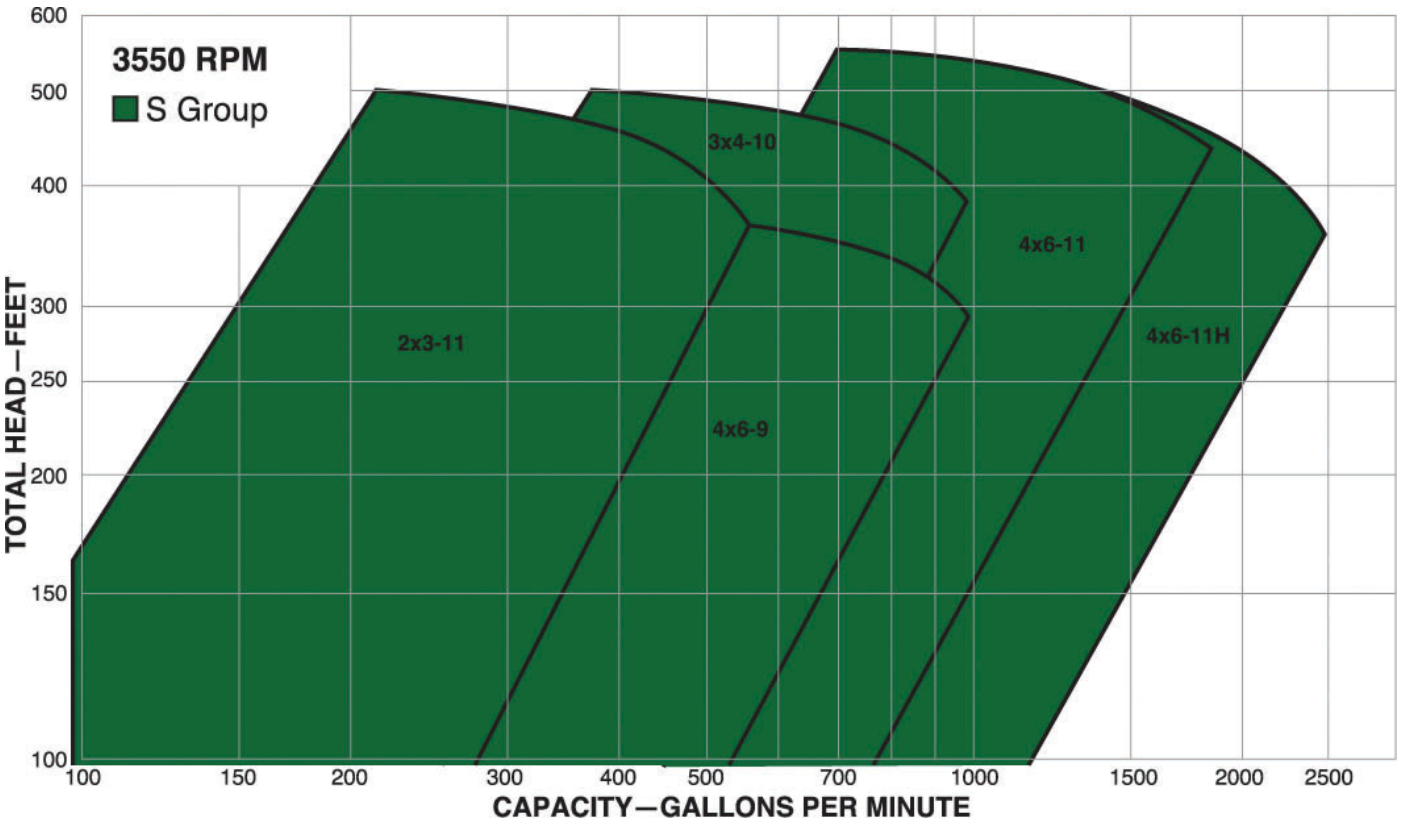


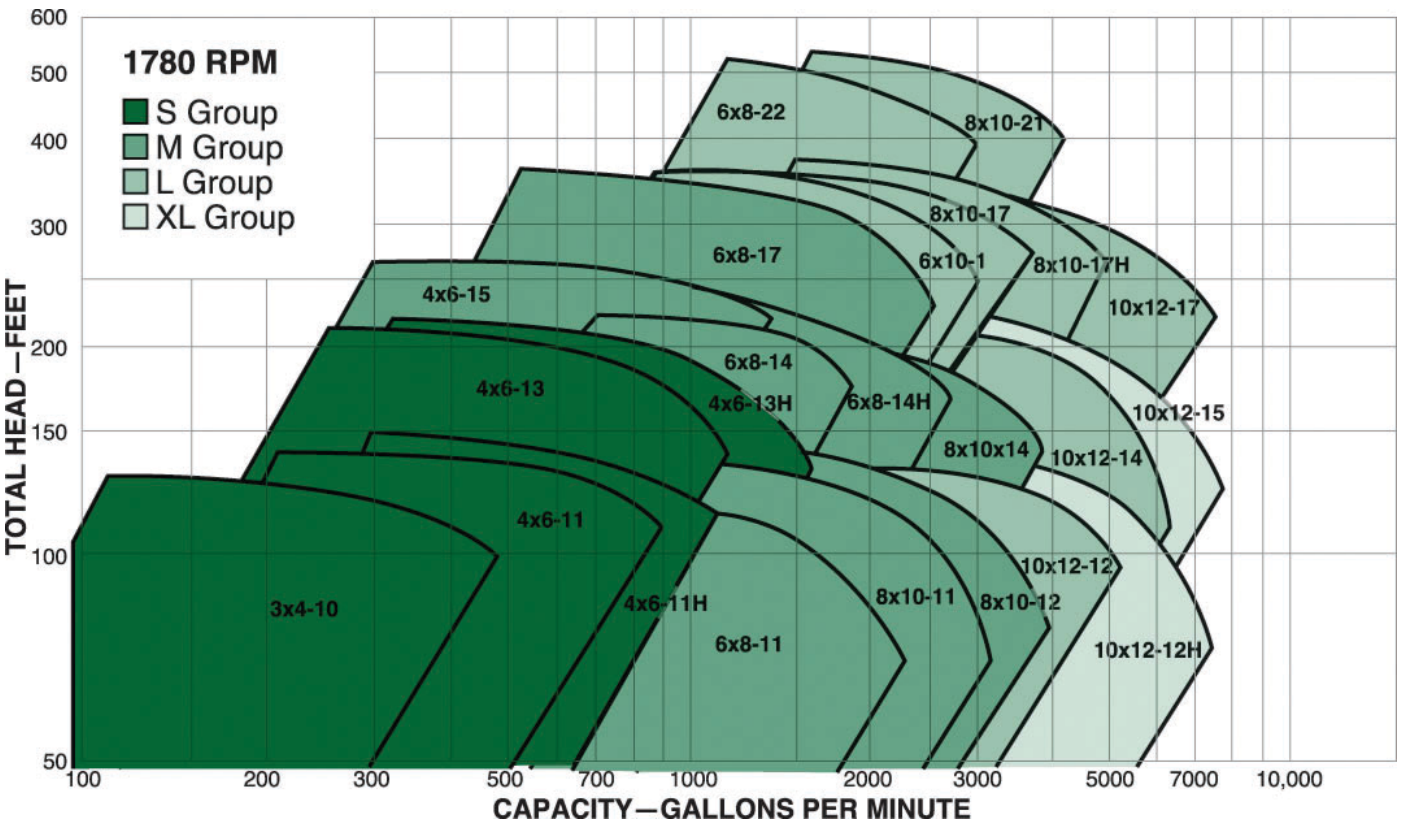
Single Unbalanced Seal



Single Balanced Seal

Hydraulic Coverage 60Hz





Specifications Model 3410

General

Pump shall be single stage, double suction design. Materials shall be bronze-fitted, 316 stainless steel trim or all 316SS. High efficiency, heavy duty design and maintenance features shall be of primary importance as described in following specifications.

Casing

Shall be horizontally split with upper and lower halves bolted together. Flanged suction and discharge connections shall be located in lower half. Removal of upper half shall permit inspection, maintenance or removal of entire rotating element without disturbing suction or discharge piping or driver. Seats for stuffing box bushing shall be cast and bored integrally with lower half casing. Casing shall be supported by integrally cast feet. Upper half shall have taps for seal piping, priming and vents. Lower half shall have taps for gauges and draining. Casing shall have permanently fixed stainless steel nameplate.

Impeller

Shall be enclosed, double suction to provide hydraulic balance, and cast in one piece. Exterior surfaces shall be machined, interior water ways hand finished. Shall be dynamically balanced and keyed to shaft.

Wearing Rings

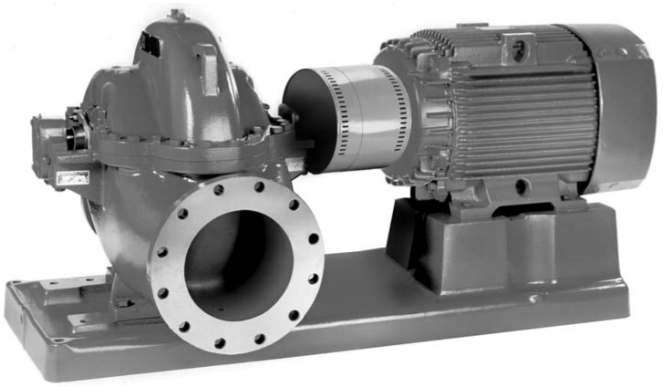
Case wear rings shall be supplied to maintain proper running clearance with impeller hubs and to minimize leakage between suction and discharge chambers of casing. Shall be held in position by anti-rotation pins. Impeller shall be designed to accept impeller wear rings. Impeller rings shall be held in position by axial set screws.

Shaft

Shall have as short a span as possible to minimize deflection and vibration. Shall be completely sealed by gaskets between the shaft sleeves and impeller hubs to assure shaft is completely dry during operation.

Shaft Sleeves (Except S Group)

Shall be held in position by sleeve nuts located outside the stuffing box area. Shall be key driven at the impeller end. An O-ring seal shall be provided to prevent leakage between sleeves and sleeve nuts.



Stuffing Boxes

Shall be integral with casing. Shall contain die-formed packing, split, removable lantern rings and renewable stuffing box throat bushings. Shall have tapped openings for water sealing either from casing or from outside source. Glands shall be split so it will be unnecessary to unbolt gland halves when repacking box.

Mechanical Seals

Pump shall be furnished with (single, double balanced, cartridge) mechanical seals.

Bearing Housings

Seats shall be cast and bored integrally with lower half casing to assure accurate alignment of rotating assembly without need for external adjustment.

Bearings

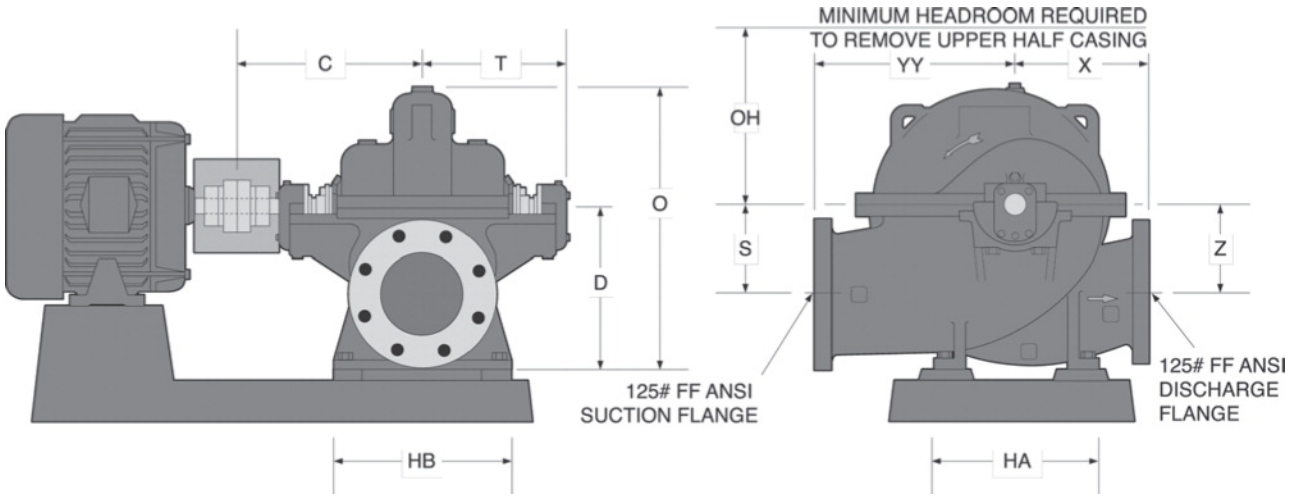
Double row ball bearing shall be provided on thrust end; single row deep grove ball bearing on coupling end. Thrust bearing shall be held in position on shaft with tapered snap ring and locked in bearing housing. Radial bearing shall be free to float axially in housing to take radial load only. Housings shall be completely sealed by Inpro VBX labyrinth seals to exclude moisture and dirt making units suitable for outdoor installation. Shall be grease lubricated with reliefs to prevent over lubrication.

Bedplate and Coupling

Bedplate shall be cast iron with drip collection chamber, tapped drain connection and opening for grouting.

Flexible coupling shall be supplied.

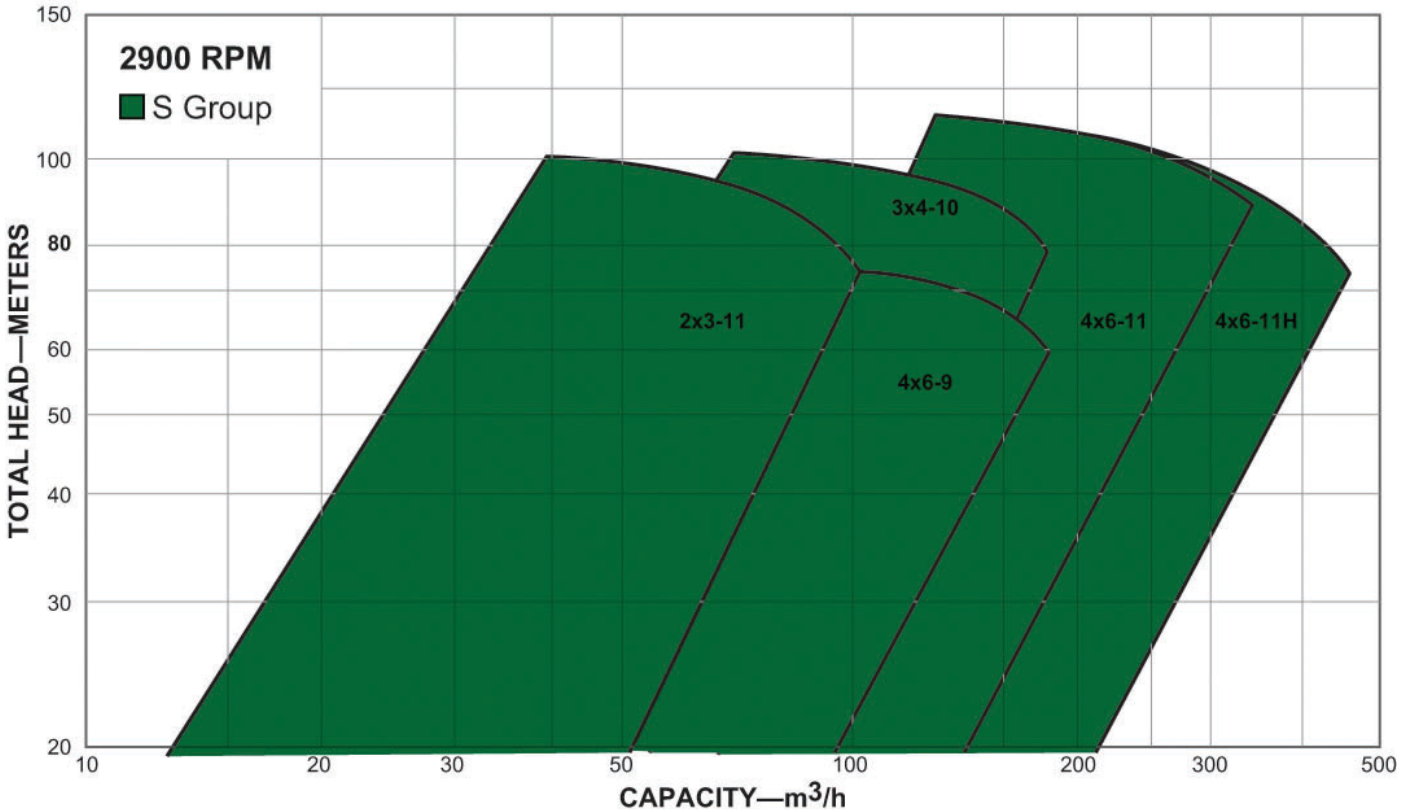
Dimensions

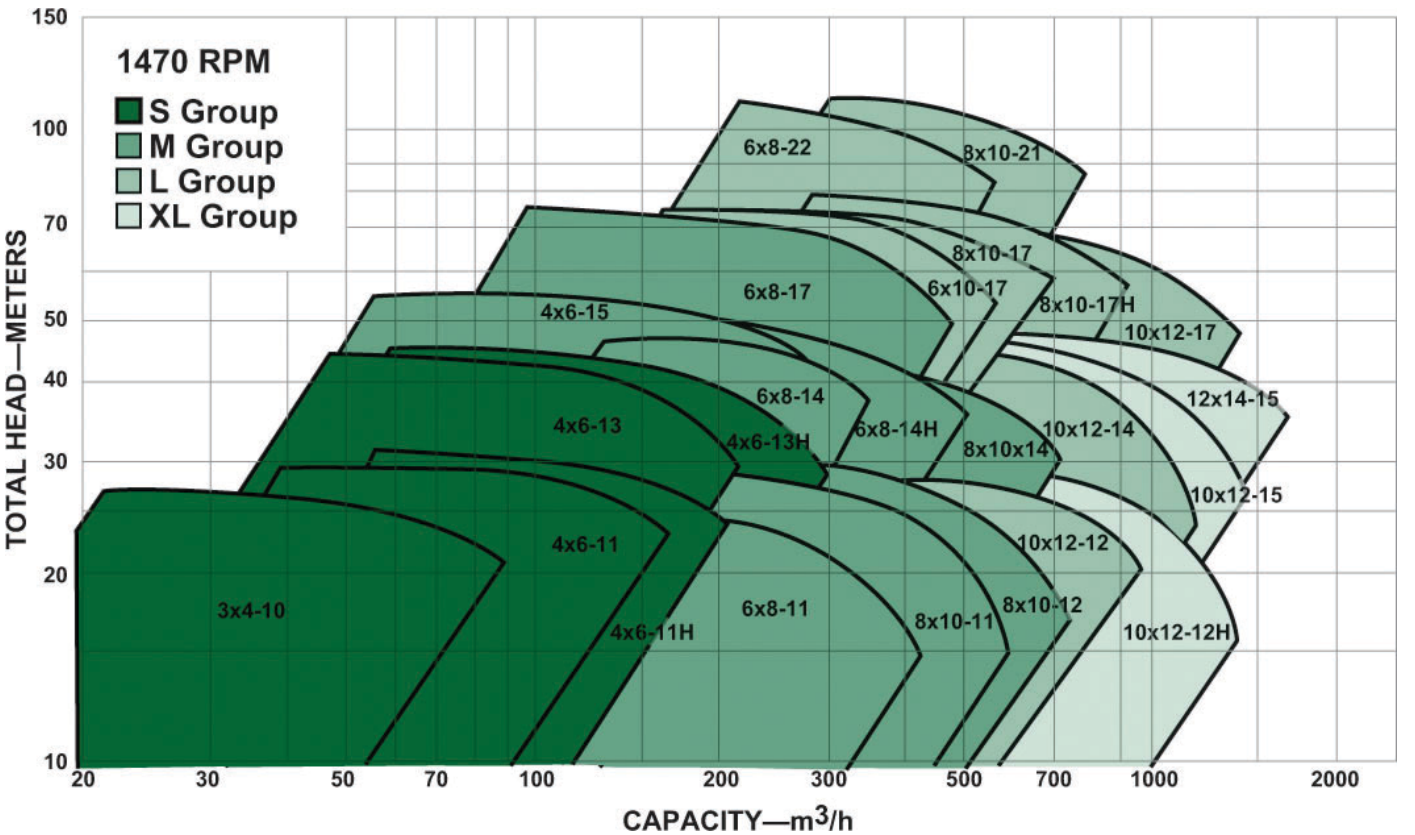


DIMENSIONS DETERMINED BY PUMP

Frame Group	PumpSize	C	T	D	O	OH	S & Z	X	YY	HA	HB	Wt. Lbs
S	2×3-11	14.62 (371)	11.76 (209)	11.50 (292)	18.38 (467)	12.38 (314)	7.25 (184)	7.50 (190)	9.00 (229)	12.00 (305)	12.50 (318)	330 (150)
	3×4-10				18.91 (480)	12.75 (324)	7.00 (178)	9.00 (229)	10.50 (267)			333 (151)
	4×6-9				17.88 (454)	10.88 (276)	6.00 (152)	8.50 (216)	10.00 (254)			334 (152)
	4×6-11/H				19.22 (488)	13.25 (336)	6.00 (152)	10.50 (267)	12.38 (314)			410 (186)
	4×6-13/H				20.59 (523)	15.88 (403)	6.00 (152)	11.00 (279)	13.25 (336)			472 (215)
M	4×6-15	18.00 (457)	13.88 (353)	16.00 (406)	25.88 (657)	17.38 (441)	9.50 (241)	10.00 (254)	14.50 (368)	16.00 (406)	16.75 (425)	637 (290)
	6×8-11				26.44 (672)	16.00 (406)	9.00 (229)	12.00 (305)	14.50 (368)			692 (315)
	6×8-14/H				25.75 (654)	16.75 (425)	9.00 (229)	13.00 (330)	15.50 (394)			665 (302)
	6×8-17				27.88 (708)	20.62 (524)	9.00 (229)	14.25 (362)	15.75 (400)			885 (402)
	8×10-11				25.50 (648)	15.25 (391)	9.00 (229)	13.25 (336)	17.00 (432)			737 (335)
	8×10-12				27.31 (694)	17.38 (441)	8.75 (222)	13.00 (330)	19.50 (495)			858 (398)
	8×10-14				28.50 (724)	19.50 (495)	8.75 (222)	13.88 (352)	19.50 (495)			996 (453)
L	6×8-22	21.00 (533)	16.28 (414)	22.00 (559)	40.50 (1029)	22.50 (572)	13.50 (343)	20.50 (520)	22.00 (559)	22.50 (572)	18.00 (457)	1495 (680)
	6×10-17				33.88 (860)	20.62 (524)	11.00 (279)	16.50 (419)	20.00 (508)			1015 (461)
	8×10-17/H				34.06 (865)	20.88 (530)	10.00 (254)	16.50 (419)	20.00 (559)			1286 (585)
	8×10-21				36.31 (922)	24.88 (632)	13.00 1(330)	17.00 (432)	20.30 (521)			1520 (691)
	10×12-12				34.88 (886)	19.12 (486)	11.00 (279)	14.00 (356)	21.00 (533)			1229 (559)
	10×12-14				34.00 (864)	19.25 (489)	11.00 (279)	16.75 (426)	21.00 (533)			1410 (641)
	10×12-17				37.50 (952)	30.75 (781)	11.50 (292)	17.62 (448)	22.50 (572)			1709 (777)
XL	10×12-12 H	23.19 (589)	17.64 (448)	24.00 (610)	39.50 (1003)	21.75 (552)	13.00 (330)	15.00 (381)	22.00 (559)	22.50 (572)	27.00 (686)	2168 (985)
	10×12-15				38.00 (965)	21.50 (533)	13.00 (330)	16.00 (406)	24.00 (610)			1720 (782)
	12×14-15				36.50 (927)	21.75 (552)	13.00 (330)	18.00 (457)	25.00 (635)			2500 (1136)

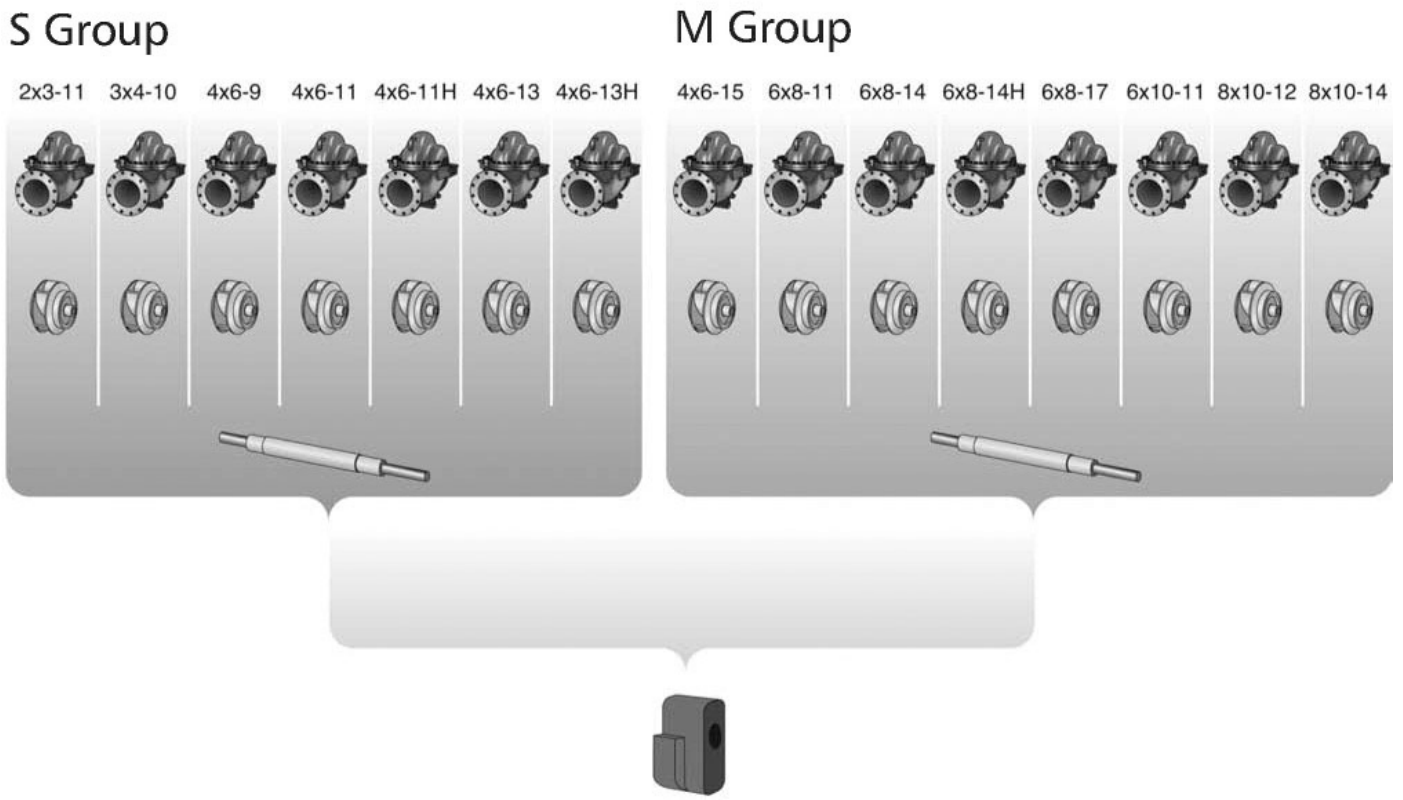
Hydraulic Coverage 50Hz

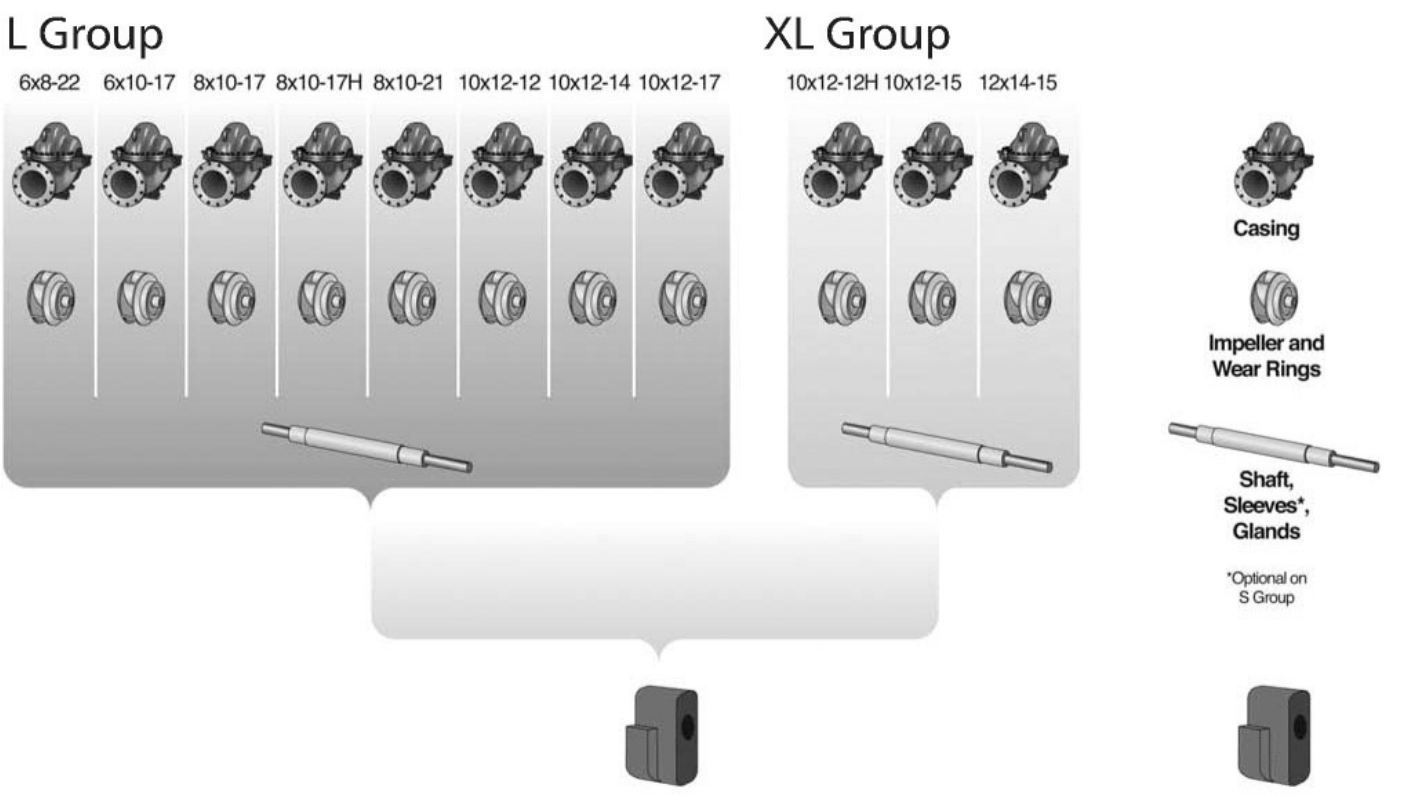




Maximum Interchangeability

Entire 3410 Product Line Utilizes Just Four Shafts And Two Bearing Assemblies





Parts List and Materials of Construction

Item No.	No Req'd Per Pump	Part Name	Material		
			Bronze Fitted	316 SS Fitted	All 316 SS
100	1 Upper 1 Lower	Casing	1003	1003	1203
101	1	Impeller	1179	1203	1203
102	2	Seal Flush Tubing (Optional, Not Illustrated)	Brass	Steel	316 SS
103	2	Wear Ring, Casing	1618	1071	
105	2	Lantern Ring	Glass-Filled Teflon		
106	1 set	Stuffing Box Packing	Square Non-Asbestos (Die-Formed S & M Groups)		
107	2	Stuffing Box Gland	1203		
109	2	Bearing End Cover	1000		
109A	1	Bearing End Cover, Thrust	Steel		
112	1	Ball Bearing, Outboard	Steel		
113	2	Grease Fitting	Steel		
113A	2	Breather (Optional Oil Lubrication Only)	Steel		
122	1	Shaft	2238*		
124	2	Sleeve Nut (M, L, and XL Groups Only)	1618	2445	
125	2	Stuffing Box Bushing	316		
126	2	Shaft Sleeve (Optional on S Group)	1618	1203	
134	2	Bearing Housing	1000		
142	2	Wear Ring, Impeller (Not Illustrated)	1179	1203	
168	1	Ball Bearing, Inboard	Steel		
178	1	Impeller Key	AISI 1018**		
251	2	Sight Oiler (Optional Oil Lubrication Only)	White Metal and Glass		
320	6	Retaining Set Screw, Impeller Wear Ring (Not Illustrated)	303 SS		
332	1	Labyrinth Seal, Outboard	Bronze/Viton		
333	2	Labyrinth Seal, Inboard	Bronze/Viton		
351	1	Casing Gasket, Parting (Not Illustrated)	1/32" Non-Asbestos		
353	4	Gland Studs	316 SS		
355	4	Hex Nuts	304 SS		
360	2	Gasket, End Cover to Bearing Housing	Kraft Paper		
361	1	Retaining Ring, Thrust Bearing	Steel		
361H	2	Retaining Ring, Impeller (S Group Only)	Steel	Stainless Steel	
371C	8	Hex Cap Screw	Steel		
372U	4	Hex Cap Screw	Steel		
428	2	Gasket, Sleeve to Impeller (M, L, and XL Groups Only)	1/32" Non-Asbestos		
443T	1	Bearing Spacer (L & XL Groups Only)	Steel		
445A	2	Anti-Rotation Pin, Case Wear Ring	AISI 420	AISI 316	
497	2	O-ring, Sleeve Nut	Buna Rubber		

*S Group AISI 420 (Bronze Fitted Constructions), AISI 316 (316 SS Fitted & All 316 SS Constructions) **S Group AISI 303

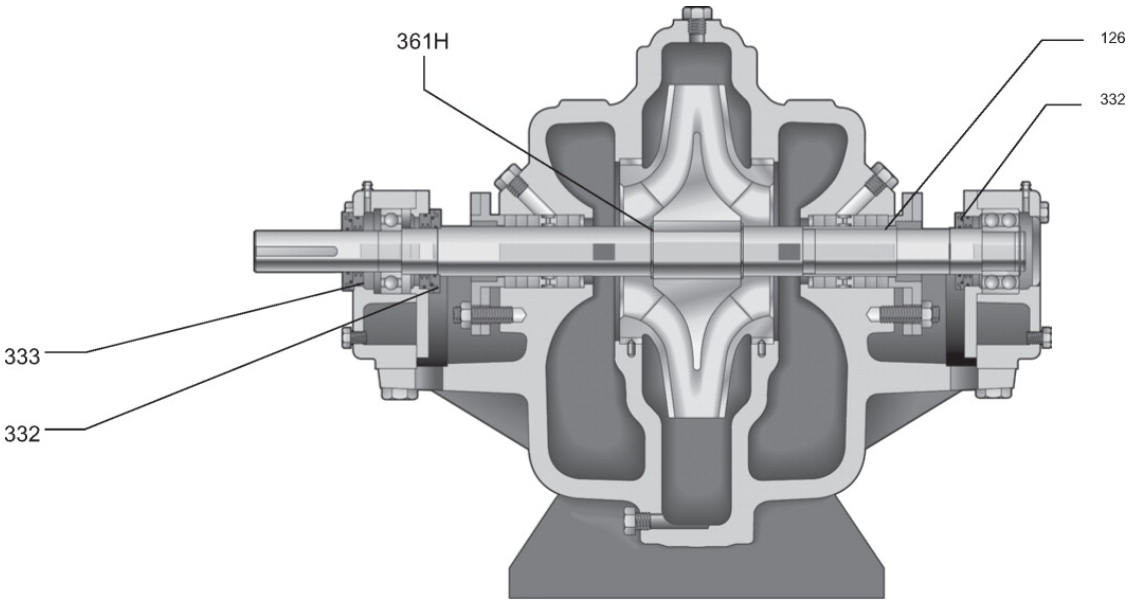
Materials of Construction

Code	Specification
1000	Cast Iron—ASTM A48 Class 25B
1003	Cast Iron—ASTM A48 Class 30B
1071	Nitronic 60—ASTM A743 Grade CF10SMnN
1179	Bronze—ASTM B584 Alloy C87600
1203	Stainless Steel—ASTM A743 Grade CF8M
1618	Bronze—ASTM B584 Alloy C80500
2238	Steel—ASTM A322 Grade 4140
2445	Nitronic 60—ASTM A276 Grade CF10SMnN
AISI 304	Stainless Steel—ASTM A276 Type 304
AISI 1018	Steel—ASTM A108 Grade 1018—B1112
AISI 420	Stainless Steel—ASTM A276 Type 420

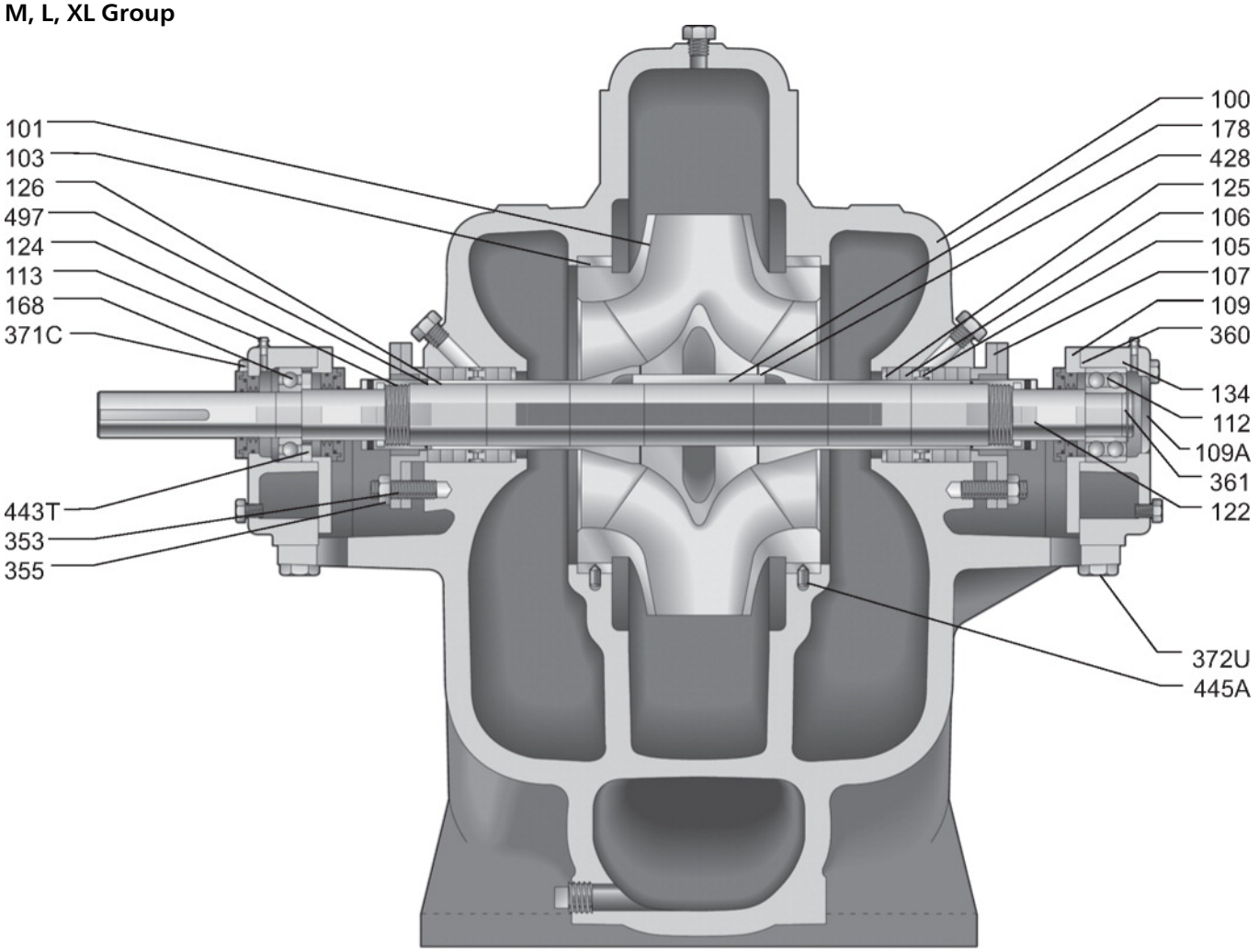
Sectional View 3410

S Group

Model 3410 S Group is standard less shaft sleeves. Optional sleeves to protect stuffing box area are optional. Impeller is key driven and held axially by retaining rings.



M, L, XL Group



Construction Details

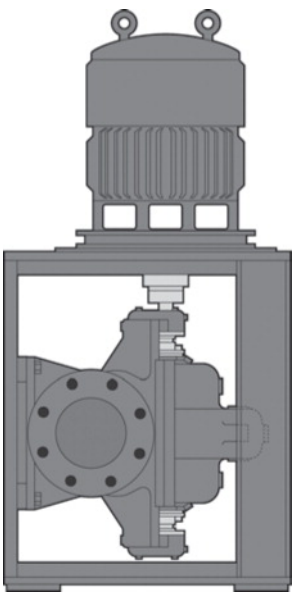
All dimensions in inches and (mm), weights in Lbs. and (kg).

		GROUP S							GROUP M							GROUP L								GROUP XL		
		2×3-11	3×4-10	4×6-9	4×6-11**	4×6-11H**	4×6-13	4×6-13H	4×6-15	6×8-11	6×8-14	6×8-14H	6×8-17	8×10-11	8×10-12	8×10-14	6×8-22	6×10-17	8×10-17**	8×10-17H**	8×10-21**	10×12-12**	10×12-14**	10×12-17**	10×12-12H**	10×12-15**	12×14-15**
PUMP	Weight, Bronze Fitted Bare Pump	330 (150)	333 (151)	334 (152)	410 (186)	410 (186)	450 (205)	472 (215)	637 (290)	692 (315)	665 (302)	665 (302)	885 (402)	737 (335)	856 (389)	996 (453)	1495 (680)	1015 (461)	1286 (585)	1306 (594)	1520 (691)	1229 (559)	1410 (641)	1709 (777)	2168 (985)	1720 (782)	2500 (1136)
	Weight, Upper Hall Casing	63 (29)	66 (30)	59 (27)	84 (38)	84 (38)	88 (40)	88 (40)	143 (65)	150 (68)	139 (63)	139 (63)	200 (91)	151 (69)	189 (86)	235 (107)	320 (145)	210 (95)	254 (115)	254 (115)	371 (169)	286 (130)	305 (139)	388 (175)	493 (224)	369 (168)	605 (275)
	Weight, BF Rot. Element	70 (32)	63 (29)	62 (28)	75 (34)	75 (34)	80 (36)	104 (47)	132 (60)	104 (47)	120 (55)	120 (55)	180 (73)	113 (51)	111 (50)	135 (61)	250 (112)	228 (104)	244 (111)	264 (120)	270 (123)	178 (81)	210 (95)	250 (114)	218 (99)	250 (114)	282 (128)
	Minimum Wall Thickness	3/8 (10)	3/8 (10)	3/8 (10)	3/8 (10)	3/8 (10)	3/8 (10)	7/16 (11)	1/2 (13)	1/2 (13)	1/2(13)	1/2 (13)	1/2 (13)	1/2 (13)	1/2 (13)	5/8 (16)	9/16 (14)	1/2 (13)	1/2 (13)	1/2 (13)	9/16 (14)	1/2 (13)	5/8 (16)	5/8 (16)	5/8 (16)	5/8 (16)	5/8 (16)
	Max. Dia. Spherical Solids	5/16 (8)	5/16 (8)	1/2 (13)	5/8 (16)	5/8 (16)	3/8 (10)	3/8 (10)	7/16 (11)	13/16 (21)	15/16 (21)	1-1/16 (27)	9/16 (14)	3/4 (19)	1-1/8 (29)	1-1/16 (27)	5/8 (16)	5/8 (16)	1-1/16 (27)	1-1/16 (27)	11/16 (17)	1-3/16 (30)	15/16 (24)	1-1/4 (32)	1-1/8 (29)	1-3/8 (35)	1-1/2 (38)
	CasingCap Gal. (L)	1.7 (6.4)	3.8 (3.2)	3.2 (12.1)	5.8 (22.0)	5.8 (22.0)	8.2 (23.5)	6.2 (23.5)	9.9 (37.5)	10.0 (379)	12.0 (45.4)	12.0 (45.4)	17.3 (65.5)	14.0 (53.0)	22.0 (83.3)	20.6 (78.0)	20.5 (77.6)	18.0 (68.1)	23.4 (886)	23.4 (88.6)	32.5 (123)	33.0 (128)	20.8 (787)	40.2 (152)	48.5 (176)	43.0 (163)	65.7 (249)
STUFFING BOX	Stuffing Box Bore	2-1/2 (64)†							2-7/8 (73)†								3-3/4 (95)†								4 (102)†		
	Stuffing Box Depth to Bushing	2-5/8 (67)							2-5/8 (67)								3-5/8 (92)								3-5/8 (92)		
	Packing Size	3/8 × 3/8 (10 × 10)							3/8 × 3/8 (10 × 10)								1/2 × 1/2 (13 × 13)								1/2 × 1/2 (13 × 13)		
	No. of Packing Rings	5							5								5								5		
	Width of Lantern Ring	5/8 (16)							5/8 (18)								7/8 (22)								1 (25)		
SHAFT AND BEARINGS	Dia. of Shaft in Impeller	1-13/16 (46)							1-15/16 (49)								2-9/16 (65)								2-13/16 (71)		
	Dia. of Shaft in Sleeve	(w/ Optional Sleeve)* 1-1/2 (33)							1-7/8 (48)								2-1/2 (65)								2-3/4 (70)		
	Dia. of Shaft in Coupling	1-3/8 (35)							1-3/8 (35)								2-1/8 (54)								2-1/8 (54)		
	O.D. of Shaft Sleeve	(w/ Optional Sleeve) 1-3/4 (45)							2-1/8 (54)								2-3/4 (70)								3 (76)		
	Bearing Span	20-1/8 (511)							24-1/2 (622)								28-7/8 (708)								31-9/18 (802)		
	Bearing Coupling End	6207							6207								6211								6211		
	Bearing Thrust End	5306							5306								5309								5309		
	Max. BHP per 100 RPM	9.72 (7.25 kW)							9.72 (7.25 kW)								35.87 (26.76 kW)								35.87 (26.76 kW)		
GENERAL	Max. Allow. Suct. Press.	75 PSIG (527 kPA)																									
	Parting Gasket Thickness	1/32 (8)																									
	Max. Liquid Temp. w/o cooling	250°F (121°C)																									
	Max. Liquid Temp. w/cooling	350°F (177°C)																									

NOTES:
*† Dimensions shown are for packed box only.
** O D. of shaft through stuffing box is 1-3/4 in. in standard S Group sleeveless construction.
** Dual Volute Casings

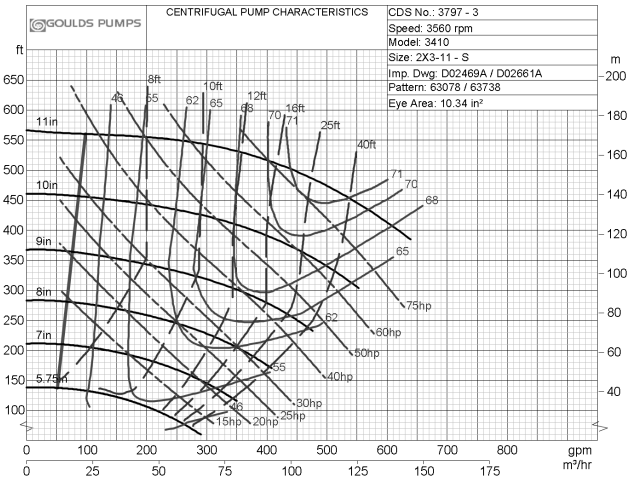
Vertical Versatility

Goulds Model 3410 is available in a vertical configuration (3410 V). This arrangement is ideal for applications with limited space such as shipboard service. A rugged fabricated steel frame supports the pump and driver, providing a machined fit for positive alignment when using standard P-base or C-Face motors.

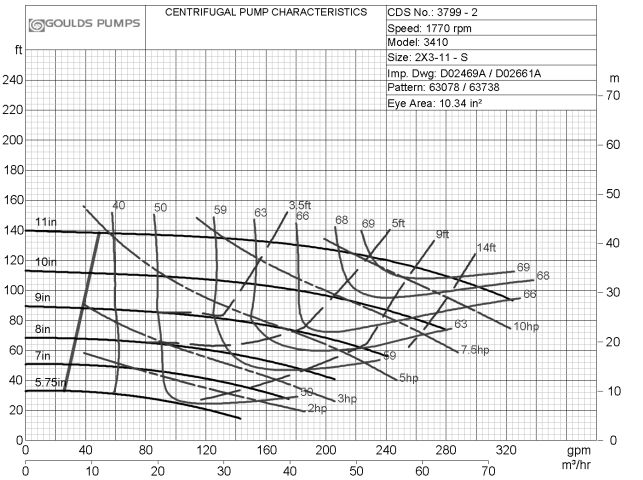


Model 3410 V

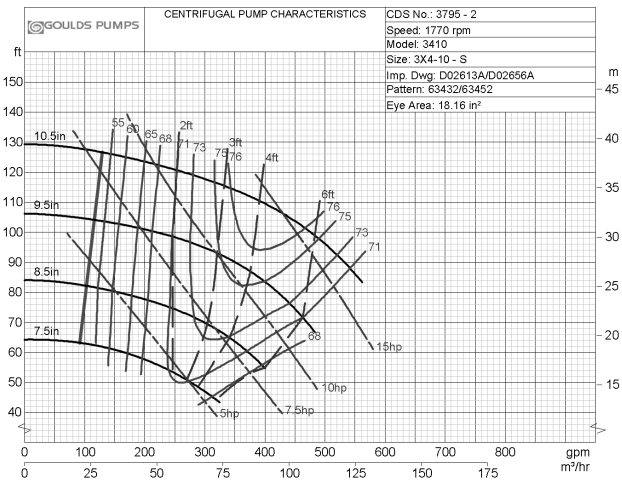
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



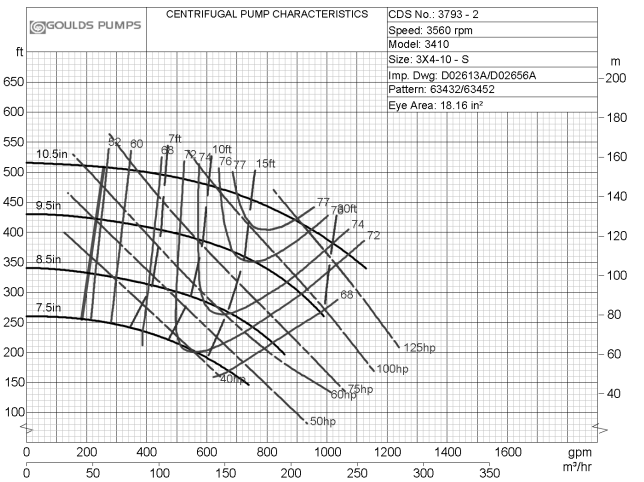
2X3-11 **3560rpm**



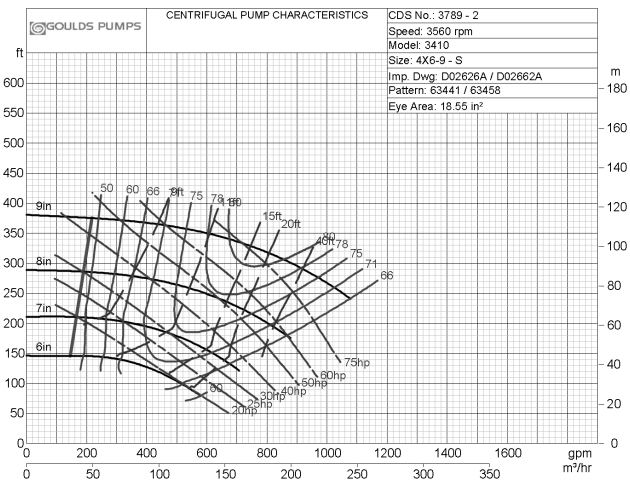
2X3-11 **1770rpm**



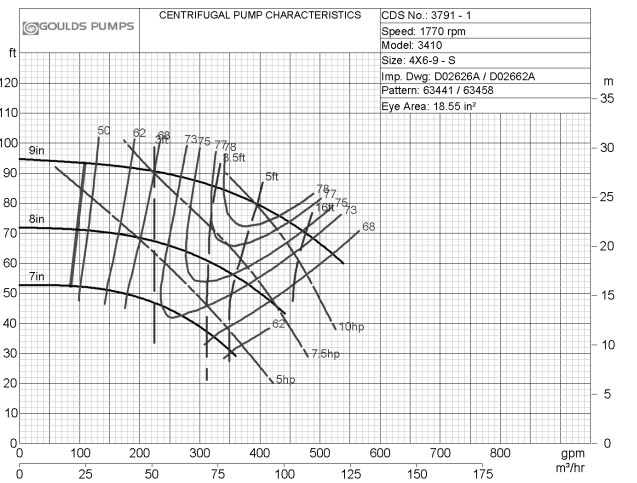
3X4-10 **1770rpm**



3X4-10 **3560rpm**

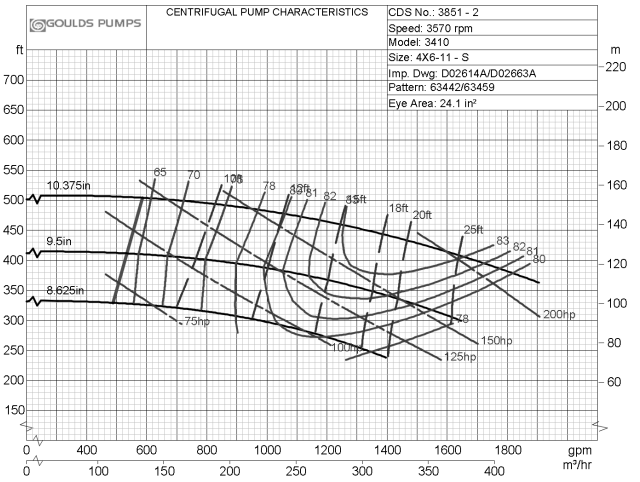


4X6-9 **3560rpm**

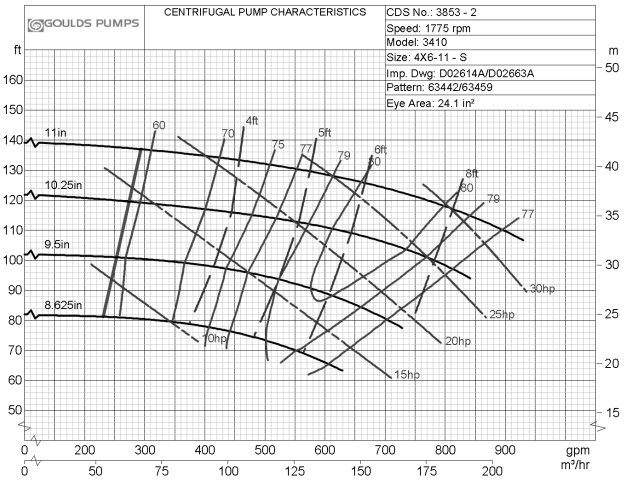


4X6-9 **1770rpm**

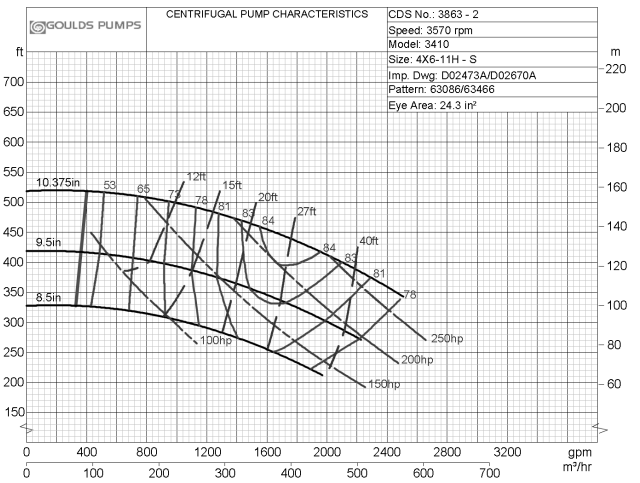
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



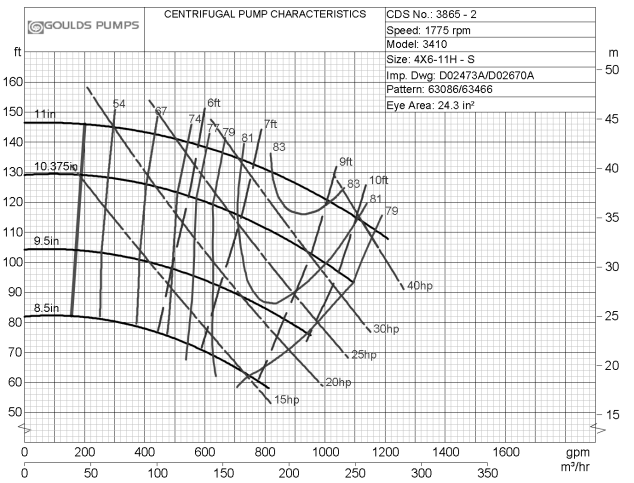
4X6-11 **3570rpm**



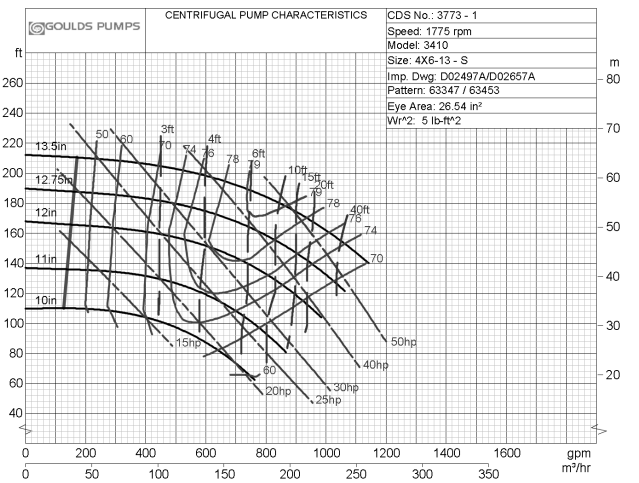
4X6-11 **1775rpm**



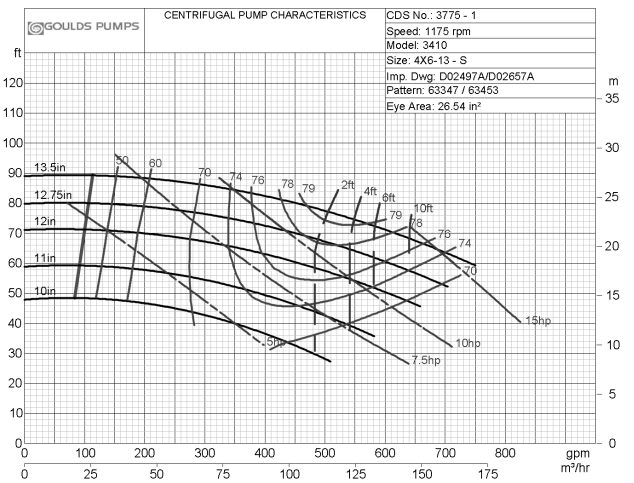
4X6-11H **3570rpm**



4X6-11H **1775rpm**

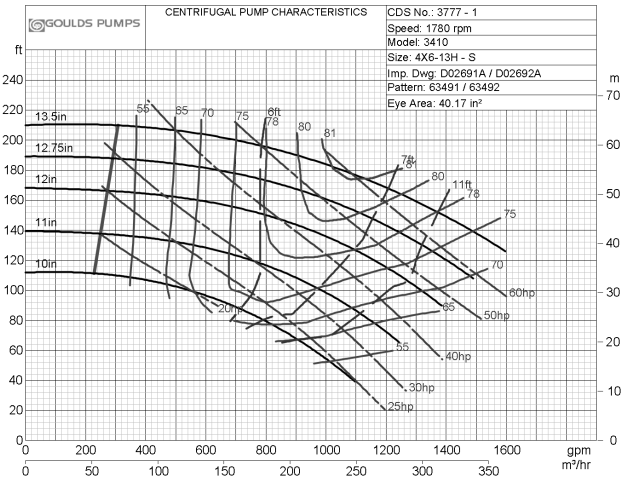


4X6-13 **1775rpm**

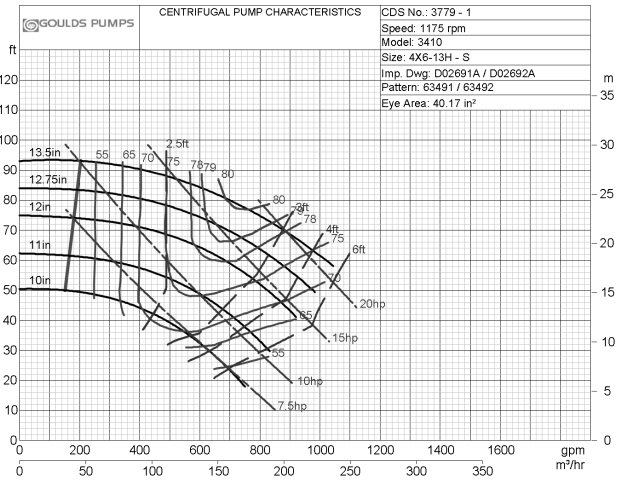


4X6-13 **1175rpm**

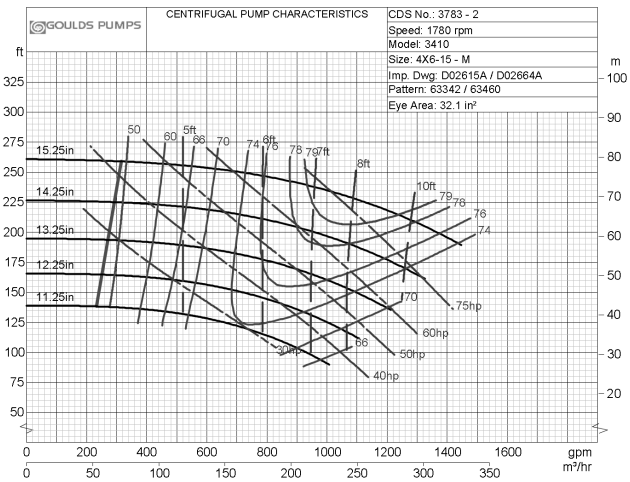
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



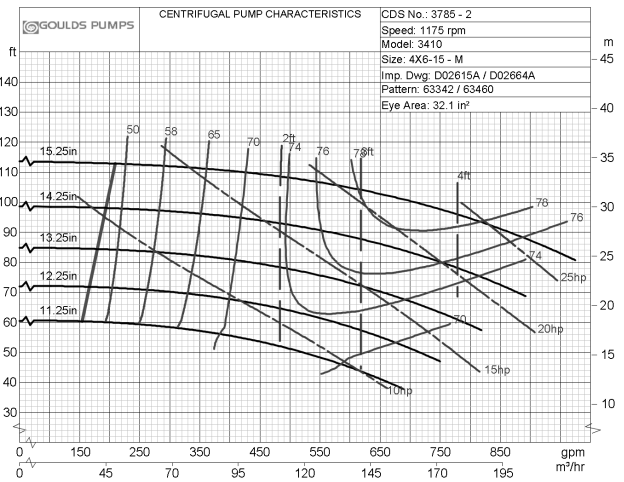
4X6-13H **1780rpm**



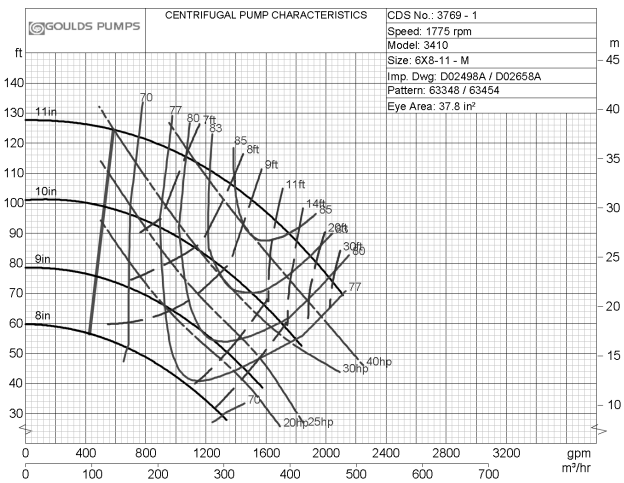
4X6-13H **1175rpm**



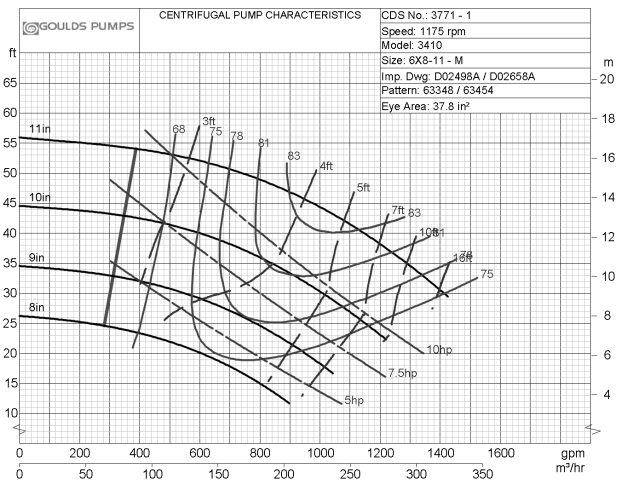
4X6-15 **1780rpm**



4X6-15 **1175rpm**



6X8-11 **1775rpm**

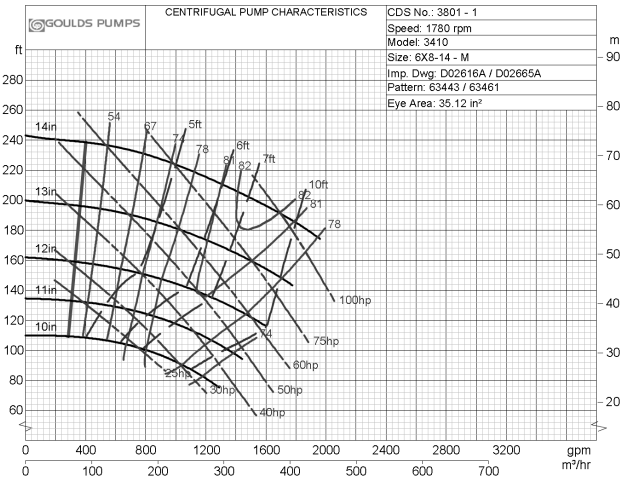


6X8-11 **1175rpm**

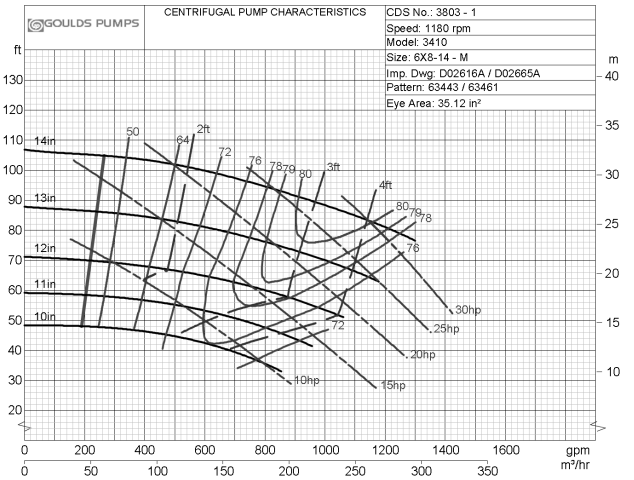
60Hz Curves

Model 3410

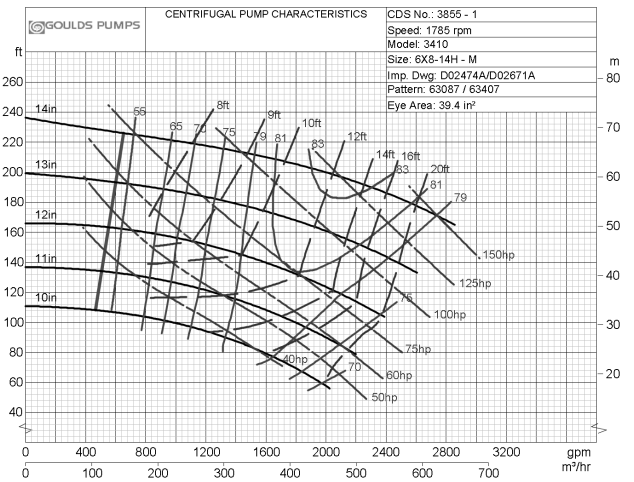
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



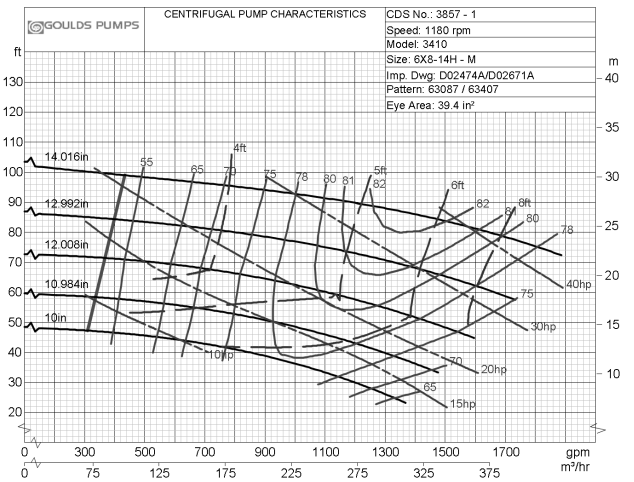
6X8-14 **1780rpm**



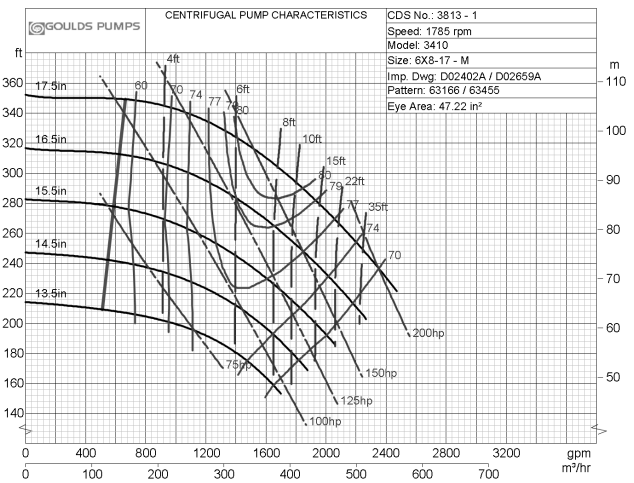
6X8-14 **1180rpm**



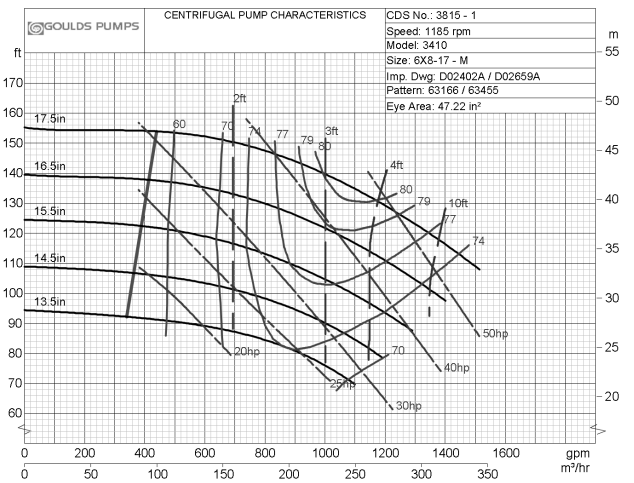
6X8-14H **1785rpm**



6X8-14H **1180rpm**

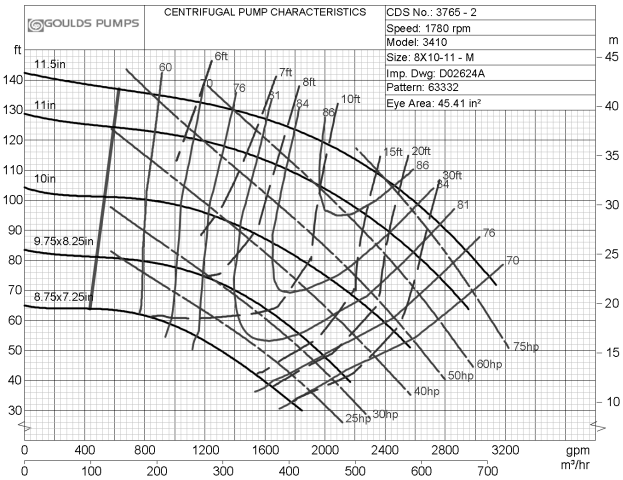


6X8-17 **1785rpm**

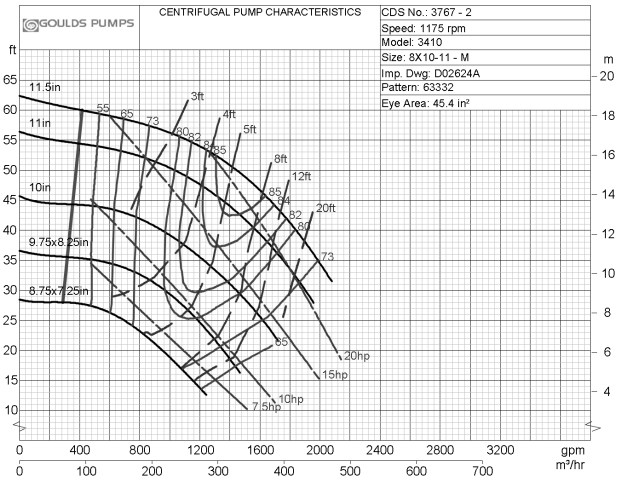


6X8-17 **1185rpm**

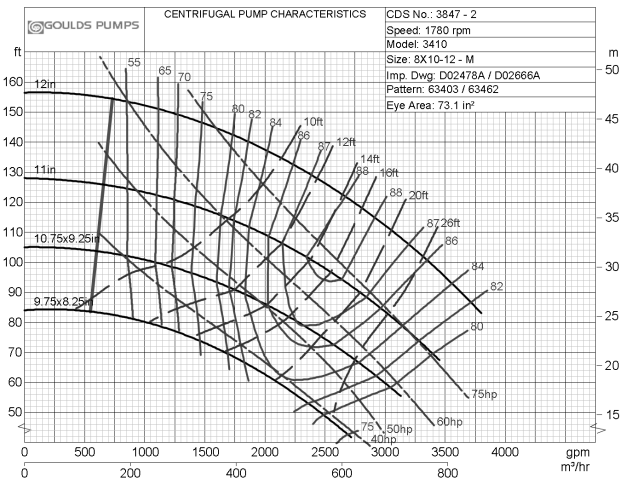
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



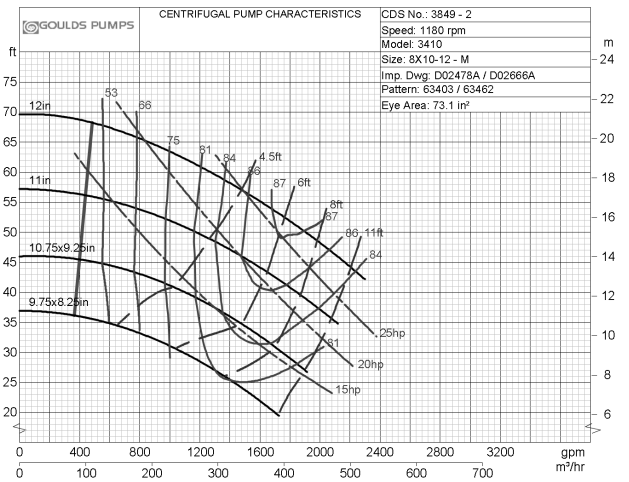
8X10-11 **1780rpm**



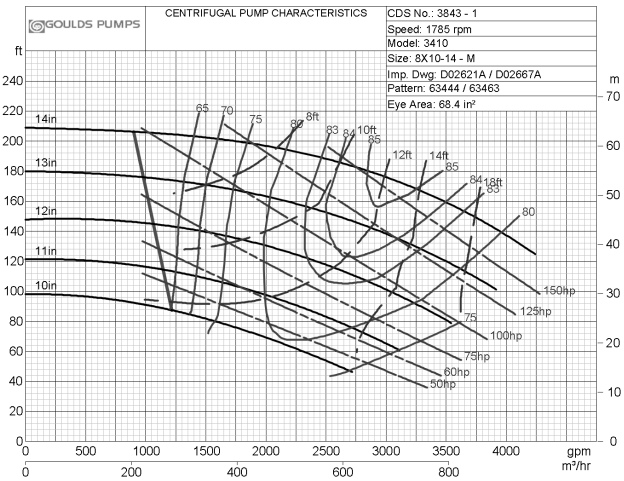
8X10-11 **1175rpm**



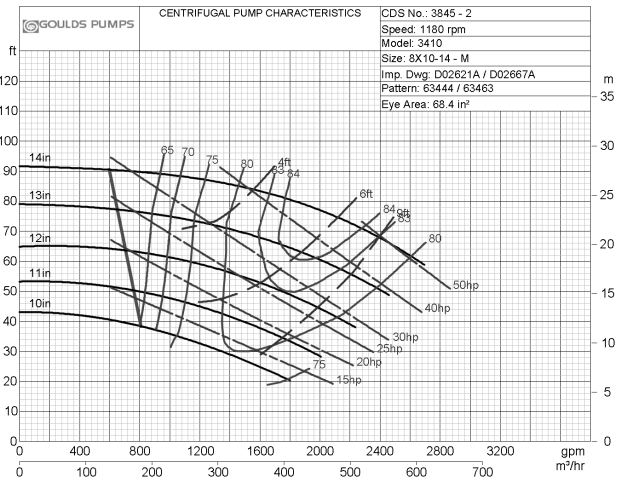
8X10-12 **1780rpm**



8X10-12 **1180rpm**



8X10-14 **1785rpm**

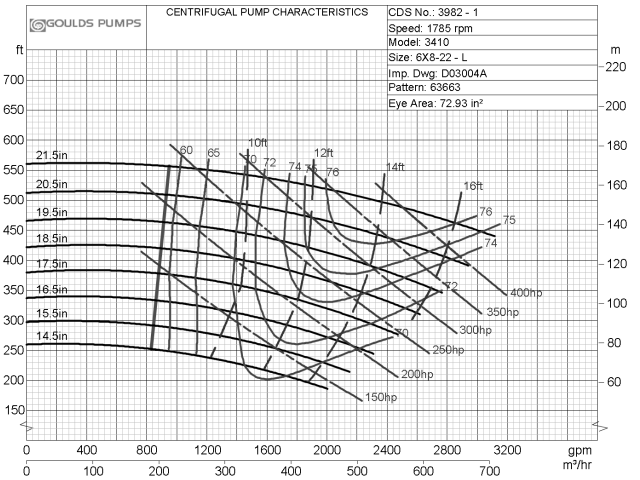


8X10-14 **1180rpm**

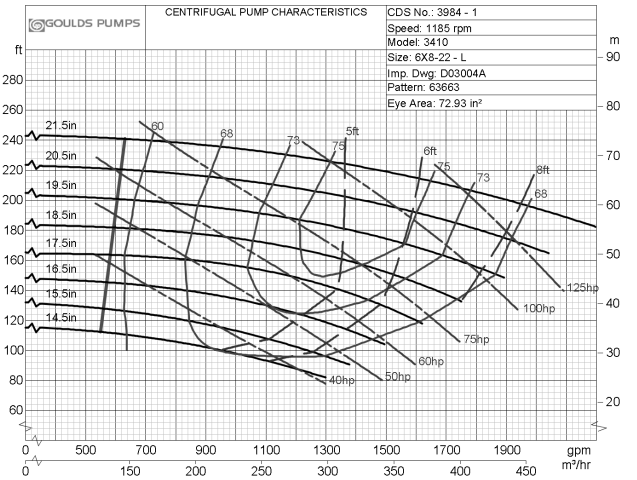
60Hz Curves

Model 3410

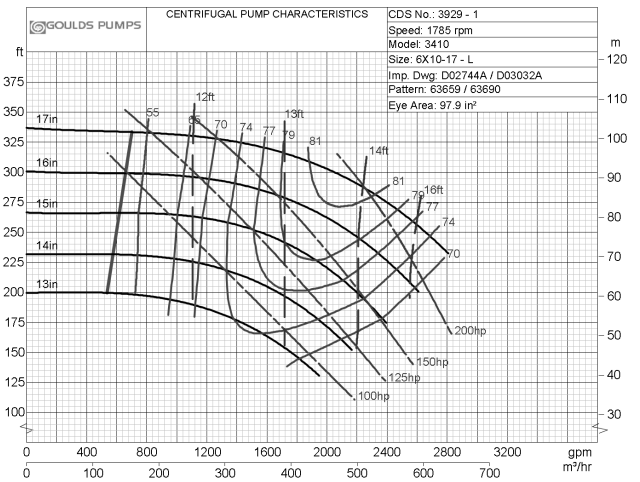
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



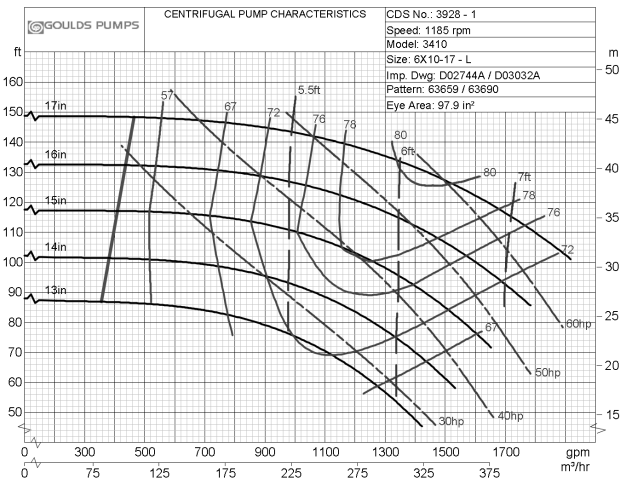
6X8-22 **1785rpm**



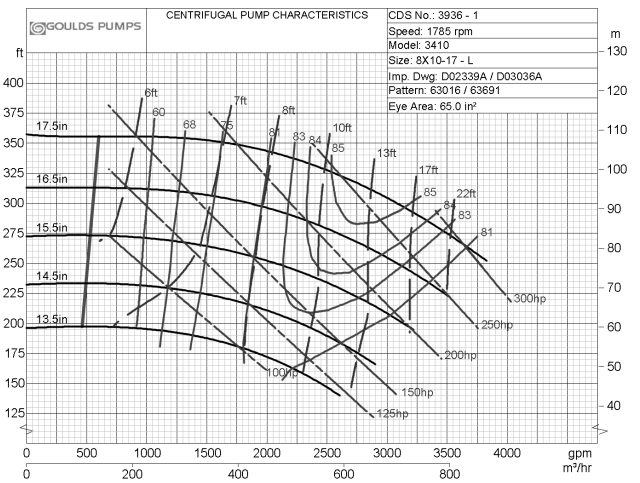
6X8-22 **1185rpm**



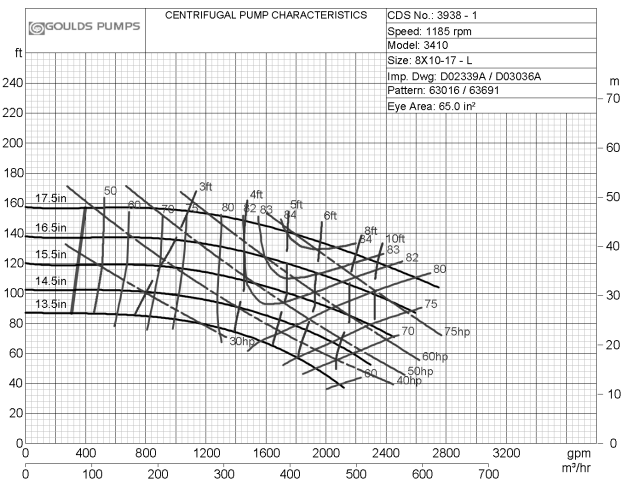
6X10-17 **1785rpm**



6X10-17 **1185rpm**

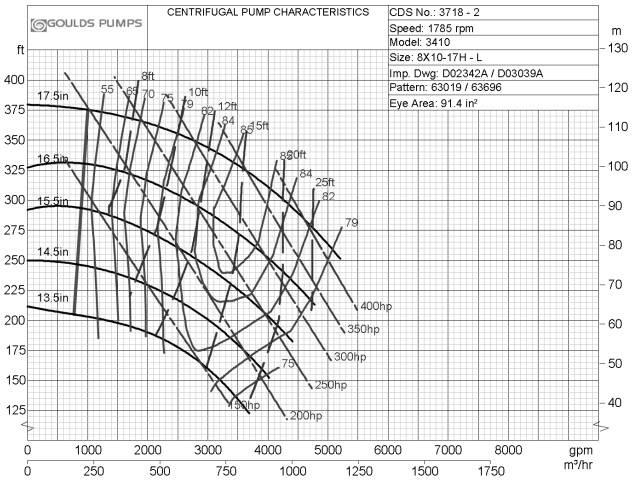


8X10-17 **1785rpm**

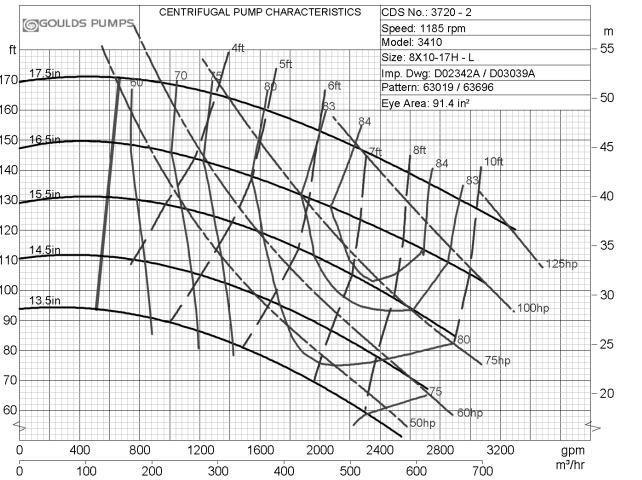


8X10-17 **1185rpm**

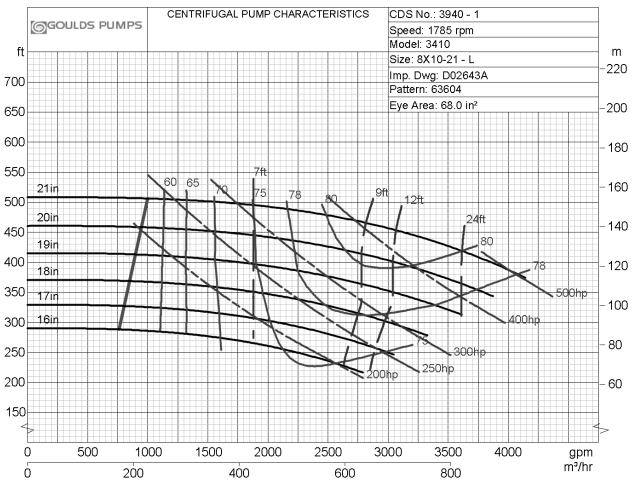
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



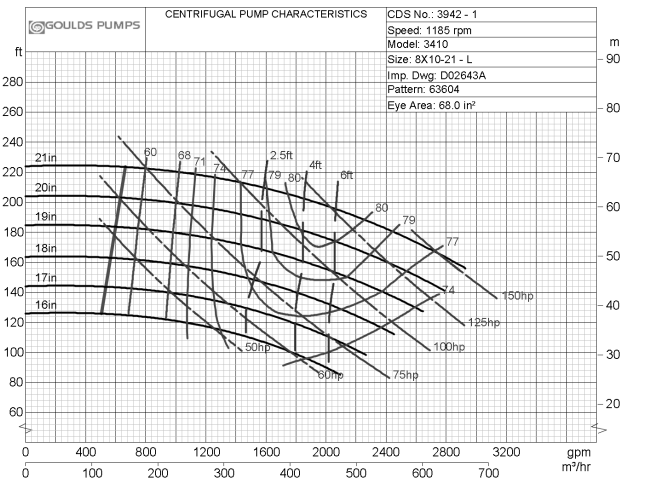
8X10-17H **1785rpm**



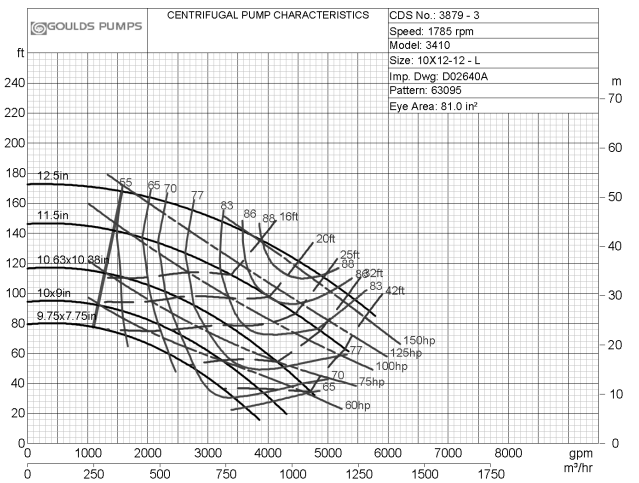
8X10-17H **1185rpm**



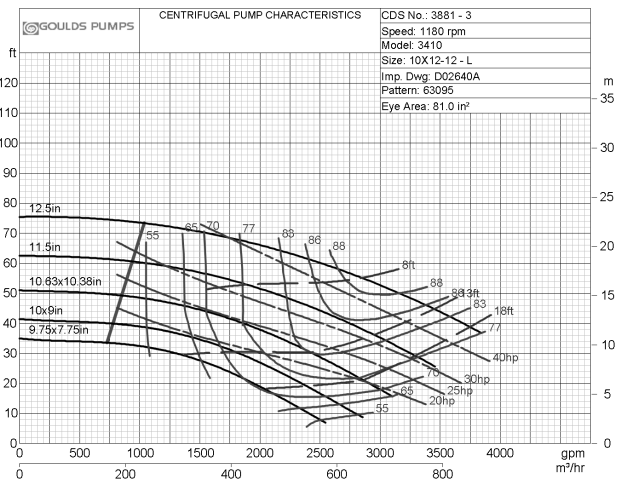
8X10-21 **1785rpm**



8X10-21 **1185rpm**

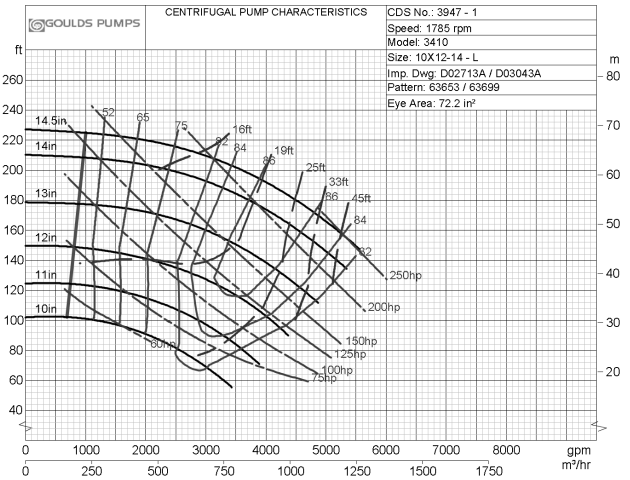


10X12-12 **1785rpm**

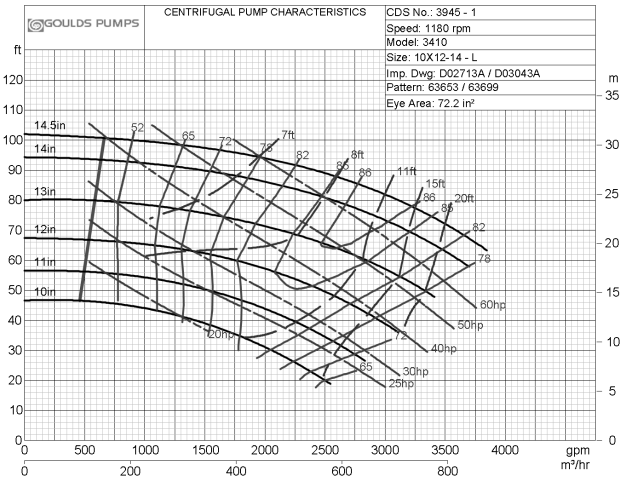


10X12-12 **1180rpm**

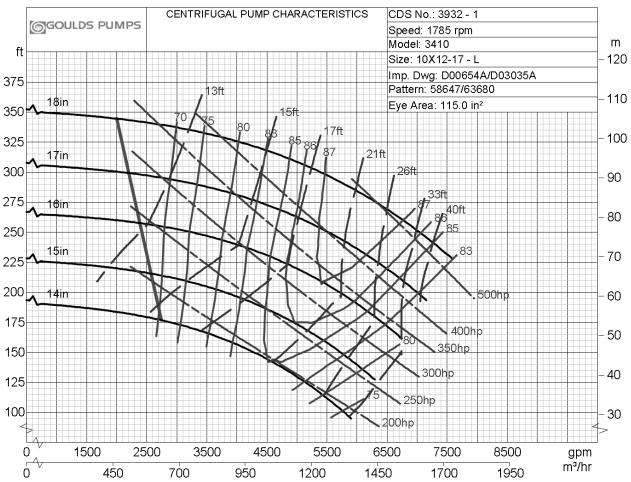
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



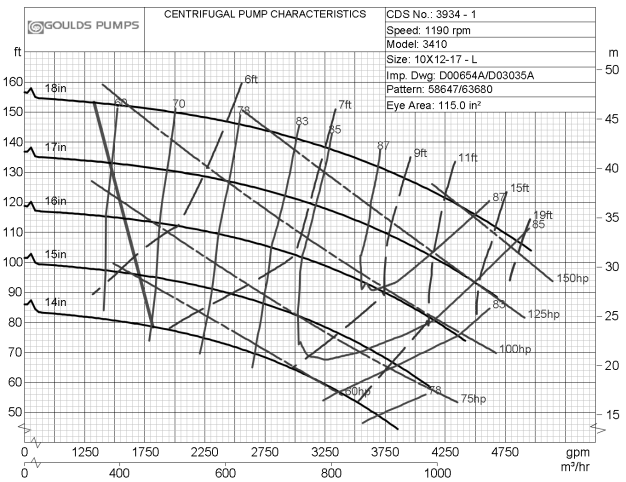
10X12-14 **1785rpm**



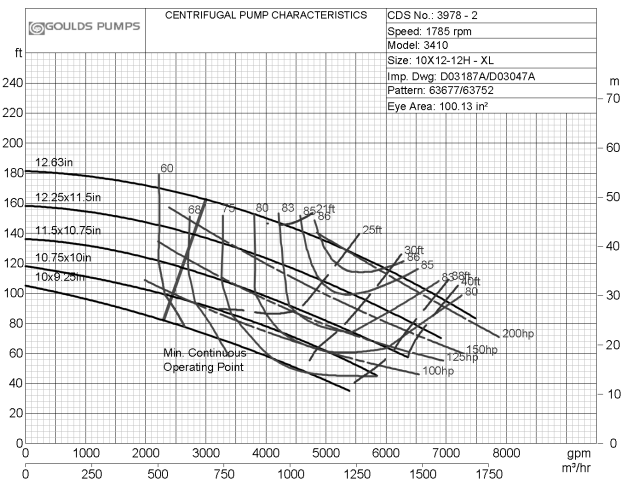
10X12-14 **1180rpm**



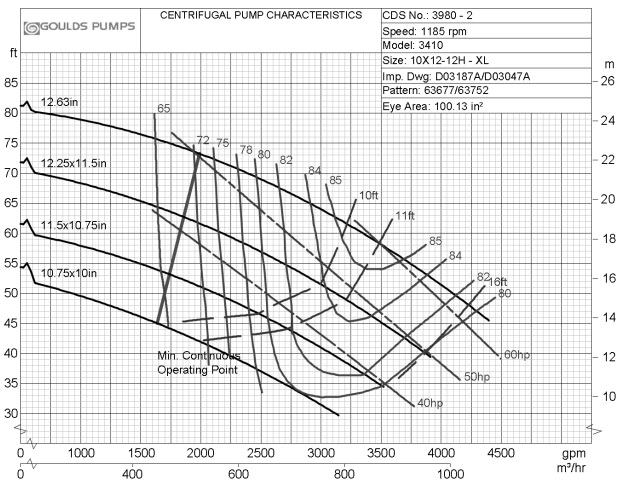
10X12-17 **1785rpm**



10X12-17 **1190rpm**



10X12-12H **1785rpm**



10X12-12H **1185rpm**

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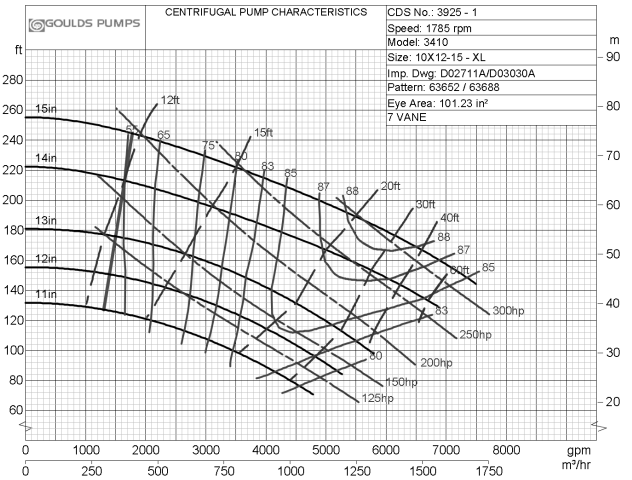
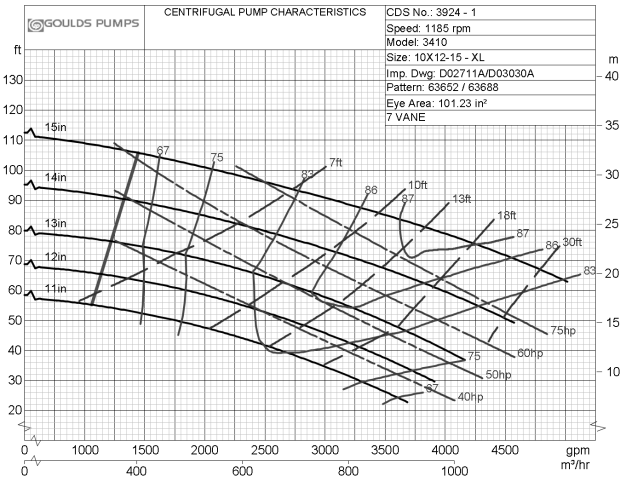
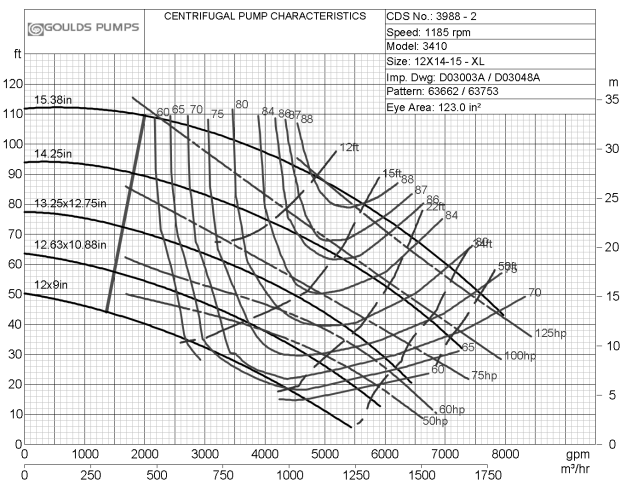


10X12-15 **1785rpm**



10X12-15 **1185rpm**

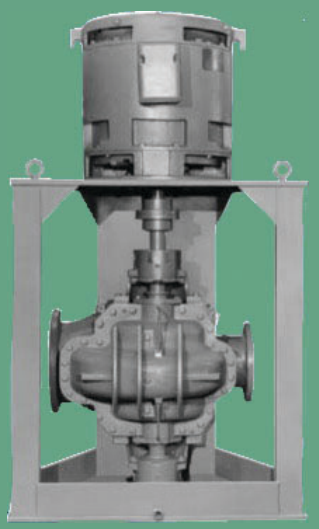


12X14-15 **1185rpm**

NOTES

Model 3409 (Medium Capacity)

- 10 sizes



Goulds Model 3409

Medium Capacity, Single Stage, Double Suction Pumps Designed for a Wide Range of Heavy Duty Industrial, Marine and Power Generation Services

- Capacities to 12,000 GPM (2,725 m ^{3}/h)
- Heads to 850 feet (259 m)
- Temperatures to 250°F (120°C)
- Working Pressures to 400 PSIG (2758 kPa)

Design Features

- **Horizontally Split Casing** In-line suction and discharge nozzles in lower half casing for ease of inspection/maintenance.
- **Double Suction Impeller** Assures Hydraulic Axial Balance for lower thrust bearing loads, longer pump life, and low maintenance.
- **Dual Volute Casing** Assures Radial Balance for lower radial bearing loads, longer pump life and low-maintenance.
- **Wear Rings** Easily replaceable wear rings renew running clearances, protect against impeller, casing wear. Overall cost of operation is minimized.
- **Sealing Flexibility** Choice of packing or mechanical seals.
- **Installation Versatility** Horizontal or vertical mounting, clockwise or counter clockwise rotation.
- **Material Flexibility** Available in a wide variety of metals from cast iron to stainless steels.

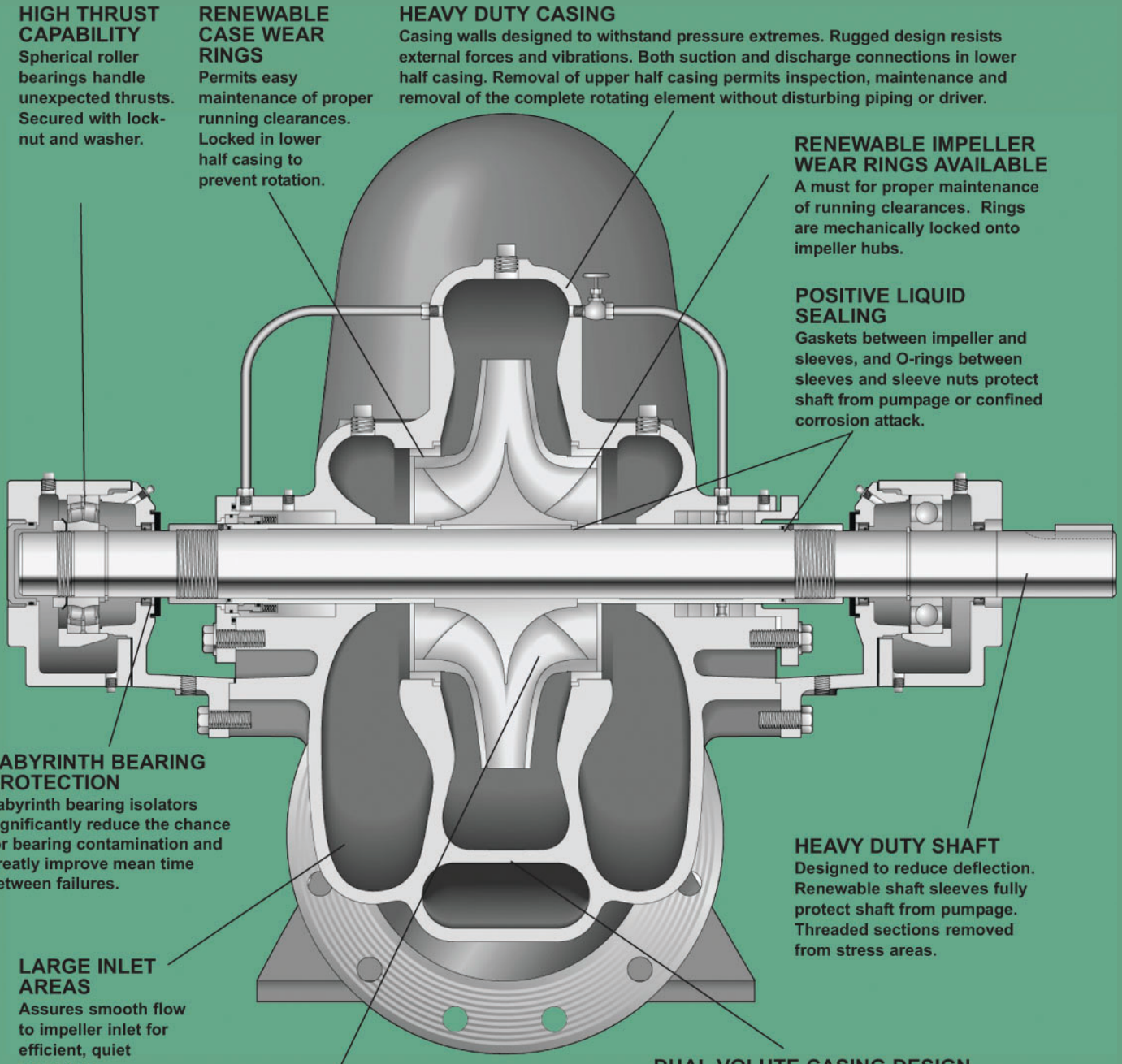
Applications

- **Process** — Quench Water, Stripper Bottoms, Reboiler Circulation, Cooling Tower
- **Pulp & Paper** — Primary and Secondary Cleaner, Filtrate, Mill Water Supply, Fan Pump, Headbox Supply, Shower
- **Primary Metals** — Cooling Water, Quench and Leaching
- **Municipal** — High Lift, Low Lift, Wash Water, Waste Water, Raw Water
- **Power Generation** — Cooling Tower, Component Cooling, Service Water, Ash Sluicing, Heater Drain
- **Marine** — Bilge and Ballast, Cargo, Cooling Water,Fire Pump
- **General** — River Water, Brine, Sea Water

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3409 Medium Capacity, Single Stage, Double Suction Pumps

Heavy Duty Design Features for a Wide Range of Heavy Duty Industrial, Marine and Power Generation Services



HIGH THRUST CAPABILITY
Spherical roller bearings handle unexpected thrusts. Secured with lock-nut and washer.

RENEWABLE CASE WEAR RINGS
Permits easy maintenance of proper running clearances. Locked in lower half casing to prevent rotation.

HEAVY DUTY CASING
Casing walls designed to withstand pressure extremes. Rugged design resists external forces and vibrations. Both suction and discharge connections in lower half casing. Removal of upper half casing permits inspection, maintenance and removal of the complete rotating element without disturbing piping or driver.

RENEWABLE IMPELLER WEAR RINGS AVAILABLE
A must for proper maintenance of running clearances. Rings are mechanically locked onto impeller hubs.

POSITIVE LIQUID SEALING
Gaskets between impeller and sleeves, and O-rings between sleeves and sleeve nuts protect shaft from pumpage or confined corrosion attack.

LABYRINTH BEARING PROTECTION
Labyrinth bearing isolators significantly reduce the chance for bearing contamination and greatly improve mean time between failures.

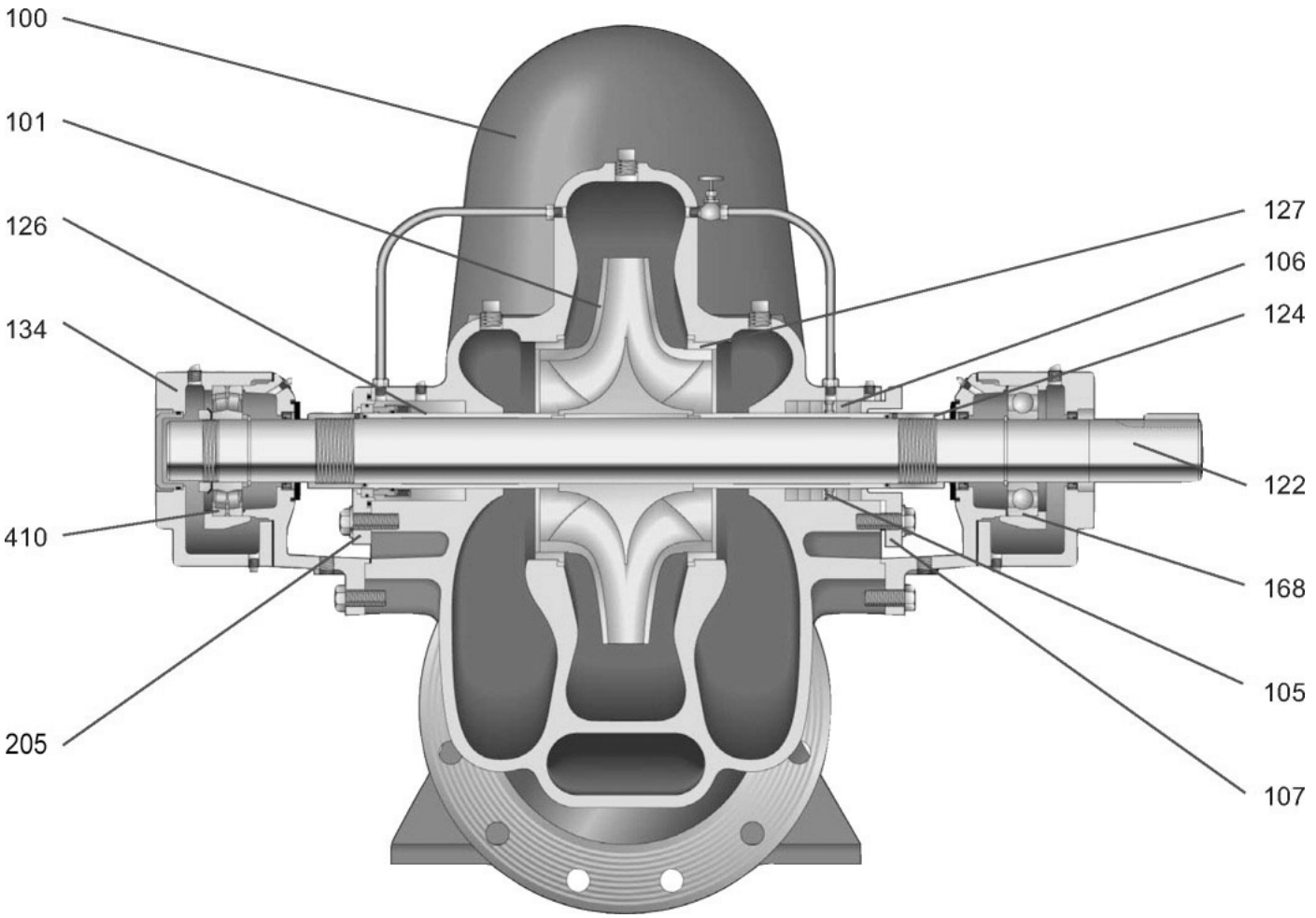
HEAVY DUTY SHAFT
Designed to reduce deflection. Renewable shaft sleeves fully protect shaft from pumpage. Threaded sections removed from stress areas.

LARGE INLET AREAS
Assures smooth flow to impeller inlet for efficient, quiet operation.

DOUBLE SUCTION IMPELLER
Minimizes axial thrust. Highly efficient for smooth, vibration-free operation.

DUAL VOLUTE CASING DESIGN
Dual volutes having cutwaters 180° apart provide opposing radial forces reducing radial loads on bearings and minimizing shaft deflection. Permits smooth, trouble-free operation over wide range of flow rates.

Sectional View Model 3409

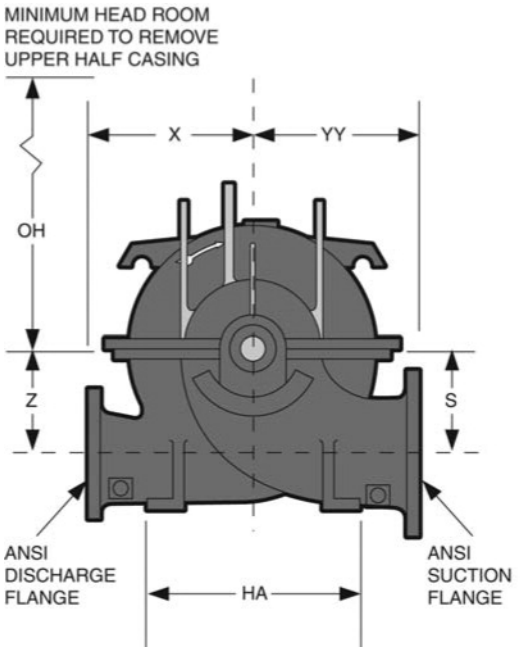


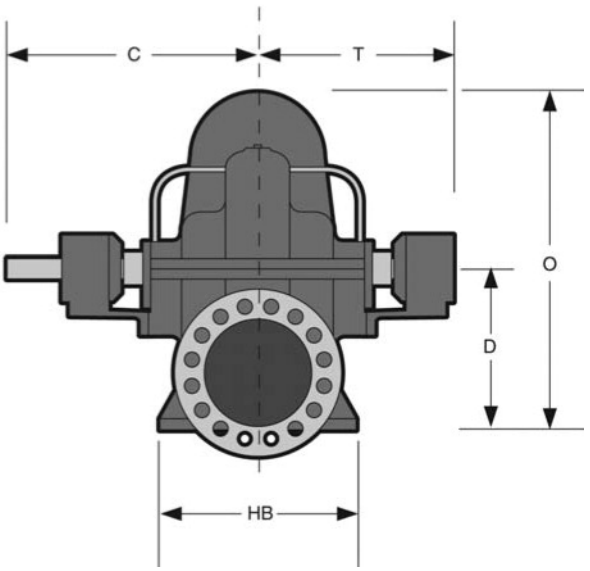
Parts List and Materials of Construction Model 3409

Item Number	Part Name	Material			
		Bronze Fitted	All Iron	316SS Fitted	All 316SS
100	Casing		Cast Iron		316SS
101	Impeller	Bronze	Cast Iron	316SS	
105	Lantern Ring	Teflon			
106	Packing	Graphite Impregnated Yarn			
107	Packing Gland	Bronze	Cast Iron	316SS	
250	Mechanical Seal Gland		Cast Iron		316SS
122	Shaft	Carbon Steel[1]			
124	Shaft Sleeve Nut	Bronze	Cast Iron	Nitronic 60	
126	Shaft Sleeve[2]	Bronze	Cast Iron	316SS	
127	Casing Wear Ring	Bronze	Cast Iron	Nitronic 60	
134	Bearing Housing	Cast Iron			
142	Impeller Wear Ring (optional on 3409)	Bronze	Cast Iron	316SS	
168 & 410	Bearings	Steel (Anti-Friction)			

1 Shaft material will be 17-4 PH for certain size and speed combinations.
2 Also available in hardened/hard metal coated materials.

Dimensions and Weights **Model 3409**

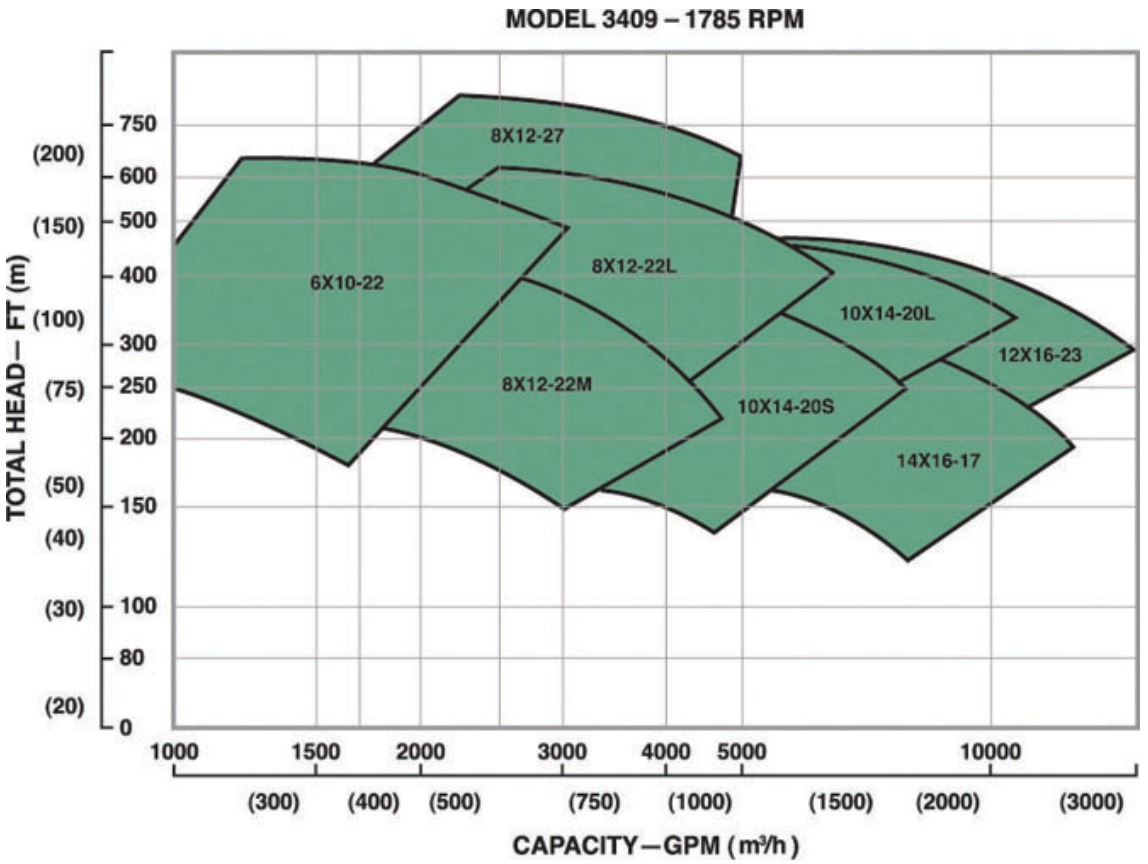


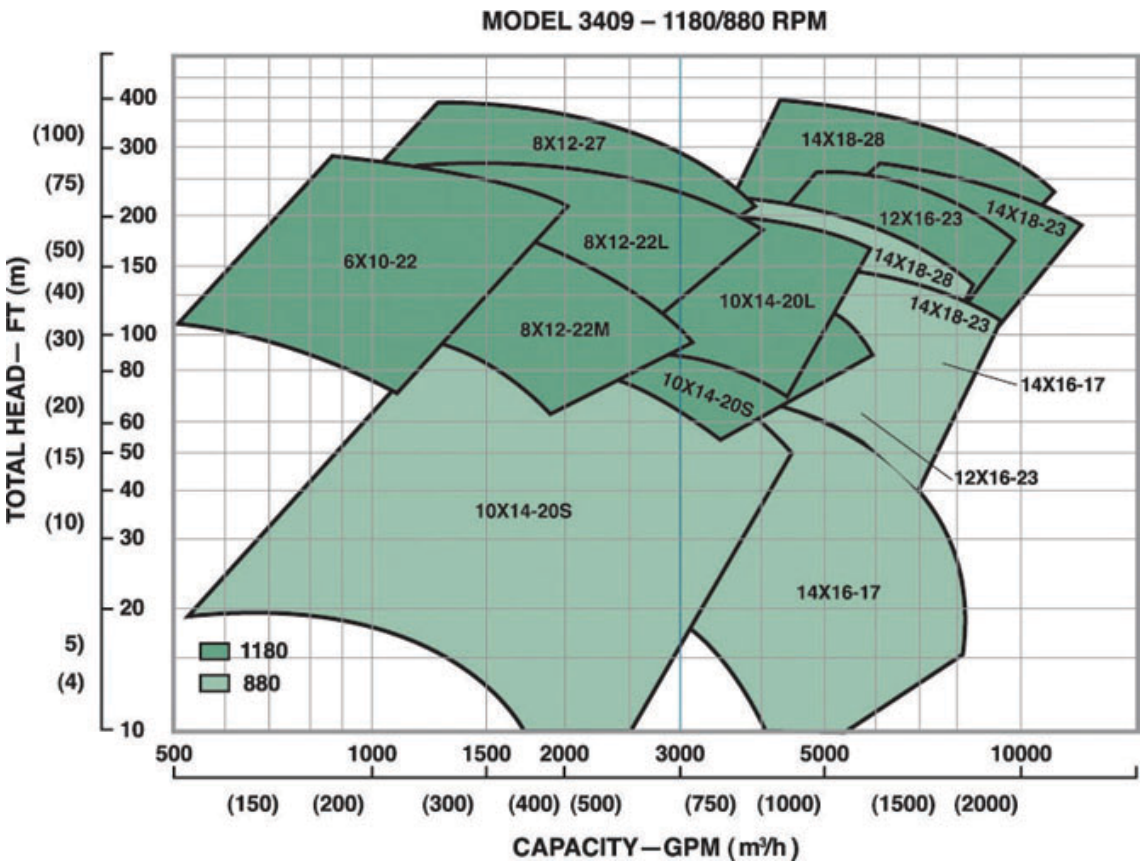


Frame Group	Pump Size	C	T	D	OH O	S & Z	X	YY	HA	HB	Weight Lbs. (kg)
37.9 (962)	6×10-22	28.3 (718)	21.8 (552)	19 (483)	30.4 (772)	12 (305)	19 (483)	20	24 (610)	18 (457)	1545 (701)
S	8×12-22M				30.4 (772)		21 (533)	21 (533)			1920 (871)
38.9 (988)	8×12-22L				31.4 (798)						1930 (875)
43.9 (1115)	8×12-27	30.5 (775)	23.8 (603)	21 (533)	36.4 (924)	14.2 (360)	23 (584)	24 (610)	24 (610)	24 (610)	2940 (1334)
42.8 (1086)	10×14-20S				31.7 (804)	13 (330)	19 (483)	21 (533)			2000 (907)
M	10×14-20L										2050 (930)
48.9 (1242)	12×16-23			23 (584)	37.4 (949)	14 (356)	25 (635)	25 (635)			2600 (1179)
46.3 (1181)	14×16-17			23.5 (597)	31.8 (806)		18 (457)	24 (610)			2860 (1297)
47.6 (1210)	14×18-23	31.6 (802)	24.8 (629)	24 (610)	35.1 (892)	14 (356)	27 (686)	27 (686)	27 (711)	26 (660)	2940 (1334)
L											
56.8 (1441)	14×18-28			26 (660)	44.7 (1135)	16 (406)	28 (711)	28 (711)			3255 (1476)

Sizes 6×10-22, 8x12-22M, 8x12-22L are furnished with 250# FF discharge flange as standard.
Size 8×12-27 is furnished with 250#FF suction and discharge flange as standard.
All dimensions in inches (mm) and are not to be used for construction or installation purposes.
Standard rotation is right hand (CW). Optional rotation is left hand (CCW).
Steel casings will have 150#RF or 300#RF flanges.

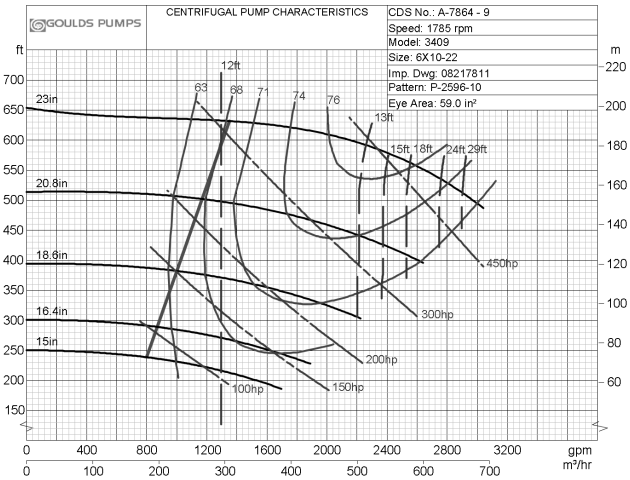
Hydraulic Coverage Model 3409



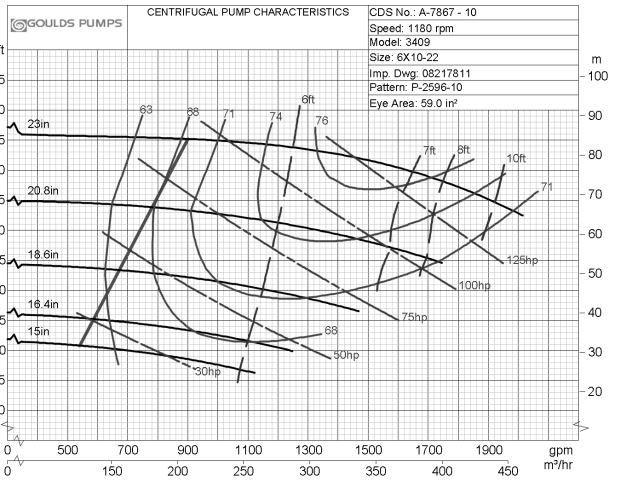


NOTES

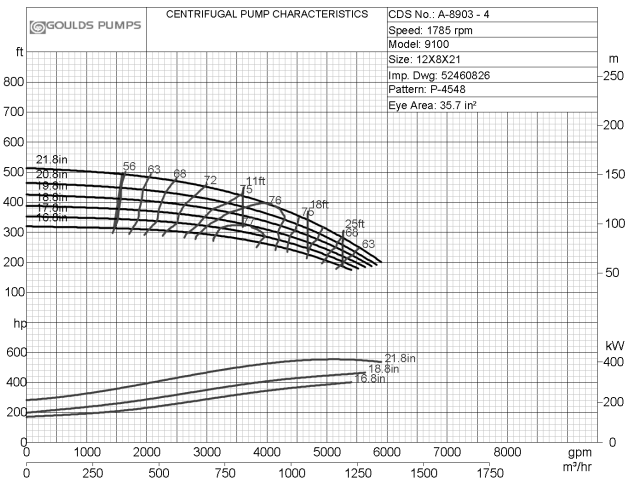
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



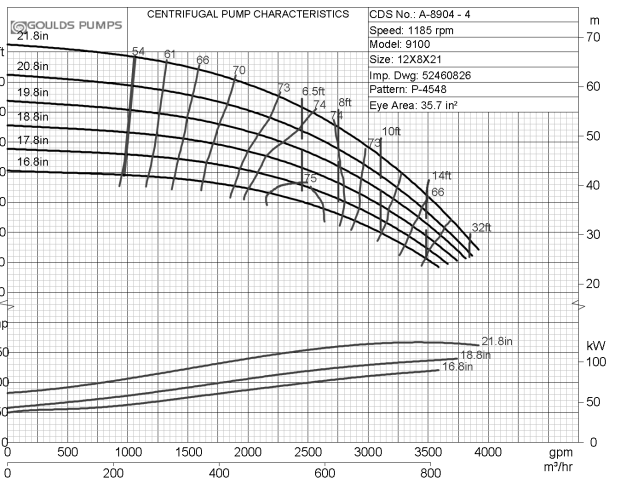
6X10-22 **1785rpm**



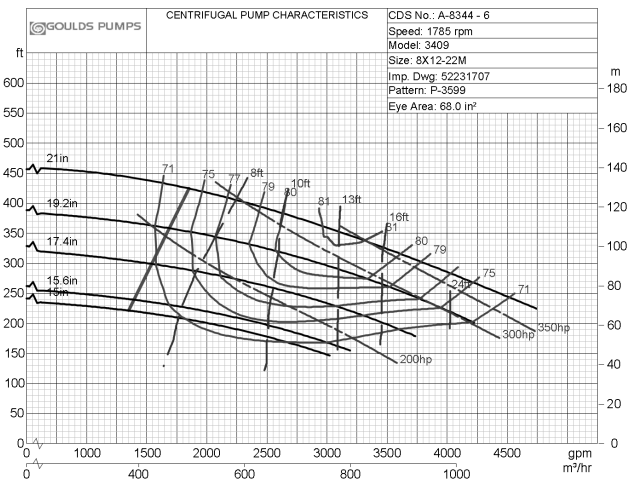
6X10-22 **1180rpm**



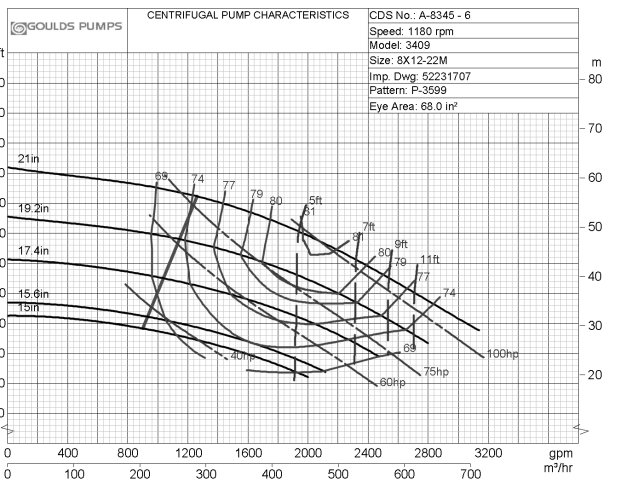
12X8X21 **1785rpm**



12X8X21 **1185rpm**



8X12-22M **1785rpm**

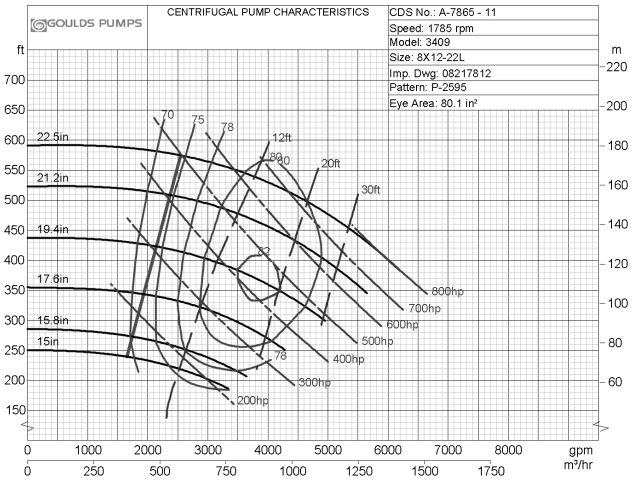


8X12-22M **1180rpm**

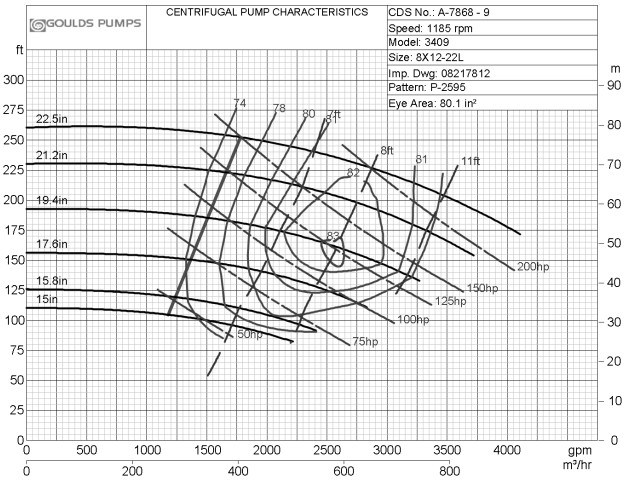
60Hz Curves

Model 3409

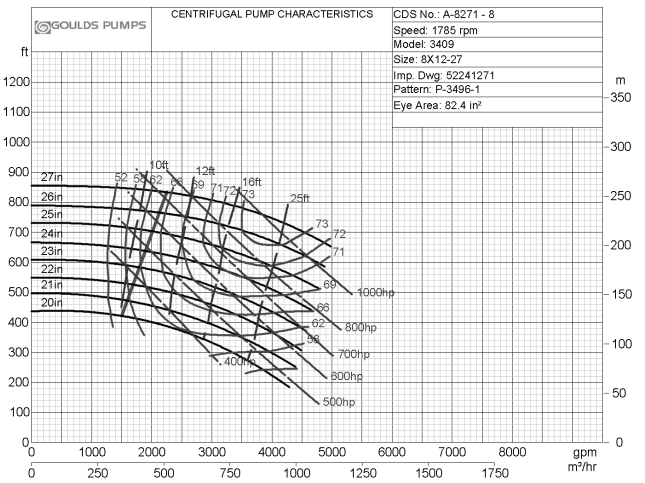
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



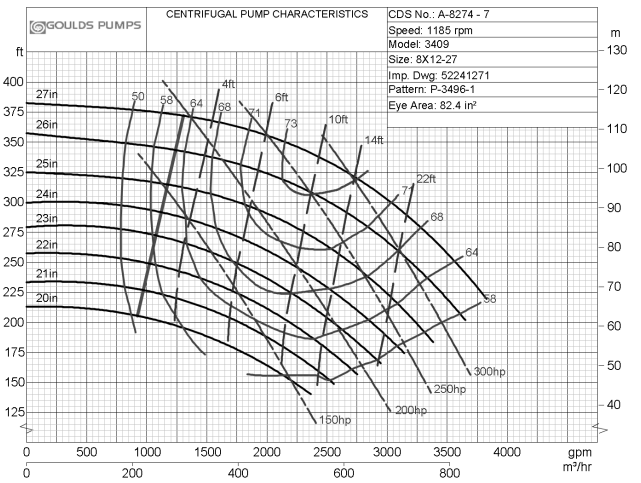
8X12-22L **1785rpm**



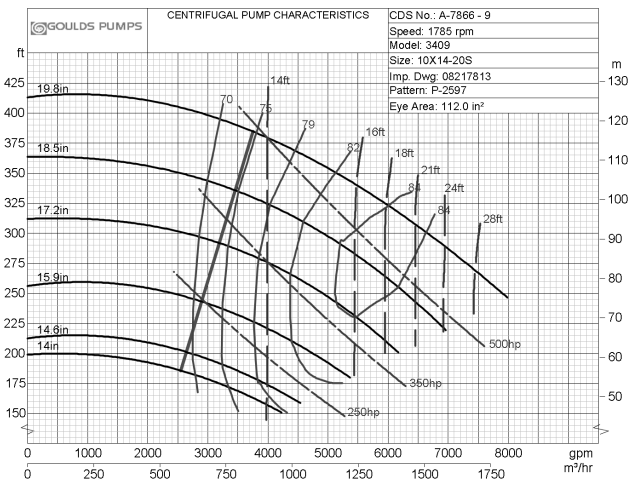
8X12-22L **1185rpm**



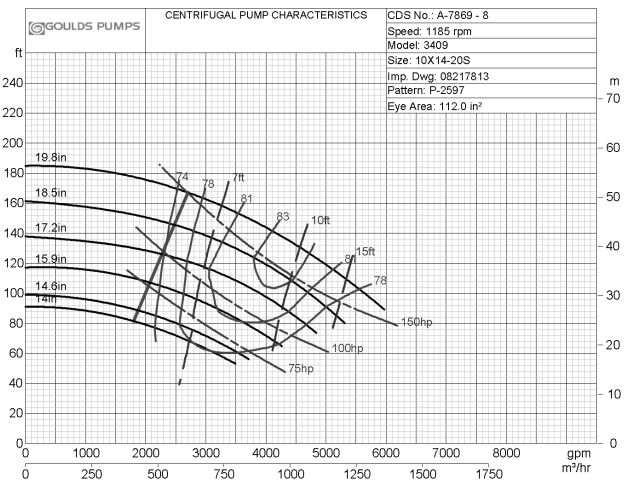
8X12-27 **1785rpm**



8X12-27 **1185rpm**

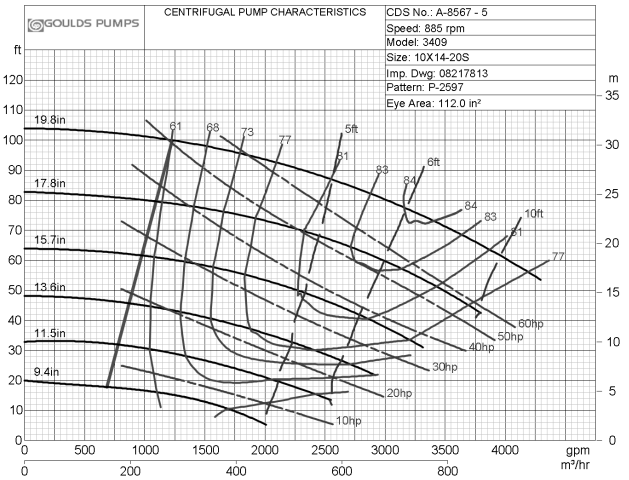


10X14-20S **1785rpm**

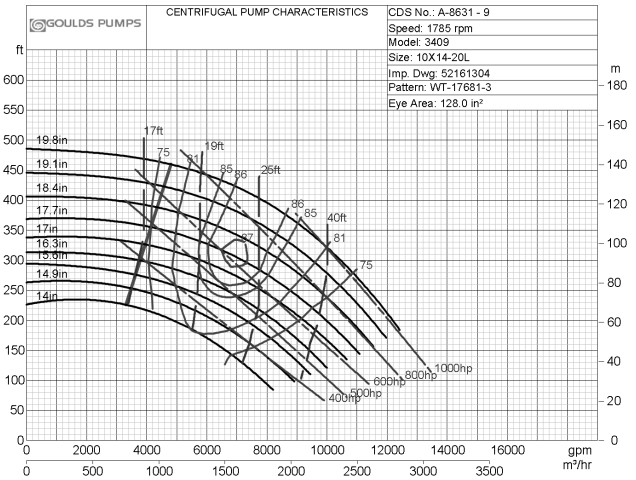


10X14-20S **1185rpm**

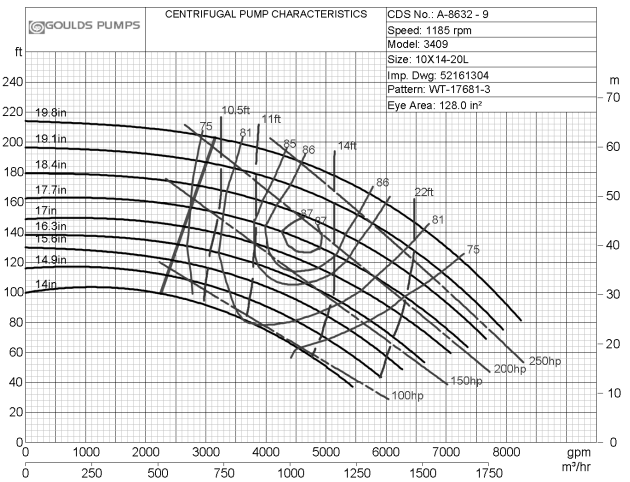
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



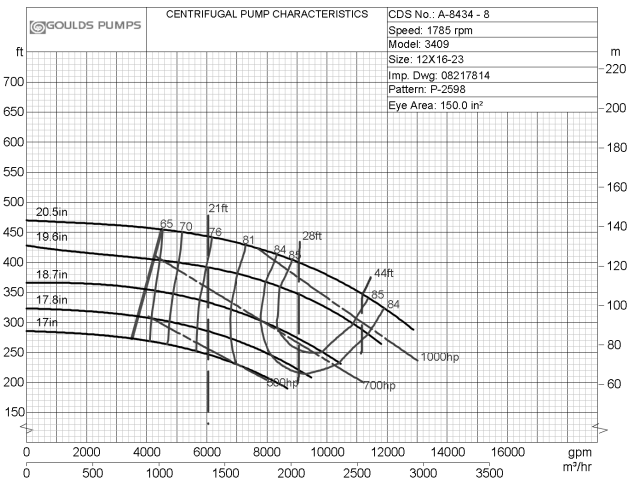
10X14-20S **885rpm**



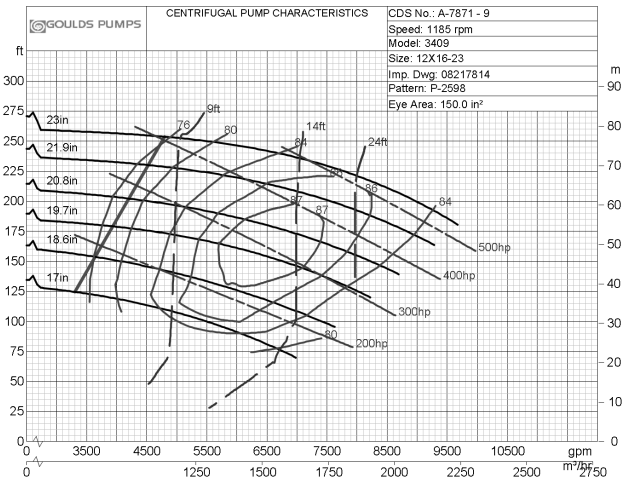
10X14-20L **1785rpm**



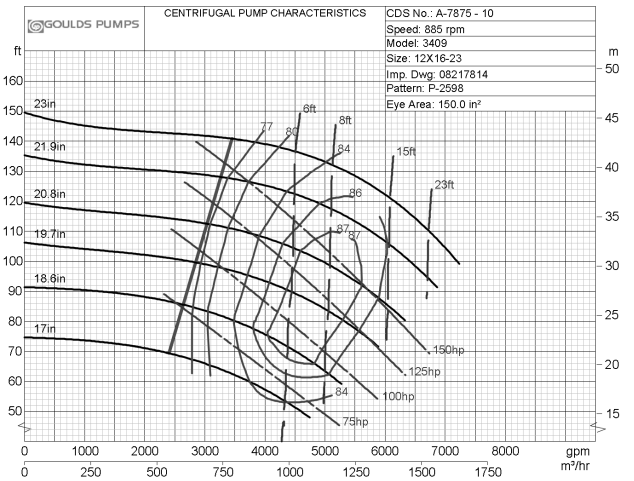
10X14-20L **1185rpm**



12X16-23 **1785rpm**



12X16-23 **1185rpm**

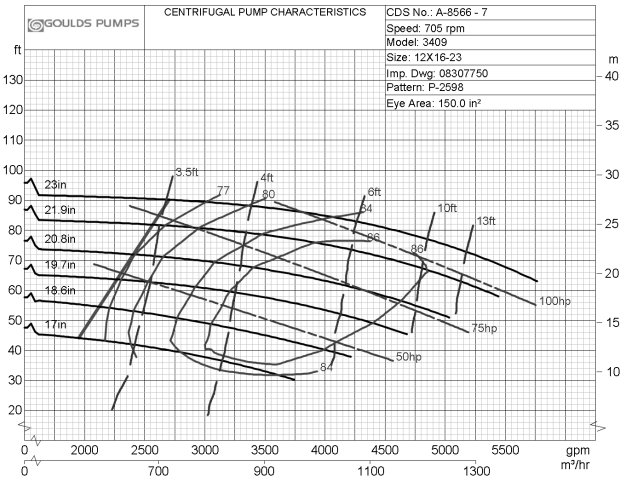


12X16-23 **885rpm**

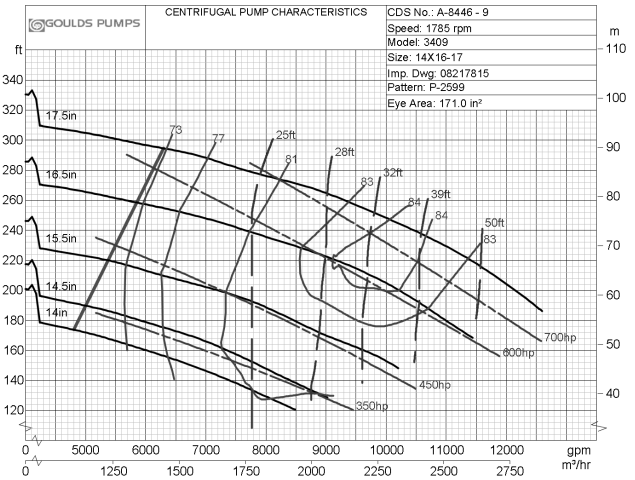
60Hz Curves

Model 3409

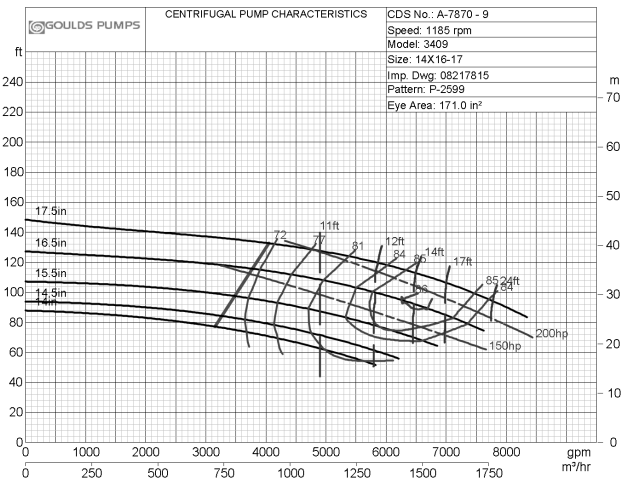
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



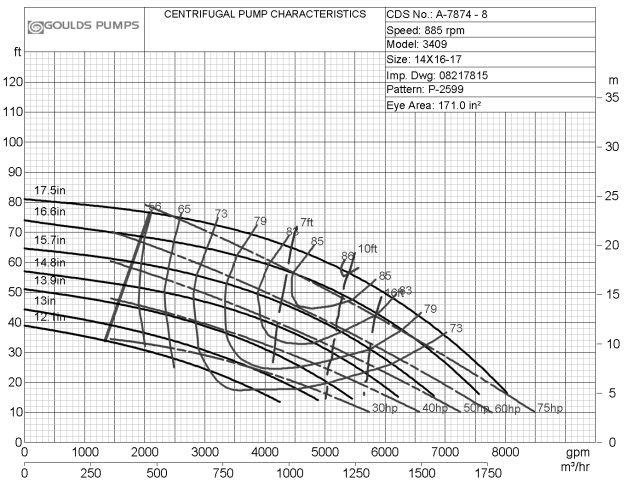
12X16-23 **705rpm**



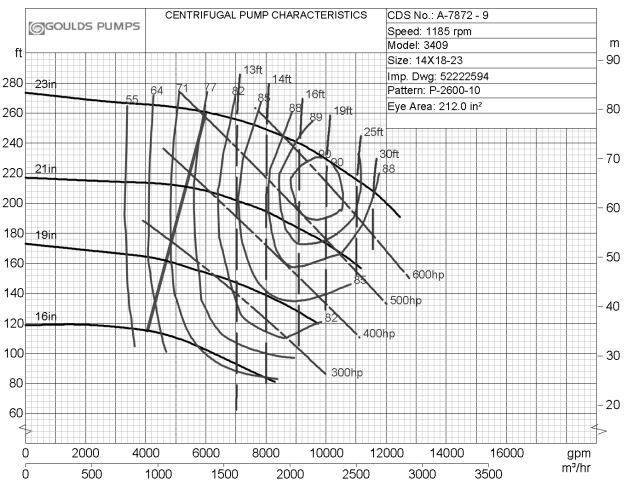
14X16-17 **1785rpm**



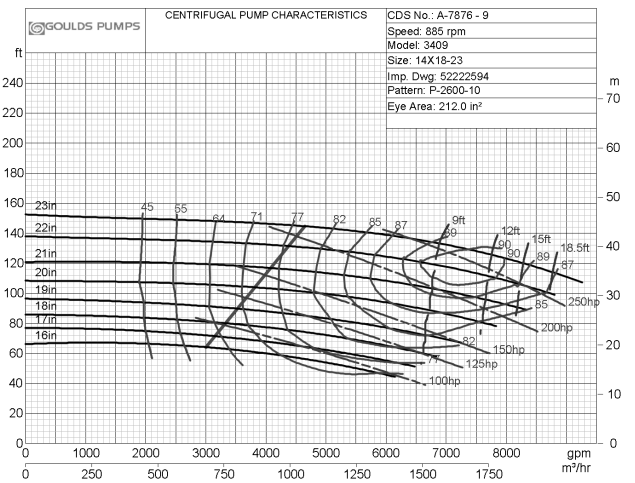
14X16-17 **1185rpm**



14X16-17 **885rpm**

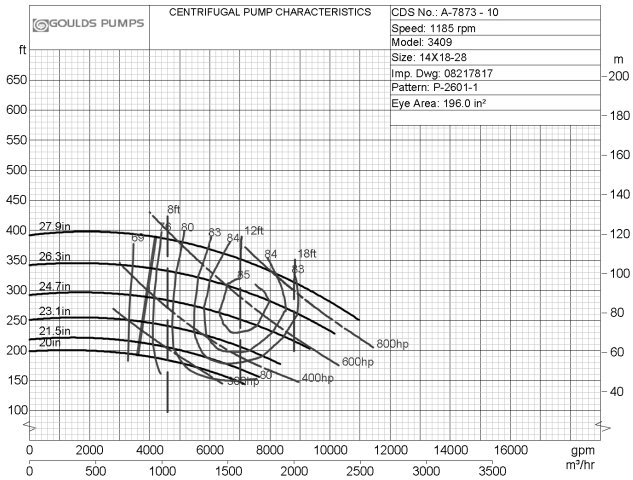


14X18-23 **1185rpm**

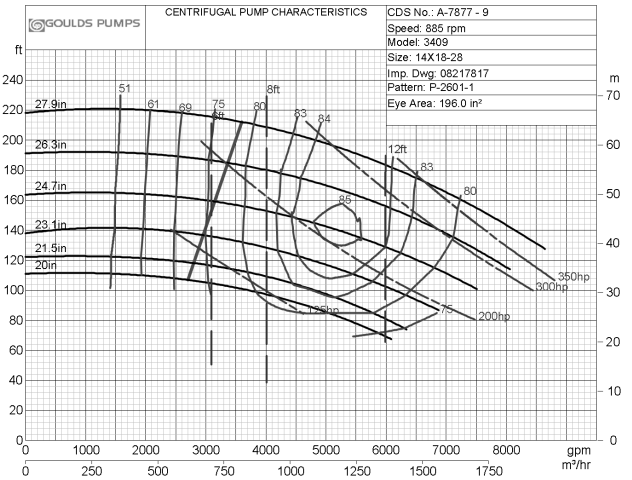


14X18-23 **885rpm**

The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.

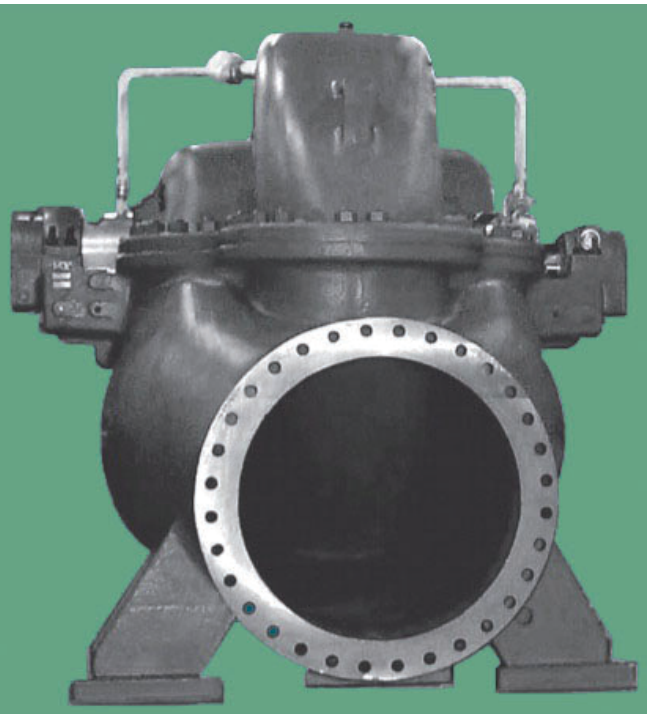


14X18-28 **1185rpm**



14X18-28 **885rpm**

NOTES



Model 3420
- 25 sizes

Goulds Model 3420

Large Capacity, Single Stage, Double Suction Pumps Designed for a Wide Range of Heavy Duty Industrial, Municipal and Power Generation Services

- Capacities to 65,000 GPM (14,762 m^3/h)
- Heads to 400 feet (122 m)
- Temperatures to 275°F (135°C)
- Working Pressures to 200 PSIG (1379 kPa)

Design Features

- **Horizontally Split Casing** In-line suction and discharge nozzles in lower half casing for ease of inspection/maintenance.
- **Double Suction Impeller** Assures Hydraulic Axial Balance for lower thrust bearing loads, longer pump life, and lower maintenance.
- **Dual Volute Casing** Assures Radial Balance for lower radial bearing loads, longer pump life and lower maintenance. (Availability is size dependent.)
- **Wear Rings** Easily replaceable wear rings renew running clearances, protect against impeller, casing wear. Overall cost of operation is minimized.
- **Sealing Flexibility** Choice of packing or wide range of mechanical seals.
- **Installation Versatility** Horizontal or vertical mounting, clockwise or counterclockwise rotation.
- **Material Flexibility** Available in a wide variety of metals from cast iron to stainless steels.

Applications

- **Process** — Quench Water, Stripper Bottoms, Reboiler Circulation, Cooling Tower.
- **Pulp & Paper** — Primary and Secondary Cleaner,Filtrate, Mill Water Supply, Fan Pump, Headbox Supply, Shower.
- **Primary Metals** — Cooling Water, Quench and Leaching.
- **Municipal** — High Lift, Low Lift, Wash Water, Waste Water, Raw Water.
- **Power Generation** — Cooling Tower, Component Cooling, Service Water, Ash Sluicing, Heater Drain.
- **Marine** — Bilge and Ballast, Cargo, Cooling Water, Fire Pump.
- **General** — River Water, Brine, Sea Water.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3420 Large Capacity, Single Stage, Double Suction Pumps

Heavy Duty Design Features for Wide Range of Water Supply and Process Services

HIGH THRUST CAPABILITY
Spherical roller bearings or double row ball thrust bearings handle unexpected thrusts. Secured with locknut and washer.

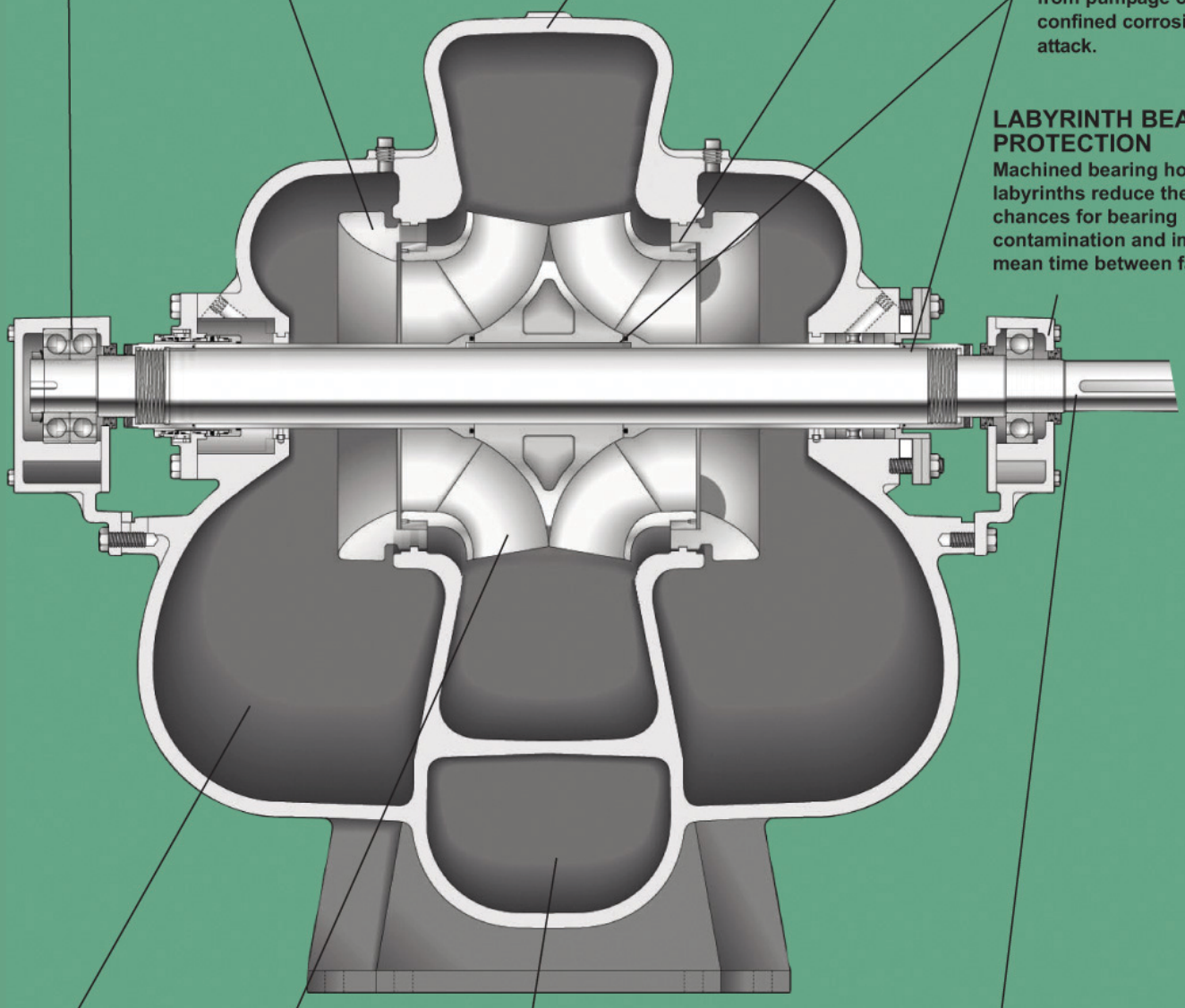
RENEWABLE CASE WEAR RINGS
Permits easy maintenance of proper running clearances. Double lock in lower half casing to prevent rotation.

HEAVY DUTY CASING
Casing walls designed to withstand pressure extremes. Rugged design resists external forces and vibrations. Both suction and discharge connections in lower half casing. Removal of upper half casing permits inspection, maintenance and removal of the complete rotating element without disturbing piping or driver.

RENEWABLE IMPELLER WEARING RINGS
A must for proper maintenance of running clearances. Mechanically locked onto impeller hubs.

POSITIVE LIQUID SEALING
Buna O-ring in controlled compression protects shaft and threaded area from pumpage or confined corrosive attack.

LABYRINTH BEARING PROTECTION
Machined bearing housing labyrinths reduce the chances for bearing contamination and improve mean time between failures.



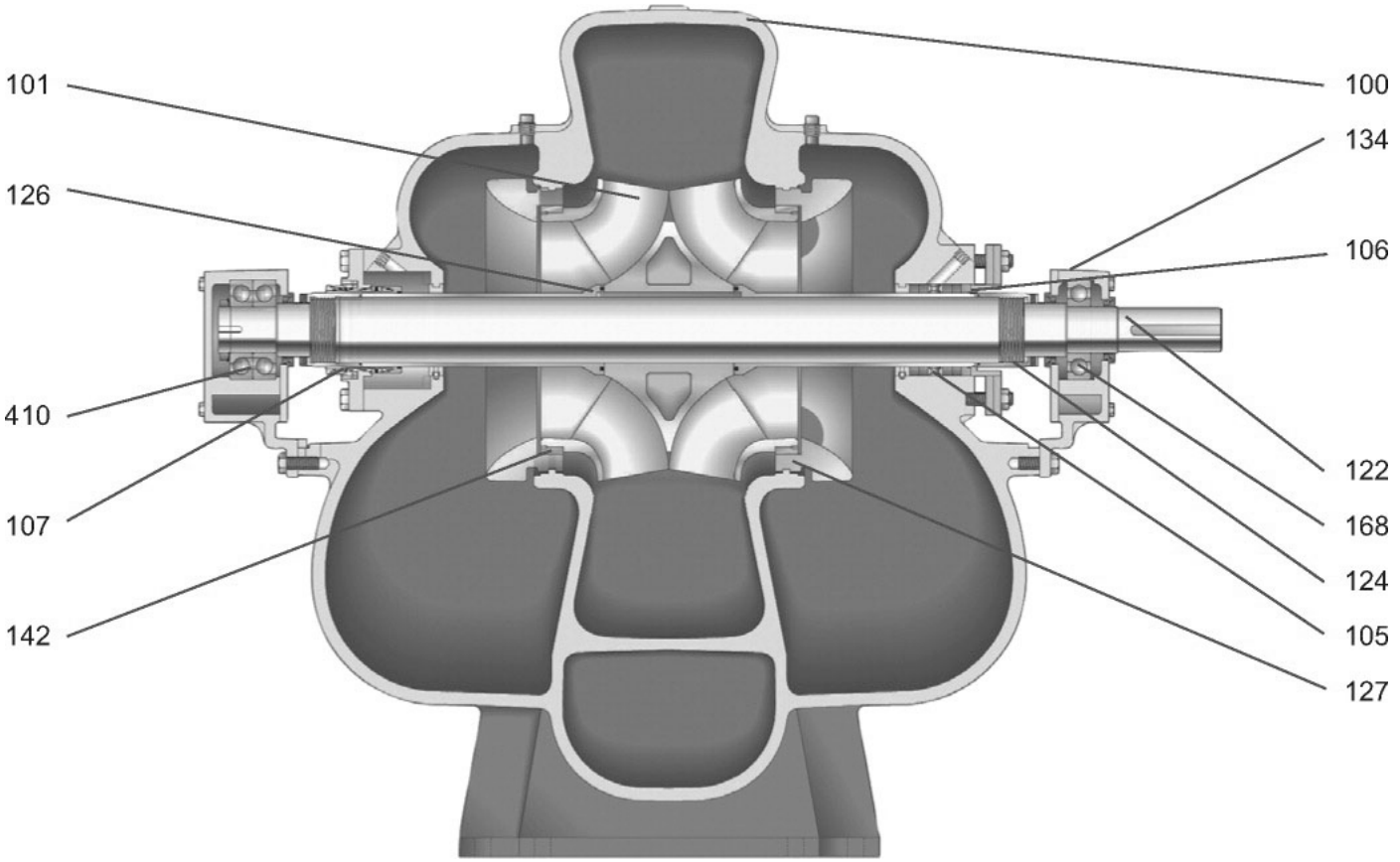
LARGE INLET AREAS
Assures smooth flow to impeller inlet for efficient, quiet operation.

DOUBLE SUCTION IMPELLER
Minimizes axial thrust. Highly efficient for smooth, vibration-free operation.

DUAL VOLUTE DESIGN
Dual volutes having cutwaters 180° apart provide opposing radial forces reducing radial loads on bearings and minimizing shaft deflection. Permits smooth, trouble-free operation over wide range of flow rates.

HEAVY DUTY SHAFT
Designed to reduce deflection. Renewable shaft sleeves fully protect shaft from pumpage. Threaded sections removed from stress areas.

Sectional View Model 3420



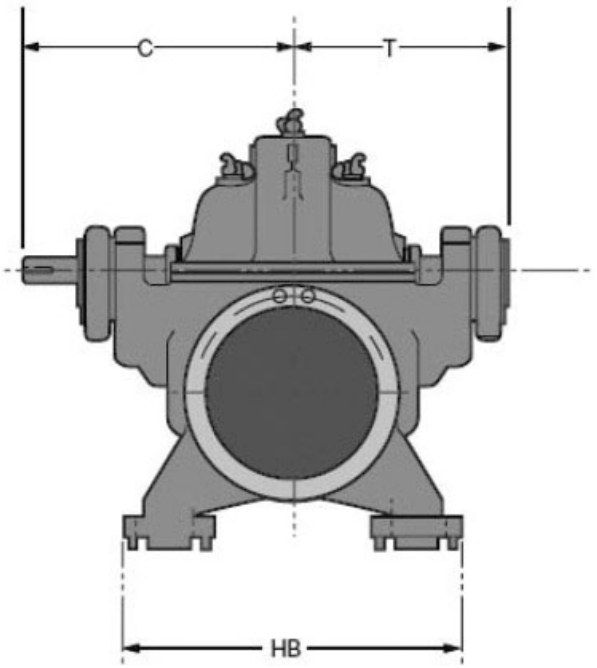
Parts List and Materials of Construction

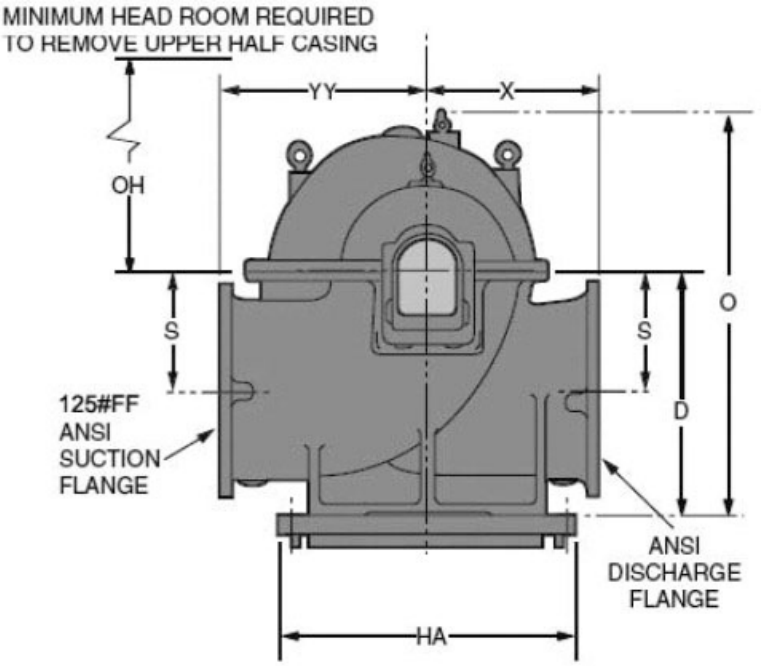
Model 3420

Item Number	Part Name	Material			
		Bronze Fitted	All Iron	316SS Fitted	All 316SS
100	Casing		Cast Iron		316SS
101	Impeller	Bronze	Cast Iron	316SS	
105	Lantern Ring	Teflon			
106	Packing	Graphite Impregnated Yarn			
107	Packing Gland	Bronze	Cast Iron	316SS	
107	Mechanical Seal Gland		Cast Iron		316SS
122	Shaft	Carbon Steel			
124	Shaft Sleeve Nut	Bronze	Cast Iron	316SS	
126	Shaft Sleeve1	Bronze	Cast Iron	316SS	
127	Casing Wear Ring	Bronze	Cast Iron	316SS	
134	Bearing Housings	Cast Iron			
142	Impeller Wear Ring	Bronze	Cast Iron	316SS	
168 & 410	Bearings	Steel (Anti-Friction)			

1 Also available in hardened/hard metal coated materials.

Dimensions and Weights **Model 3420**



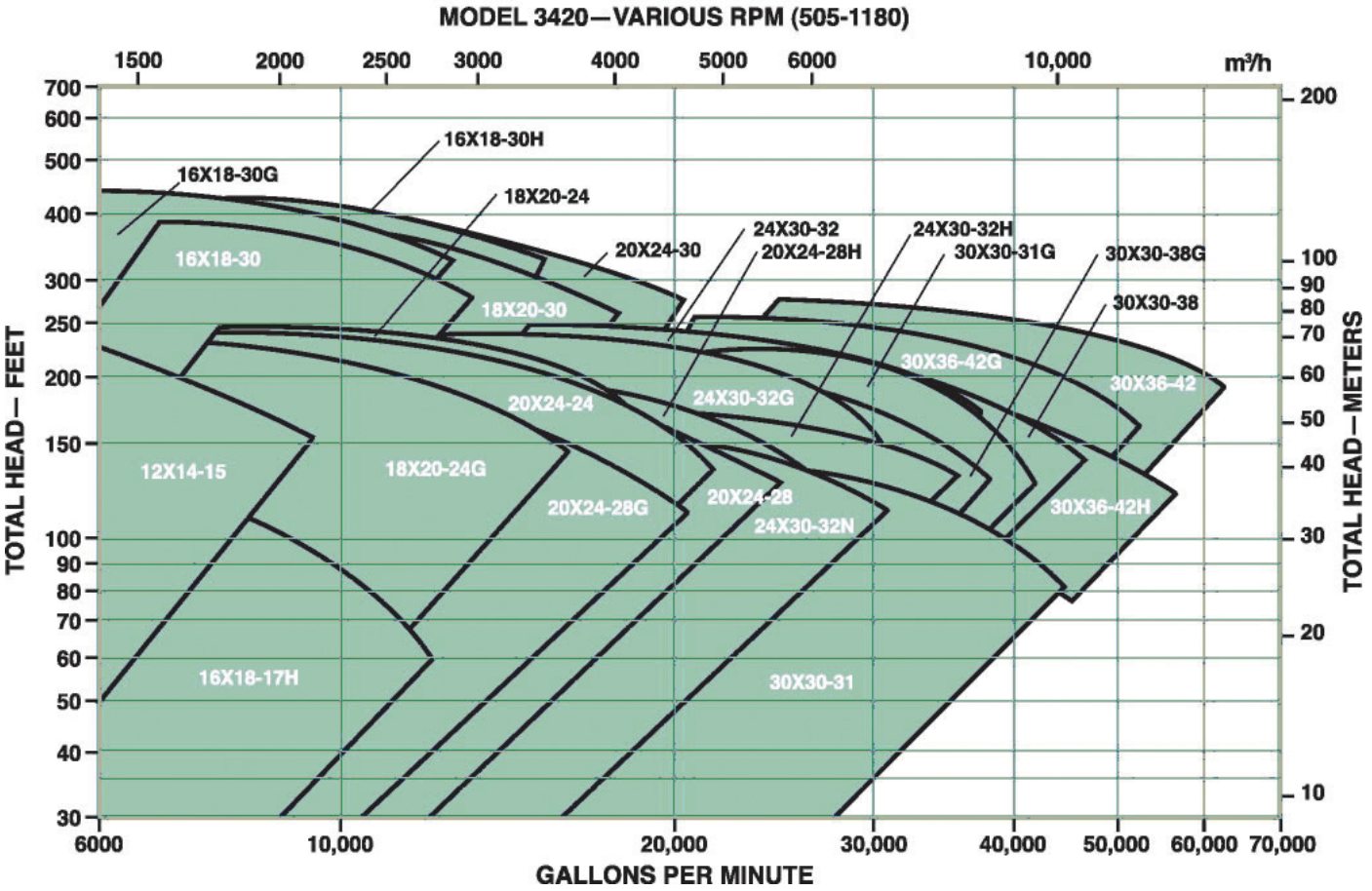


Pump Size	C	T	D	O	OH	S & Z	X	YY	HA	HB	Weight Lbs. (kg)
12×14-15	33.0 (838)	26.8 (679)	26.4 (670)	42.3 (1073)	25.0 (635)	14.8 (375)	17.8 (451)	24.8 (629)	33.0 (838)	24.0 (610)	2600 (1179)
16×18-17/H	33.0 (838)	26.8 (679)	33.5 (851)	54.3 (1378)	31.0 (787)	18.8 (476)	20.9 (530)	31.5 (800)	33.0 (838)	24.0 (610)	3500 (1588)
16×18-30/G/H	44.4 (1127)	36.6 (930)	36.0 (914)	62.3 (1581)	41.3 (1048)	22.5 (572)	28.0 (711)	34.0 (864)	46.0 (1168)	47.0 (1194)	7060 (3202)
18×20-24/G	39.1 (992)	30.8 (783)	35.5 (902)	59.9 (1521)	38.0 (965)	19.5 (495)	20.6 (524)	38.9 (989)	49.0 (1245)	46.0 (1168)	5650 (2563)
18×20-30	44.4 (1127)	36.6 (930)	37.5 (953)	64.3 (1632)	41.8 (1060)	22.8 (578)	29.0 (737)	35.0 (889)	48.0 (1219)	47.0 (1194)	7500 (3402)
20×24-24	44.4 (1127)	36.6 (930)	38.0 (965)	63.8 (1619)	37.8 (959)	20.5 (521)	26.6 (675)	34.0 (864)	42.0 (1067)	47.0 (1194)	7200 (3266)
20×24-28/G/H	37.9 (962)	37.9 (962)	42.1 (1070)	70.3 (1784)	44.0 (1118)	23.1 (587)	24.5 (622)	46.2 (1173)	56.0 (1422)	54.0 (1372)	8650 (3924)
20×24-30	46.0 (1168)	36.6 (930)	40.5 (1029)	68.0 (1727)	42.5 (1080)	23.5 (597)	29.5 (749)	36.0 (914)	50.0 (1270)	47.0 (1194)	8000 (3629)
24×30-32/G/H/N	44.4 (1127)	39.8 (1010)	44.0 (1118)	74.1 (1883)	45.0 (1143)	22.5 (572)	36.0 (914)	50.0 (1270)	56.0 (1422)	51.0 (1295)	11,500 (5216)
30×30-31/G	50.0 (1270)	42.9 (1089)	53.3 (1353)	86.4 (2196)	50.7 (1287)	33.4 (848)	40.0 (1016)	52.0 (1321)	63.4 (1610)	53.4 (1356)	16,200 (7348)
30×30-38/G	53.0 (1346)	42.9 (1089)	53.3 (1353)	87.5 (2223)	53.3 (1353)	30.8 (781)	36.5 (927)	54.5 (1384)	63.4 (1610)	53.4 (1356)	15,400 (6985)
30×36-42/G/H	60.8 (1545)	47.6 (1210)	58.0 (1473)	97.5 (2477)	62.0 (1575)	34.0 (864)	36.0 (914)	54.5 (1384)	78.0 (1981)	76.0 (1930)	25,250 (11,453)

All dimensions in inches (mm) and are not to be used for construction or installation purposes.
Standard rotation is right hand (CW). Optional rotation is left hand (CCW).
Steel casings will have 150#RF flanges.

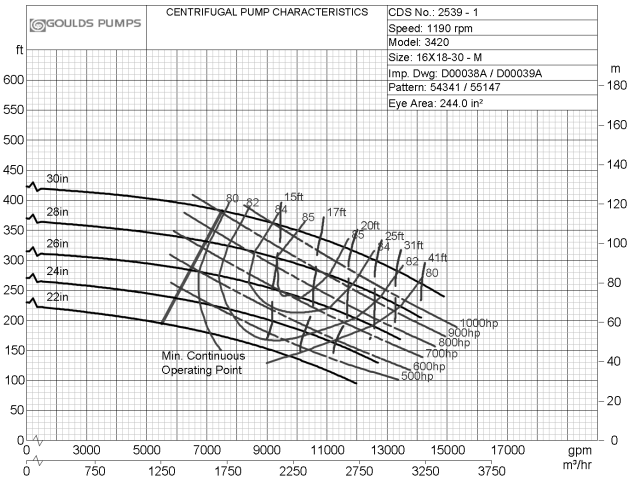
Hydraulic Coverage Model 3420

MODEL 3420 - VARIOUS RPM (1180 - 505)

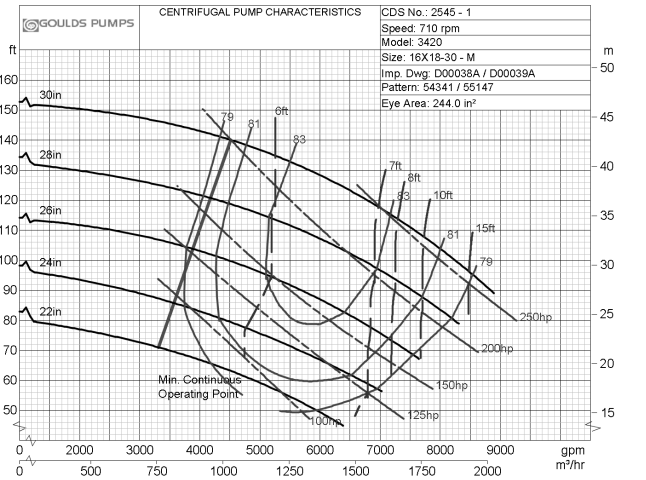


NOTES

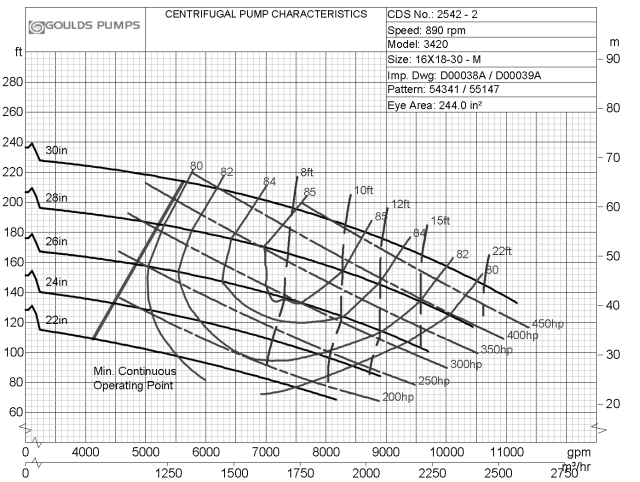
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



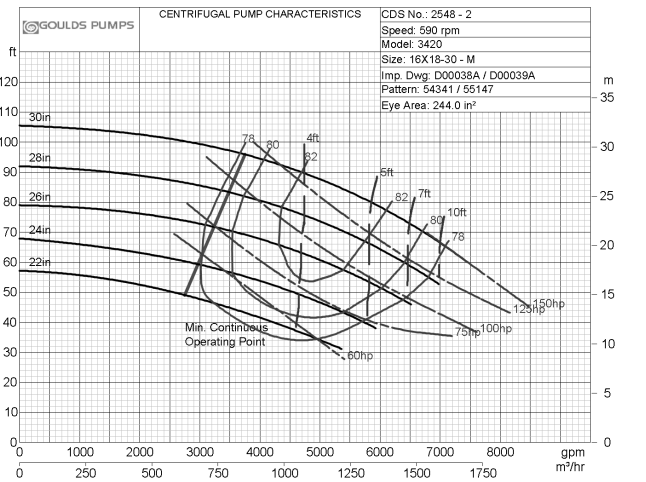
16X18-30 **1190rpm**



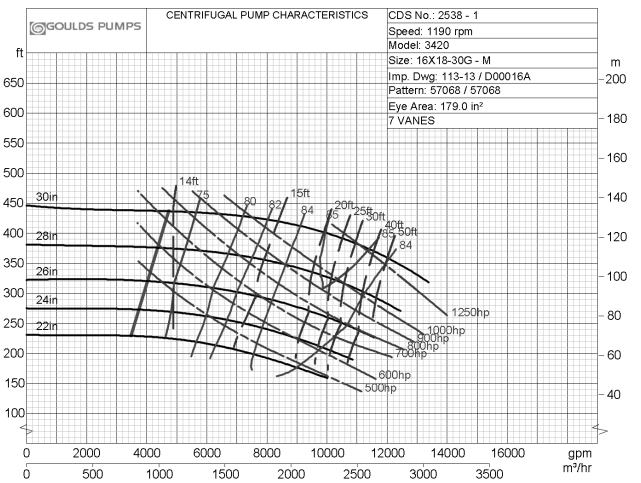
16X18-30 **710rpm**



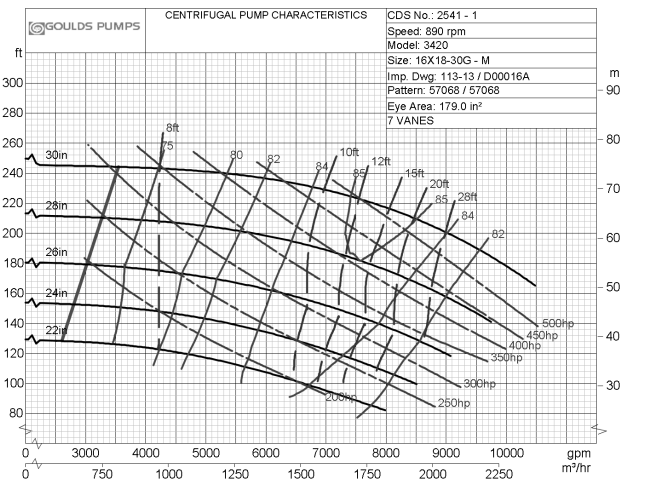
16X18-30 **890rpm**



16X18-30 **590rpm**



16X18-30G **1190rpm**

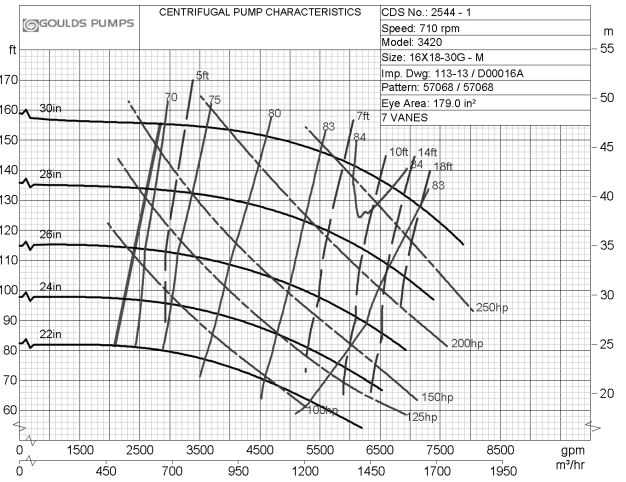


16X18-30G **890rpm**

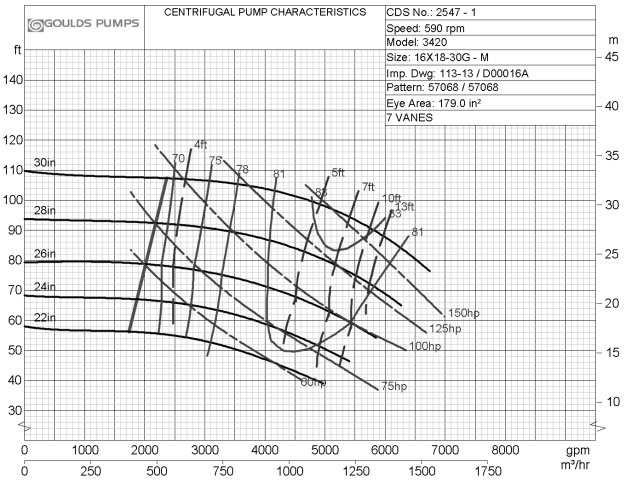
60Hz Curves

Model 3420

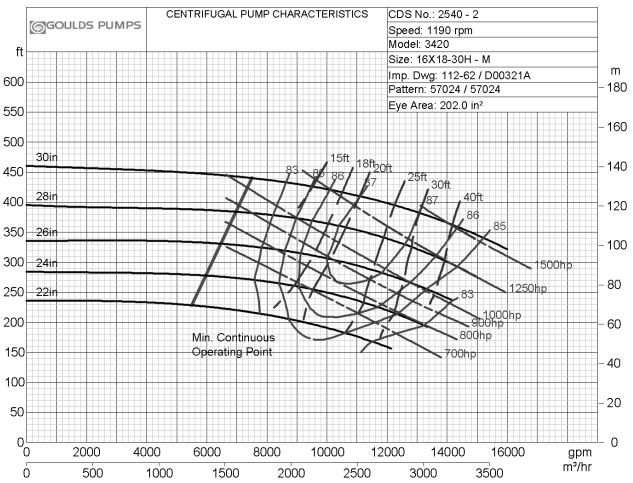
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



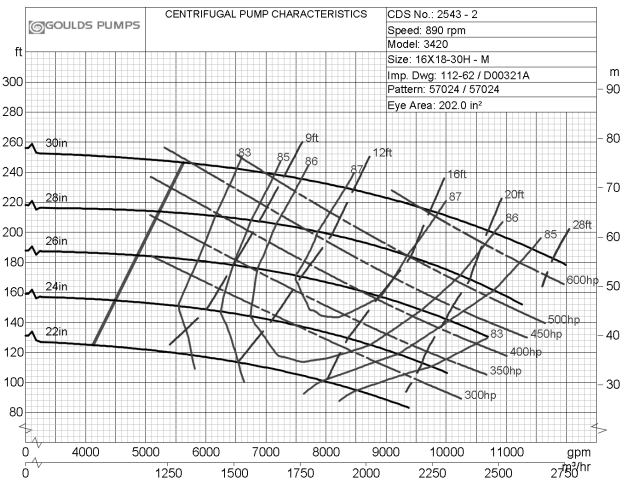
16X18-30G **710rpm**



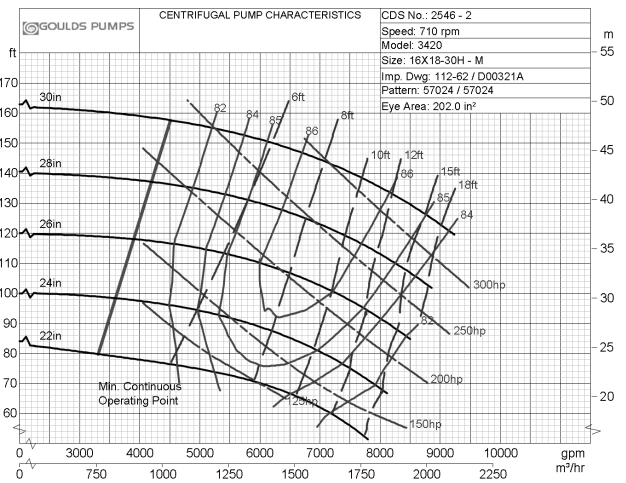
16X18-30G **590rpm**



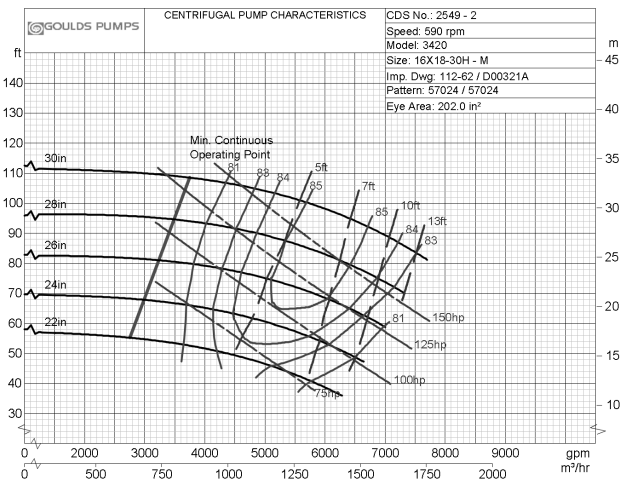
16X18-30H **1190rpm**



16X18-30H **890rpm**



16X18-30H **710rpm**



16X18-30H **590rpm**

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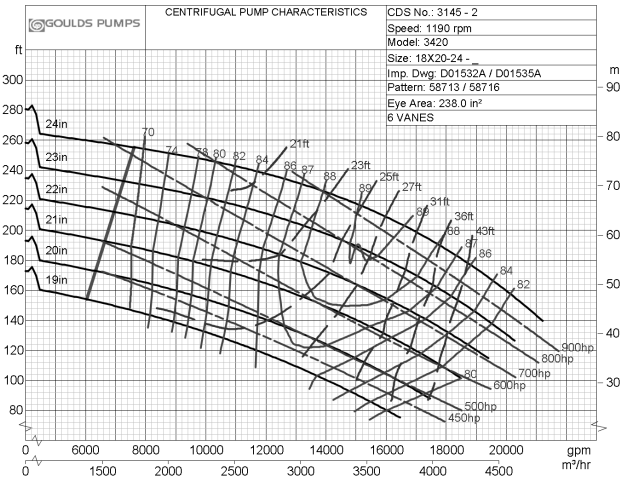
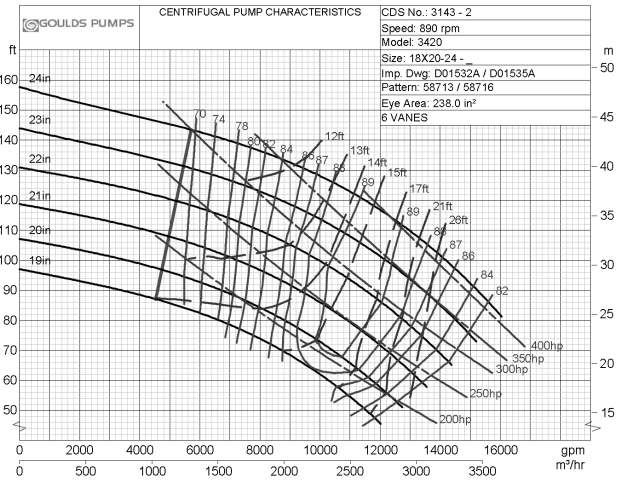
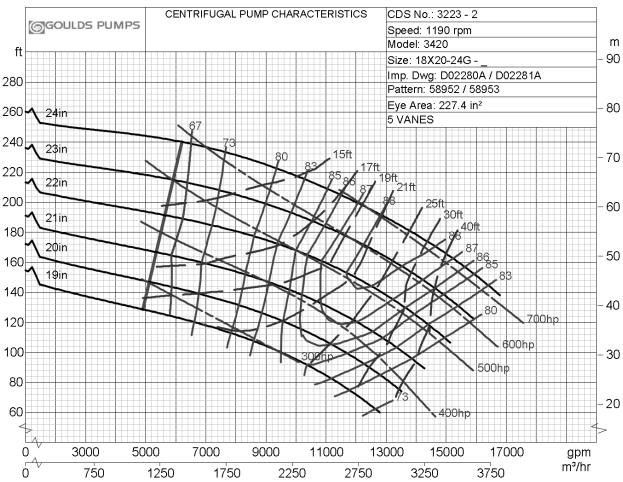


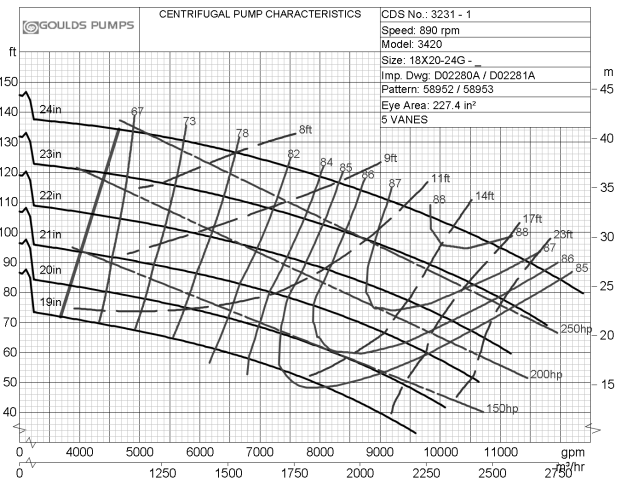
18X20-24 **1190rpm**



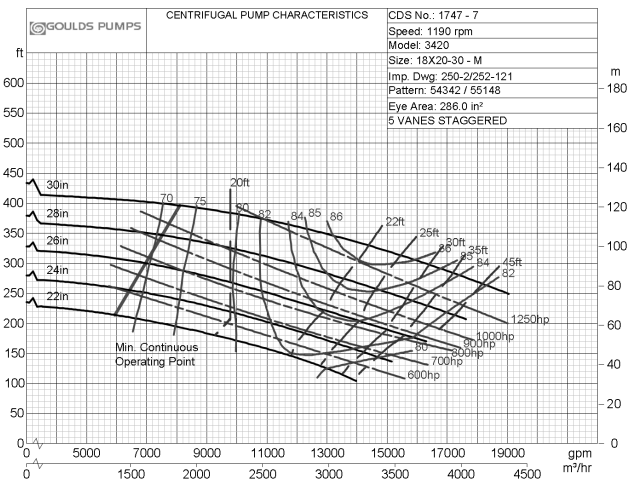
18X20-24 **890rpm**



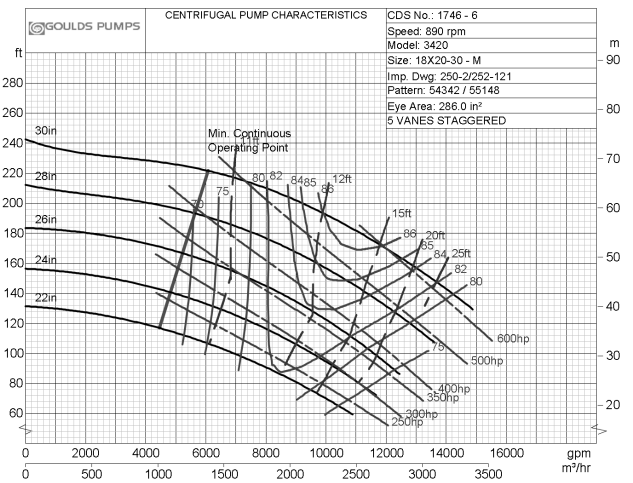
18X20-24G **1190rpm**



18X20-24G **890rpm**



18X20-30 **1190rpm**



18X20-30 **890rpm**

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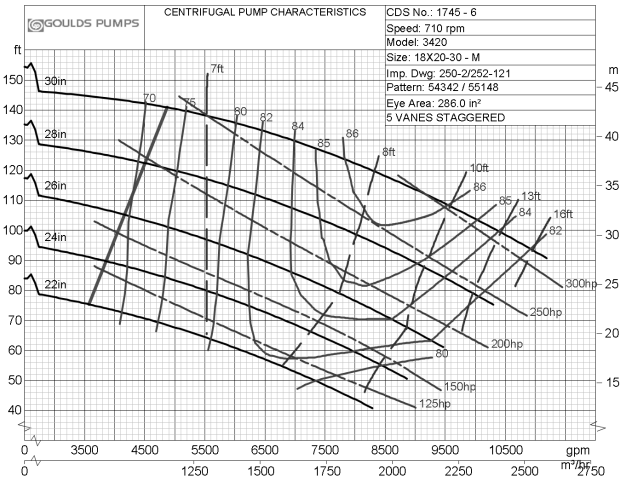
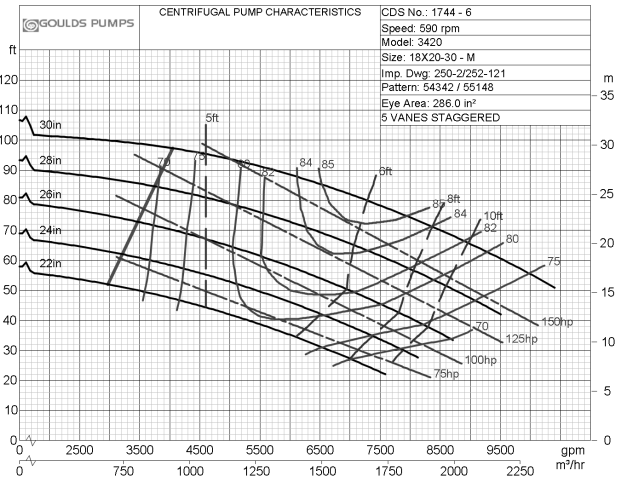
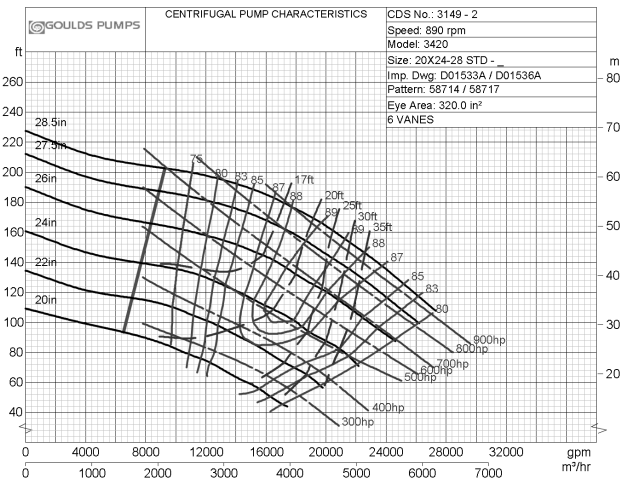


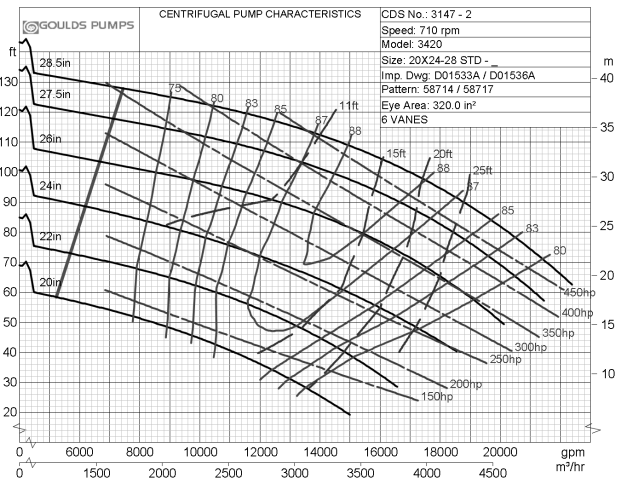
18X20-30 **710rpm**



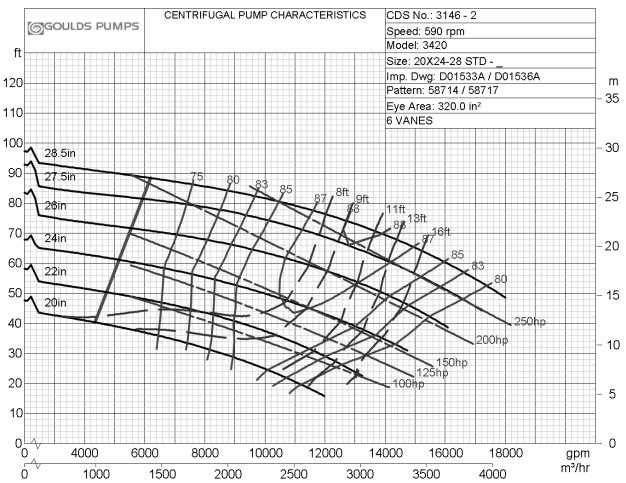
18X20-30 **590rpm**



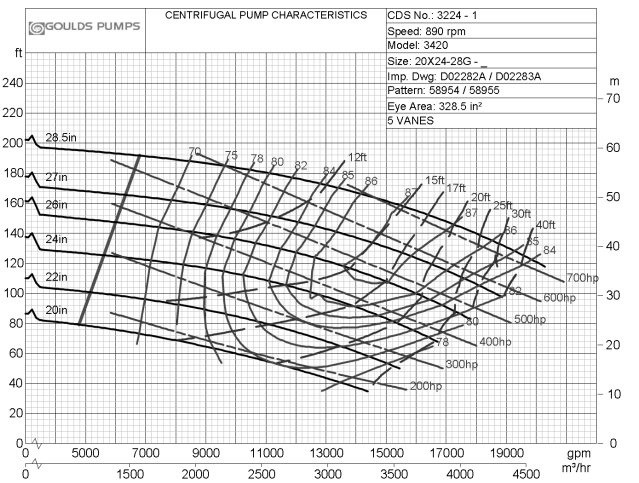
20X24-28 STD **890rpm**



20X24-28 STD **710rpm**

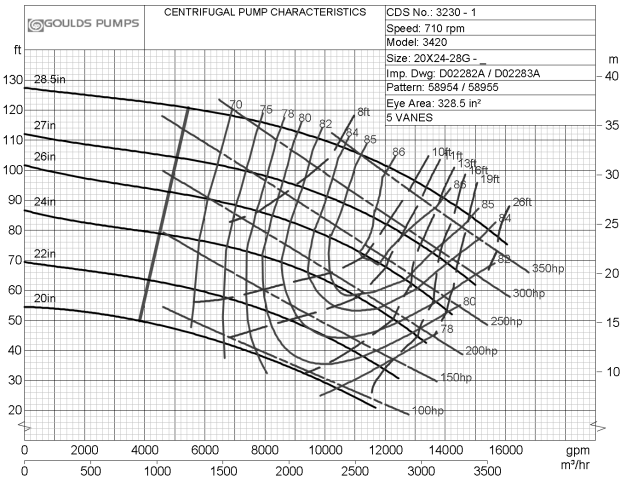


20X24-28 STD **590rpm**

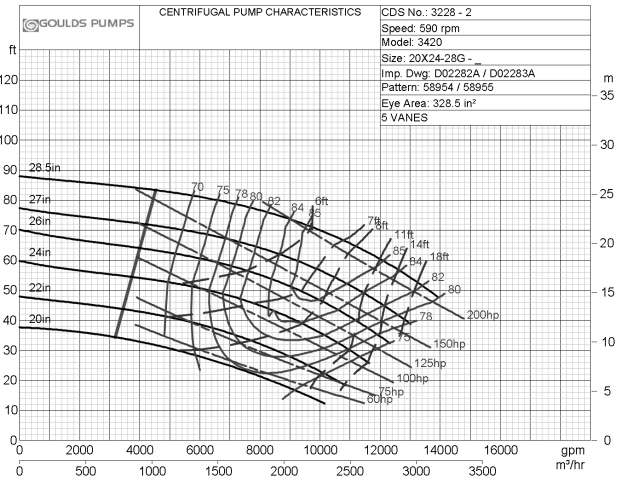


20X24-28G **890rpm**

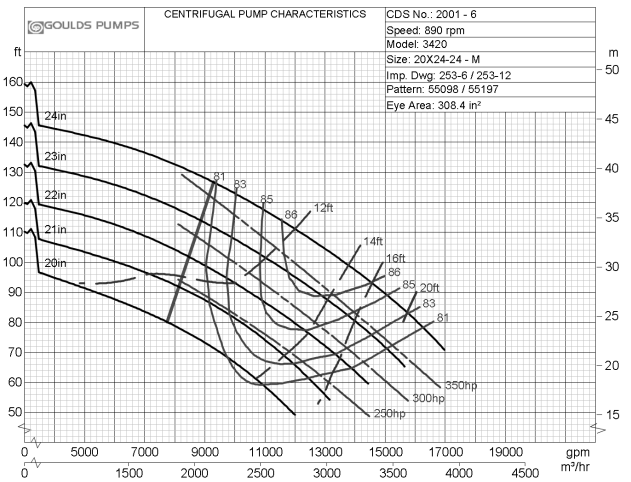
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



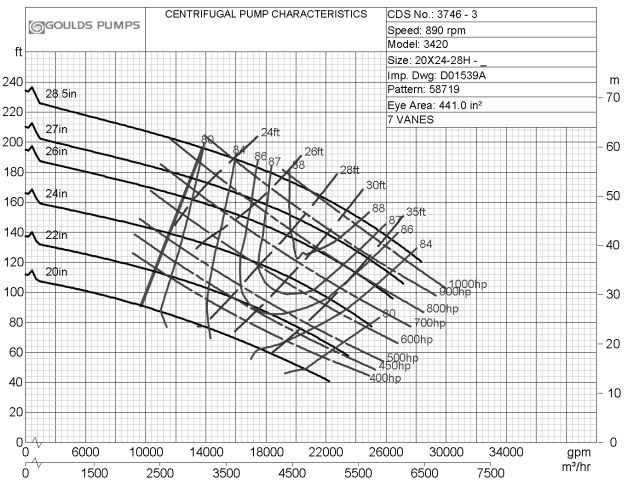
20X24-28G **710rpm**



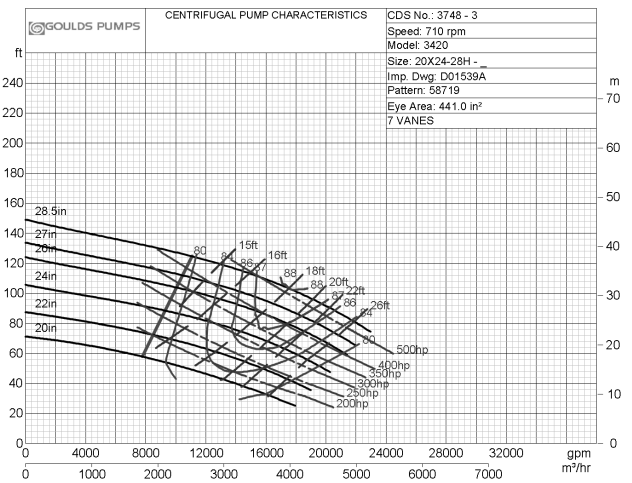
20X24-28G **590rpm**



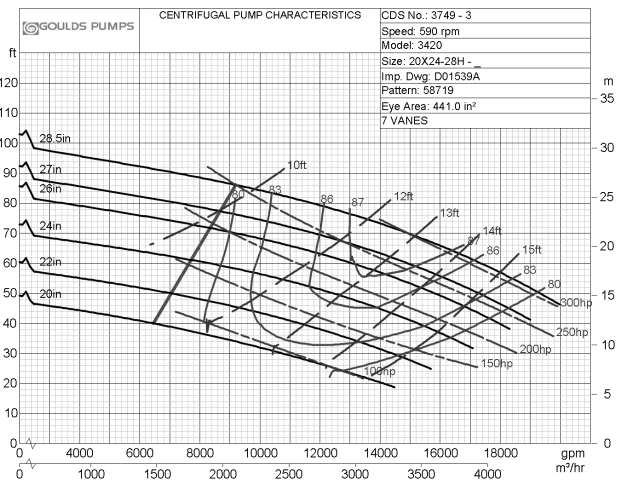
20X24-24 **890rpm**



20X24-28H **890rpm**



20X24-28H **710rpm**



20X24-28H **590rpm**

60Hz Curves

Model 3420

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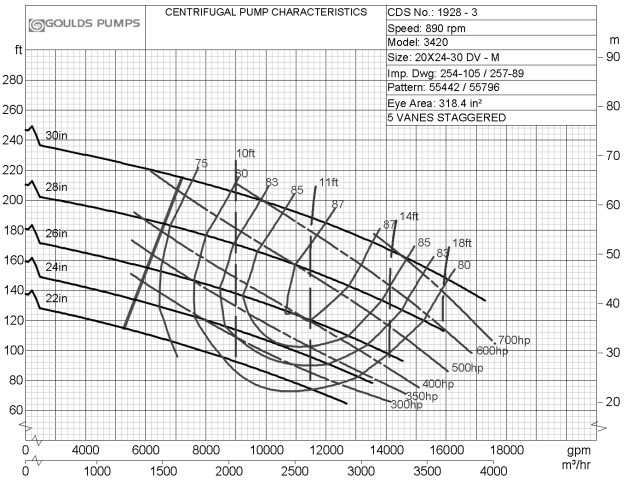
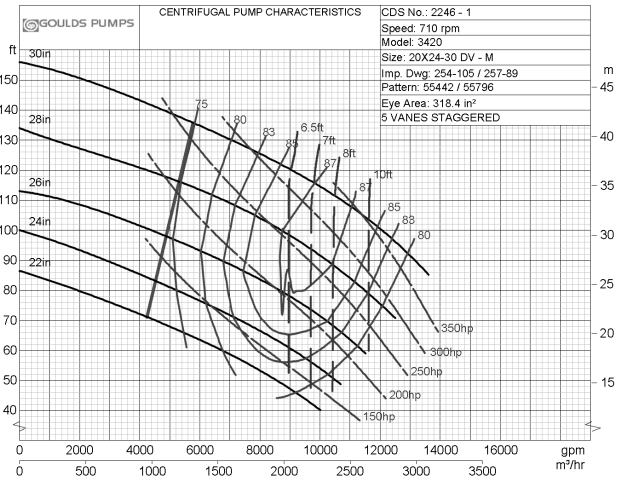
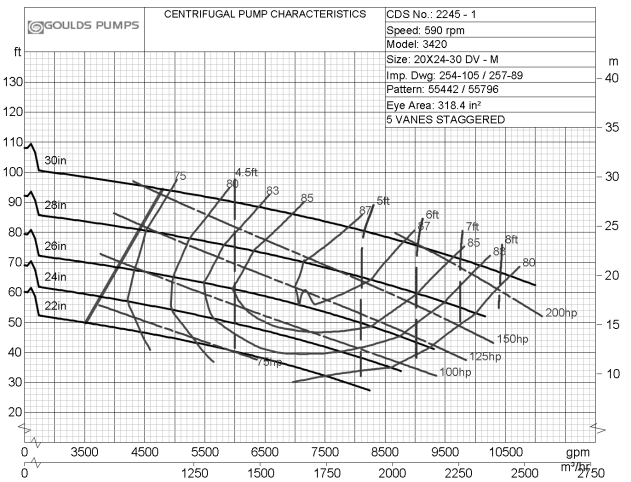


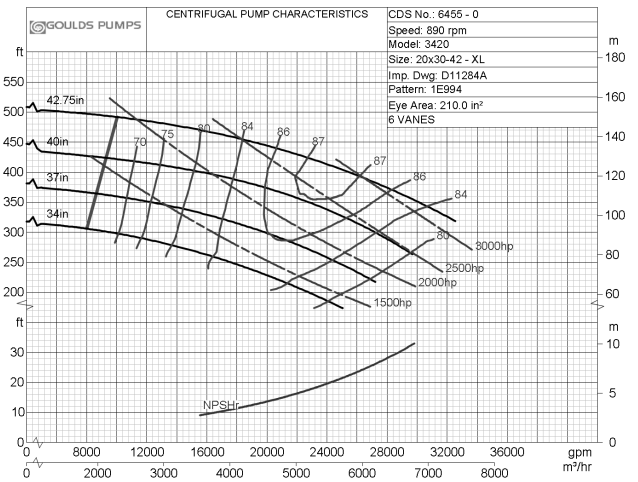
20X24-30 DV **890rpm**



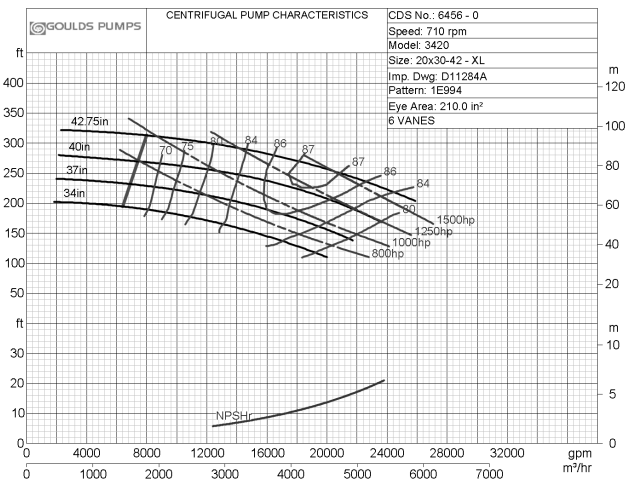
20X24-30 DV **710rpm**



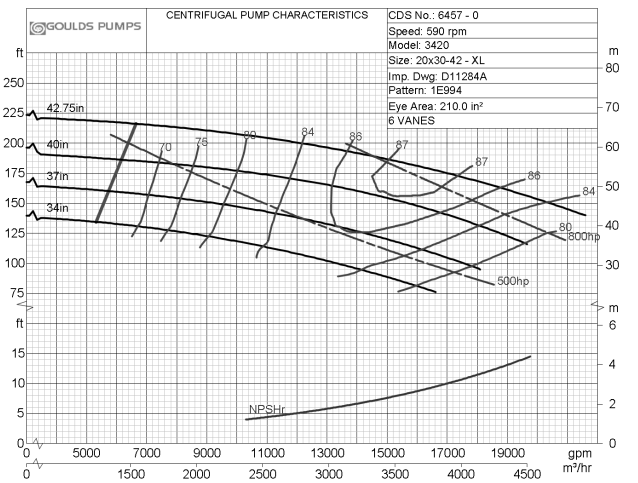
20X24-30 DV **590rpm**



20x30-42 **890rpm**



20x30-42 **710rpm**



20x30-42 **590rpm**

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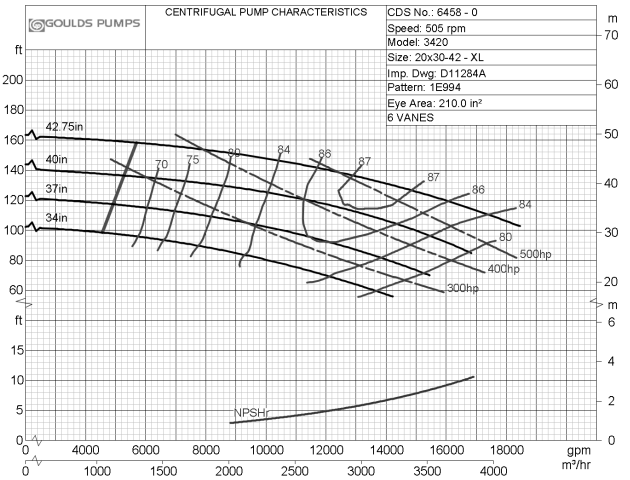
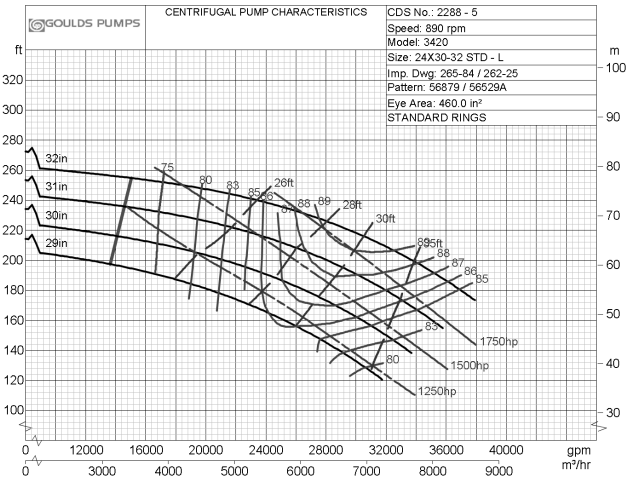
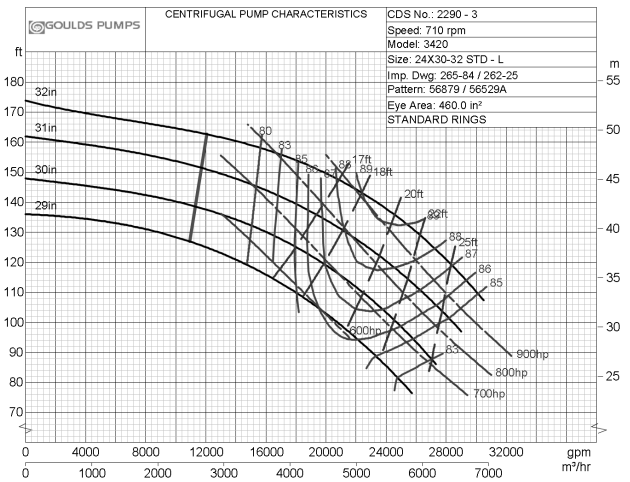


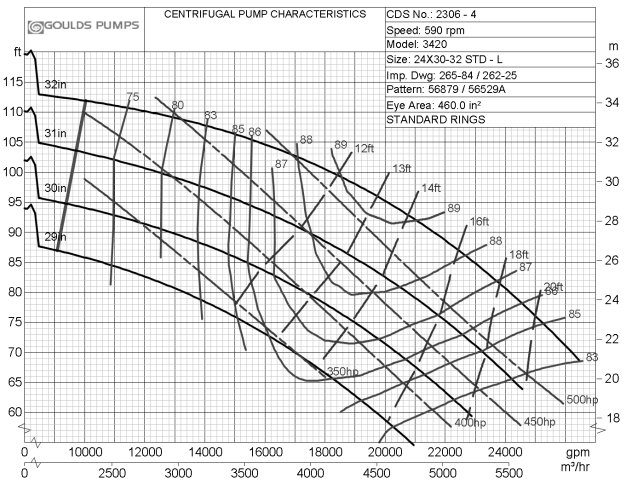
20x30-42 **505rpm**



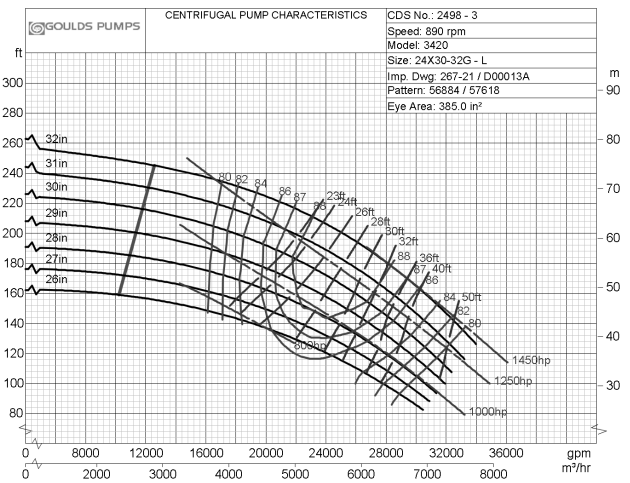
24X30-32 STD **890rpm**



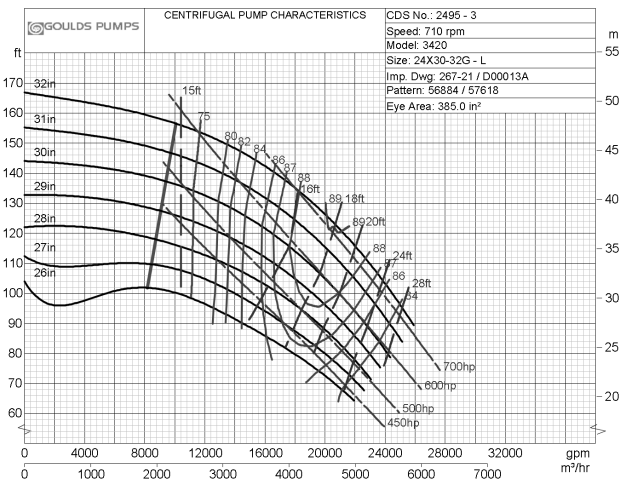
24X30-32 STD **710rpm**



24X30-32 STD **590rpm**



24X30-32G **890rpm**

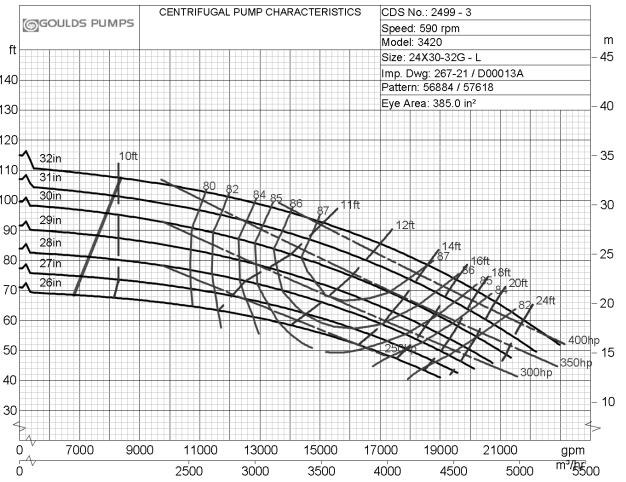


24X30-32G **710rpm**

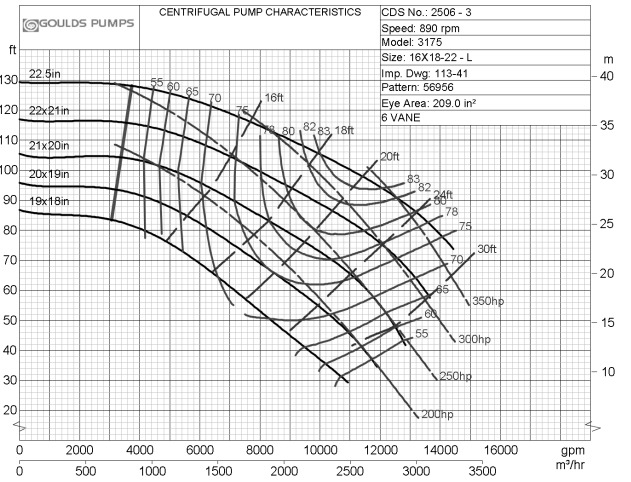
60Hz Curves

Model 3420

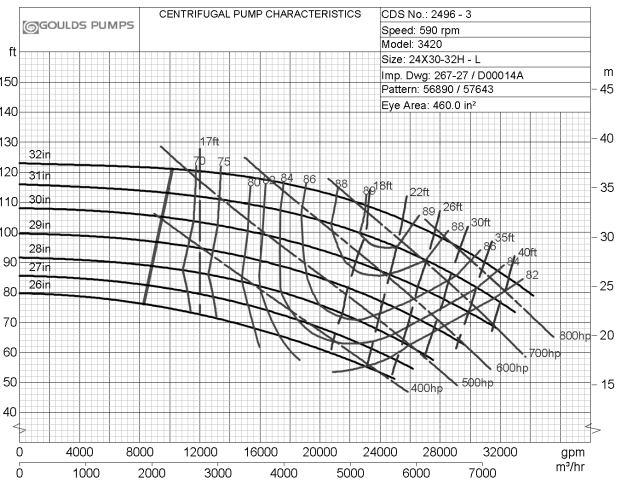
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



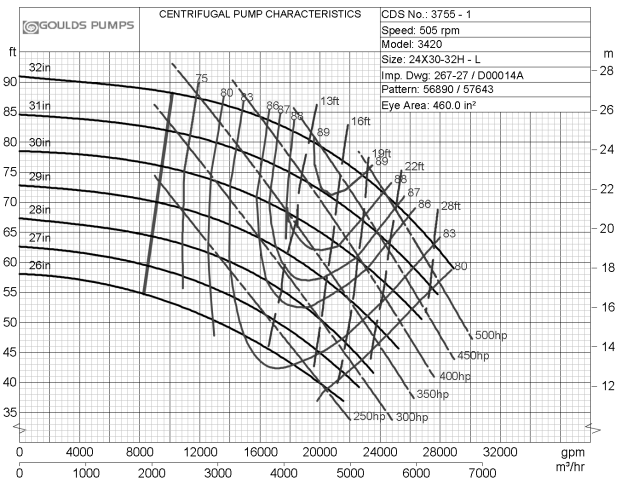
24X30-32G **590rpm**



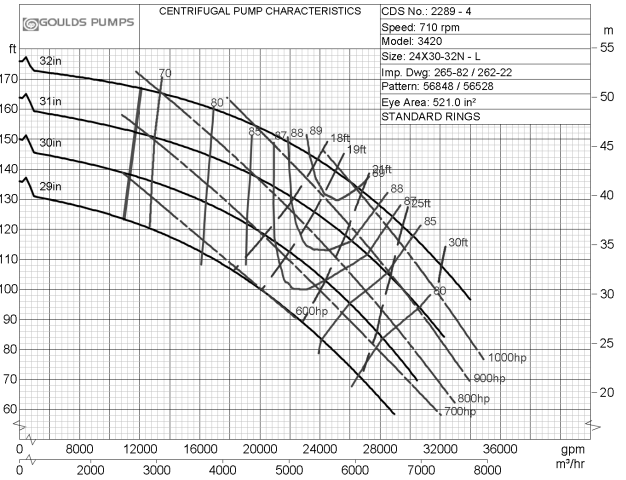
16X18-22 **890rpm**



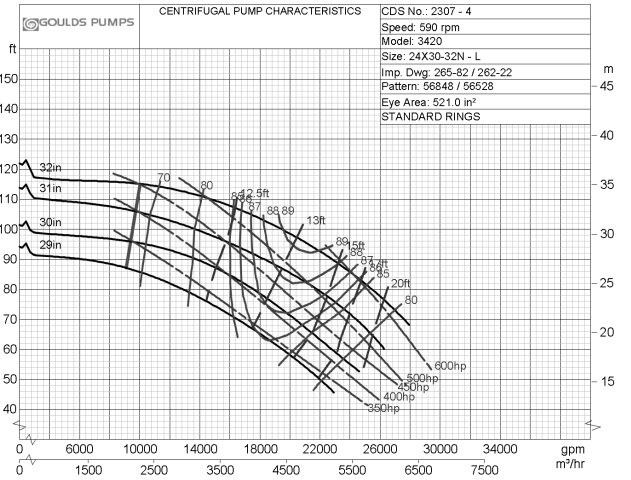
24X30-32H **590rpm**



24X30-32H **505rpm**

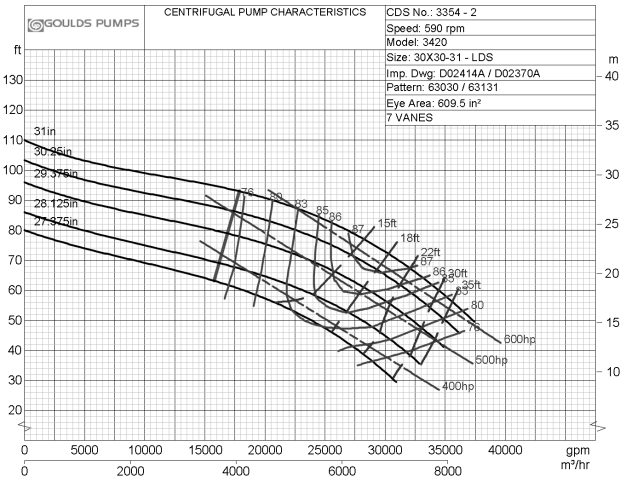


24X30-32N **710rpm**

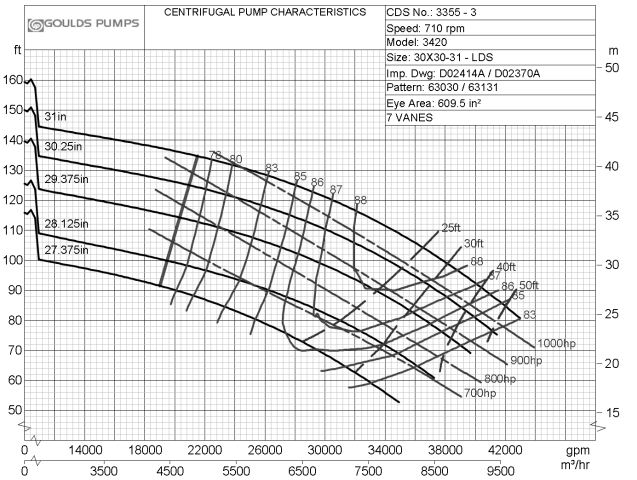


24X30-32N **590rpm**

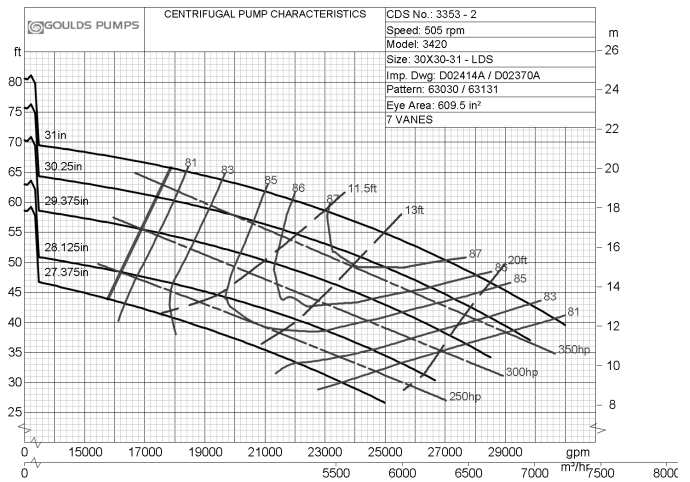
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



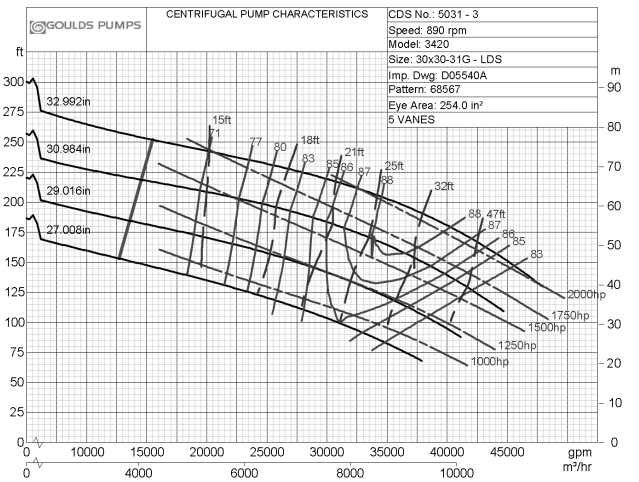
30X30-31 **590rpm**



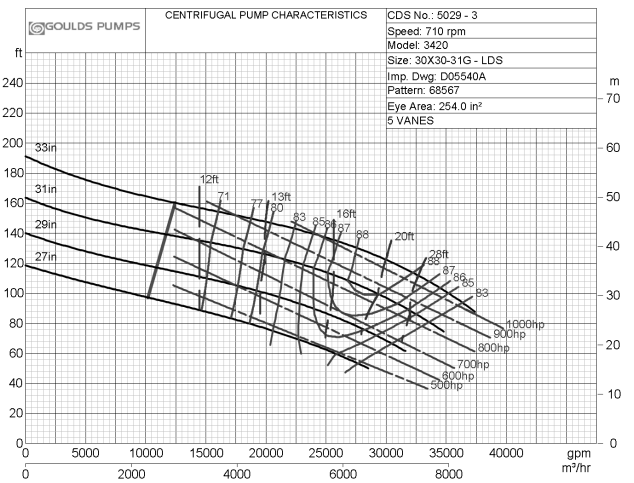
30X30-31 **710rpm**



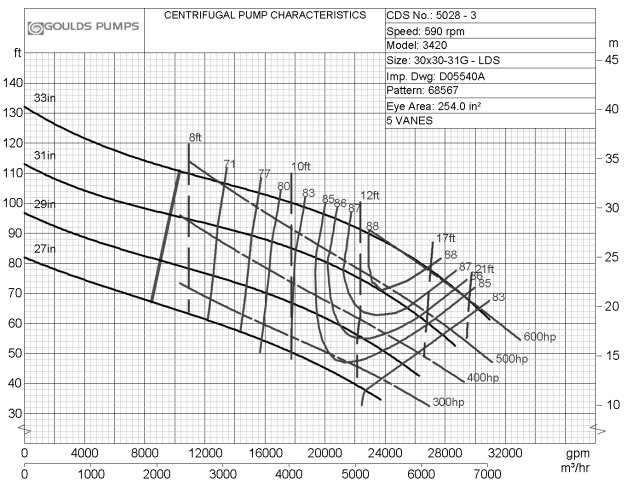
30X30-31 **505rpm**



30x30-31G **890rpm**



30X30-31G **710rpm**

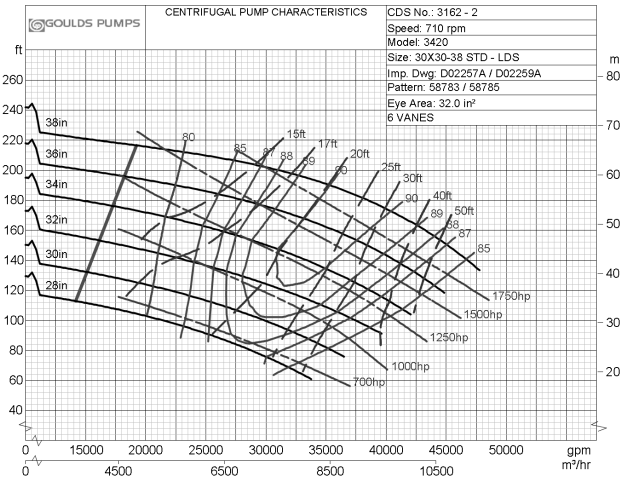


30x30-31G **590rpm**

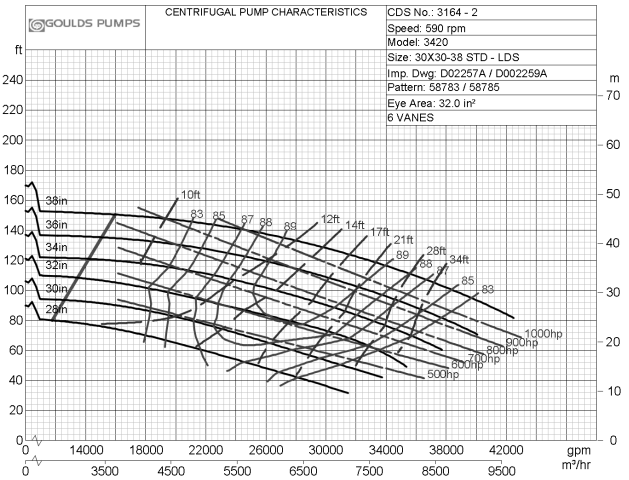
60Hz Curves

Model 3420

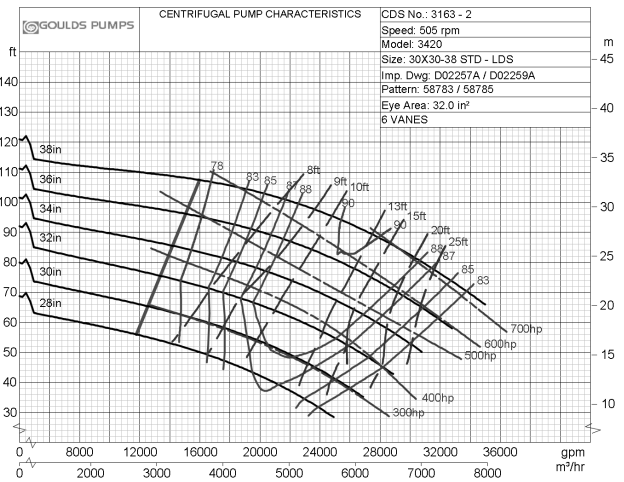
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



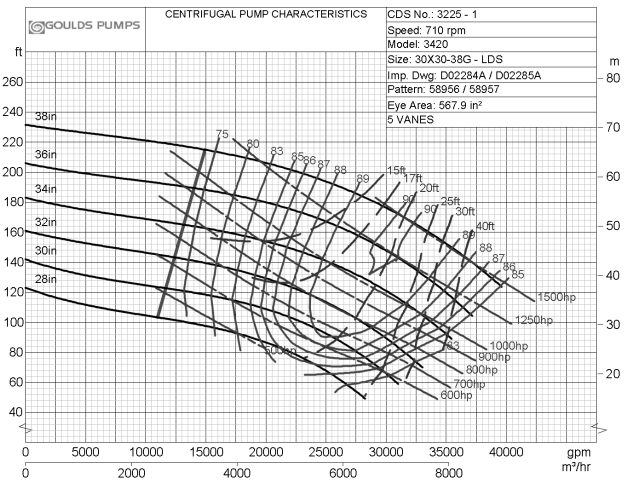
30X30-38 STD **710rpm**



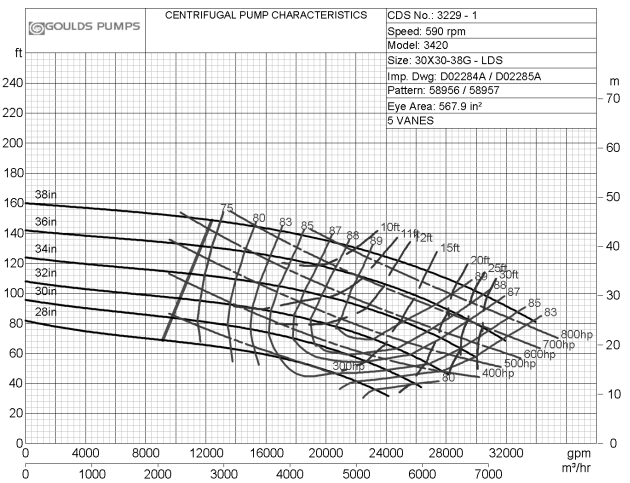
30X30-38 STD **590rpm**



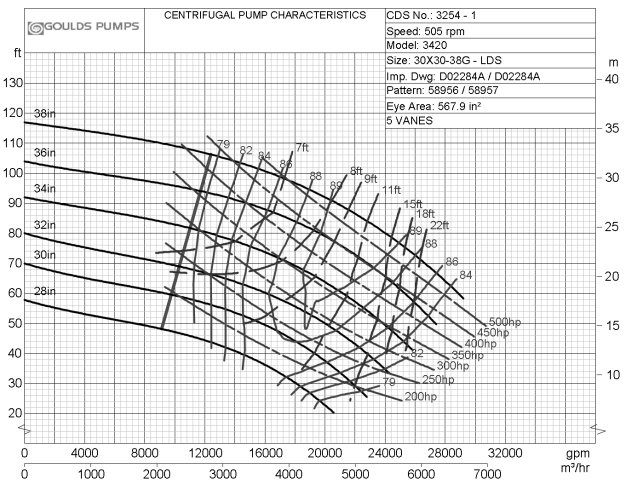
30X30-38 STD **505rpm**



30X30-38G **710rpm**

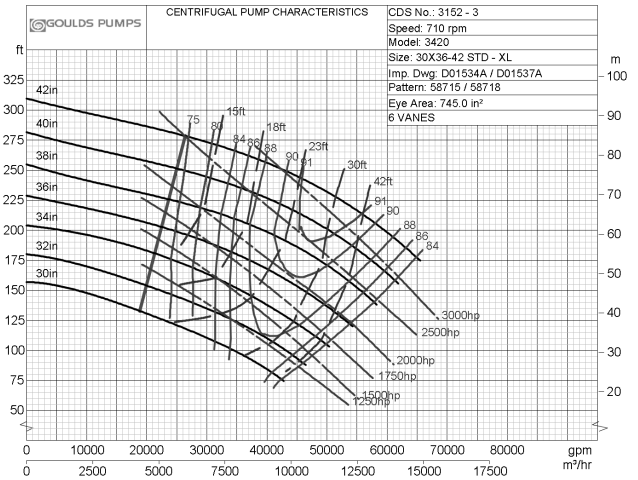


30X30-38G **590rpm**

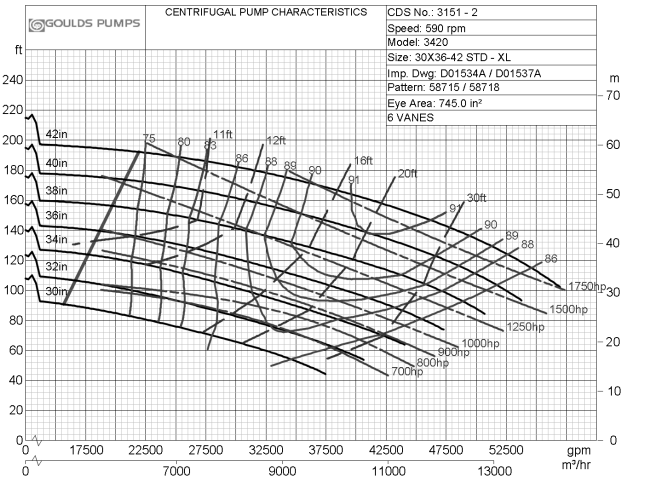


30X30-38G **505rpm**

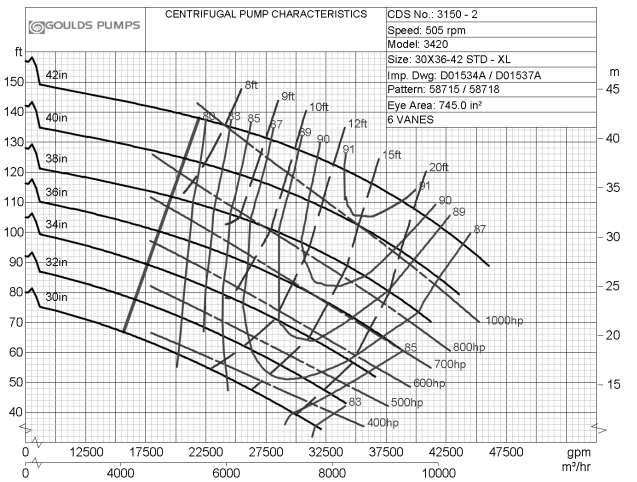
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



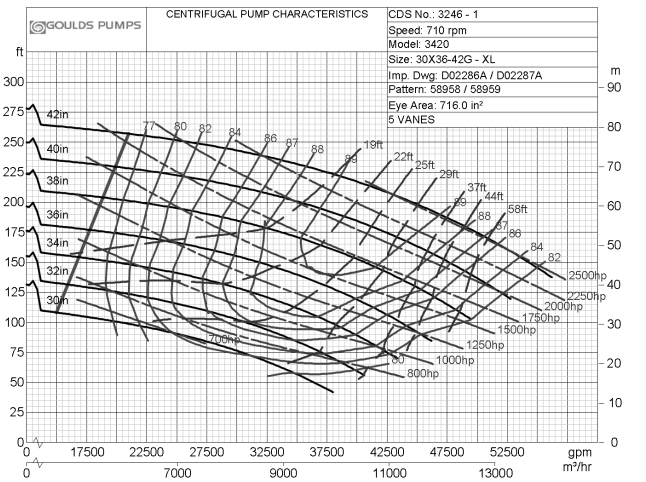
30X36-42 STD **710rpm**



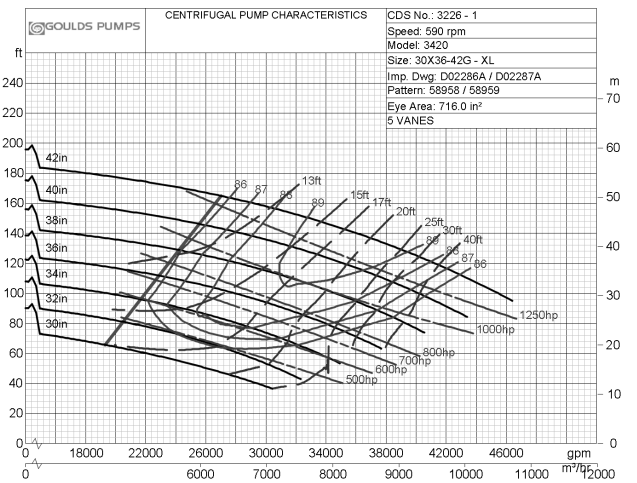
30X36-42 STD **590rpm**



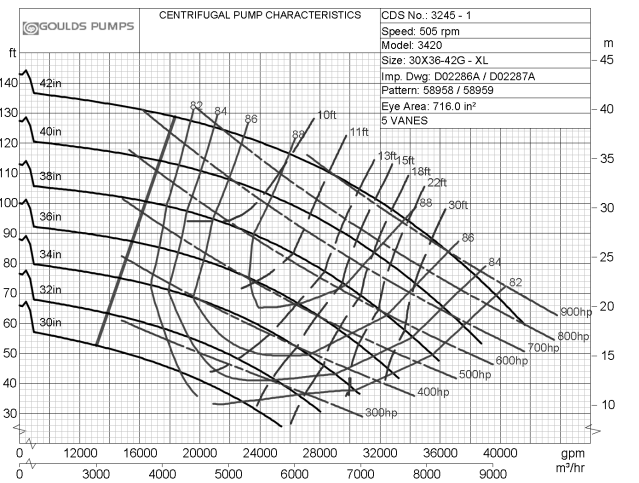
30X36-42 STD **505rpm**



30X36-42G **710rpm**



30X36-42G **590rpm**

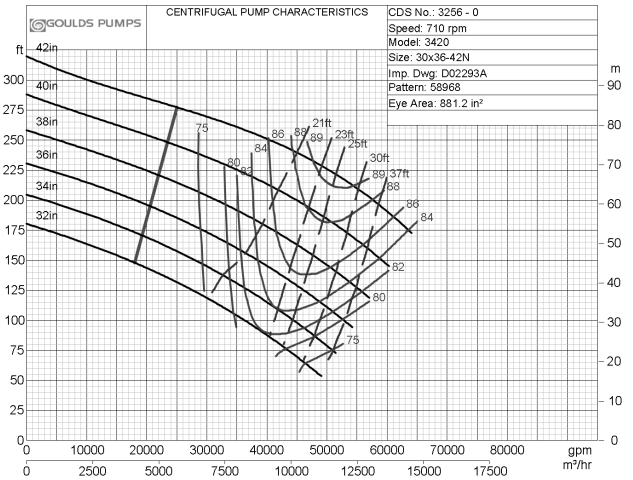


30X36-42G **505rpm**

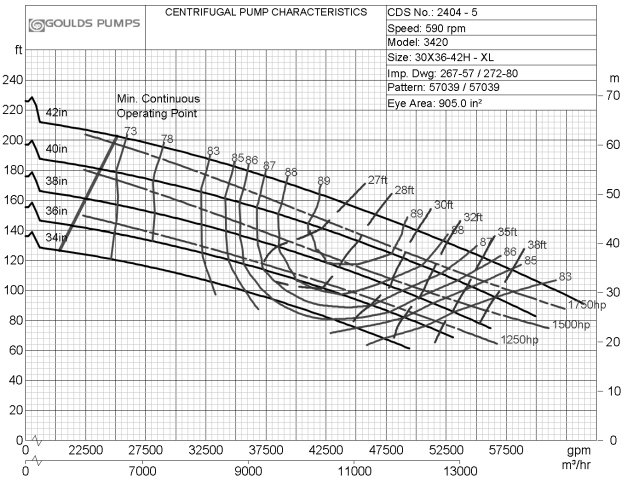
60Hz Curves

Model 3420

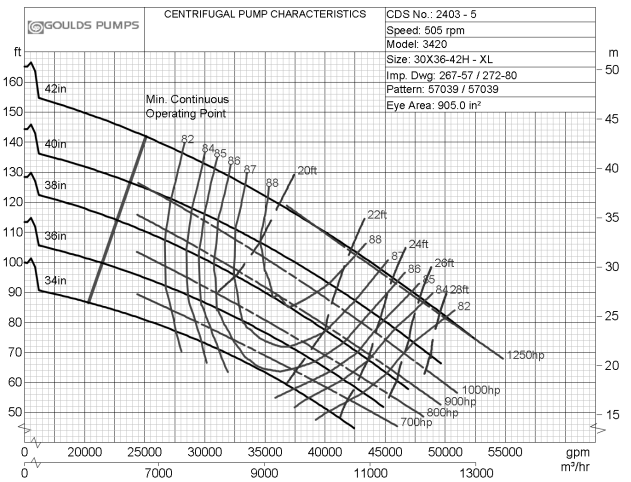
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



30x36-42N **710rpm**



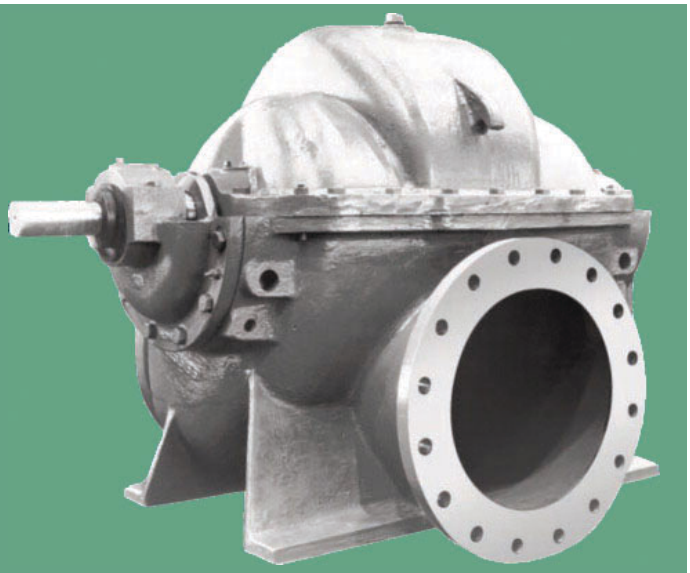
30X36-42H **590rpm**



30X36-42H **505rpm**

NOTES

NOTES



Model 3498

Goulds Model 3498

Large Capacity, Single Stage, Double Suction Pumps Designed for a Wide Range of Heavy Duty Industrial, Marine and Power Generation Services

- Capacities to 225,000 GPM (51,098 m^3/h)
- Heads to 800 feet (244 m)
- Temperatures to 275°F (135°C)
- Working Pressures to 250 PSIG (1724 kPa)

Design Features

- **Horizontally Split Casing** In-line suction and discharge nozzles in lower half casing for ease of inspection/maintenance.
- **Double Suction Impeller** Assures Hydraulic Axial Balance for lower thrust bearing loads, longer pump life, and lower maintenance.
- **Dual Volute Casing** Assures Radial Balance for lower radial bearing loads, longer pump life and lower maintenance. (Availability is size dependent.)
- **Wear Rings** Easily replaceable wear rings renew running clearances, protect against impeller, casing wear. Overall cost of operation is minimized.
- **Sealing Flexibility** Choice of packing or wide range of mechanical seals.
- **Installation Versatility** Horizontal or vertical mounting, clockwise or counterclockwise rotation, side suction or bottom suction.
- **Material Flexibility** Available in a wide variety of metals from cast iron to stainless steels.

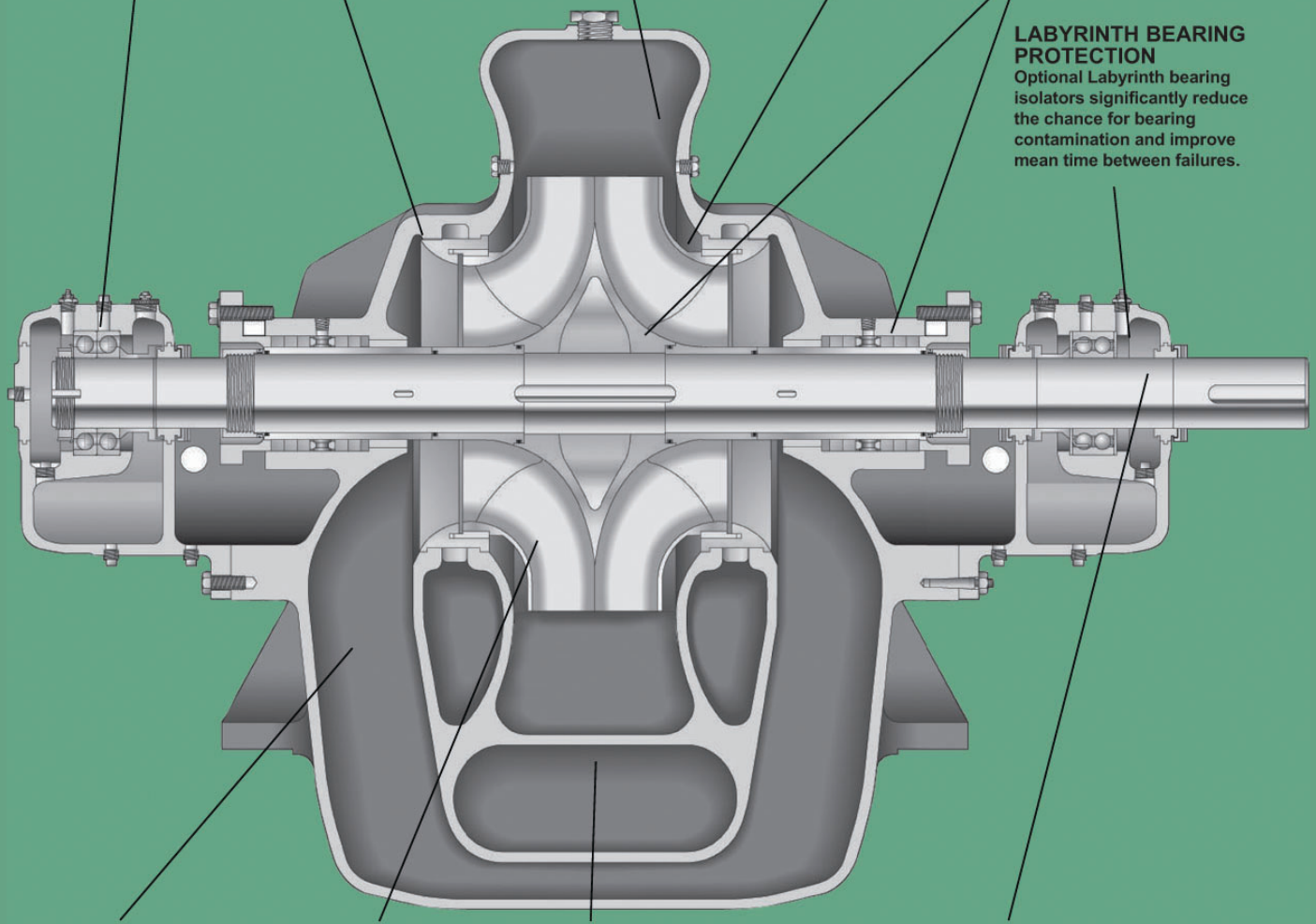
Applications

- **Process** — Quench Water, Stripper Bottoms, Reboiler Circulation, Cooling Tower.
- **Pulp & Paper** — Primary and Secondary Cleaner, Filtrate, Mill Water Supply, Fan Pump, Headbox Supply, Shower.
- **Primary Metals** — Cooling Water, Quench and Leaching.
- **Municipal** — High Lift, Low Lift, Wash Water, Waste Water, Raw Water.
- **Power Generation** — Cooling Tower, Component Cooling, Service Water, Ash Sluicing, Heater Drain.
- **Marine** — Bilge and Ballast, Cargo, Cooling Water, Fire Pump.
- **General** — River Water, Brine, Sea Water.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3498 Extra Large Capacity, Single Stage, Double Suction Pumps

Heavy Duty Design Features for Wide Range of Water Supply and Process Services



HIGH THRUST CAPABILITY
Spherical roller bearings or double row ball thrust bearings handle unexpected thrusts. Secured with locknut and washer.

RENEWABLE CASE WEARING RINGS
Permits easy maintenance of proper running clearances. Double lock in lower half casing to prevent rotation.

HEAVY DUTY CASING
Casing walls designed to withstand pressure extremes. Rugged design resists external forces and vibrations. Both suction and discharge connections in lower half casing. Removal of upper half casing permits inspection, maintenance and removal of the complete rotating element without disturbing piping or driver.

RENEWABLE IMPELLER WEAR RINGS
A must for proper maintenance of running clearances. Mechanically locked onto impeller hubs.

POSITIVE LIQUID SEALING
Buna O-ring in controlled compression protects shaft and threaded area from pumpage or confined corrosive attack.

LABYRINTH BEARING PROTECTION
Optional Labyrinth bearing isolators significantly reduce the chance for bearing contamination and improve mean time between failures.

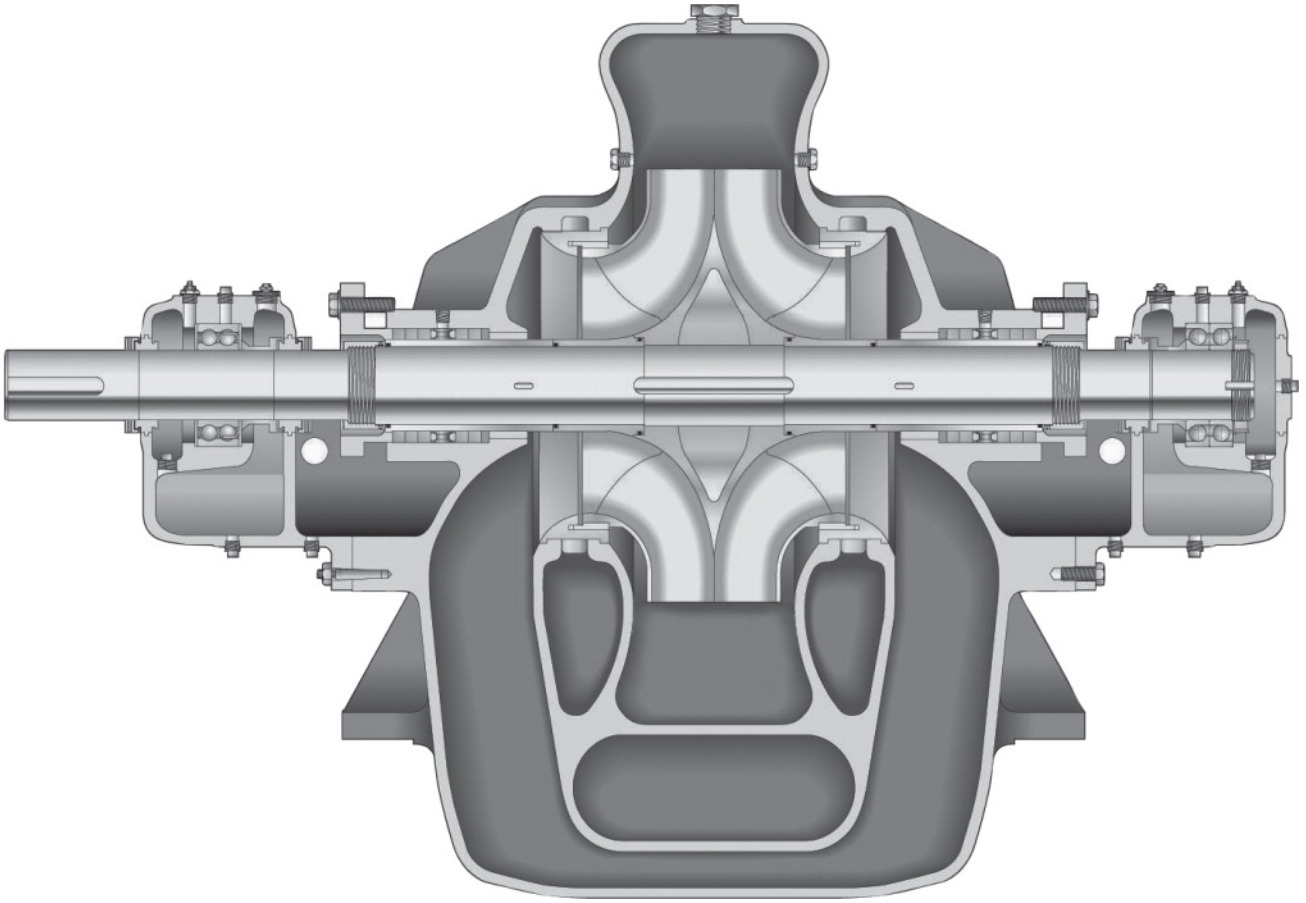
LARGE INLET AREAS
Assures smooth flow to impeller inlet for efficient, quiet operation.

DOUBLE SUCTION IMPELLER
Minimizes axial thrust. Highly efficient for smooth, vibration-free operation.

DUAL VOLUTE DESIGN
Dual volutes having cutwaters 180° apart provide opposing radial forces reducing radial loads on bearings and minimizing shaft deflection. Permits smooth, trouble-free operation over wide range of flow rates. (Size dependent.)

HEAVY DUTY SHAFT
Designed to reduce deflection. Renewable shaft sleeves fully protect shaft from pumpage. Threaded sections removed from stress areas.

Sectional View Model 3498

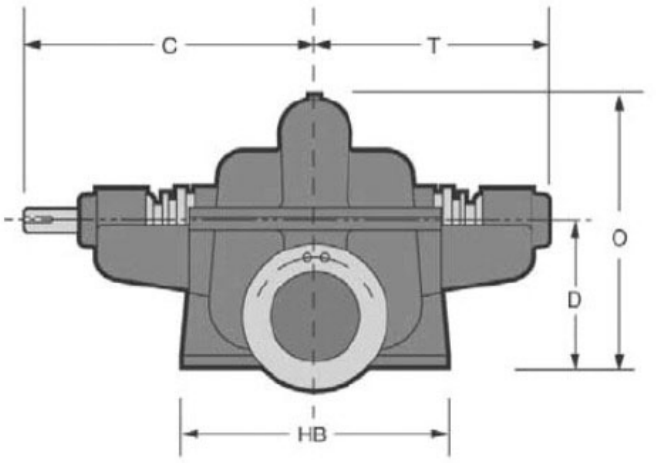


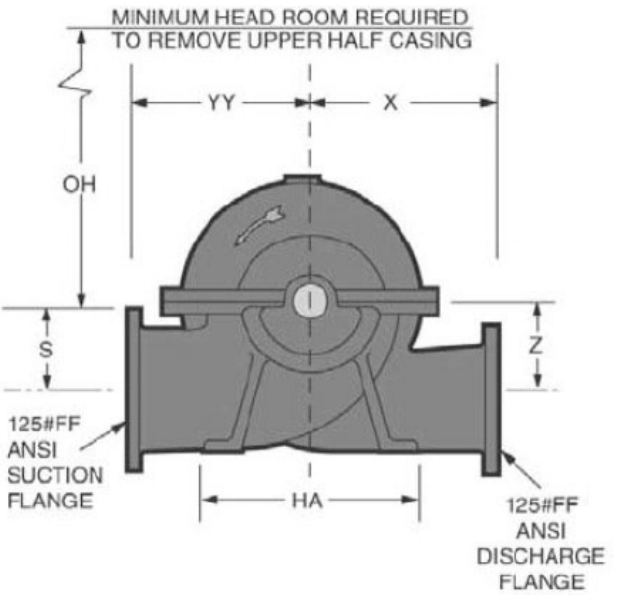
Parts List and Materials of Construction Model 3498

Part Description	Bronze Fitted	All Iron	316 SS Fitted	All 316 SS
Casing	Cast Iron			316 SS
Impeller	Bronze	Cast Iron	316 SS	
Lantern Ring	Teflon			
Packing	Graphite Impregnated Yarn			
Packing Gland	Bronze	Cast Iron	316 SS	
Mechanical Seal Gland	Cast Iron			316 SS
Shaft	Carbon Steel			
Shaft Sleeve Nut	Bronze	Cast Iron	316 SS	
Shaft Sleeve [1]	Bronze	Cast Iron	316 SS	
Casing Wear Ring [1]	Bronze	Cast Iron	316 SS	
Bearing Housings	Cast Iron			
Impeller Wear Ring [1]	Bronze	Cast Iron	316 SS	
Bearings	Steel (Anti-Friction)			

[1] Also available in hardened/hard metal coated materials.

Dimensions Model 3498



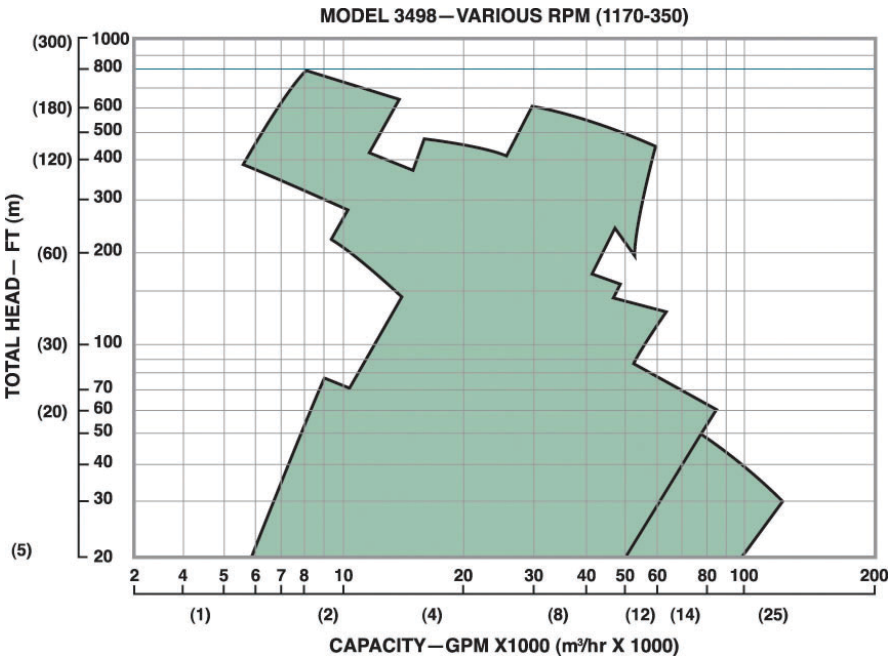


Pump Size	C	T	D	O	OH	S	Z	X	YY	HA	HB	Weight Lbs. (kg)
12×16-28	39.0 (991)	49.0 (1245)	7.0 (178)	23.0 (584)	29.5 (749)	19.0 (483)	19.0 (483)	36.0 (914)	34.0 (864)	31.0 (787)	44.0 (1118)	5900 (2676)
12×18-34*	42.0 (1067)	35.0 (889)	29.0 (737)	54.0 (1372)	42.3 (1073)	22.5 (572)	24.0 (610)	30.0 (762)	38.0 (965)	51.0 (1295)	44.0 (1118)	6600 (2994)
16×18-18*	33.0 (838)	31.0 (787)	23.0 (584)	38.0 (965)	23.9 (606)	13.0 (330)	14.0 (356)	17.0 (432)	24.0 (610)	24.0 (610)	38.0 (965)	3000 (1361)
16×18-28*	40.0 (1016)	36.0 (914)	29.0 (737)	52.0 (1321)	36.7 (931)	23.0 (584)	22.0 (559)	34.0 (864)	35.0 (889)	51.0 (1295)	42.0 (1067)	5000 (2268)
16×20-24	45.0 (1143)	35.5 (902)	28.0 (711)	49.0 (1245)	33.5 (851)	17.0 (432)	19.5 (495)	24.0 (610)	30.0 (762)	30.0 (762)	42.0 (1067)	4600 (2087)
18×20-24*	39.0 (991)	32.0 (813)	26.0 (660)	47.0 (1194)	33.3 (845)	18.0 (457)	19.0 (483)	21.0 (533)	32.0 (813)	35.0 (889)	51.0 (1295)	4380 (1987)
20×20-18	36.0 (914)	31.0 (787)	29.0 (737)	47.0 (1194)	26.5 (673)	18.0 (457)	18.0 (457)	18.0 (457)	29.0 (737)	31.0 (787)	40.0 (1016)	3480 (1579)
16×24-24	40.0 (1016)	33.0 (838)	20.0 (508)	41.0 (1041)	33.5 (851)	20.0 (508)	20.0 (508)	22.0 (559)	34.0 (864)	36.0 (914)	42.0 (1067)	5700 (2585)
16×24-38*	49.0 (1245)	41.0 (1041)	32.0 (813)	59.5 (1511)	46.5 (1181)	26.0 (660)	26.0 (660)	48.0 (1219)	42.0 (1067)	53.0 (1346)	50.0 (1270)	11,000 (4990)
18×24-34*	45.0 (1143)	38.0 (965)	24.0 (610)	48.0 (1219)	40.5 (1029)	24.0 (610)	21.0 (533)	36.0 (914)	39.0 (991)	56.0 (1422)	50.0 (1270)	6980 (3166)
20×24-20	40.0 (1016)	38.0 (965)	34.0 (864)	55.0 (1397)	30.7 (780)	21.0 (533)	21.0 (533)	25.0 (635)	33.0 (838)	40.0 (1016)	46.0 (1168)	5500 (2495)
20×24-20S/L	34.0 (864)	28.0 (711)	20.0 (508)	40.0 (1016)	29.6 (752)	20.0 (508)	20.0 (508)	20.0 (508)	42.0 (1067)	38.0 (965)	48.0 (1219)	5100 (2313)
24×24-26*	40.0 (1016)	36.0 (914)	35.0 (889)	56.0 (1422)	33.8 (857)	21.0 (533)	21.0 (533)	26.0 (660)	35.0 (889)	40.0 (1016)	54.0 (1372)	6650 (3016)
20×30-28	44.0 (1118)	36.0 (914)	23.0 (584)	48.0 (1219)	39.0 (991)	23.0 (584)	23.0 (584)	27.0 (686)	40.0 (1016)	42.0 (1067)	48.0 (1219)	6750 (3062)
20×30-34*	51.0 (1295)	40.0 (1016)	30.3 (768)	56.0 (1422)	43.0 (1092)	22.5 (572)	22.5 (572)	34.3 (870)	42.0 (1067)	44.0 (1118)	60.0 (1524)	12,200 (5534)
20×30-40*	52.0 (1321)	41.0 (1041)	34.0 (864)	64.0 (1626)	49.5 (1257)	26.3 (667)	26.3 (667)	33.0 (838)	46.0 (1168)	44.0 (1118)	60.0 (1524)	13,500 (6123)
24×30-30*	51.0 (1295)	55.0 (1397)	31.0 (787)	59.0 (1499)	43.4 (1102)	19.0 (483)	22.0 (559)	30.0 (762)	45.0 (1143)	52.0 (1321)	56.0 (1422)	9500 (4309)
24×36-40*	62.0 (1575)	49.0 (1245)	34.0 (864)	68.0 (1727)	54.0 (1372)	29.0 (737)	29.0 (737)	63.0 (1600)	50.0 (1270)	72.0 (1829)	65.0 (1651)	17,500 (7938)
24×36-48*	58.0 (1473)	56.0 (1422)	40.0 (1016)	82.0 (2083)	66.0 (1676)	40.0 (1016)	39.0 (991)	46.0 (1168)	66.0 (1676)	92.0 (2337)	66.0 (1676)	26,200 (11,884)
30×36-34*	56.0 (1422)	49.0 (1245)	36.0 (914)	66.0 (1676)	47.5 (1207)	24.0 (610)	27.0 (686)	33.0 (838)	51.0 (1295)	57.0 (1448)	78.0 (1981)	13,000 (5897)
30×36-35*	62.0 (1575)	50.0 (1270)	36.0 (914)	66.0 (1676)	47.5 (1207)	24.0 (610)	27.0 (686)	33.0 (838)	51.0 (1295)	57.0 (1448)	78.0 (1981)	15,000 (6804)
30×36-36	58.0 (1473)	49.0 (1245)	48.0 (1219)	79.0 (2007)	49.3 (1251)	27.0 (686)	30.0 (762)	38.0 (965)	50.0 (1270)	51.0 (1295)	72.0 (1829)	18,500 (8391)
30×42-46	72.0 (1829)	61.0 (1549)	48.0 (1219)	86.0 (2184)	60.5 (1537)	31.0 (787)	36.0 (914)	84.0 (2134)	54.0 (1372)	75.0 (1905)	96.0 (2438)	22,500 (10,206)
30×42-48*	66.0 (1676)	63.0 (1600)	42.0 (1067)	81.0 (2057)	63.0 (1600)	38.0 (965)	38.0 (965)	50.0 (1270)	72.0 (1829)	90.0 (2286)	79.0 (2007)	24,400 (11,068)
30×42-72*	69.0 (1753)	67.0 (1702)	54.0 (1372)	106.0 (2692)	87.5 (2223)	51.0 (1295)	51.0 (1295)	78.0 (1981)	84.0 (2134)	126.0 (3200)	84.0 (2134)	34,200 (15,513)
36×42-40*	62.0 (1575)	51.0 (1295)	45.0 (1143)	81.0 (2057)	55.5 (1410)	29.0 (737)	30.0 (762)	39.0 (991)	57.0 (1448)	69.0 (1753)	92.0 (2337)	23,300 (10,569)
42×48-48*	69.0 (1753)	58.0 (1473)	54.0 (1372)	97.0 (2464)	67.4 (1711)	33.0 (838)	37.0 (940)	48.0 (1219)	69.0 (1753)	76.0 (1930)	102.0 (2591)	34,000 (15,422)
48×54-58	83.0 (2108)	72.0 (1829)	60.0 (1524)	113.0 (2870)	82.2 (2088)	44.0 (1118)	44.0 (1118)	45.0 (1143)	84.0 (2134)	95.0 (2413)	124.0 (3150)	44,000 (19,958)
48×54-64	69.0 (1753)	60.0 (1524)	45.0 (1143)	90.0 (2286)	76.8 (1951)	45.0 (1143)	45.0 (1143)	50.0 (1270)	86.0 (2184)	102.0 (2591)	88.0 (2235)	50,400 (22,861)
54" to 78" Suction	CONSULT FACTORY											

All dimensions in inches (mm) and are not to be used for construction or installation purposes.
Standard rotation is right hand (CW). Optional rotation is left hand (CCW).
Side suction casing illustrated. Asterisks indicate sizes available with bottom suction casing.
Steel casings will have 150#RF flanges.

Hydraulic Coverage Model 3498

Pump Size
12×16-28
12×18-34
16×18-18
16×18-24
16×18-28
16×20-24
18×20-24
20×20-18
16×24-24
16×24-38
18×24-34
20×24-20
20×24-20S/L
20×24-24
24×24-26
20×30-28
20×30-34
20×30-40
24×30-30



NOTES

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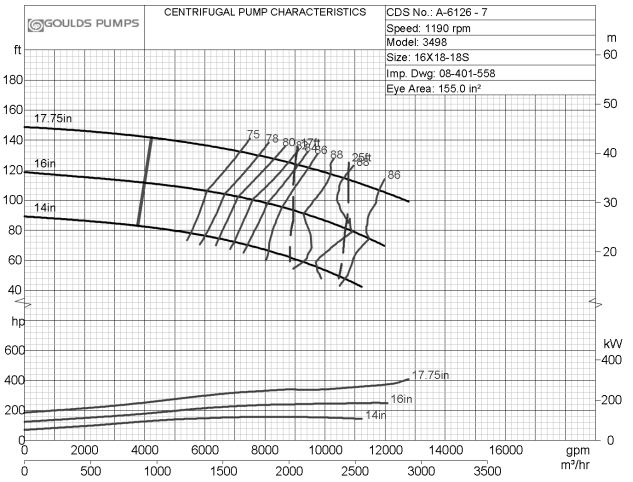
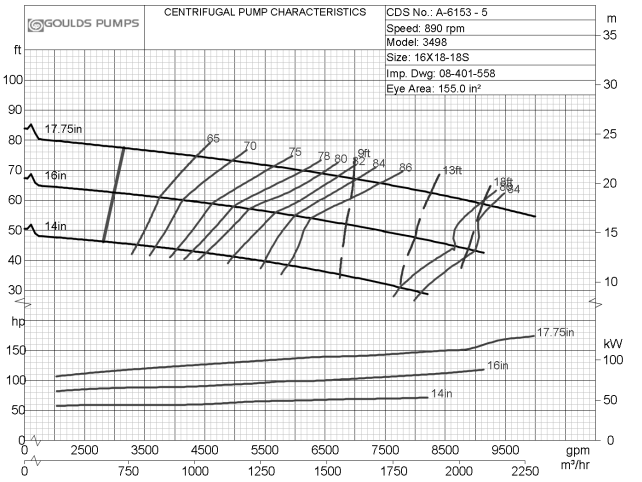
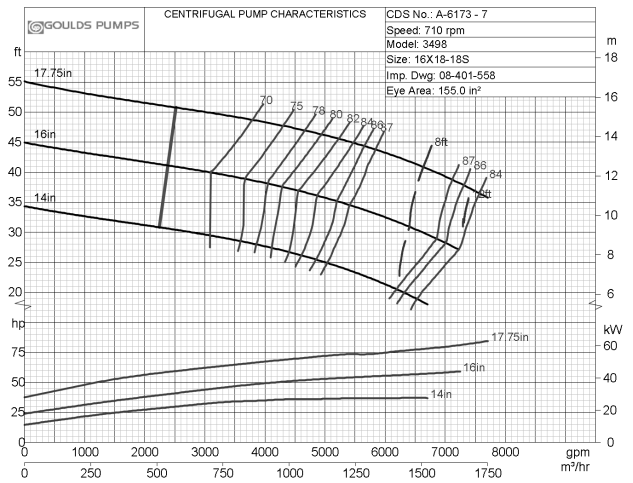


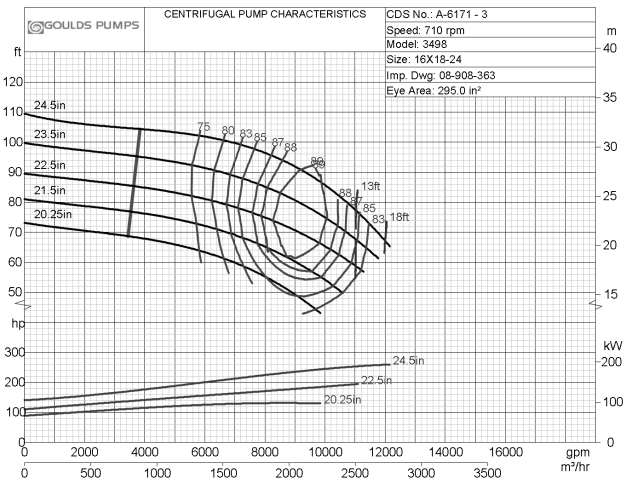
16X18-18S **1190rpm**



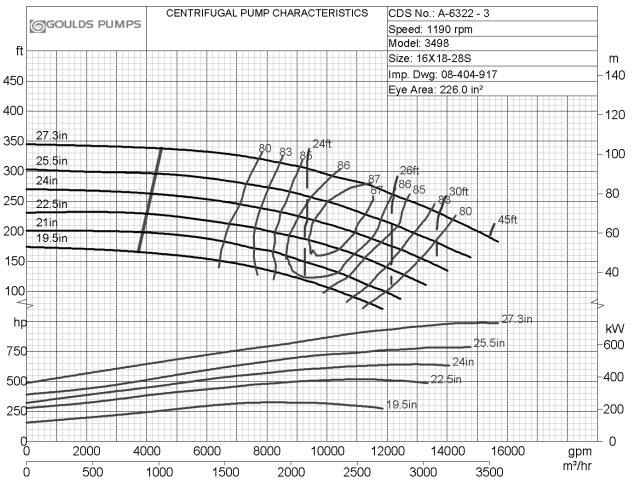
16X18-18S **890rpm**



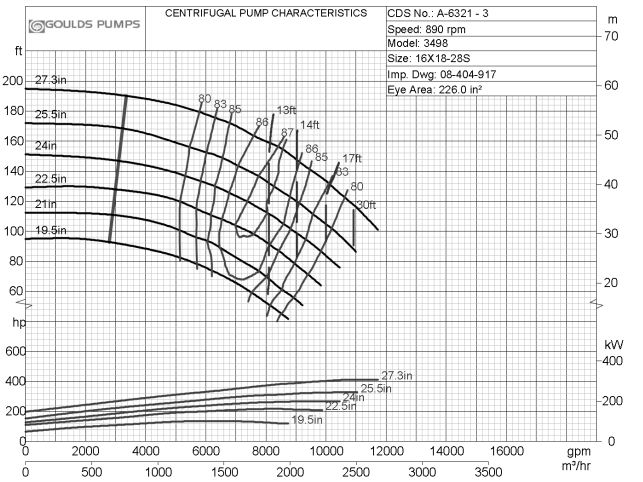
16X18-18S **710rpm**



16X18-24 **710rpm**



16X18-28S **1190rpm**

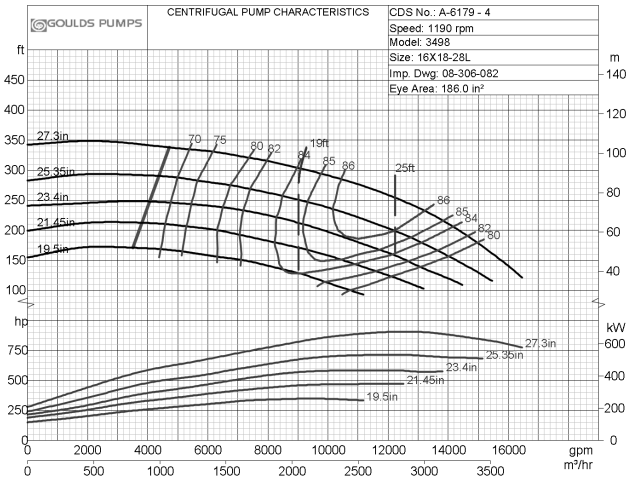


16X18-28S **890rpm**

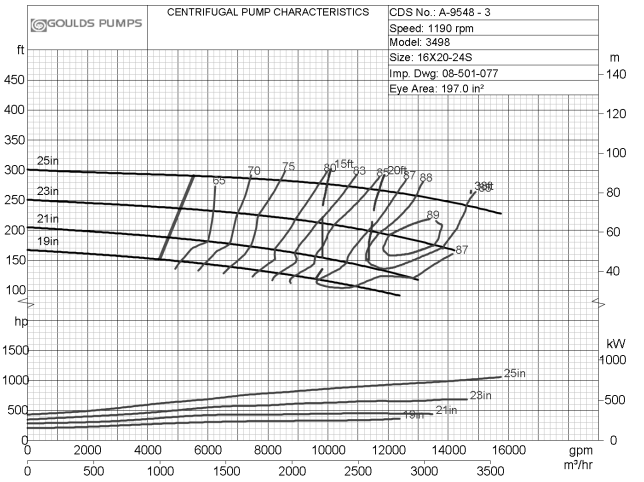
60Hz Curves

Model 3498

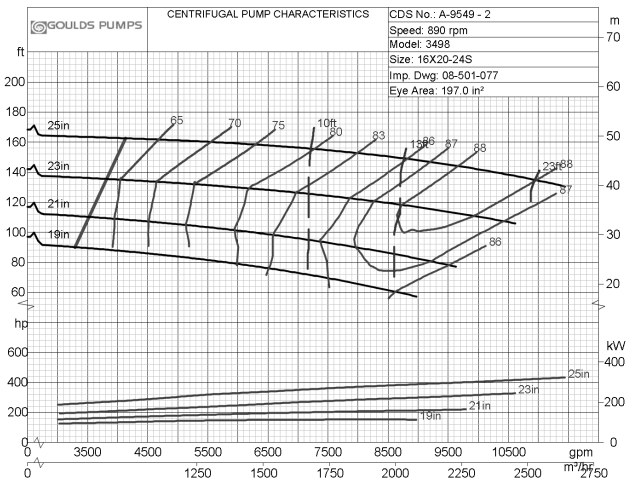
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



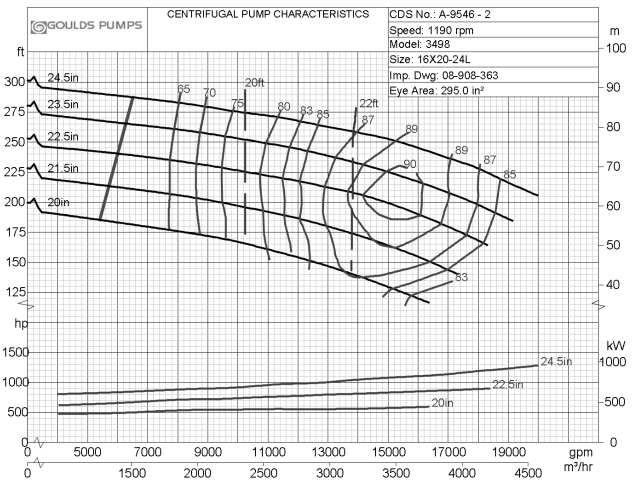
16X18-28L **1190rpm**



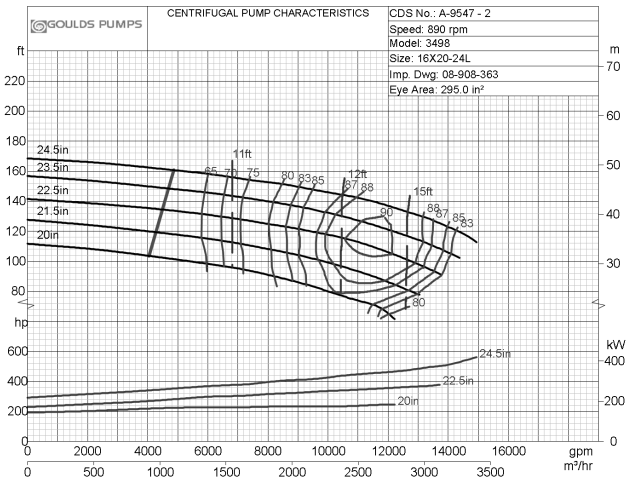
16X20-24S **1190rpm**



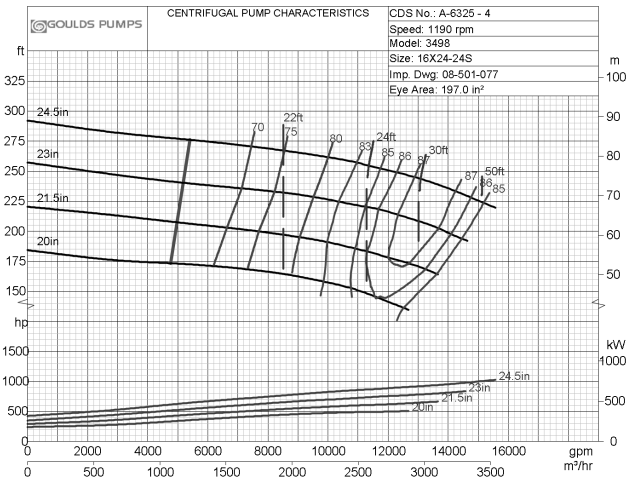
16X20-24S **890rpm**



16X20-24L **1190rpm**



16X20-24L **890rpm**



16X24-24S **1190rpm**

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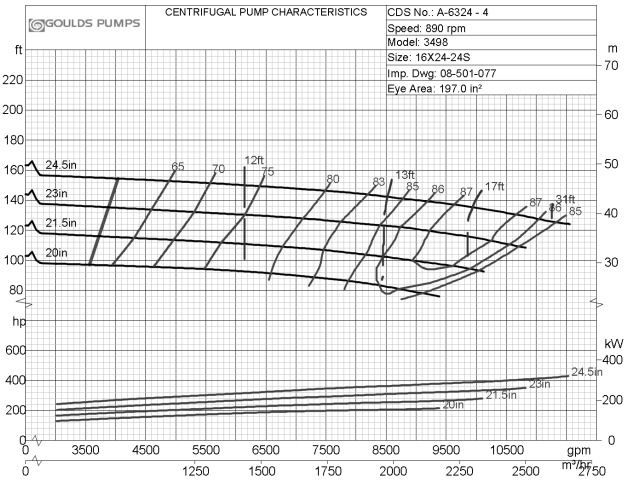
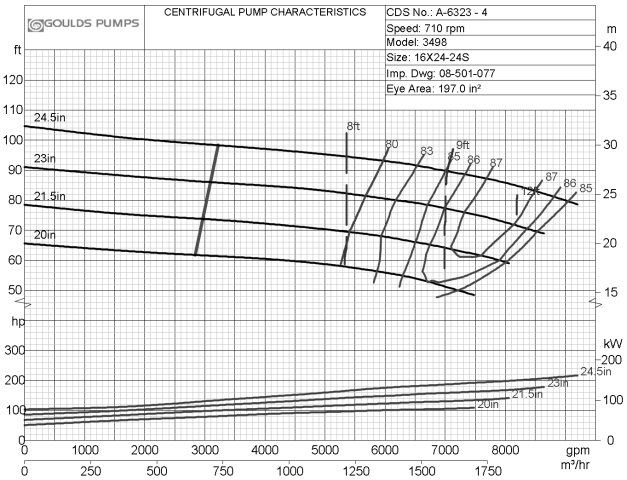
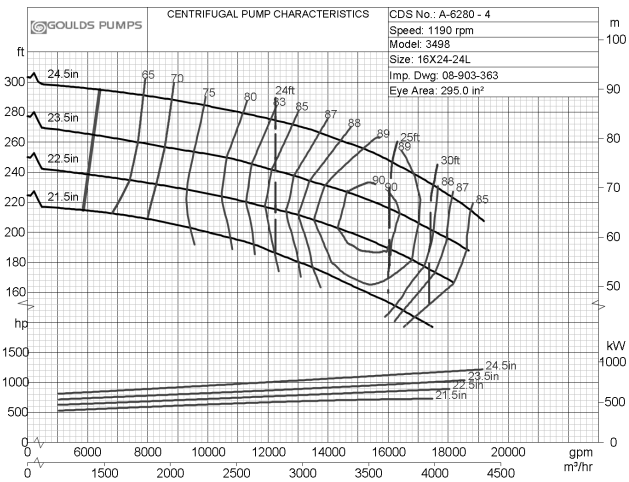


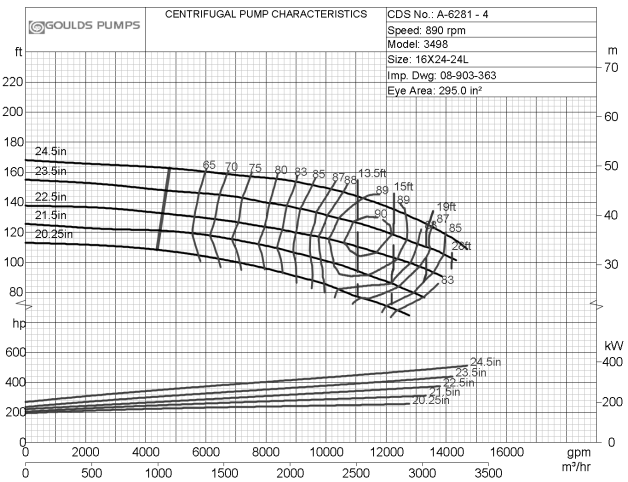
16X24-24S **890rpm**



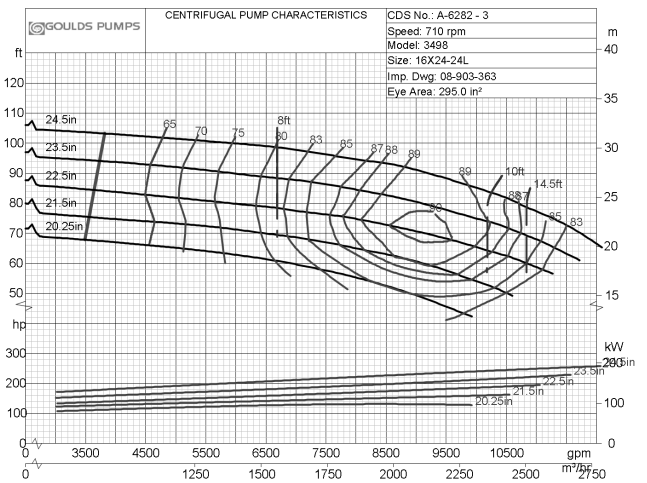
16X24-24S **710rpm**



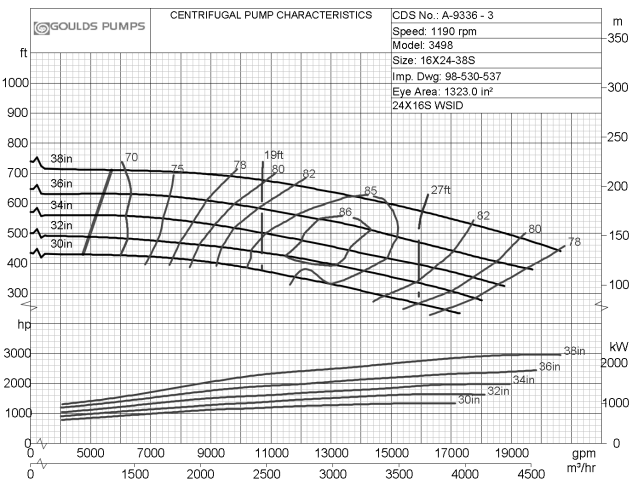
16X24-24L **1190rpm**



16X24-24L **890rpm**



16X24-24L **710rpm**



16X24-38S **1190rpm**

60Hz Curves

Model 3498

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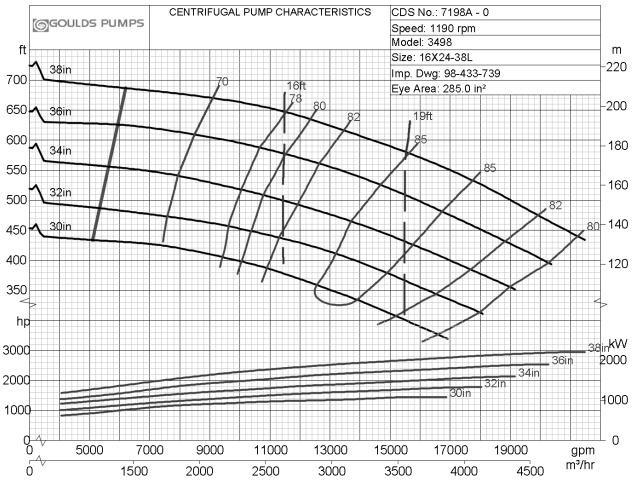
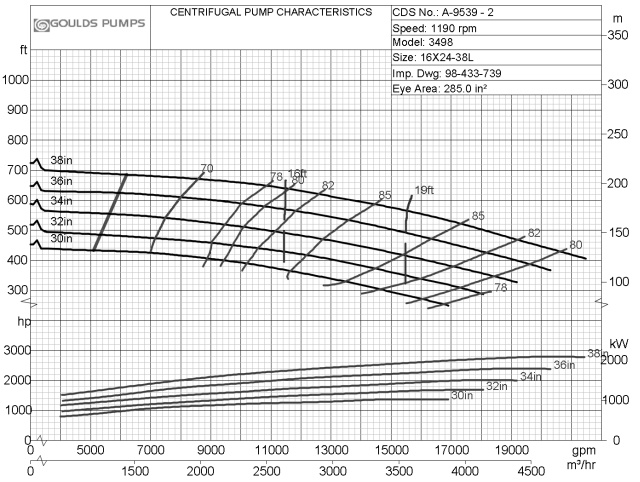
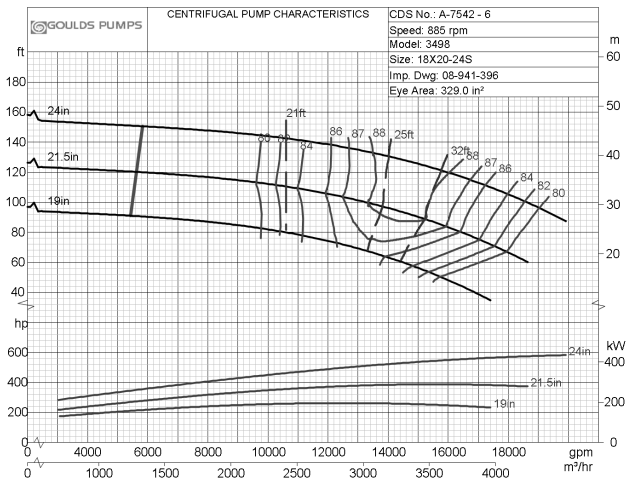


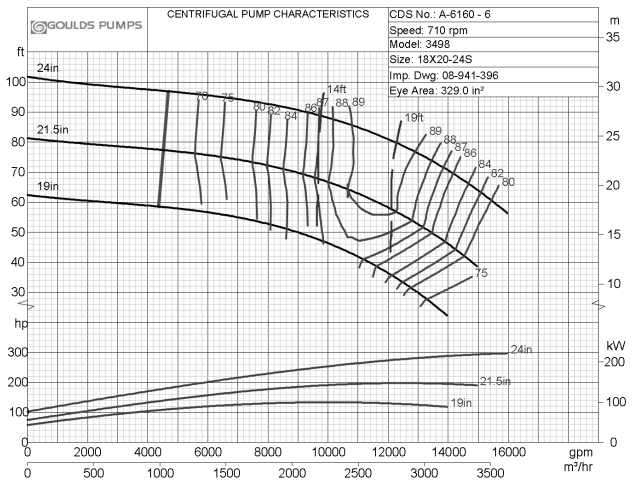
16X24-38L **1190rpm**



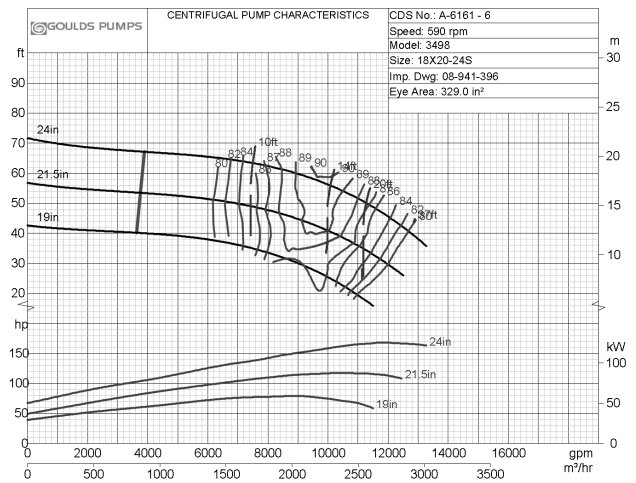
16X24-38L **1190rpm**



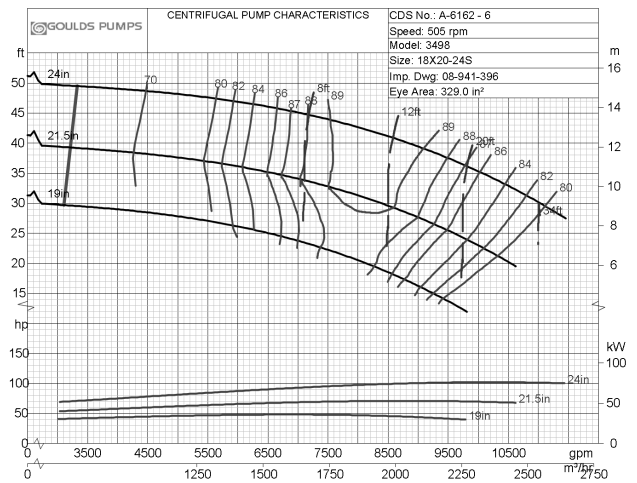
18X20-24S **885rpm**



18X20-24S **710rpm**



18X20-24S **590rpm**



18X20-24S **505rpm**

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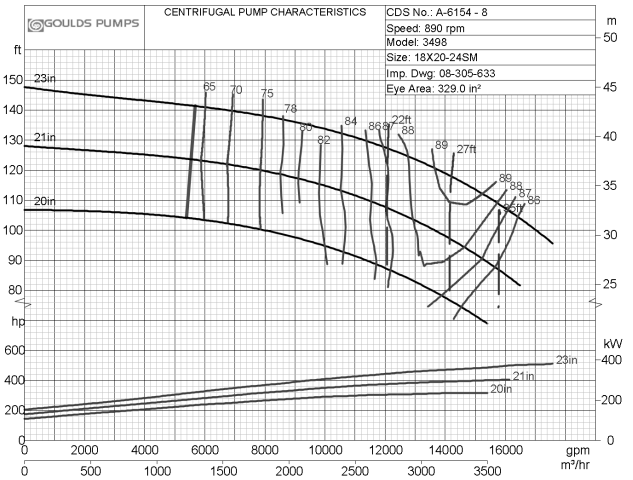
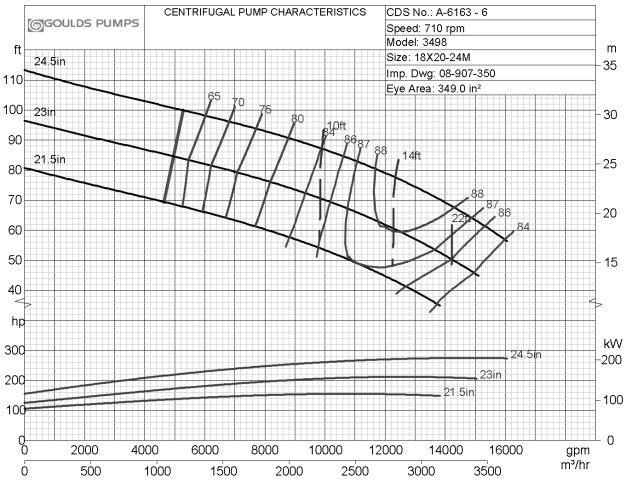
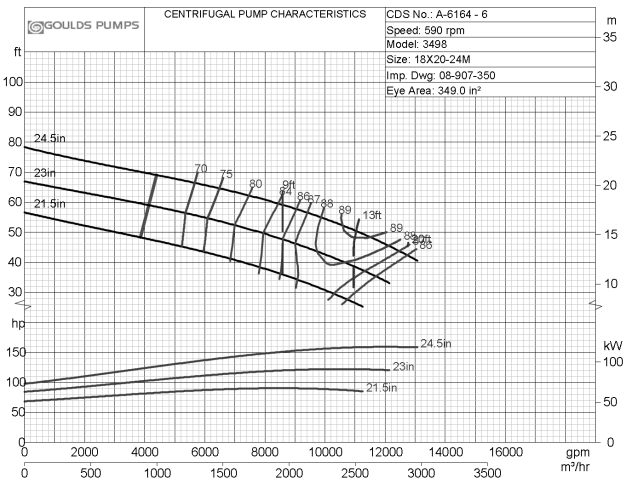


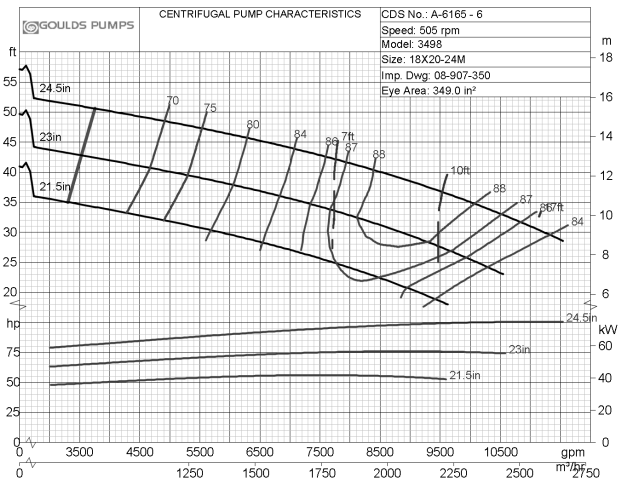
18X20-24SM **890rpm**



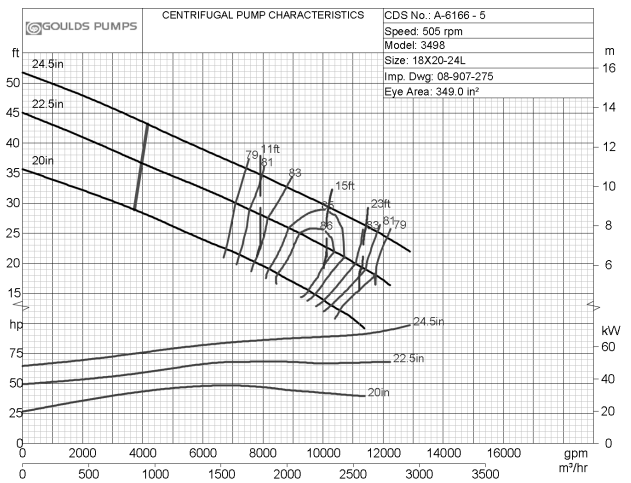
18X20-24M **710rpm**



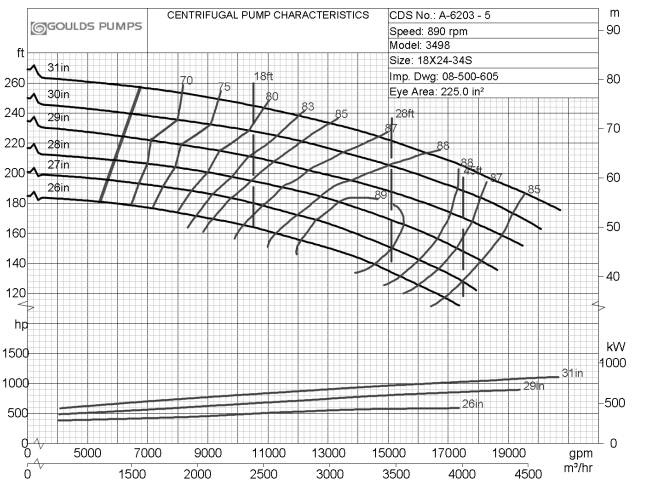
18X20-24M **590rpm**



18X20-24M **505rpm**



18X20-24L **505rpm**



18X24-34S **890rpm**

60Hz Curves

Model 3498

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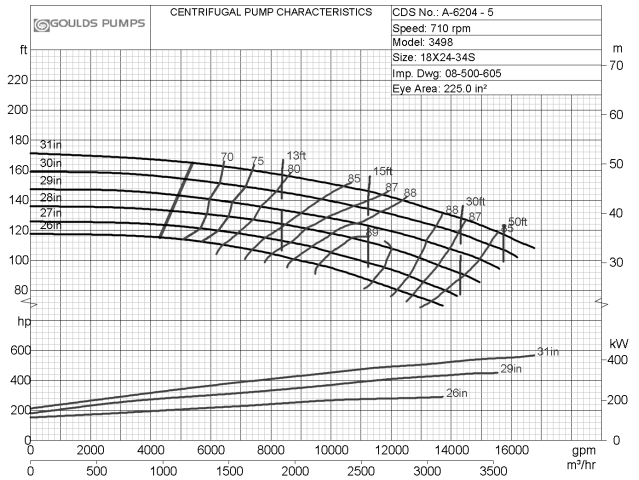
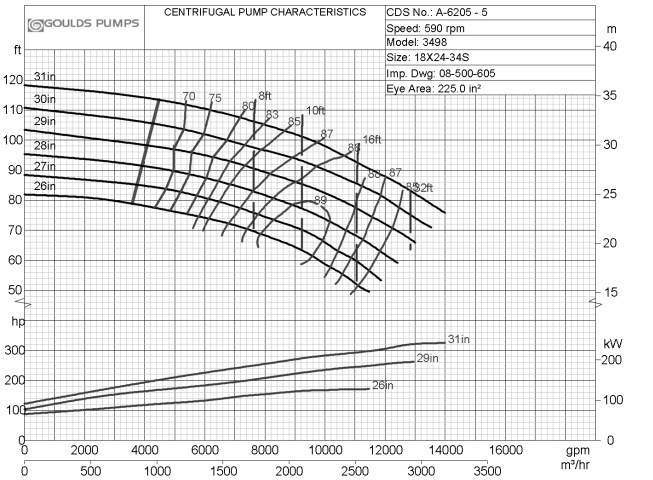
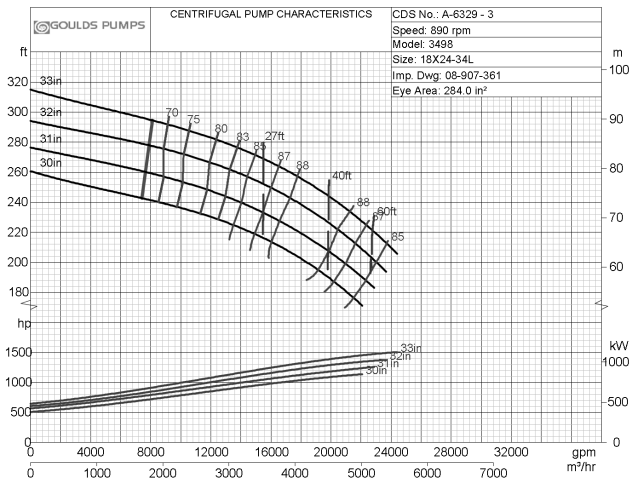


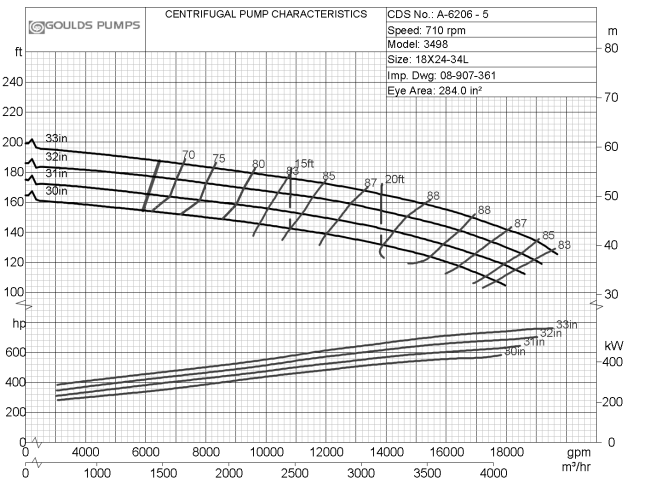
18X24-34S **710rpm**



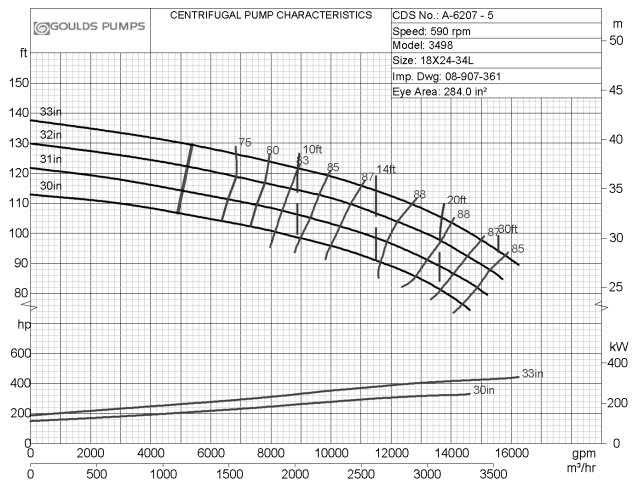
18X24-34S **590rpm**



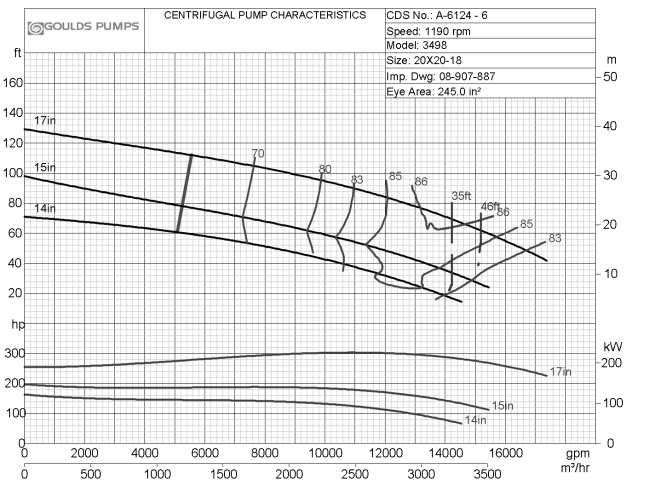
18X24-34L **890rpm**



18X24-34L **710rpm**

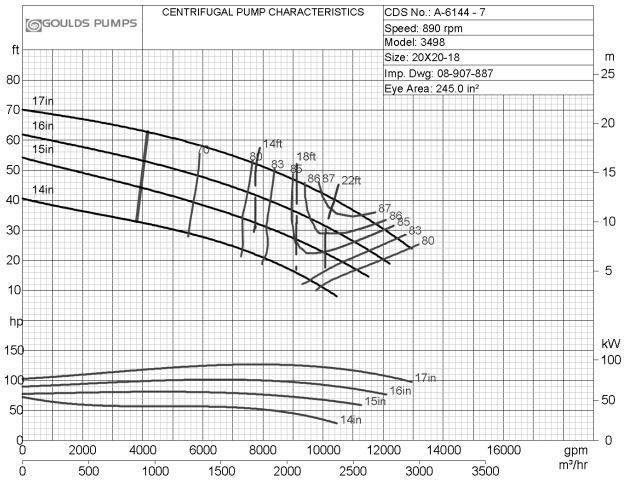


18X24-34L **590rpm**

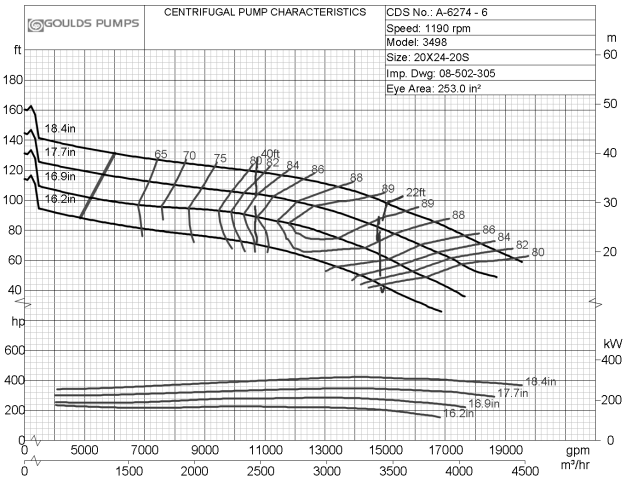


20X20-18 **1190rpm**

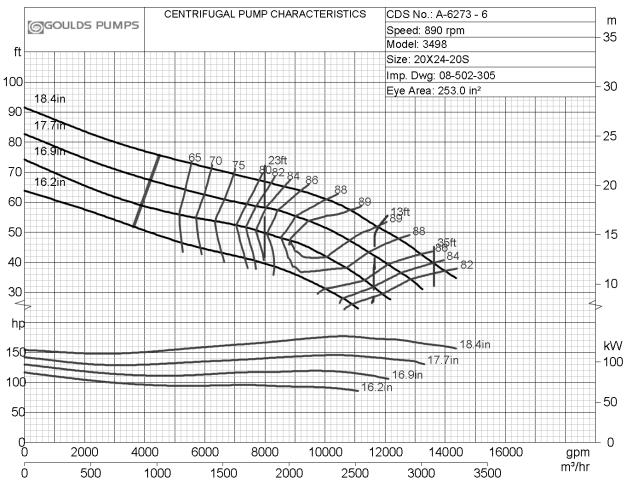
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



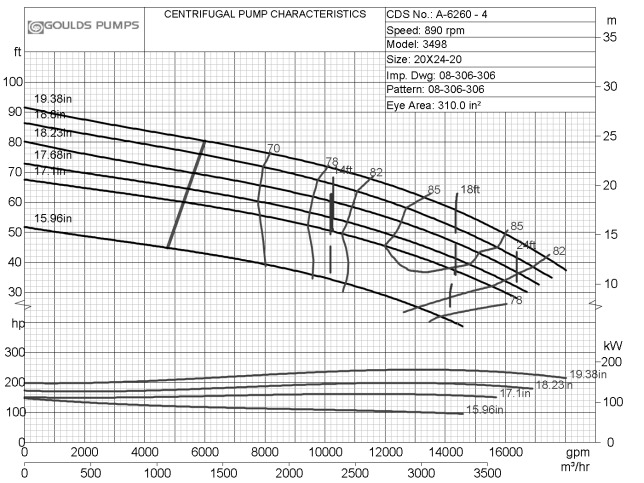
20X20-18 **890rpm**



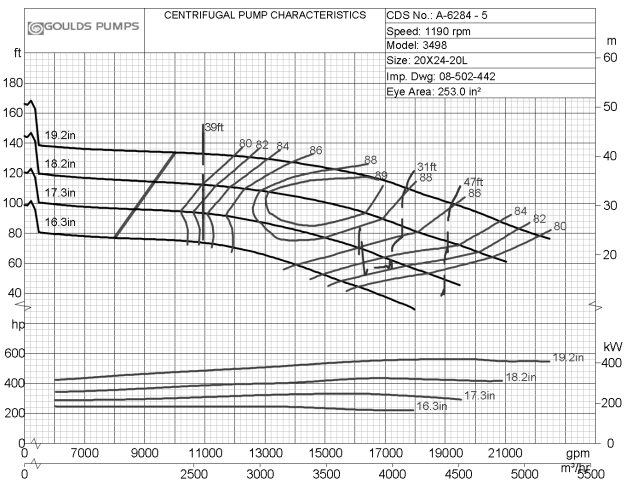
20X24-20S **1190rpm**



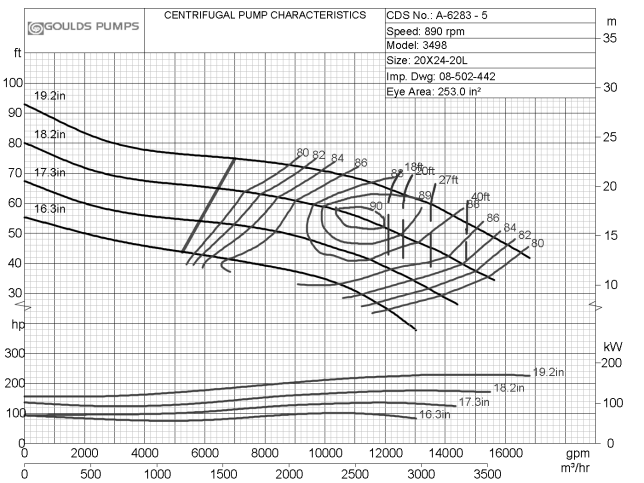
20X24-20S **890rpm**



20X24-20 **890rpm**



20X24-20L **1190rpm**

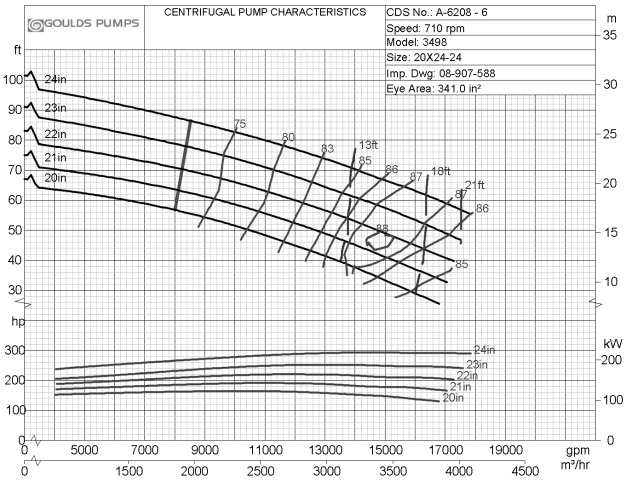


20X24-20L **890rpm**

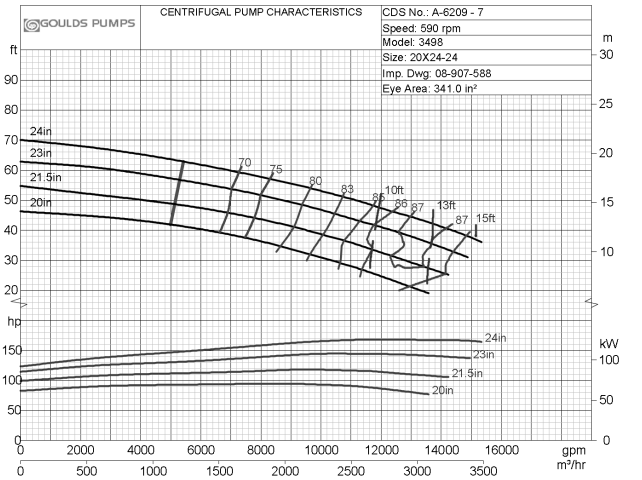
60Hz Curves

Model 3498

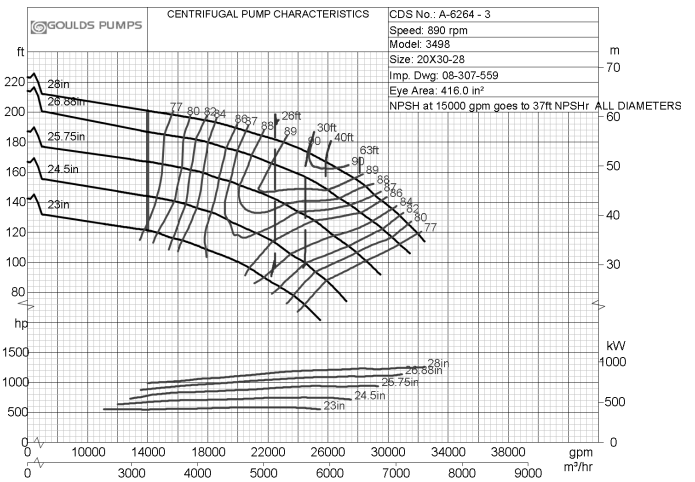
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



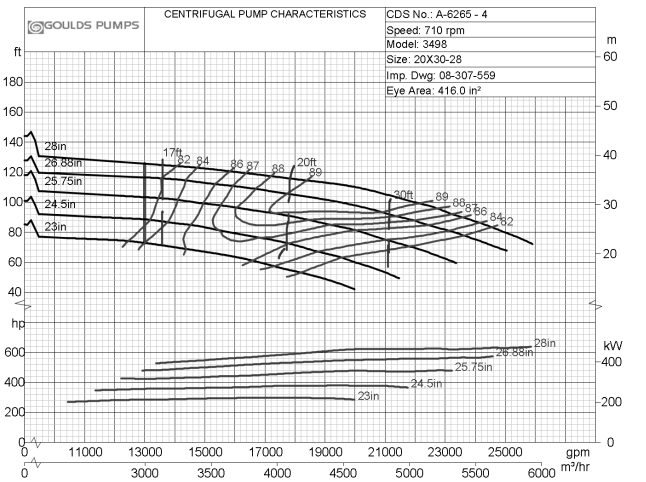
20X24-24 **710rpm**



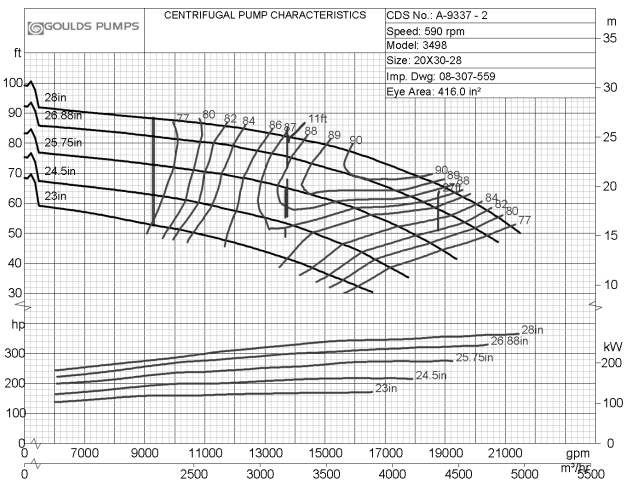
20X24-24 **590rpm**



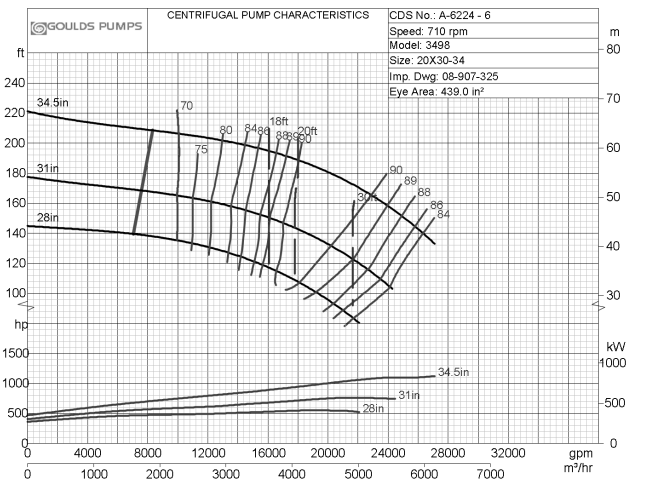
20X30-28 **890rpm**



20X30-28 **710rpm**

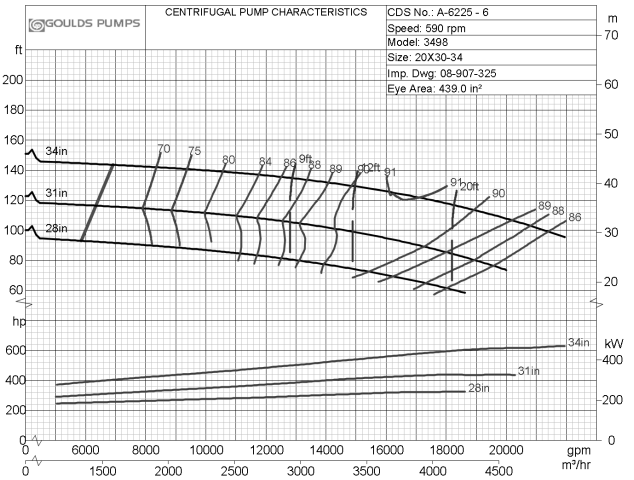


20X30-28 **590rpm**

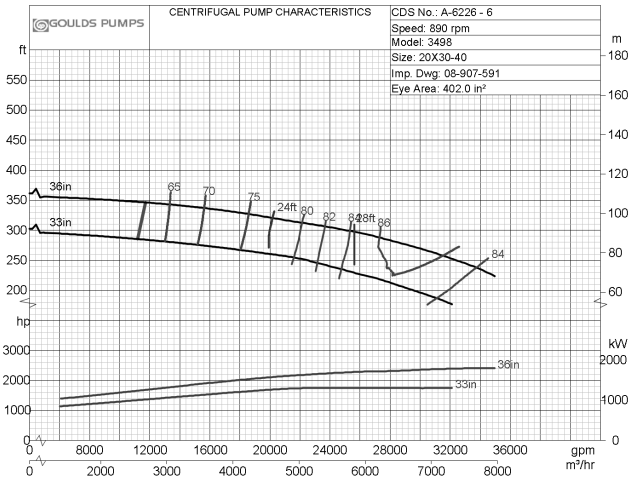


20X30-34 **710rpm**

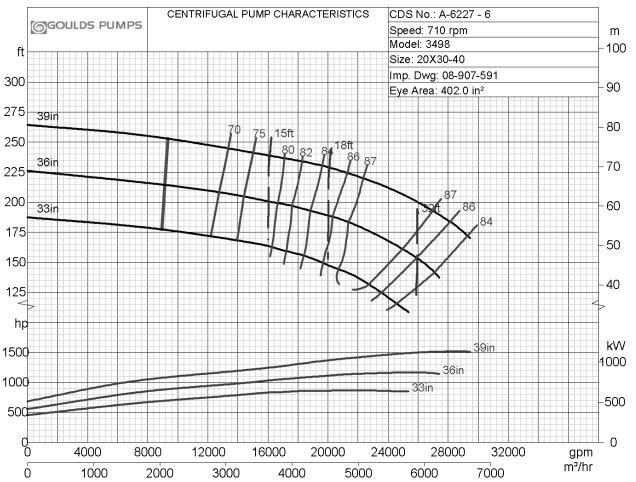
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



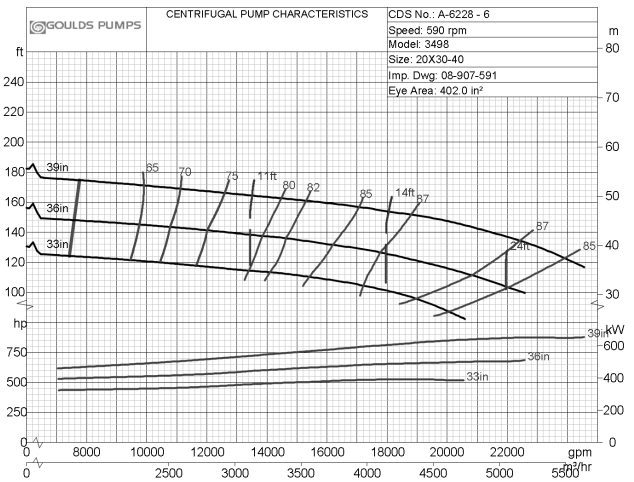
20X30-34 **590rpm**



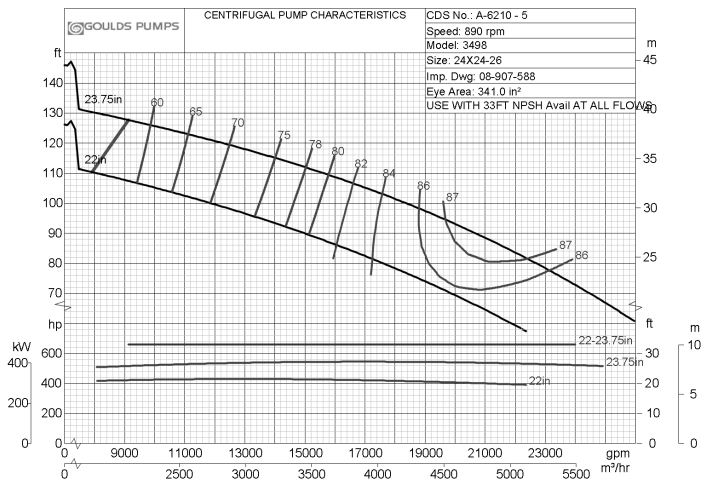
20X30-40 **890rpm**



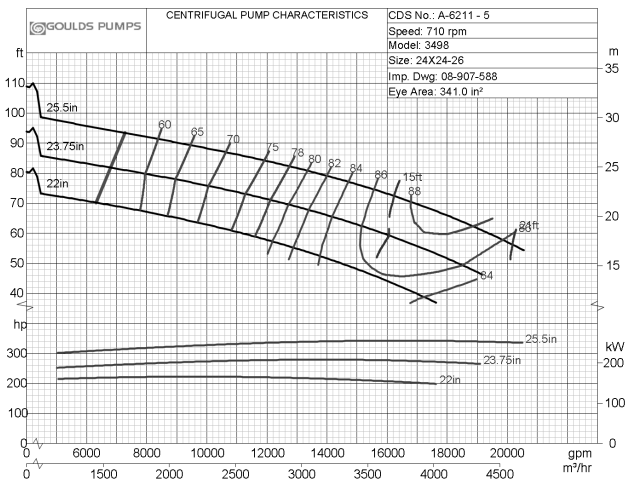
20X30-40 **710rpm**



20X30-40 **590rpm**



24X24-26 **890rpm**

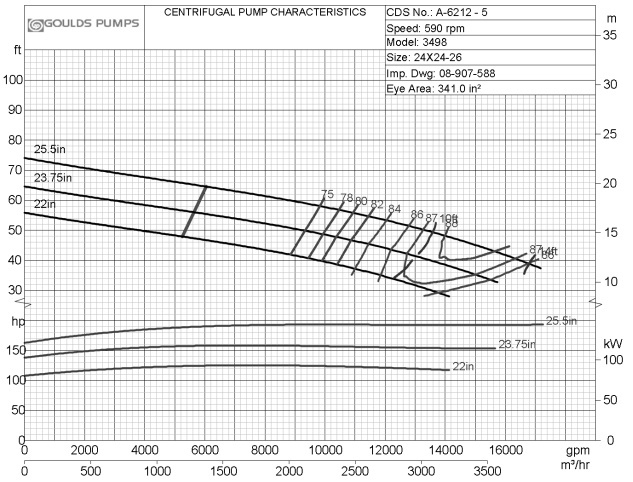


24X24-26 **710rpm**

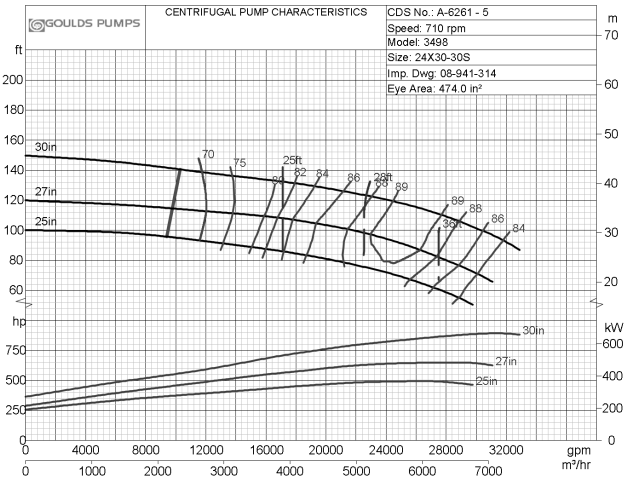
60Hz Curves

Model 3498

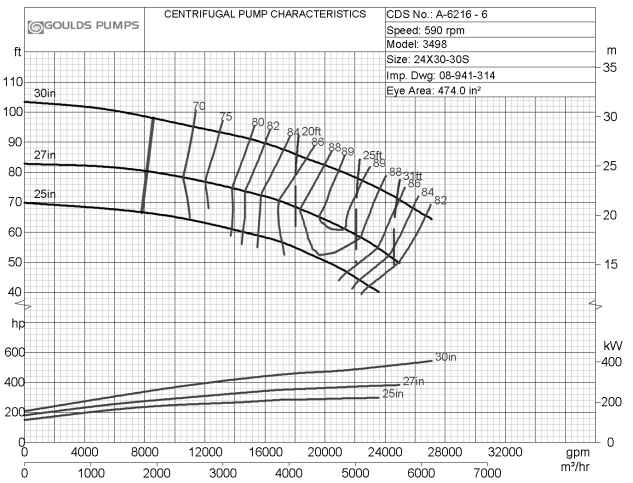
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



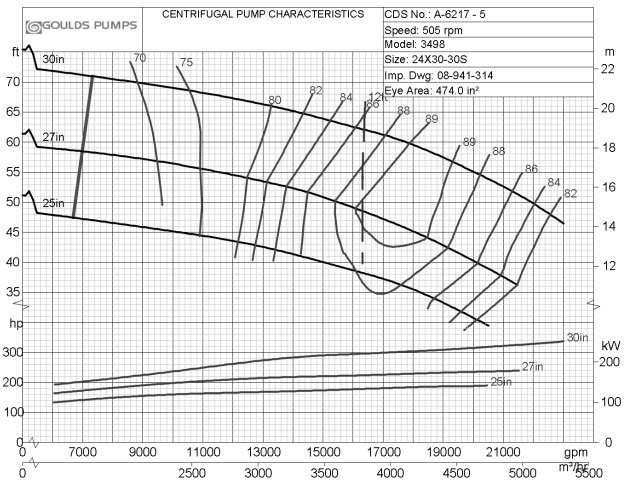
24X24-26 **590rpm**



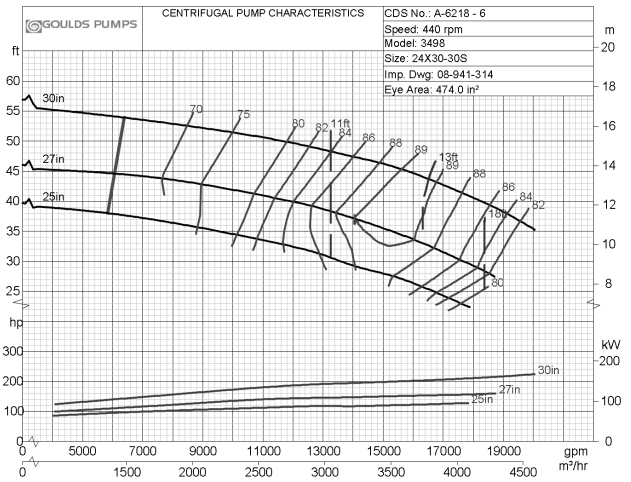
24X30-30S **710rpm**



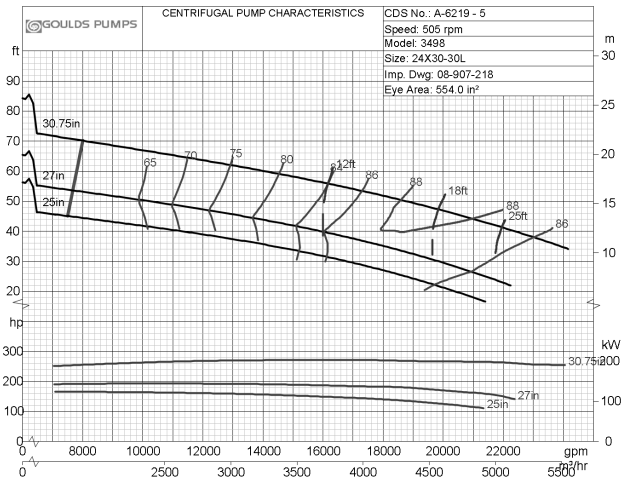
24X30-30S **590rpm**



24X30-30S **505rpm**



24X30-30S **440rpm**

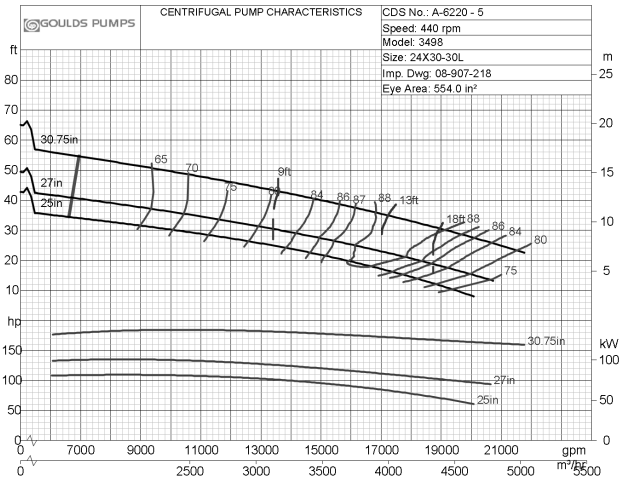


24X30-30L **505rpm**

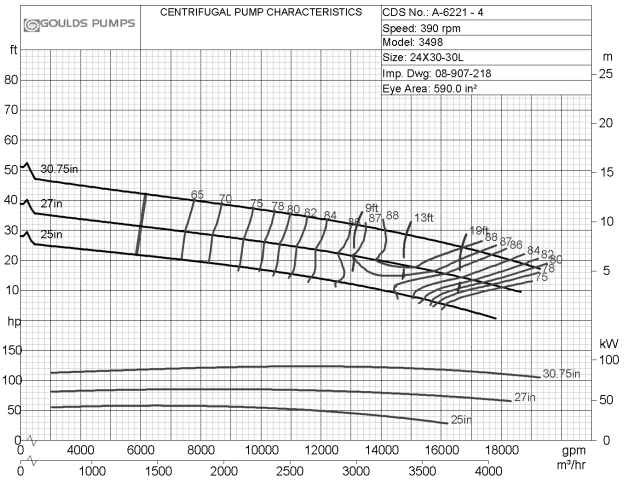
60Hz Curves

Model 3498

The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



24X30-30L **440rpm**

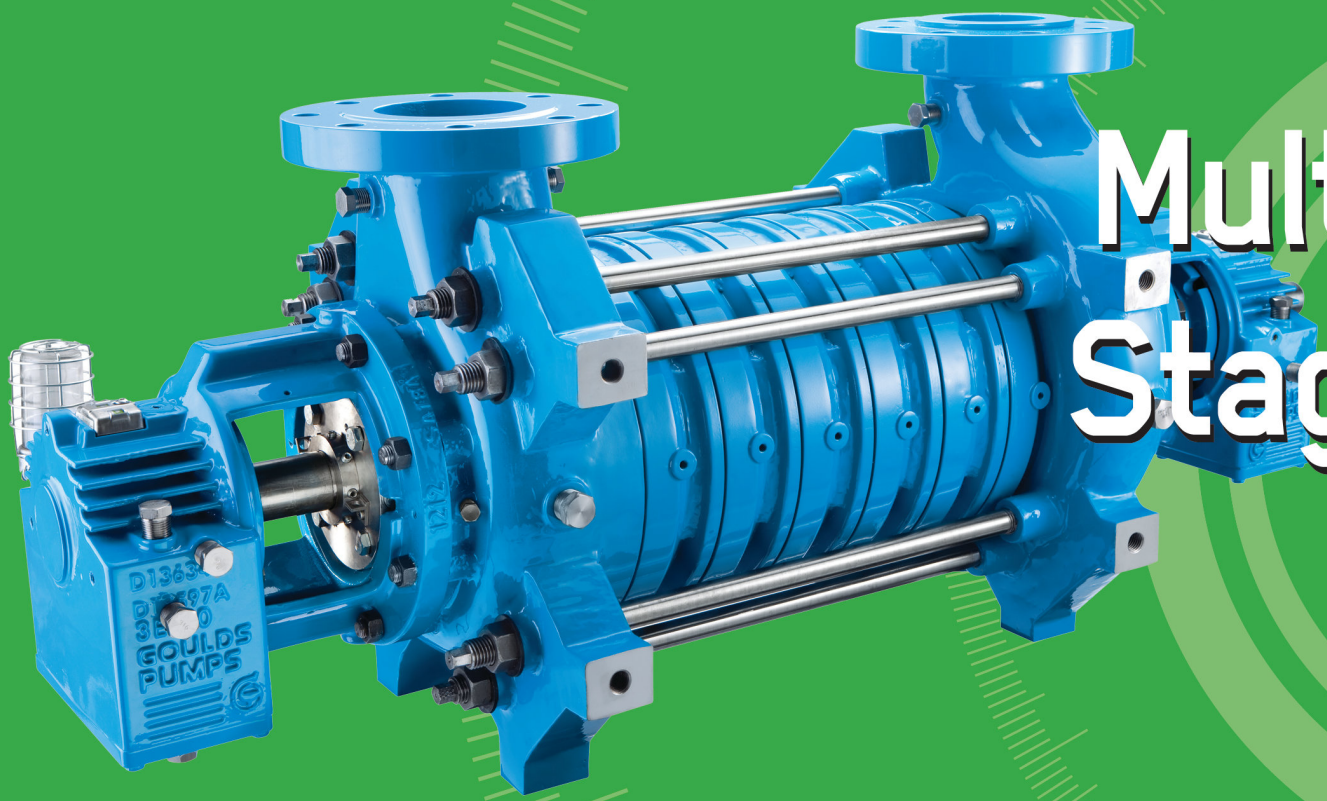


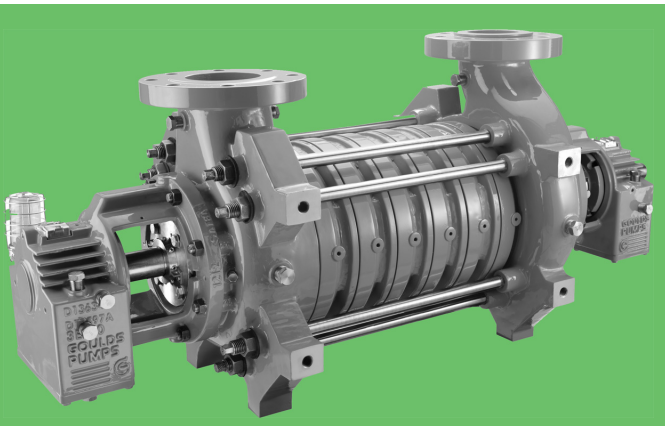
24X30-30L **390rpm**

NOTES

5

Multi-Stage





Goulds Model 3393

High Pressure, Multistage Ring Section Pump

- Capacities to 3,000 GPM (680 m^3/hr)
- Heads to 3,300 feet (1,000 m)
- Temperatures to 400° F (204°C)
- Pressures to 1,650 psig (114 bar)

Design Features

- Designed for world class efficiency and reliability
- Precision cast components
- Modular design
- End or radial suction configurations
- Multiple hydraulics
- Multiple nozzle orientations for radial suction pump

Applications

- Reverse osmosis
- Boiler feed
- Cogeneration
- Shower / spray service
- Pressure boosting
- High pressure cleaning
- Snow making

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

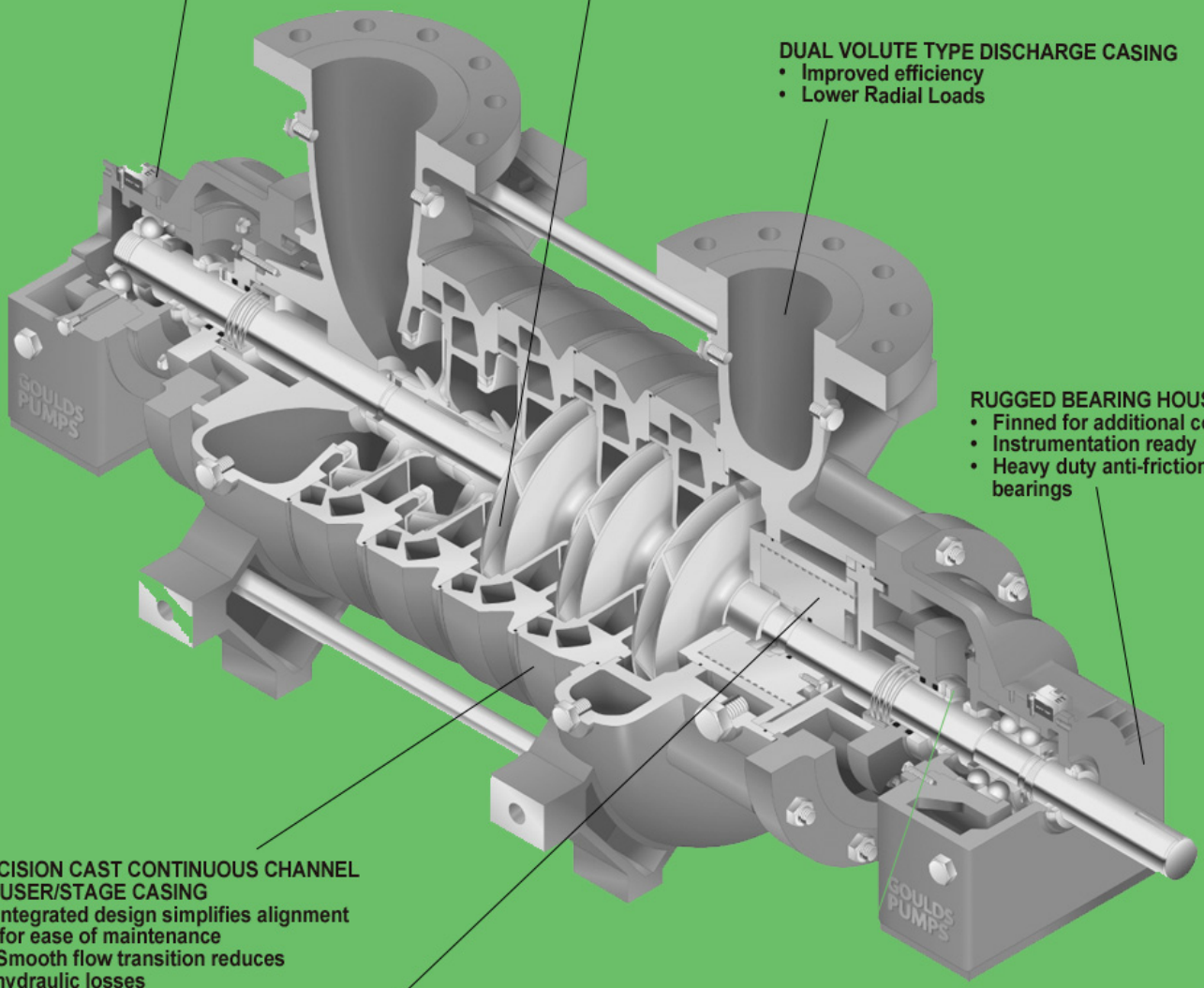
Model 3393 High Pressure Multi-Stage Pumps

High Pressure, Multistage Ring Section Pumps

i-ALERT™ CONDITION MONITOR
(U.S. Patent 8,154,417)
- Proprietary on-board condition monitoring integrated with bearing housings is standard
- Early visual indication of operating performance facilitates proactive maintenance practices

PRECISION CAST IMPELLER
- Optional impeller wear ring renews efficiencies to as-new condition
- Multiple hydraulic designs maximize efficiency for customer applications

DUAL VOLUTE TYPE DISCHARGE CASING
- Improved efficiency
- Lower Radial Loads



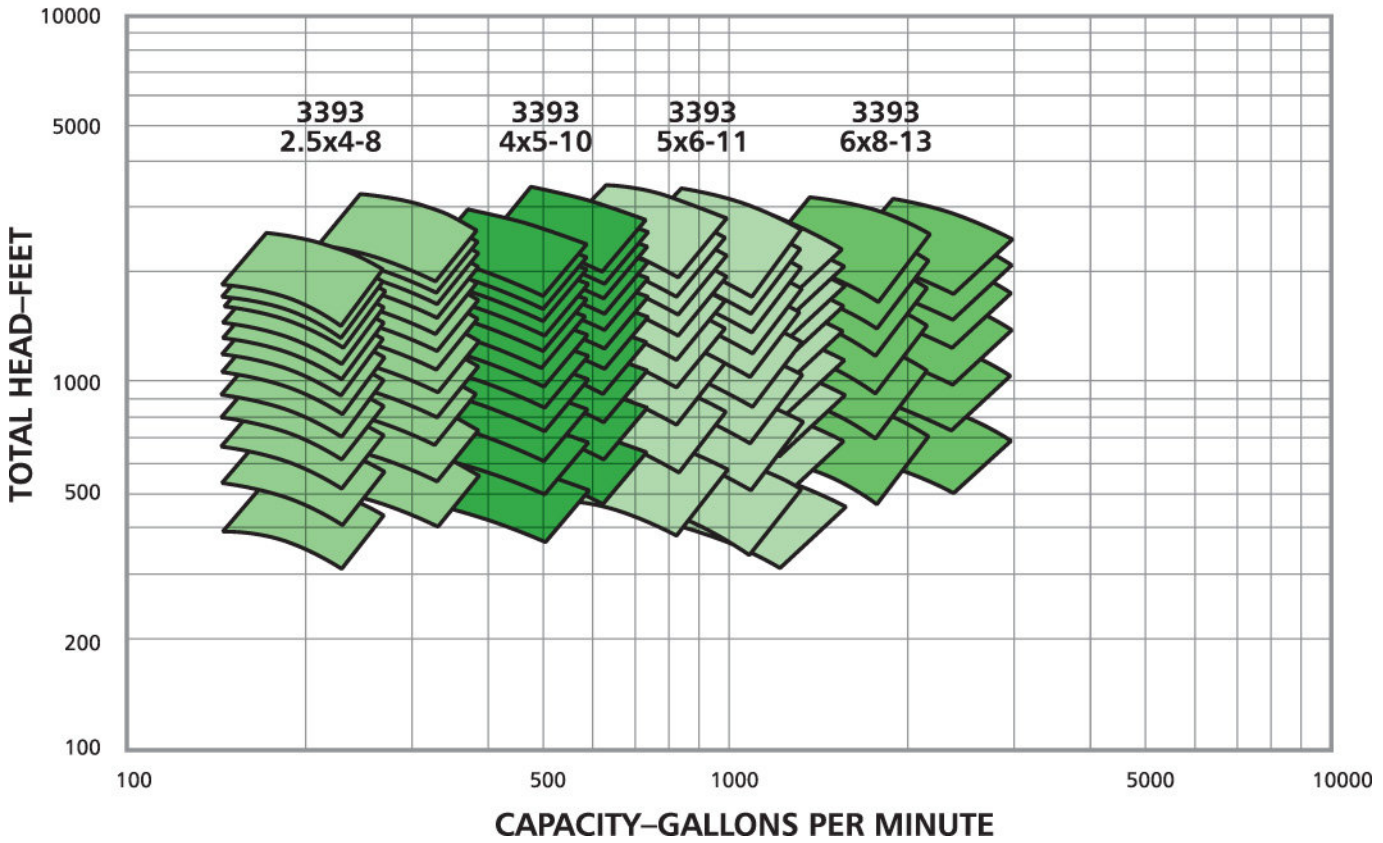
RUGGED BEARING HOUSING
- Finned for additional cooling
- Instrumentation ready
- Heavy duty anti-friction bearings

PRECISION CAST CONTINUOUS CHANNEL DIFFUSER/STAGE CASING
- Integrated design simplifies alignment for ease of maintenance
- Smooth flow transition reduces hydraulic losses

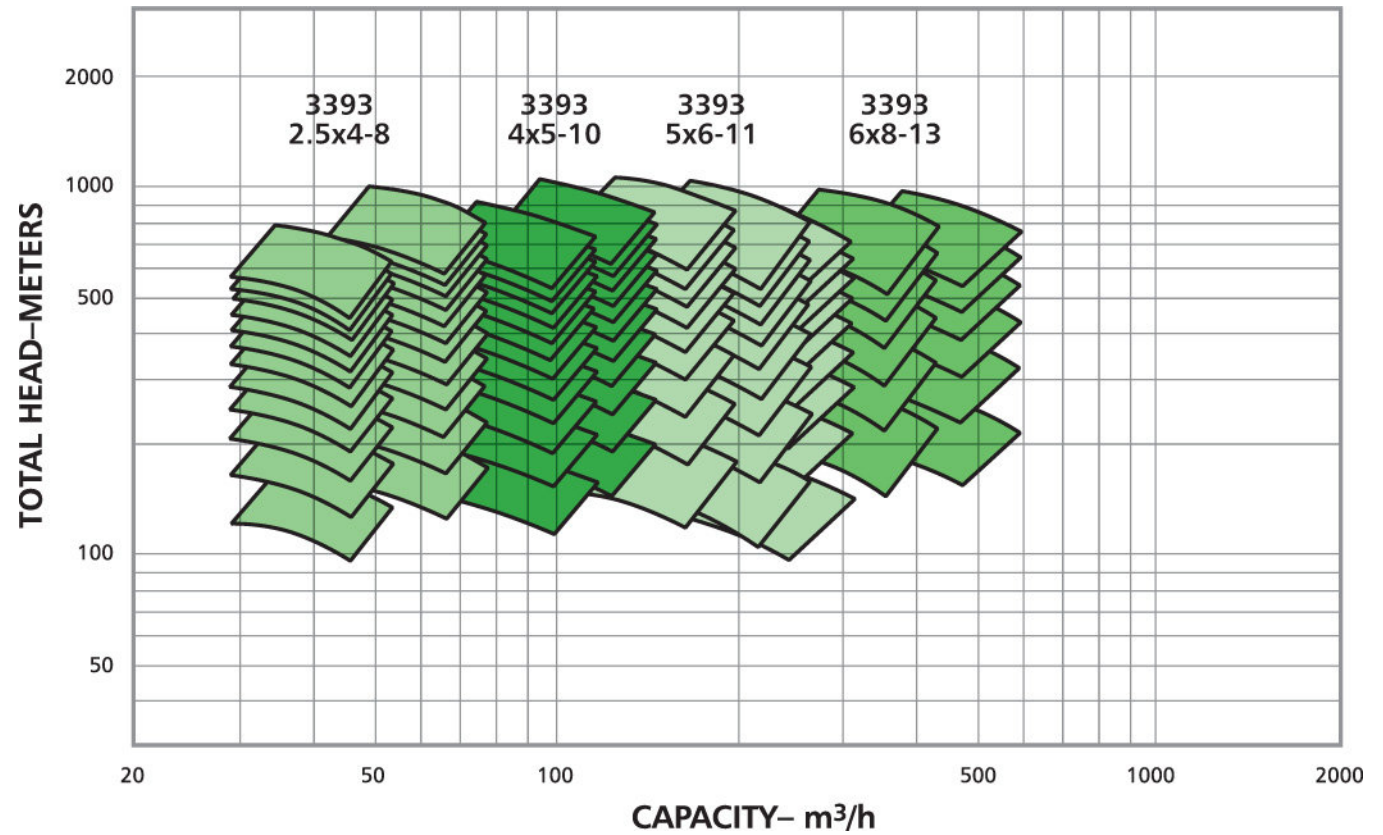
INVOLUTE BALANCE DRUM
- Involute configuration reduces installation footprint
- Accessibility from discharge side simplifies maintenance
- Dual step surface yields reliability under all conditions

SEAL CHAMBER
- Accepts a range of mechanical seals and piping plans

Hydraulic Coverage Model 3393 60 Hz

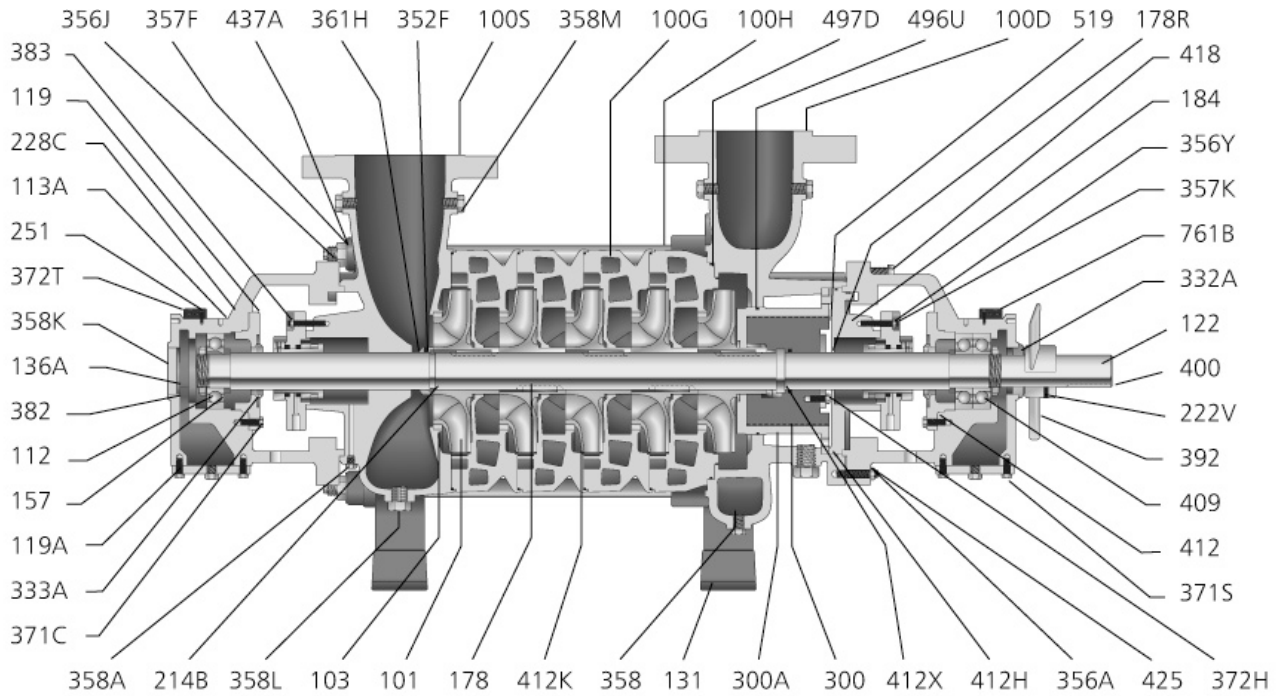


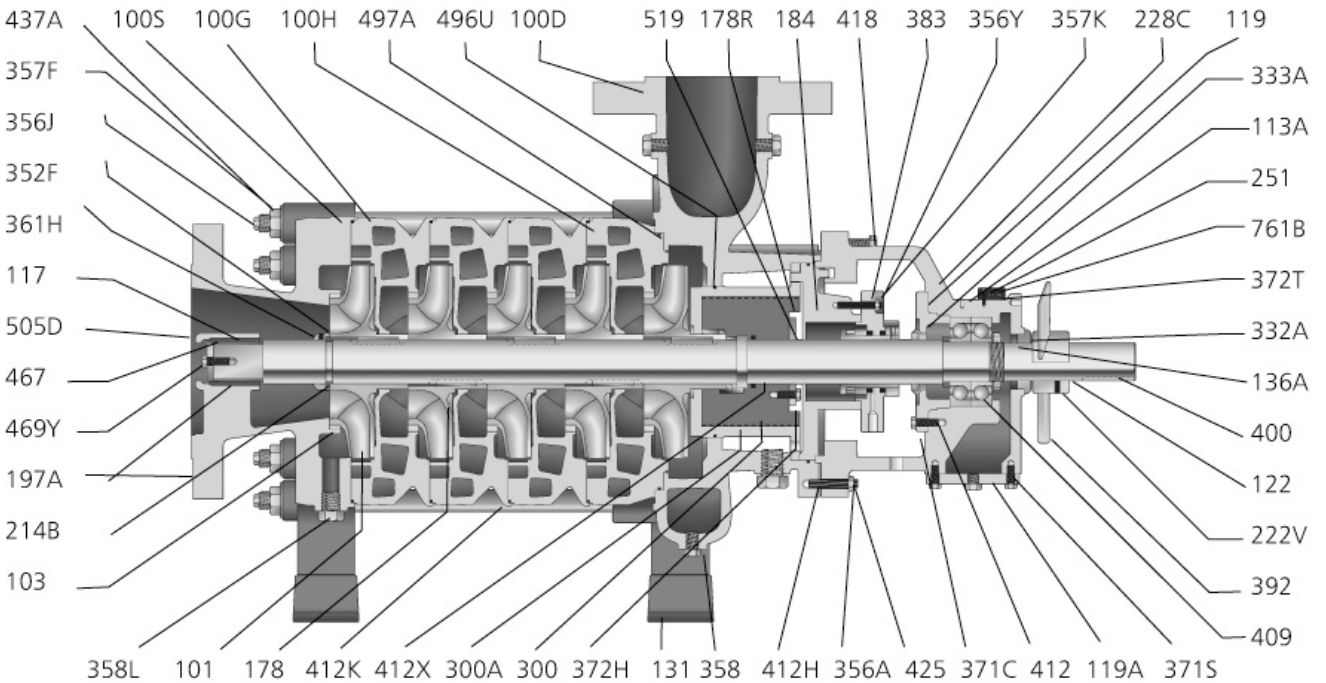
Hydraulic Coverage Model 3393 50 Hz

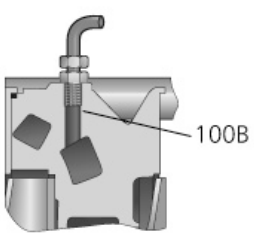


Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves .

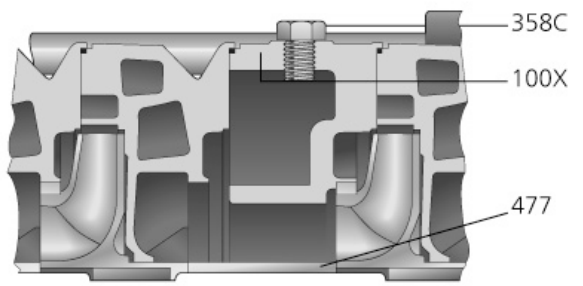
Sectional View Model 3393



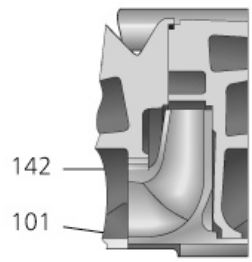




3393 Optional Tapping



3393 Optional Interstage

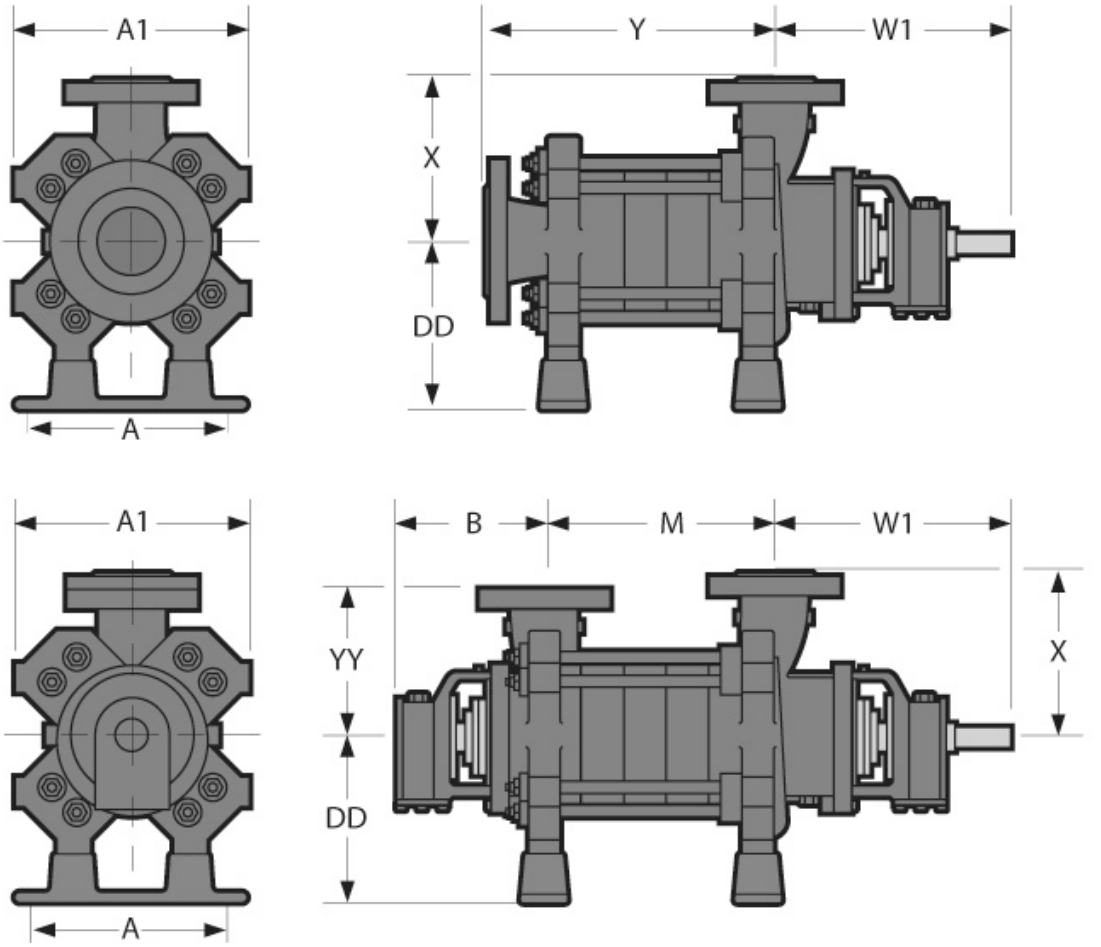


3393 Optional Impeller Wear Rings

Parts List and Materials of Construction

Item Number	Description	Duplex	Super Duplex	Chrome Steel	Carbon Steel chrome fitted	Carbon Steel
100B	1st Stage Remachine for Plan 11 takeoff	Duplex SS	Super Duplex SS	12 Chrome	Carbon Steel	
100D	Casing (Discharge)	Duplex SS	Super Duplex SS	12 Chrome	Carbon Steel	
100G	Diffuser Stage Casing	Duplex SS	Super Duplex SS	12 Chrome	Carbon Steel	
100H	Diffuser Final Stage Casing	Duplex SS	Super Duplex SS	12 Chrome	Carbon Steel	
100S	Casing (Suction)	Duplex SS	Super Duplex SS	12 Chrome	Carbon Steel	
100X	Casing (Destaging and Takeoff - Optional)	Duplex SS	Super Duplex SS	12 Chrome	Carbon Steel	
101	Impeller (Series)	Duplex SS	Super Duplex SS	12 Chrome		Carbon Steel
103	Case Wear Ring (Standard Clearance)	PEEK		Nitronic 60 + PEEK		
112	Ball Bearing (Radial)	Steel				
113A	Breather	Steel				
117	Bearing Sleeve (End Suction Only)	Silicon Carbide				
119	Cover (Bearing Housing)	Ductile Iron				
119A	Cover (Bearing Housing Sump)	Steel				
122	Shaft	Duplex SS		17-4 PH		
131	Foot	Steel				
136A	Bearing Lock Nut	Steel				
142	Impeller Wear Ring (Optional)	Duplex SS		17-4 PH		
157	Bearing Spacer	Carbon Steel				
178	Key (Impeller)	Duplex SS		17-4 PH		
178R	Key (Balance Drum)	Duplex SS		17-4 PH		
184	Seal Chamber	Duplex SS	Super Duplex SS	12 Chrome	Carbon Steel	
197A	Bearing Bushing (End Suction Only)	Silicon Carbide				
214B	Split Ring	Duplex SS		17-4 PH		
222V	Set Screw (Fan) On 5"(125) and 6"(150) pumps only	316 SS				
228C	Bearing Housing	Ductile Iron				
251	Oiler (Constant Level)	Aluminum/Glass				
300	Balance Drum	Duplex SS	Super Duplex SS	12 Chrome		Carbon Steel
300A	Balance Drum Stator	Duplex SS	Super Duplex SS	12 Chrome		Carbon Steel
332A	Bearing Isolator (Outboard)	Bronze/Viton				
333A	Bearing Isolator (Inboard)	Bronze/Viton				
352F	Set Screw (Retaining Ring)	20Cb3 SS		316 SS		
356A	Stud (Bearing Housing to Suction/Discharge Casing)	Alloy Steel				
356J	Tie Rod	4140 Steel				
356Y	Stud (Seal Chamber)	316 SS				
357F	Nut (Tie Rod)	Alloy Steel				
357K	Nut (Seal Chamber)	316 SS				
358	Drain Plug (Casing)	20Cb3 SS		316 SS	Carbon Steel	
358A	Plug (Seal Chamber Flush)	20Cb3 SS		316 SS	Carbon Steel	
358C	Plug (Destage Casing)	20Cb3 SS		316 SS	Carbon Steel	
358K	Plug (Bearing Housing Opening)	Carbon Steel				
358L	Plug (Balance Return)	20Cb3 SS		316 SS	Carbon Steel	
358M	Plug (Casing Branch Tapping)	20Cb3 SS	20Cb3 SS	316 SS	Carbon Steel	
361H	Retaining Ring	Duplex SS		17-4 PH		
371C	Cap Screw (Bearing Housing Cover)	316 SS				
371S	Cap Screw (Bearing Housing Sump Cover)	316 SS				
372H	Cap Screw (Balance Drum Locking Plate)	20Cb3 SS		316 SS		
372T	Cap Screw (i-ALERT to Bearing Housing)	316 SS				
382	Bearing Lock Washer	Steel				
383	Mechanical Seal					
392	Fan (Brg. Cooling) On 5"(125) and 6"(150) pumps only	Aluminum				
400	Key (Coupling)	1018 Steel				
409	Ball Bearing (Thrust)	Steel				
412	O Ring (Bearing Housing Cover)	Buna-N				
412H	O Ring (Seal Chamber)	EPDM				
412K	O Ring (Diffuser Stage Casing)	EPDM				
412X	O Ring (Balance Drum)	EPDM				
418	Cap Screw (Bearing Housing Jacking)	316 SS				
424	Screw (Shaft Guard - Optional)	304 SS				
425	Nut (Bearing Housing to Suction/Discharge Casing)	Alloy Steel				
437A	Washer (Tie Rod)	Carbon Steel				
467	Retaining Plate (Bearing Bushing) End Suction Only	Duplex SS		17-4 PH		
469Y	Cap Screw (Retaining Plate to Shaft) End Suction Only	20Cb3 SS		316 SS		
477	Sleeve (Destaging and Takeoff)	Duplex SS		17-4 PH		
496U	O Ring (Balance Drum Stator)	EPDM				
497D	O Ring (Discharge Casing)	EPDM				
499	Guard (Shaft - Optional)	304 SS				
505D	Tolerance Ring (Bearing Sleeve) End Suction Only	Hastelloy C				
519	Locking Plate (Balance Drum)	Super Duplex SS		12 Chrome		
534C	Bolt Retainer (Guard to Bearing Housing)	Steel				
569F	Cap Screw (Guard to Bearing Housing)	316 SS				
761B	i-ALERTTM	Stainless Steel/Epoxy				

Dimensions Model 3393



Note: All dimensions shown are in inches and (millimeters) and are not to be used for construction.

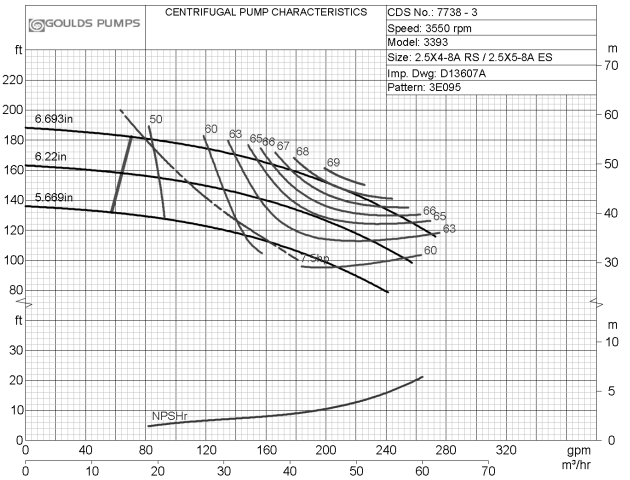
DIMENSIONS

	Suction Flange (in.)		Discharge Flange (in.)	A	A1	U	DD	X	YY	W1	B
Size	ES	RS	ES / RS								
2.5×4-8A, B	5 (125)	4 (125)	2.5 (65)	14.25(362)	17.32 (440)	1.46 (37)	12.50 (318)	10.43 (265)	10.43 (265)	18.00 (457)	13.36 (339)
4×5-10A, B	6 (150)	5 (125)	4 (125)	15.50 (394)	20.08 (510)	1.65 (42)	14.25 (362)	13.58 (345)	11.81 (300)	18.54 (471)	13.78 (350)
5×6-11A,B,C	8 (200)	6 (150)	5 (125)	17.50 (445)	23.23 (590)	2.05 (52)	16.00 (406)	15.55 (395)	13.98 (355)	23.12 (587)	15.02 (382)
6×8-13A	10(250)	8 (200)	6 (150)	19.75 (502)	28.75 (730)	2.60 (66)	18.25 (464)	17.52 (445)	17.24 (438)	25.00 (635)	16.97 (431)
6×8-13B	10(250)	8 (200)	6 (150)	19.75 (502)	28.75 (730)	2.60 (66)	18.25 (464)	19.09 (485)	17.24 (438)	25.00 (635)	16.97 (431)

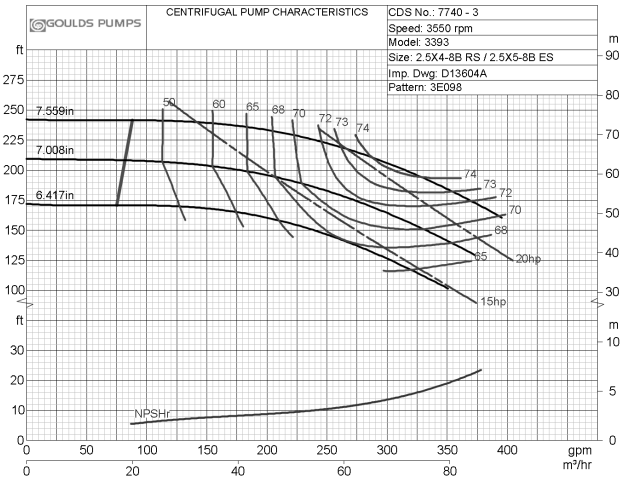
NUMBER OF STAGES

		2	3	4	5	6	7	8	9	10	11	12	13	14
2.5x4-8A	Y	9.36 (232)	11.52 (293)	13.88 (353)	16.15 (410)	18.41 (468)	20.68 (525)	22.94 (583)	25.21 (640)	27.47 (698)	29.74 (755)	32.00 (813)	34.26 (870)	36.52 (928)
	M	5.86 (149)	8.12 (206)	10.39 (264)	12.65 (321)	14.91 (379)	17.18 (436)	19.44 (494)	21.71 (551)	23.97 (609)	26.23 (666)	28.50 (724)	30.76 (781)	33.03 (839)
2.5×4-8B	Y	9.62 (244)	12.16 (309)	14.70 (373)	17.24 (438)	19.78 (502)	22.32 (567)	24.86 (631)	27.40 (696)	29.94 (760)	32.48 (825)	35.02 (890)	37.56 (954)	40.10 (1019)
	M	6.12 (155)	8.66 (220)	11.20 (284)	13.74 (349)	16.28 (414)	18.82 (478)	21.36 (543)	23.90 (607)	26.43 (671)	28.97 (736)	31.51 (800)	34.05 (865)	36.59 (929)
4x5-10A	Y	11.82 (300)	14.64 (372)	17.45 (443)	20.27 (515)	23.08 (586)	25.90 (658)	28.72 (729)	31.53 (801)	34.34 (872)	37.16 (944)	39.97 (1015)	42.79 (1087)	45.60 (1158)
	M	7.05 (179)	9.87 (251)	12.68 (322)	15.50 (394)	18.31 (465)	21.13 (537)	23.94 (608)	26.76 (680)	29.57 (751)	32.39 (823)	35.20 (894)	38.02 (966)	40.83 (1037)
4x5-10B	Y	11.69 (297)	14.82 (376)	17.95 (456)	21.08 (535)	24.20 (615)	27.33 (694)	30.46 (774)	33.59 (853)	36.72 (933)	39.85 (1012)	42.98 (1092)	46.11 (1171)	
	M	7.36 (187)	10.49 (266)	13.62 (346)	16.75 (425)	19.88 (505)	23.01 (584)	26.14 (664)	29.27 (743)	32.40 (823)	35.53 (902)	38.65 (982)	41.78 (1061)	
5x6-11A	Y	14.57 (370)	18.50 (470)	22.43 (570)	26.36 (670)	30.29 (769)	34.22 (869)	38.15 (969)	42.08 (1069)	46.01 (1169)				
	M	9.42 (239)	13.36 (339)	17.30 (439)	21.24 (539)	25.18 (640)	29.12 (740)	33.06 (840)	37.00 (940)	40.94 (1040)				
5x6-11B	Y	14.57 (370)	18.50 (470)	22.43 (570)	26.36 (670)	30.29 (769)	34.22 (869)	38.15 (969)	42.08 (1069)	46.01 (1169)				
	M	9.42 (239)	13.36 (339)	17.30 (439)	21.24 (539)	25.18 (640)	29.12 (740)	33.06 (840)	37.00 (940)	40.94 (1040)				
5x6-11C	Y	15.34 (390)	19.67 (500)	24.00 (610)	28.33 (720)	32.66 (830)	36.99 (940)	41.32 (1050)	45.65 (1160)	49.98 (1269)				
	M	10.20 (259)	14.53 (369)	18.86 (479)	23.19 (589)	27.52 (699)	31.85 (809)	36.18 (919)	40.51 (1029)	44.84 (1139)				
6x8-13A	Y	17.39 (442)	22.10 (561)	26.81 (681)	31.52 (801)	36.23 (920)	40.94 (1040)							
	M	11.61 (295)	16.32 (415)	21.03 (534)	25.74 (654)	30.45 (773)	35.16 (893)							
6x8-13B	Y	18.32 (465)	23.63 (600)	28.94 (735)	34.25 (870)	39.56 (1005)	44.87 (1140)							
	M	12.30 (312)	17.61 (447)	22.92 (582)	28.23 (717)	33.54 (852)	38.85 (987)							

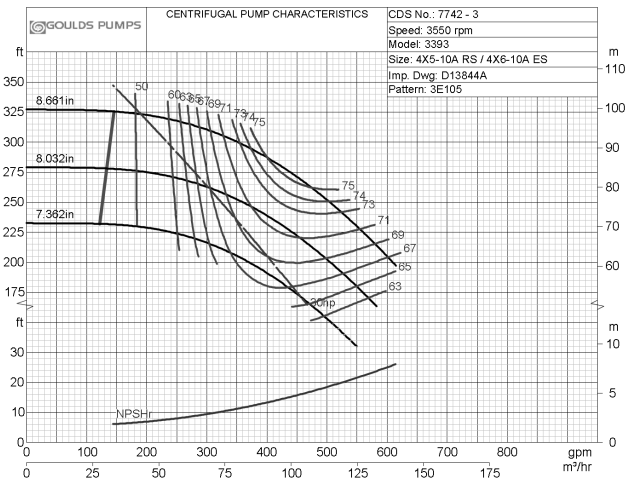
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



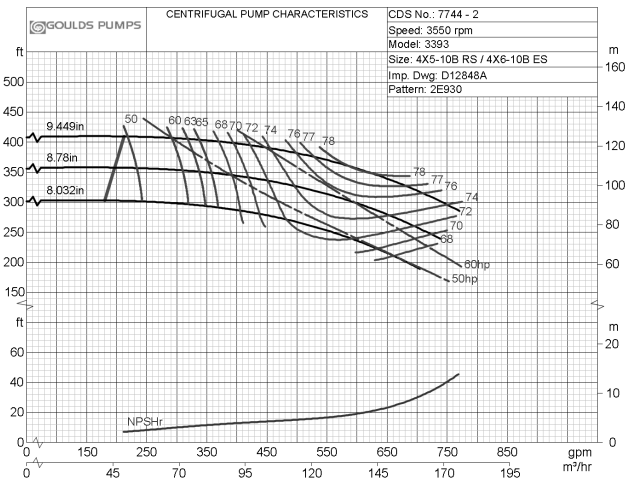
2.5X4-8A RS / 2.5X5-8A ES **3550rpm**



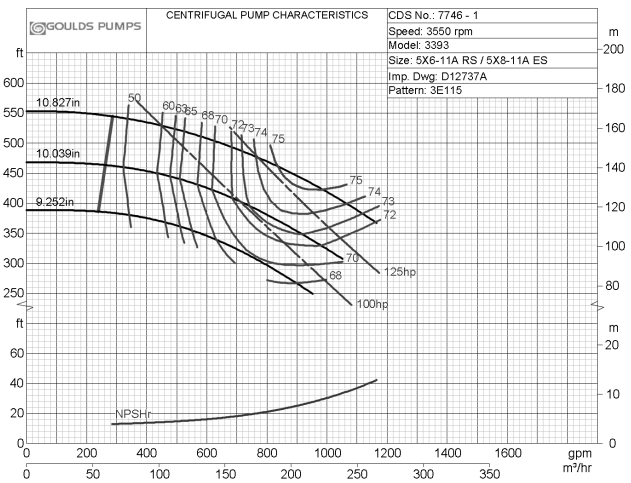
2.5X4-8B RS / 2.5X5-8B ES **3550rpm**



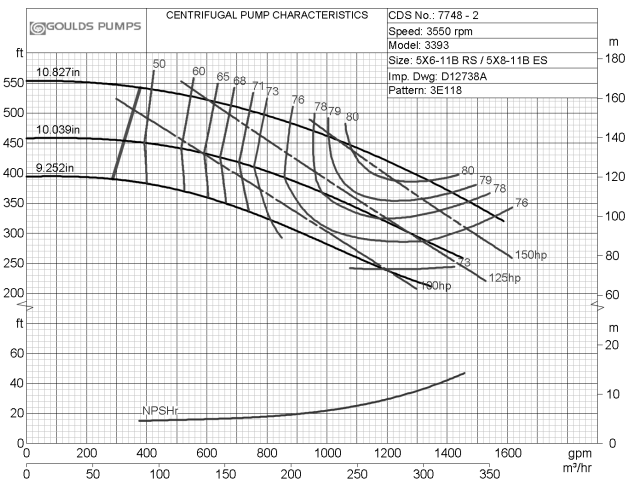
4X5-10A RS / 4X6-10A ES **3550rpm**



4X5-10B RS / 4X6-10B ES **3550rpm**

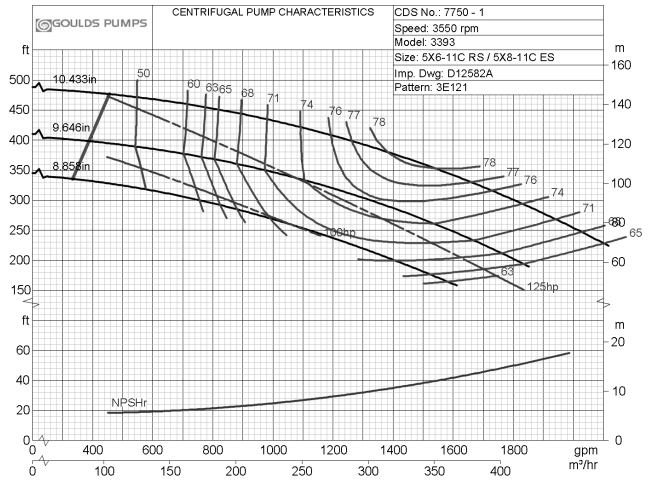


5X6-11A RS / 5X8-11A ES **3550rpm**

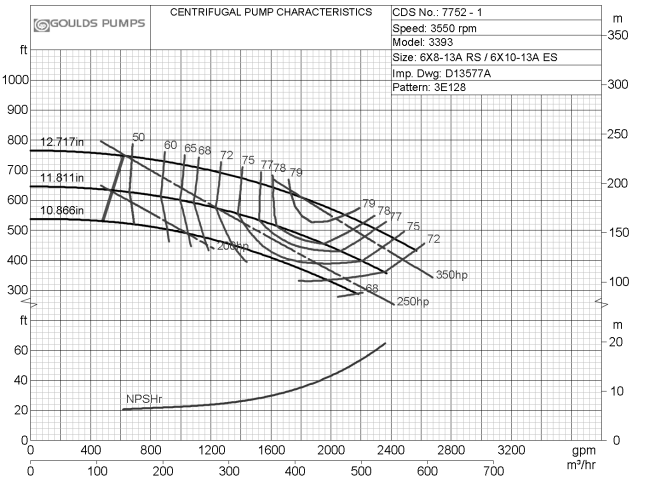


5X6-11B RS / 5X8-11B ES **3550rpm**

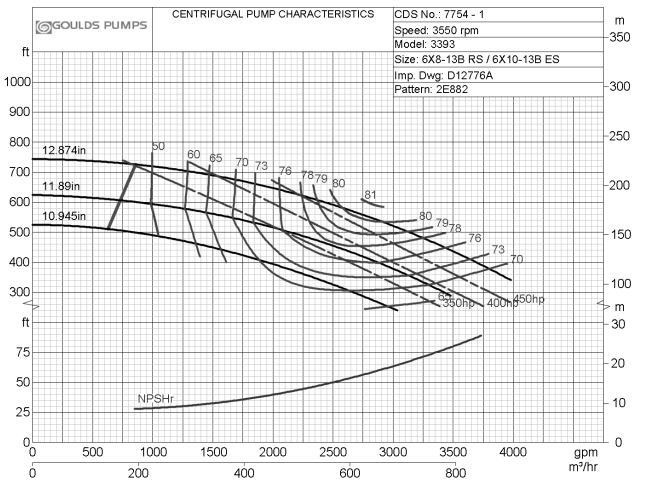
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



5X6-11C RS / 5X8-11C ES **3550rpm**



6X8-13A RS / 6X10-13A ES **3550rpm**



6X8-13B RS / 6X10-13B ES **3550rpm**

NOTES

NOTES

Multiple nozzle orientations to fit your piping configurations.

Radial Suction Configuration. Radial nozzles are rotatable at 90° increments.

End Suction configuration. Optional inducer is available for low NPSH applications.

Goulds Model 3355

Multi-Stage Pumps Designed for a Wide Range of High Pressure Services

- Capacities to 1,500 GPM (340 m^3/hr)
- Heads to 1,640 feet (500 m)
- Temperatures to 280° F (140° C)
- Pressures to 800 psig (55 bar)

Performance Features for High Pressure Services

Improved Reliability

- Heavy-duty bearing design
- No external balance lines
- Internal seal flushing
- Metal to metal casing fits

Ease of Maintenance

- Modular design
- Off-the-shelf components
- Fully interchangeable stages
- No balancing drum/disc
- Fewer parts than traditional designs
- Metal fits guarantee alignment
- No flush/bypass lines
- Easily retrofitted

Safety

- ANSI B15.1 Coupling Guard
- Fully confined stage o-rings
- Internal flushing & balance
- Raised face flanges

Applications

- Boiler Feed
- Condensate return
- Deaerator
- Reverse osmosis
- Shower/spray service
- Mine de-watering
- Cleaning systems
- Seal water booster
- Product transfer
- Reactor feed
- Pressure boosting

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3355 Multi-Stage Pumps

Rugged Design Features for Wide Range of Services

The 3355 is also available in end suction configuration.

DIFFUSERS
Eliminate radial loads to assure long bearing life.

ANGULAR CONTACT, DOUBLE-ROW THRUST BEARINGS
Can carry a thrust load in either direction.

PRODUCT LUBRICATED BEARINGS (ES Configuration)
Front sleeve bearing is located behind the first stage impeller for improved performance and reliability.

HIGH-STRENGTH TIE RODS
Bolting machined to SAE standards using high-tensile-strength steel, resulting in easy maintenance.

INTERSTAGE CASING FITS
Metal fits ensure proper alignment of the stages at any temperature.

INTERNAL BALANCING
Eliminates the need for balance lines outside the pump.

WEAR RINGS
Optional case wear rings available.

SHAFT
Standard material is 12 to 13% chrome for improved shaft strengths and corrosion resistance.

KEYED IMPELLERS
Offset keys ensure rotational shaft balance.

DEEP-GROOVE BALL BEARINGS
Are unconstrained to accommodate thermal expansion.

INTERNAL SEAL FLUSHING
Special internal channels ensure the seal always has sufficient flushing fluid.

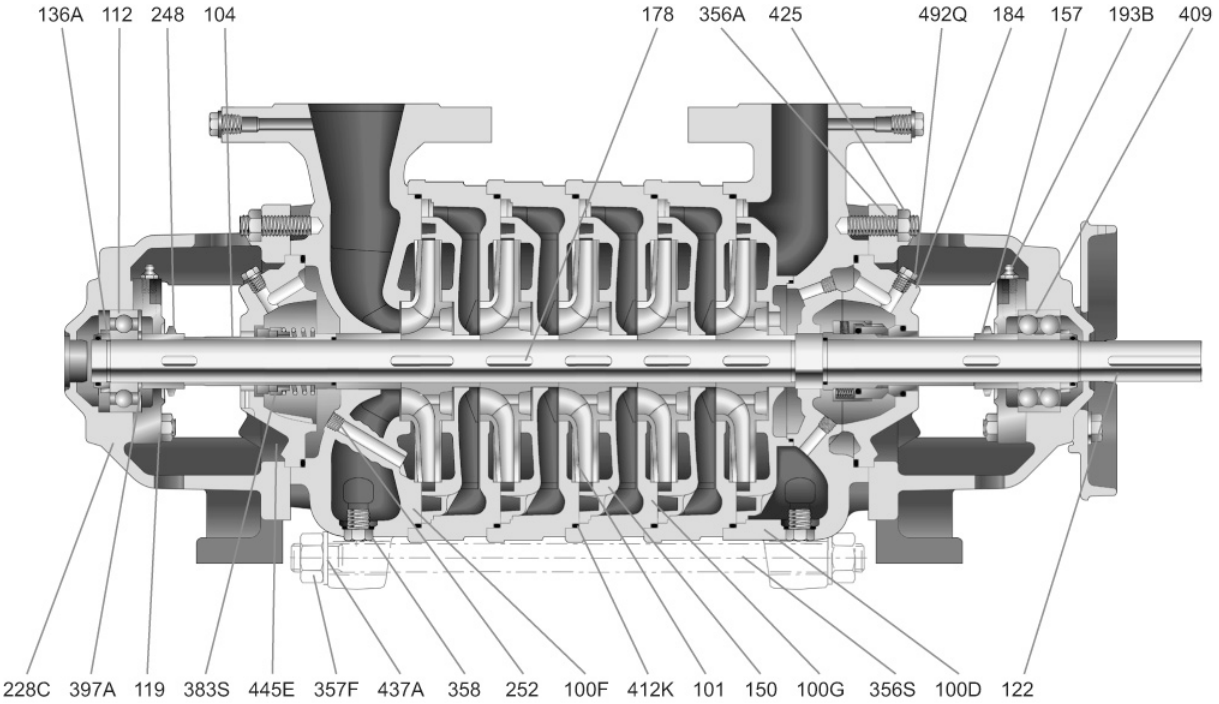
SEAL CHAMBER
TaperBore design eliminates the worry associated with venting. Improved flow to the seal helps extend seal life.

MULTIPLE HYDRAULICS
Two impeller/diffuser combinations per size maximizes efficiency at all conditions of service.

An optional inducer is available on the end suction configuration for low NPSH applications.

FEWER PARTS
The 3355 uses fewer parts than traditional multistage pumps with balancing devices, which means less inventory and easier maintenance.

Sectional View Model 3355

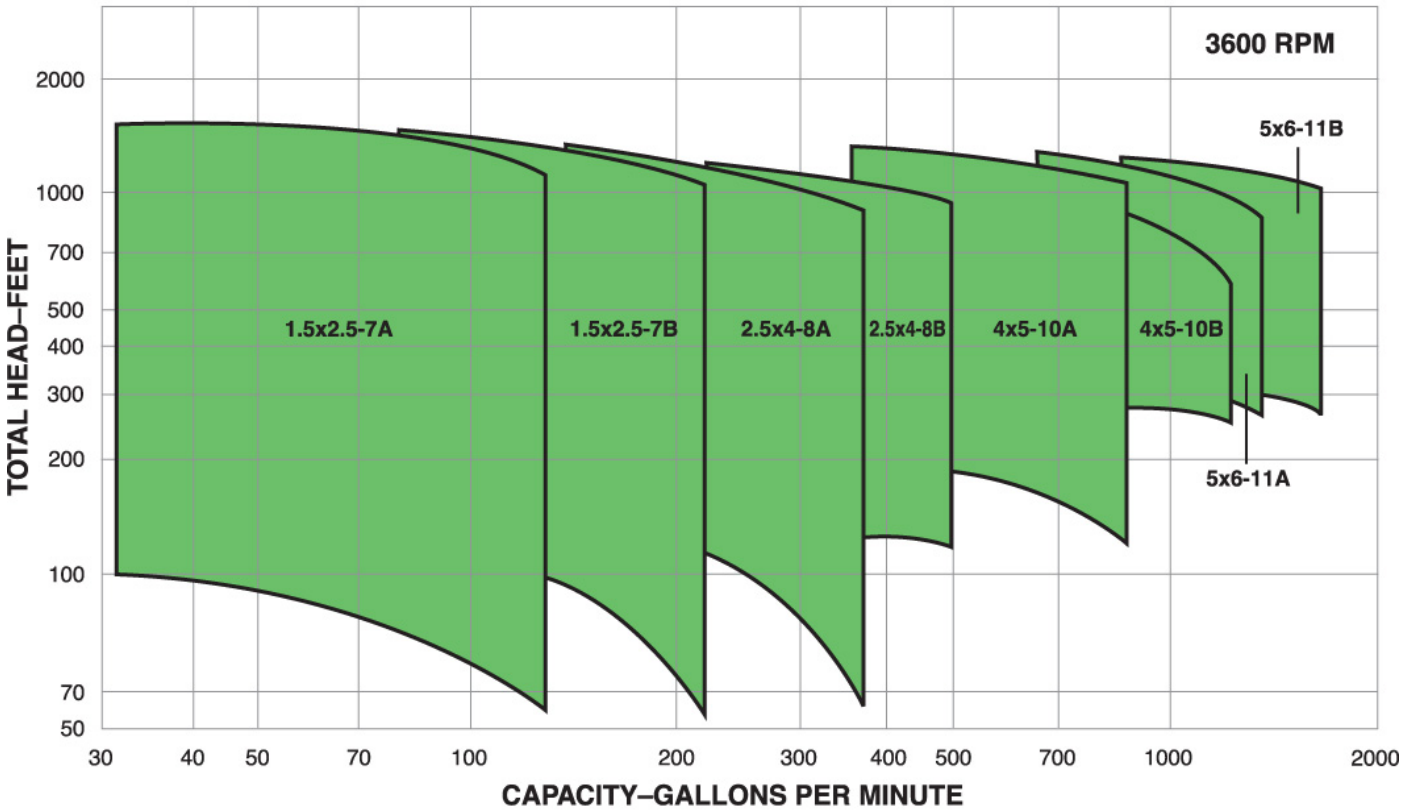


Parts List and Materials of Construction

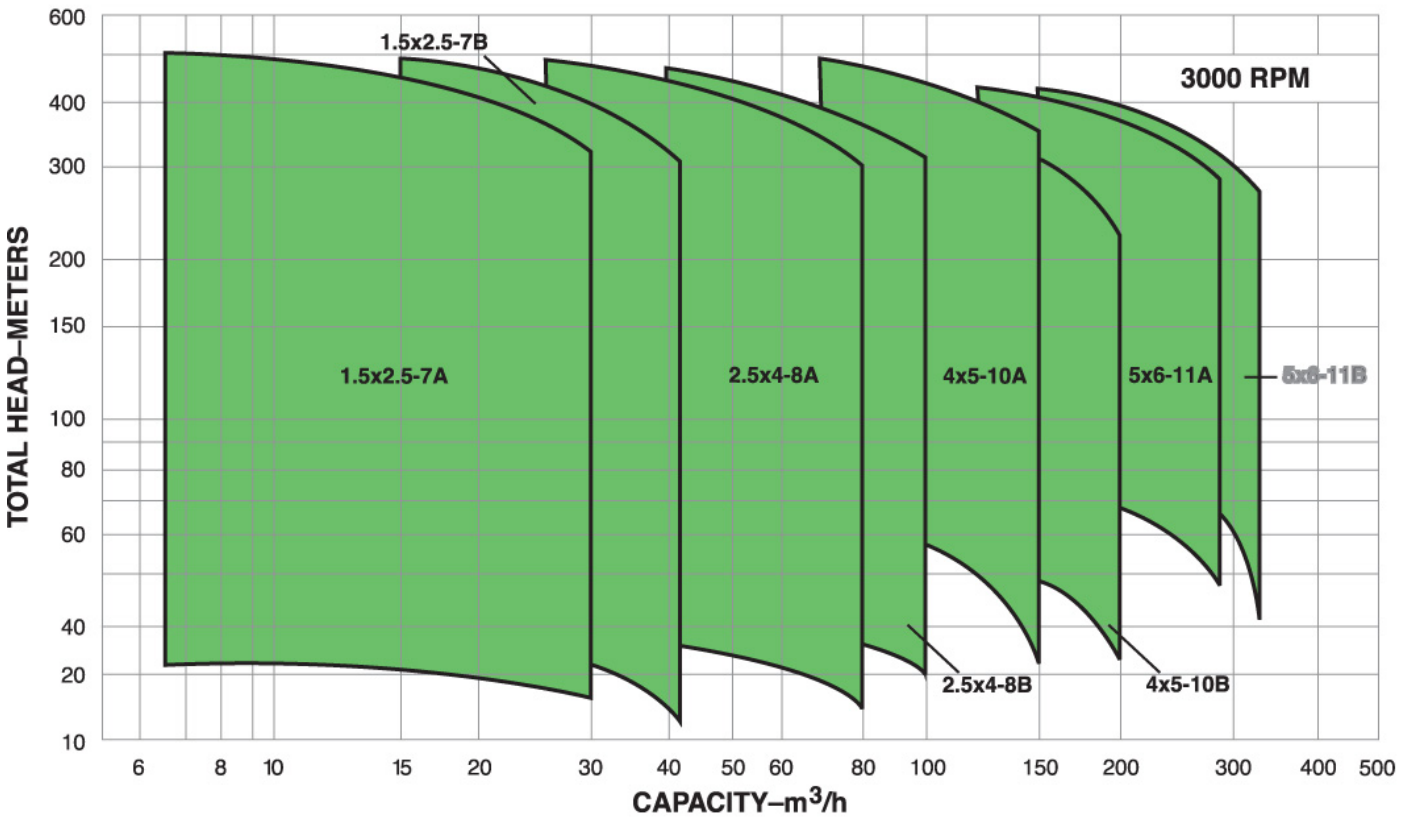
Item Number	Part Name	Material		
		Cast Iron	CI/SS Fitted	All Stainless Steel
100F	Casing (Suction)	Ductile Iron (1)	Ductile Iron (1)	Stainless Steel (3)
100D	Casing (Discharge)	Ductile Iron (2)	Ductile Iron (2)	Stainless Steel (2)
101	Impeller	Cast Iron	Stainless Steel	Stainless Steel
150/150L	Diffuser	Cast Iron	Cast Iron	Stainless Steel
103	Case Wear Ring (Optional)	Stainless Steel	Stainless Steel	Stainless Steel
228C	Bearing Bracket	Cast Iron	Cast Iron	Cast Iron
119	Bearing Cover	Cast Iron	Cast Iron	Cast Iron
184	Seal Cover	Cast Iron	Cast Iron	Stainless Steel
197A	Bearing - Bushing (4)	Bronze	Bronze	Bronze
122	Shaft	13% Chrome	13% Chrome	Duplex St. St.
104/126	Sleeve	13% Chrome	13% Chrome	Duplex St. St.
356S	Tie Rod	Carbon Steel	Carbon Steel	Carbon Steel
136A	Bearing Nut	Carbon Steel	Carbon Steel	Carbon Steel
100G	Stage Casing	Cast Iron	Cast Iron	Stainless Steel
157	Spacer Sleeve	Stainless Steel	Stainless Steel	Stainless Steel
248	Thrower	Rubber	Rubber	Rubber
358	Drain Plug	Carbon Steel	Carbon Steel	Stainless Steel
252	Throttling Element		316 Ti	
193B	Grease Nipple	Carbon Steel		
383/383S	Mech Seal	depends on seal configuration		
409	Radial Ball Bearing	Steel	Steel	Steel
112	Radial Ball Bearing	Steel	Steel	Steel
357F	Nut	Carbon Steel		
425	Nut	Carbon Steel		
412K	O-Ring - all	EPDM	EPDM	EPDM
178	Key - all	Carbon Steel		Stainless Steel
356A	Stud	Carbon Steel		
445E	Pin	316 SS		
397A	Disc Spacer	Carbon Steel		
492Q	Plug	Carbon Steel		
437A	Washer - all	Carbon Steel		

(1) Standard flange rating is 150#RF for radial suction and 150#RF for end suction. End suction casing is cast iron material.
(2) Standard flange rating is 300#RF with optional 600#RF flange.
(3) Standard flange rating is 150#RF for radial suction and 150#RF for end suction. 300#RF is available.
(4) Only on end suction configuration.

Hydraulic Coverage 60 Hz/3600 rpm

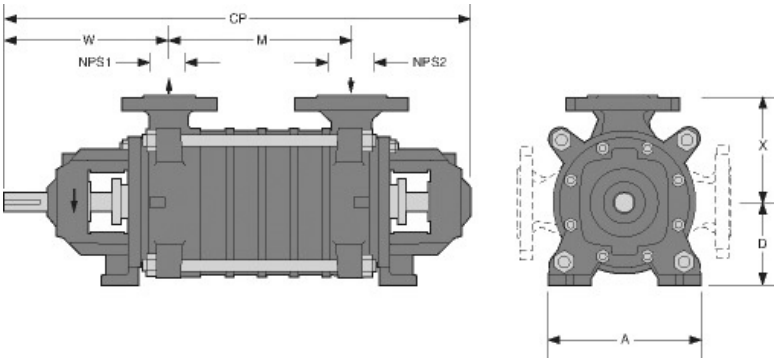


Hydraulic Coverage 50 Hz/3000 rpm

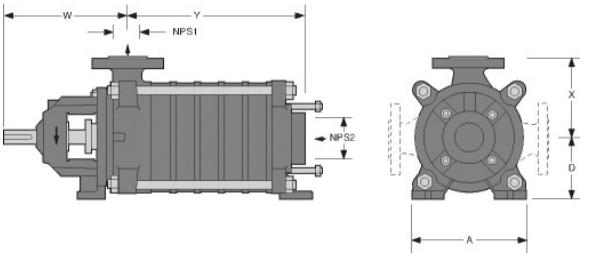


Dimensions Model 3355

Radial Suction



End Suction



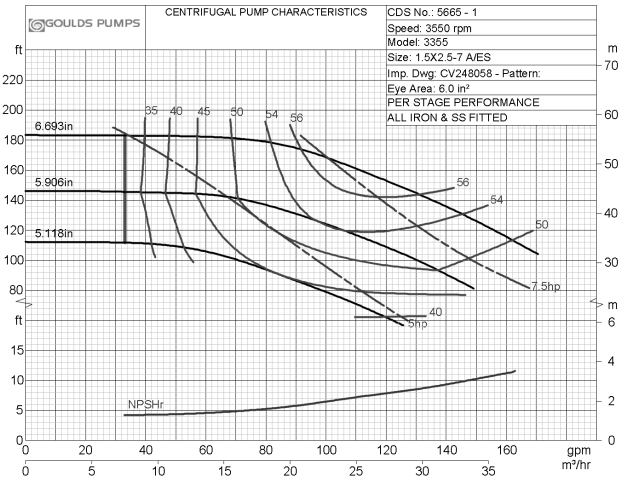
DIMENSIONS						
Pump Size	**NPSI**	**NPS2**	**A**	**W**	**D**	**X**
1.5×2.5-7	1.5	2.5	9.06	11.02	5.51	7.09
2.5×4-8	2.5	4	9.84	12.40	6.30	8.27
4×5-10	4	5	13.38	14.58	8.27	9.84
5×6-11	5	6	15.75	17.72	9.84	11.81

Pump Size		**NUMBER OF STAGES**														
		2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1.5×2.5-7	**M**	5.71	7.87	10.04	12.20	14.37	16.54	18.70	20.87	23.03	25.20	27.36	29.53	31.69	33.86	36.02
	CP	24.72	26.88	29.05	31.21	33.38	35.55	37.71	39.88	42.04	44.21	46.37	48.54	50.70	52.87	55.03
	Y	9.44	11.61	13.78	15.94	18.11	20.28	22.44	24.60	26.77	28.94	31.10	33.27	35.43	37.60	39.77
2.5×4-8	**M**	7.09	9,84	12.60	15.35	18.11	20.87	23.62	26.38	29.13	31.88	34.65	37.40			
	CP	28.54	31.29	34.05	36.80	39.56	42.32	45.07	47.83	50.58	53.33	56.10	58.85			
	Y	11.02	13.78	16.54	19.29	22.05	24.80	27.56	30.31	33.07	35.83	38.58	41.33			
4×5-10	**M**	10.03	13.39	16.73	20.08	23.43	26.77	30.12	33.47							
	CP	35.26	38.62	41.96	45.31	48.66	52.00	55.35	58.70							
	Y	15.75	19.09	22.44	25.79	29.13	32.48	35.83	39.18							
5×6-11	**M**	12.40	16.54	20.67	24.80	28.94	33.07									
	CP	43.31	47.45	51.58	55.71	59.85	63.98									
	Y	18.90	23.03	27.17	31.30	35.43	39.57									

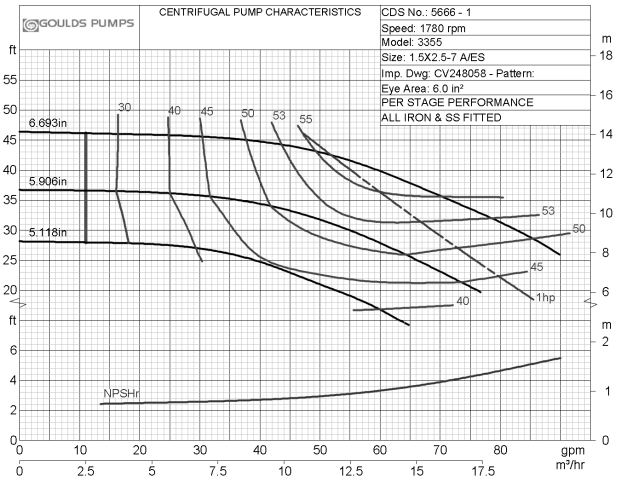
***Note:** All dimensions in inches (mm) and are not to be used for construction or installation purposes.
Add 0.79" to "Y" dim for size 2.5x4-8 with inducer design.

NOTES

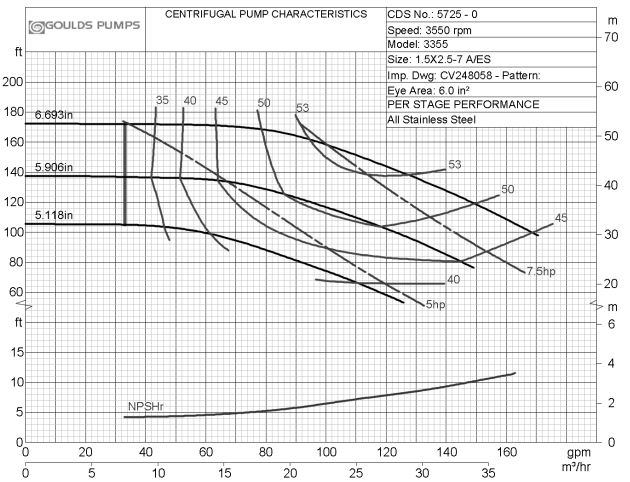
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



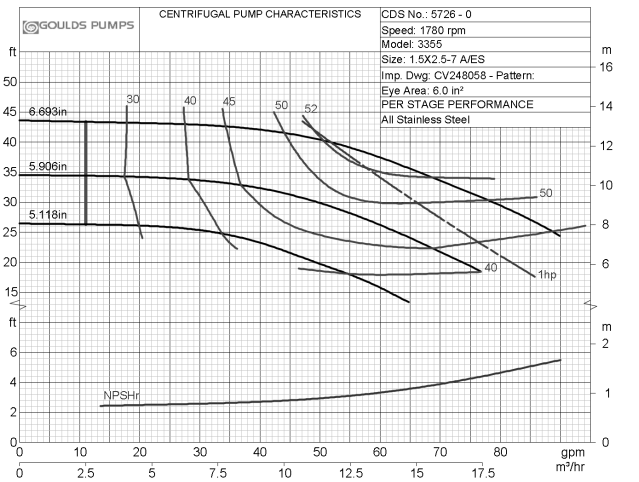
1.5X2.5-7 A/ES **3550rpm**



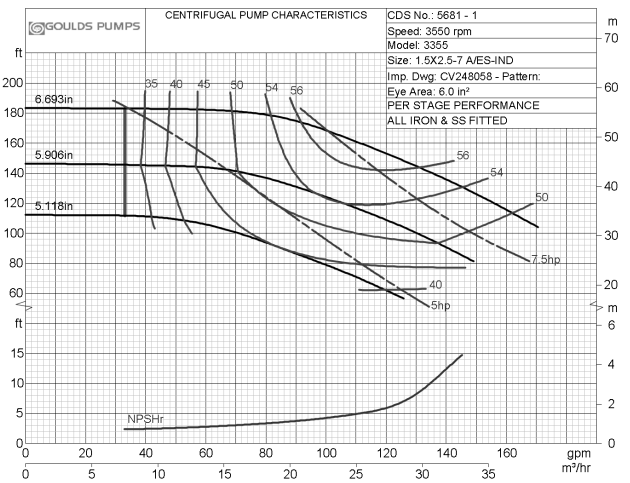
1.5X2.5-7 A/ES **1780rpm**



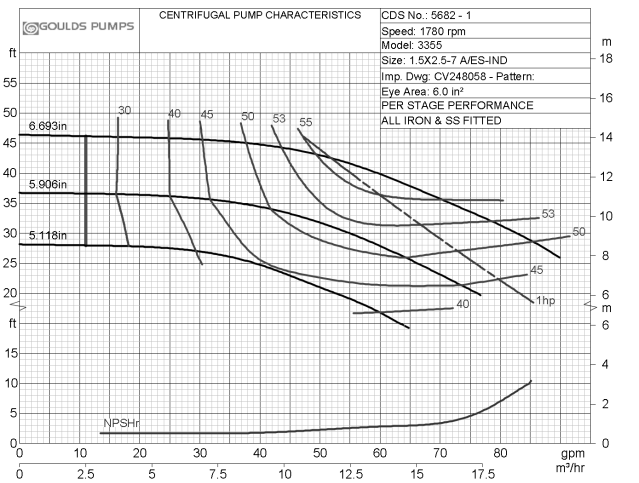
1.5X2.5-7 A/ES **3550rpm**



1.5X2.5-7 A/ES **1780rpm**

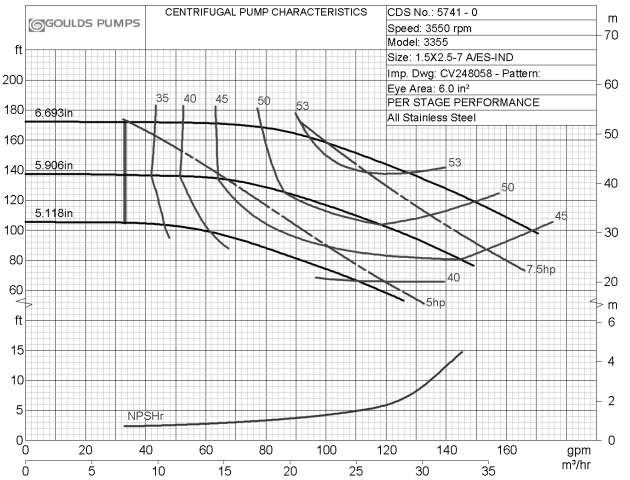


1.5X2.5-7 A/ES-IND **3550rpm**

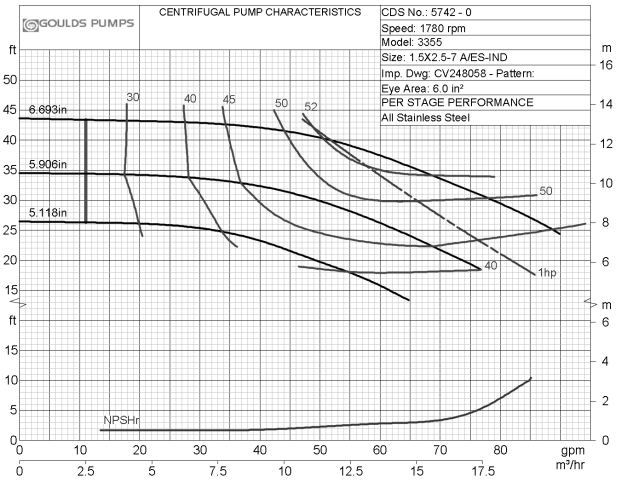


1.5X2.5-7 A/ES-IND **1780rpm**

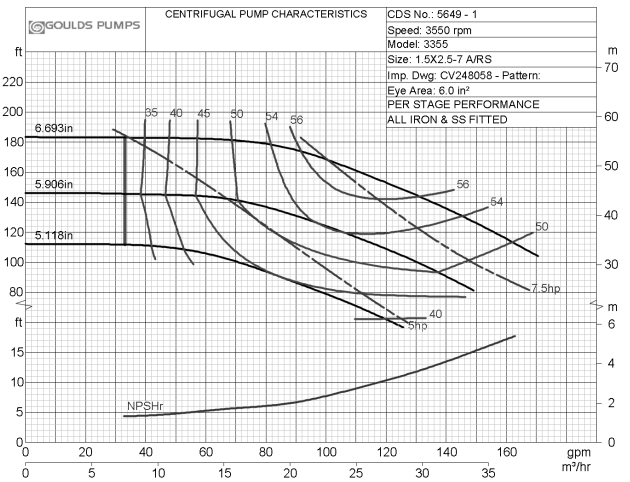
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



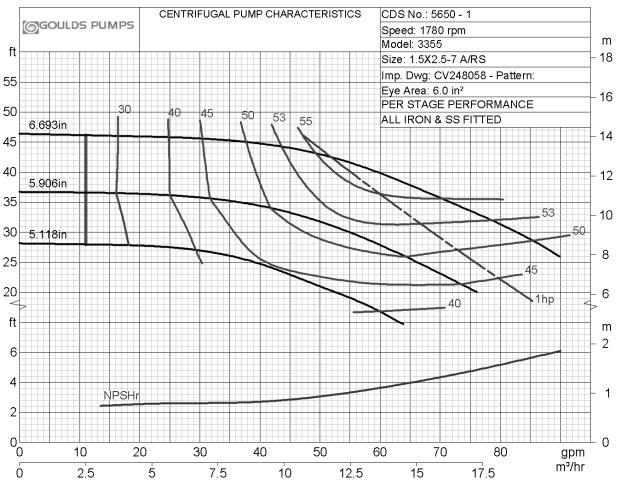
1.5X2.5-7 A/ES-IND **3550rpm**



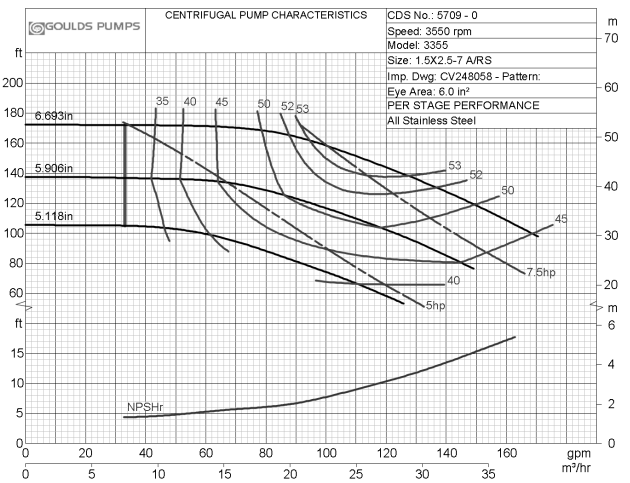
1.5X2.5-7 A/ES-IND **1780rpm**



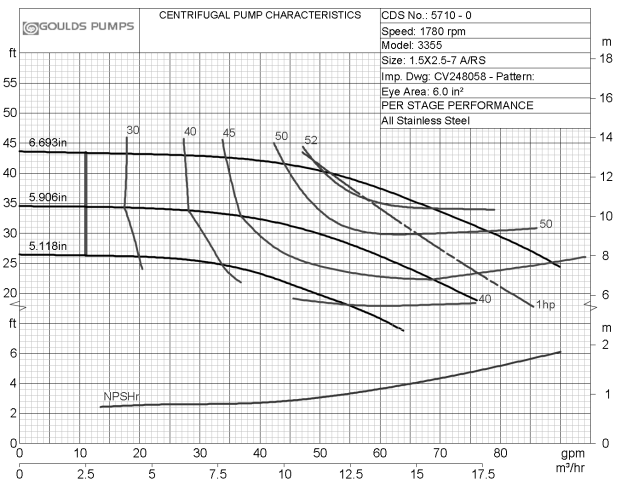
1.5X2.5-7 A/RS **3550rpm**



1.5X2.5-7 A/RS **1780rpm**



1.5X2.5-7 A/RS **3550rpm**



1.5X2.5-7 A/RS **1780rpm**

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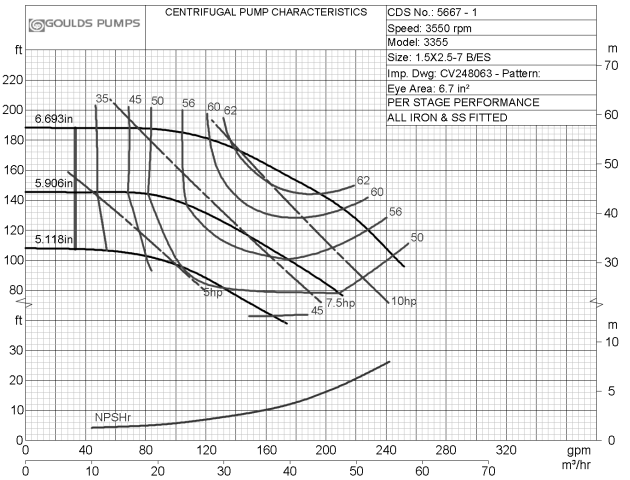
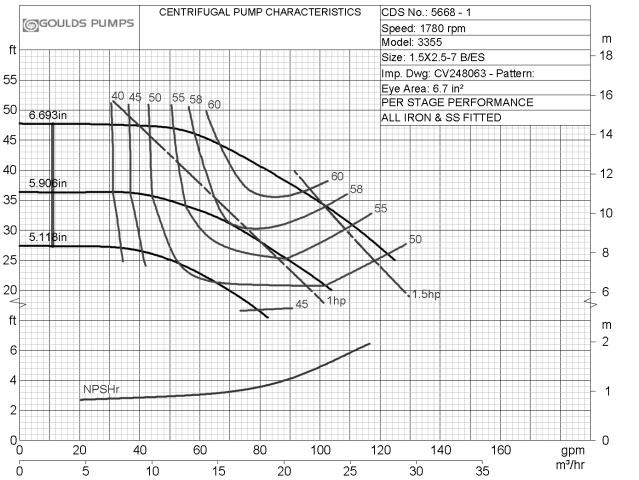
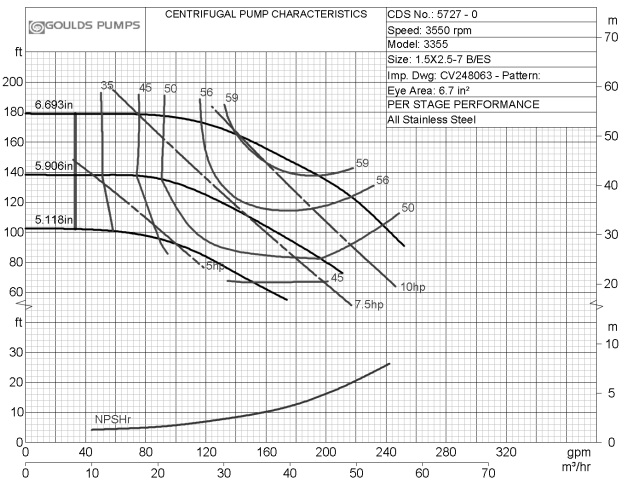


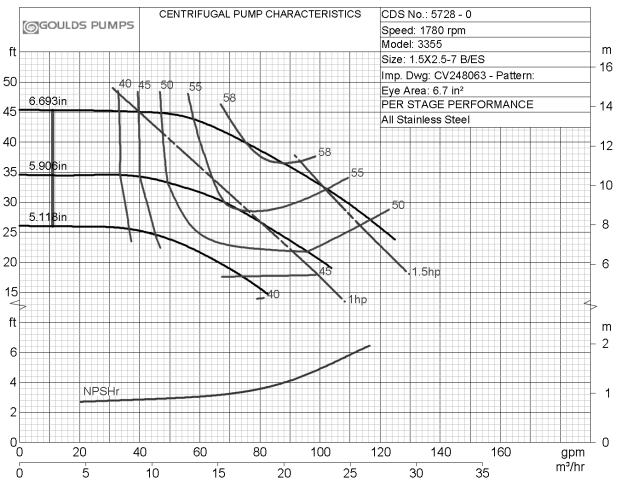
1.5X2.5-7 B/ES **3550rpm**



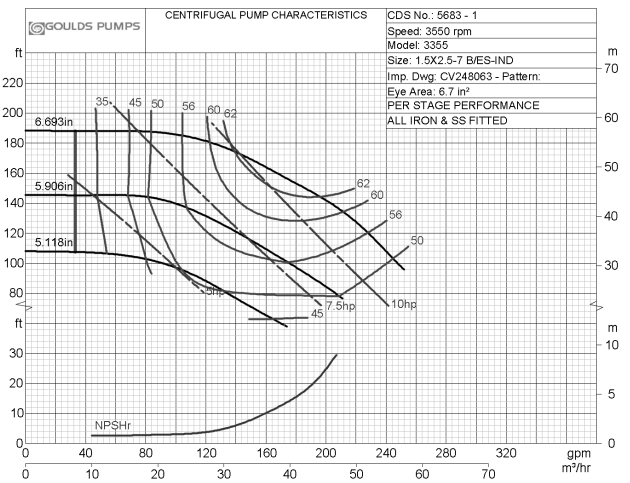
1.5X2.5-7 B/ES **1780rpm**



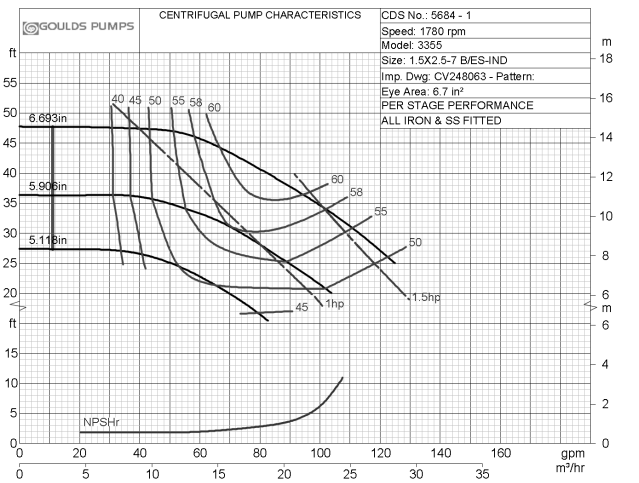
1.5X2.5-7 B/ES **3550rpm**



1.5X2.5-7 B/ES **1780rpm**



1.5X2.5-7 B/ES-IND **3550rpm**



1.5X2.5-7 B/ES-IND **1780rpm**

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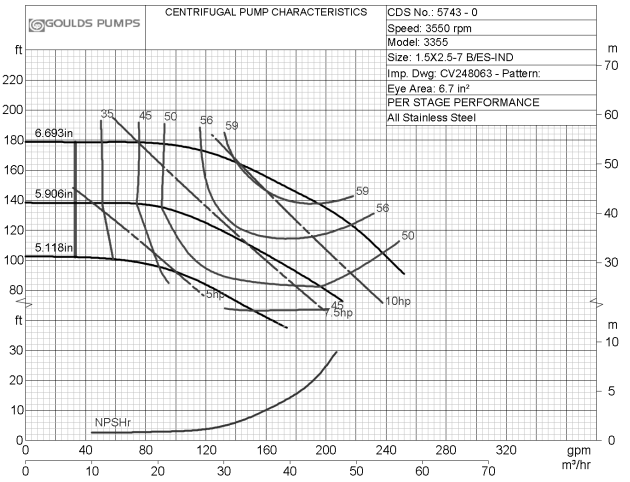
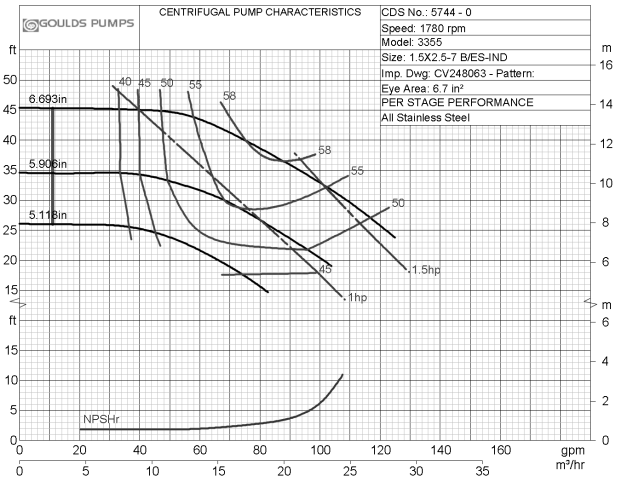
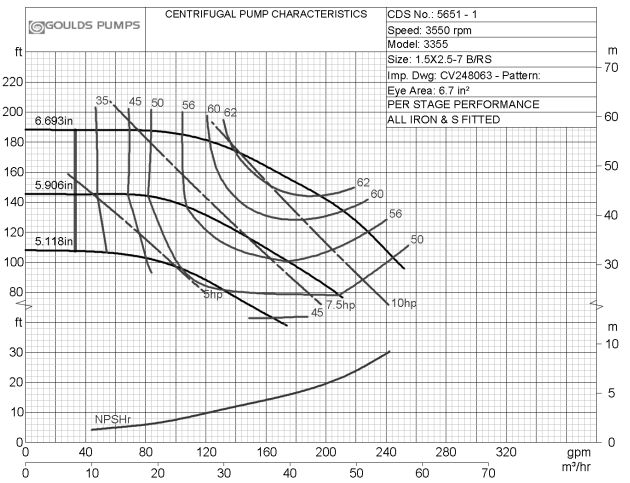


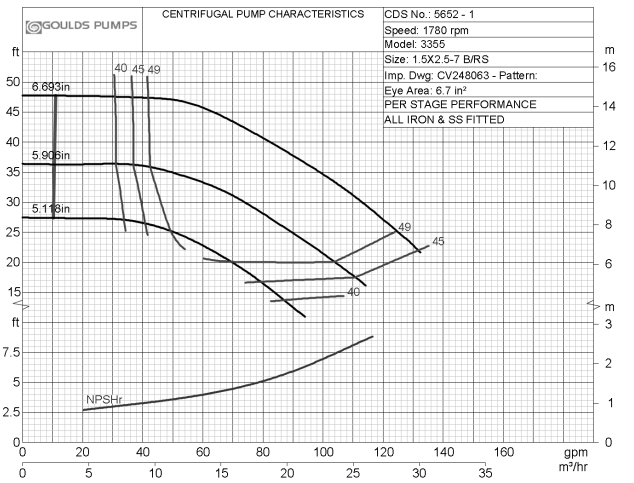
1.5X2.5-7 B/ES-IND **3550rpm**



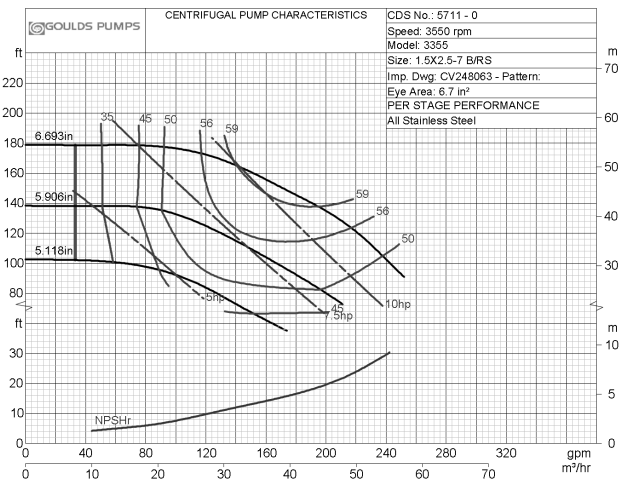
1.5X2.5-7 B/ES-IND **1780rpm**



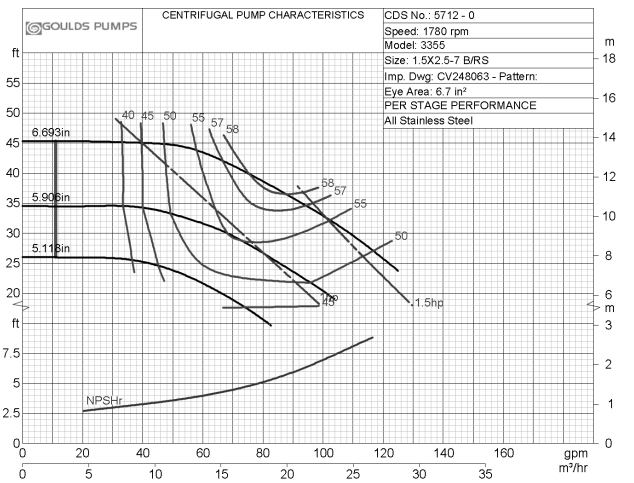
1.5X2.5-7 B/RS **3550rpm**



1.5X2.5-7 B/RS **1780rpm**



1.5X2.5-7 B/RS **3550rpm**



1.5X2.5-7 B/RS **1780rpm**

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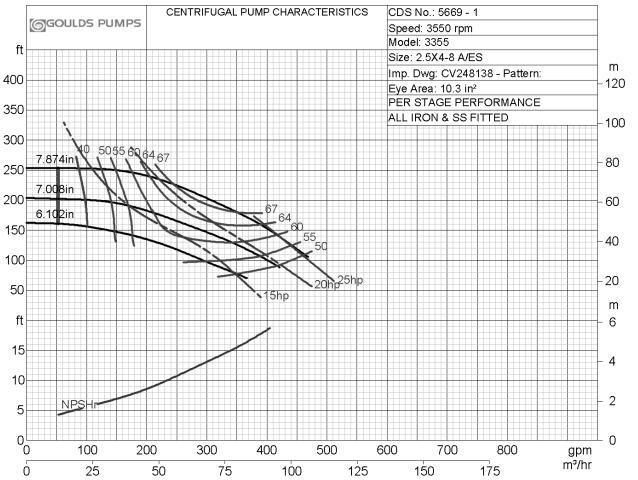
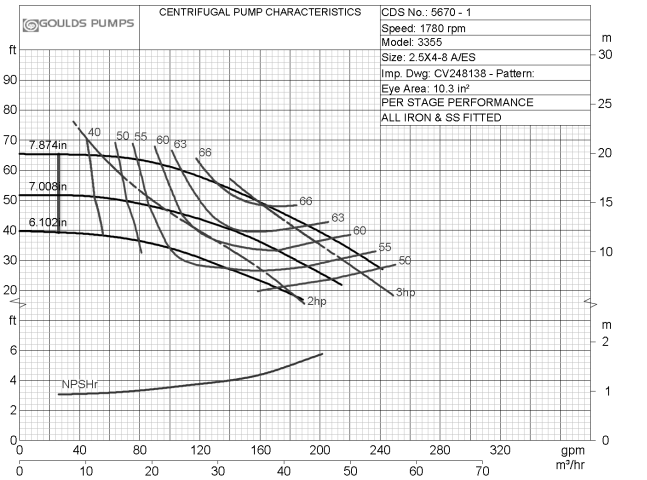
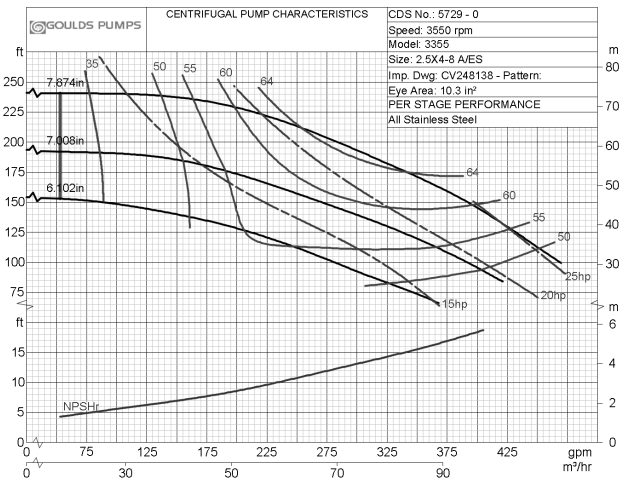


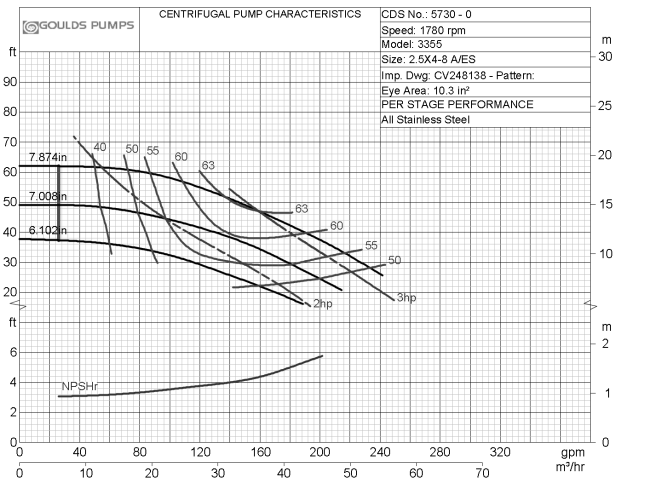
2.5X4-8 A/ES **3550rpm**



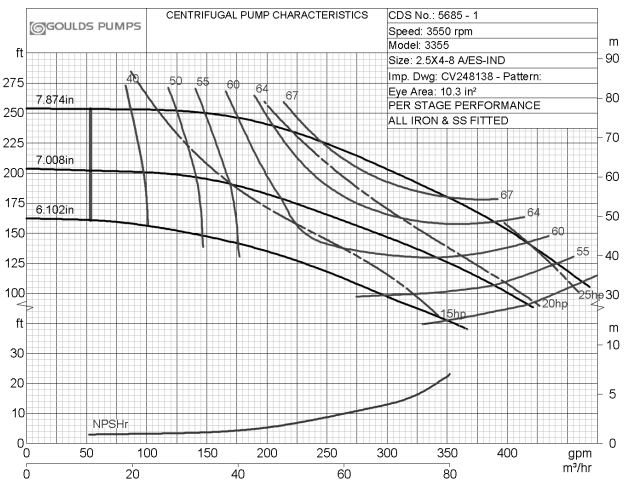
2.5X4-8 A/ES **1780rpm**



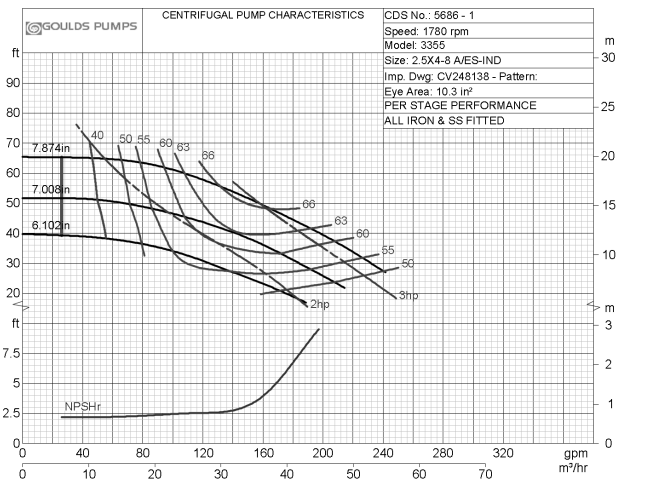
2.5X4-8 A/ES **3550rpm**



2.5X4-8 A/ES **1780rpm**



2.5X4-8 A/ES-IND **3550rpm**



2.5X4-8 A/ES-IND **1780rpm**

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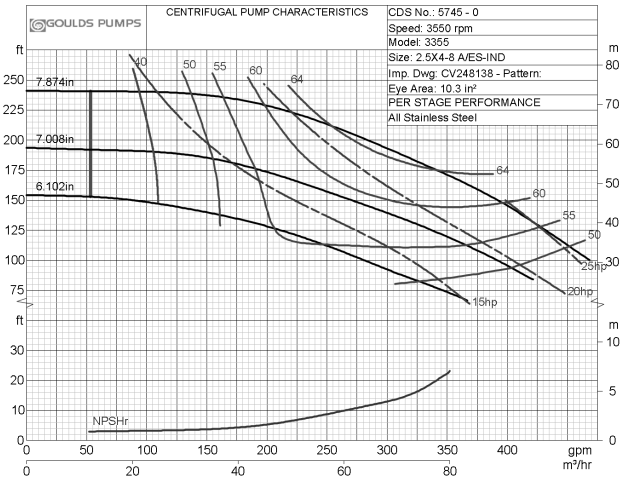
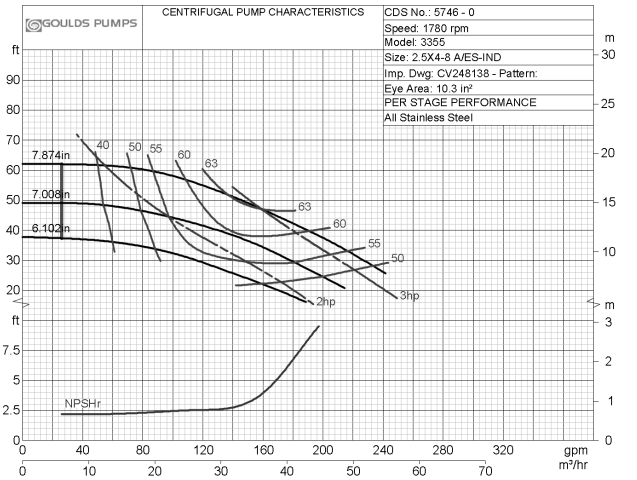
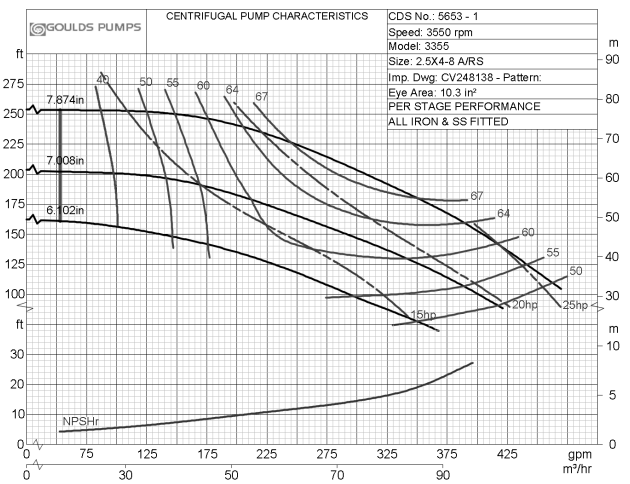


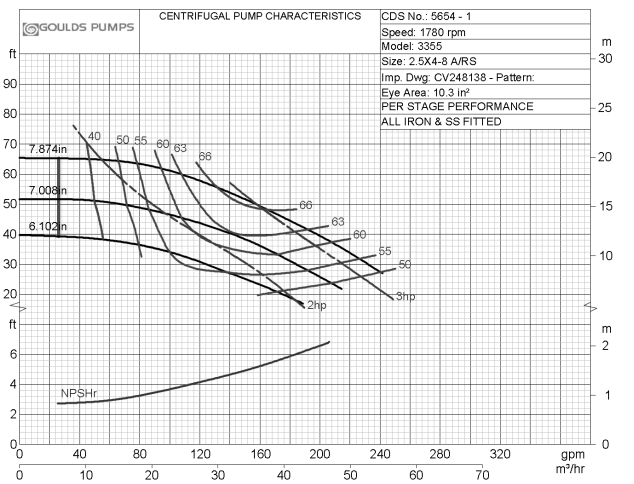
2.5X4-8 A/ES-IND **3550rpm**



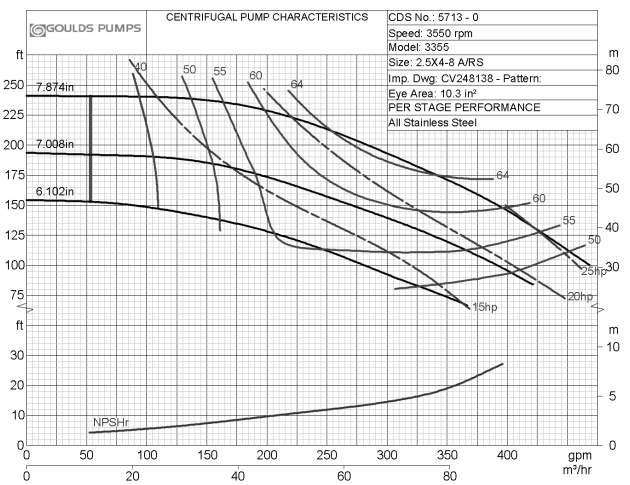
2.5X4-8 A/ES-IND **1780rpm**



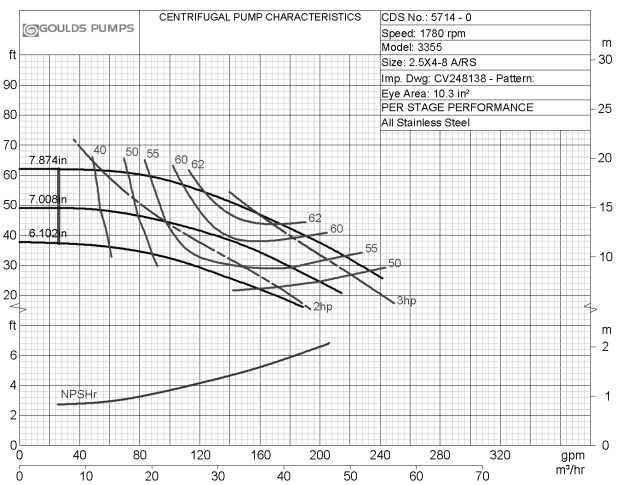
2.5X4-8 A/RS **3550rpm**



2.5X4-8 A/RS **1780rpm**



2.5X4-8 A/RS **3550rpm**



2.5X4-8 A/RS **1780rpm**

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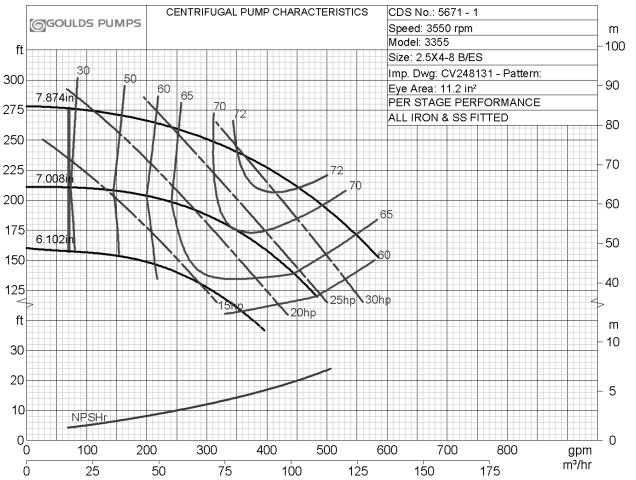
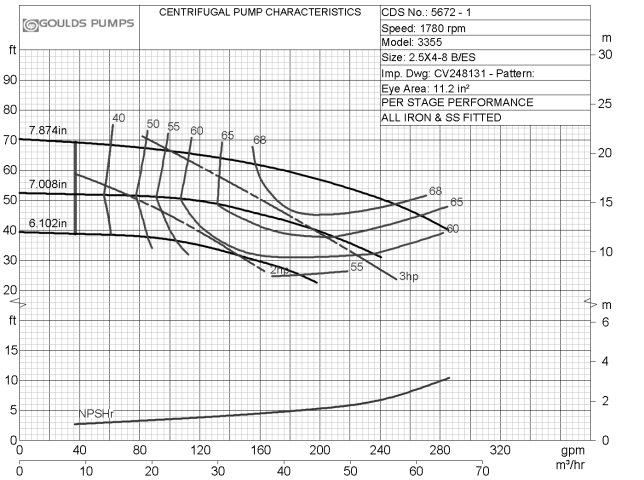
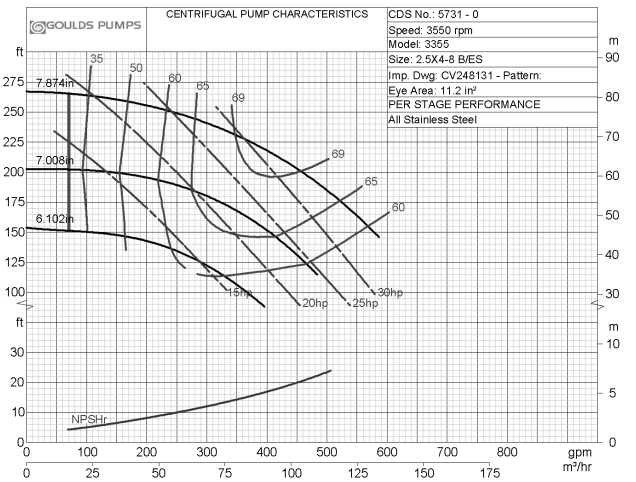


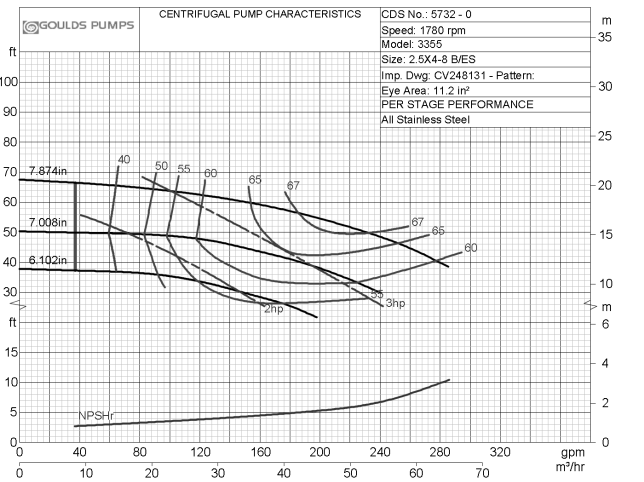
2.5X4-8 B/ES **3550rpm**



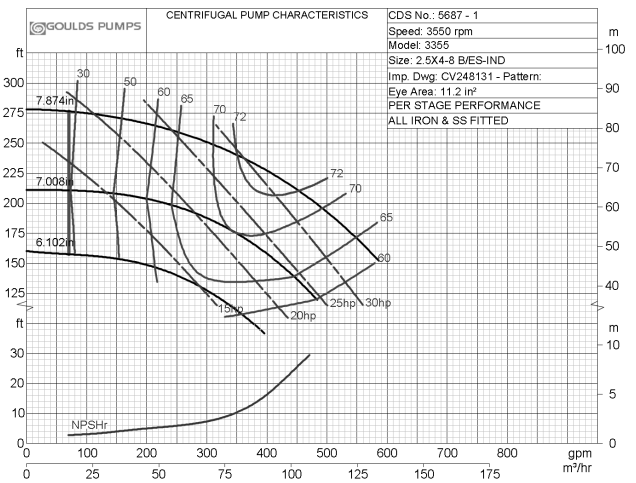
2.5X4-8 B/ES **1780rpm**



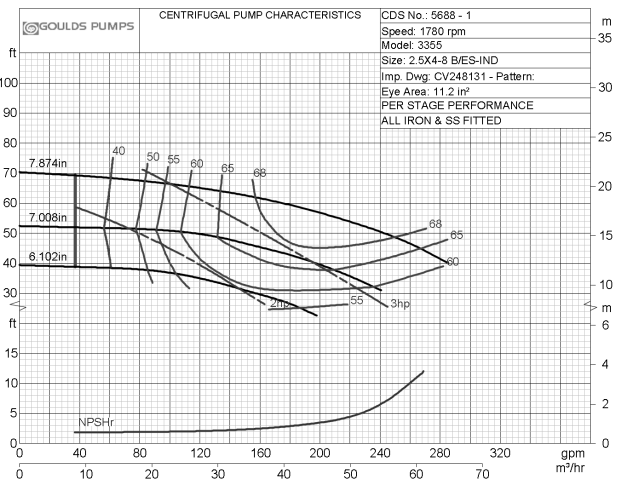
2.5X4-8 B/ES **3550rpm**



2.5X4-8 B/ES **1780rpm**



2.5X4-8 B/ES-IND **3550rpm**



2.5X4-8 B/ES-IND **1780rpm**

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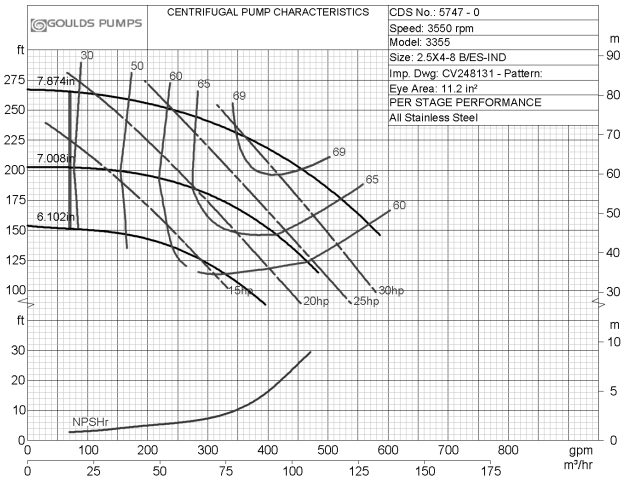
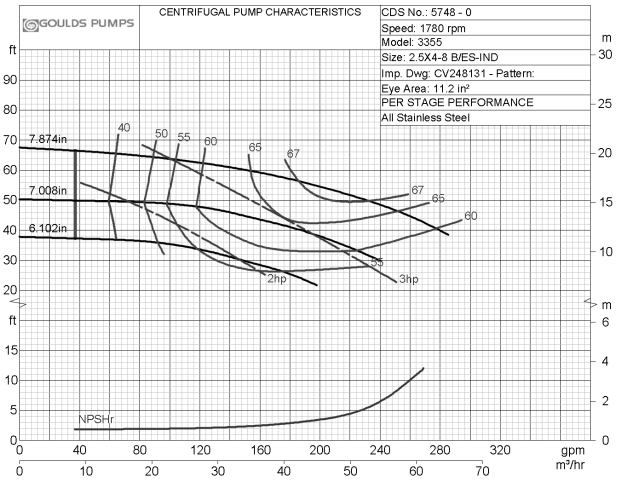
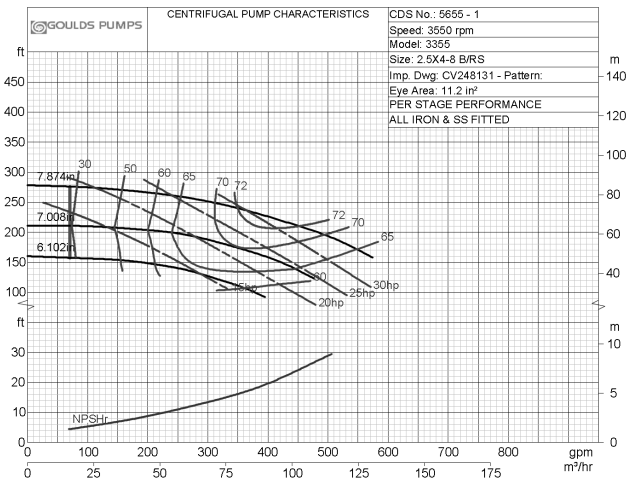


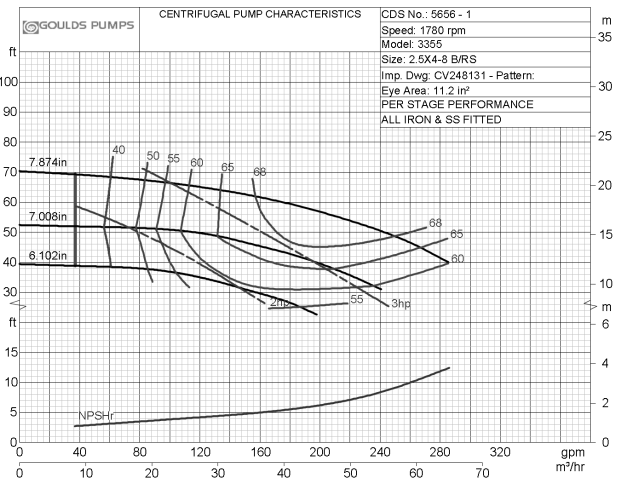
2.5X4-8 B/ES-IND **3550rpm**



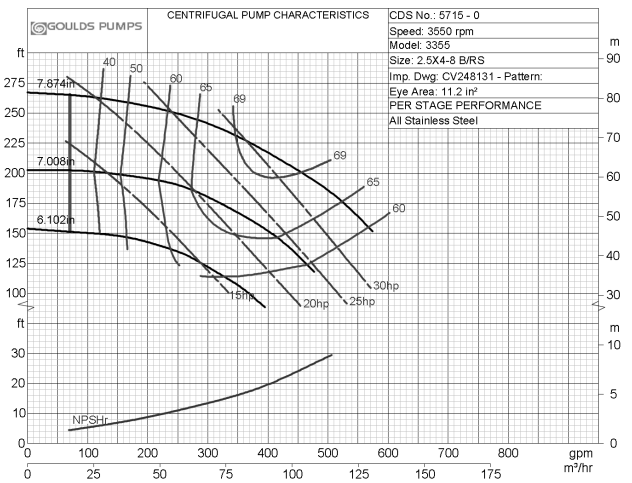
2.5X4-8 B/ES-IND **1780rpm**



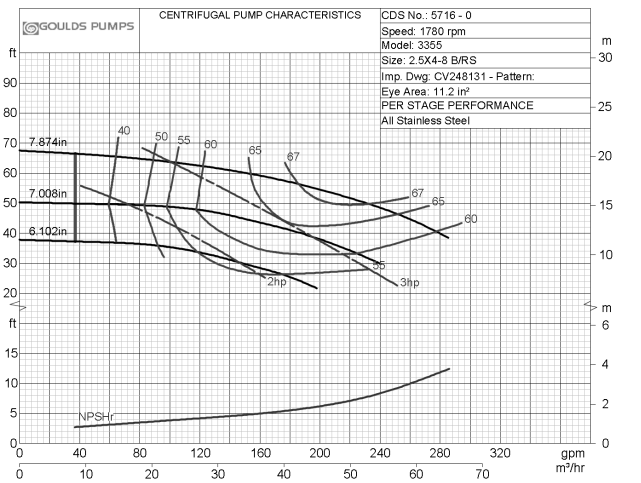
2.5X4-8 B/RS **3550rpm**



2.5X4-8 B/RS **1780rpm**



2.5X4-8 B/RS **3550rpm**



2.5X4-8 B/RS **1780rpm**

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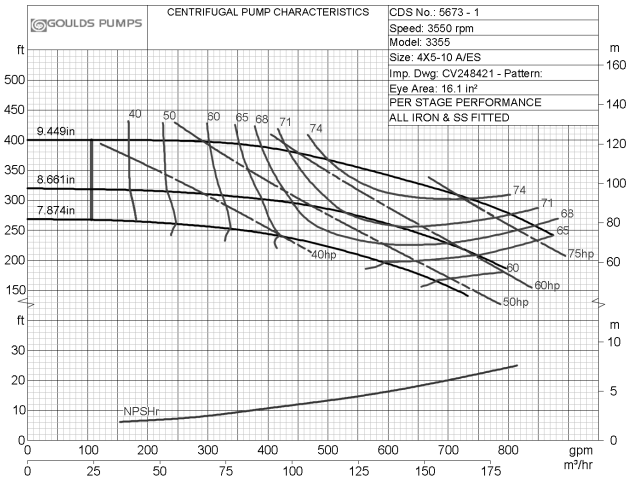
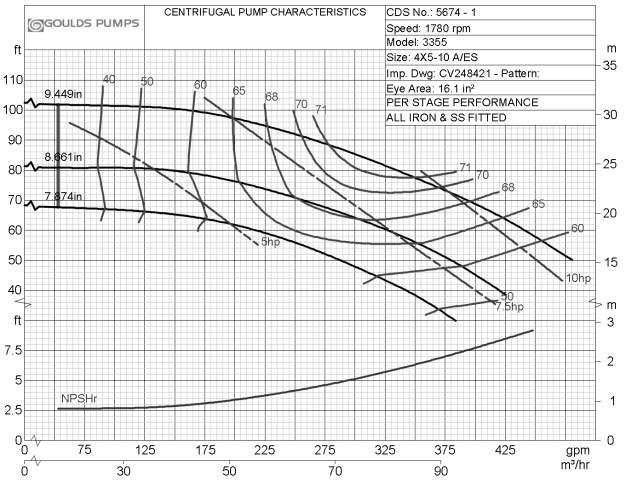
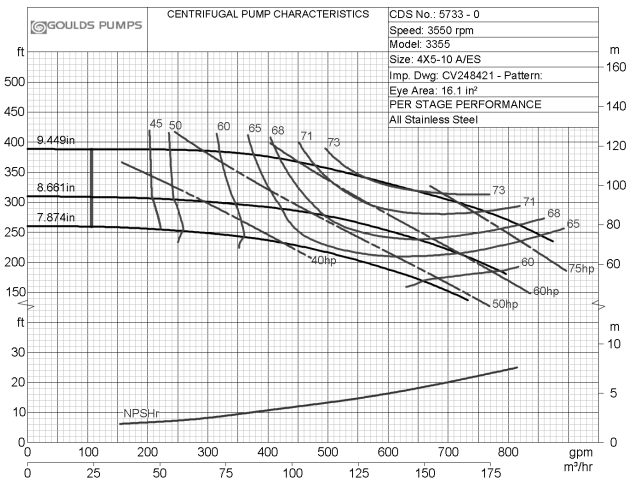


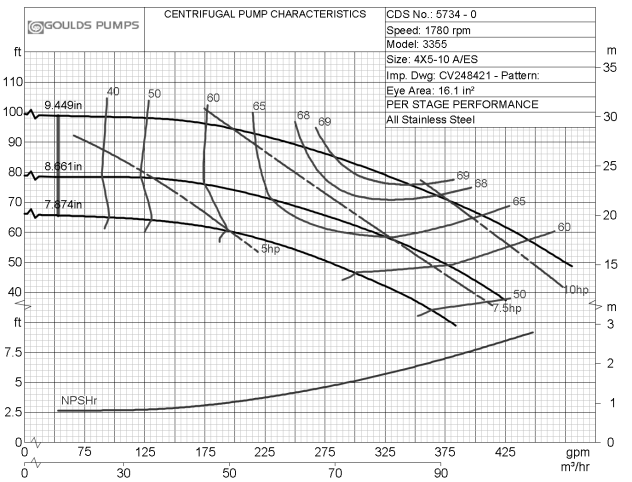
4X5-10 A/ES **3550rpm**



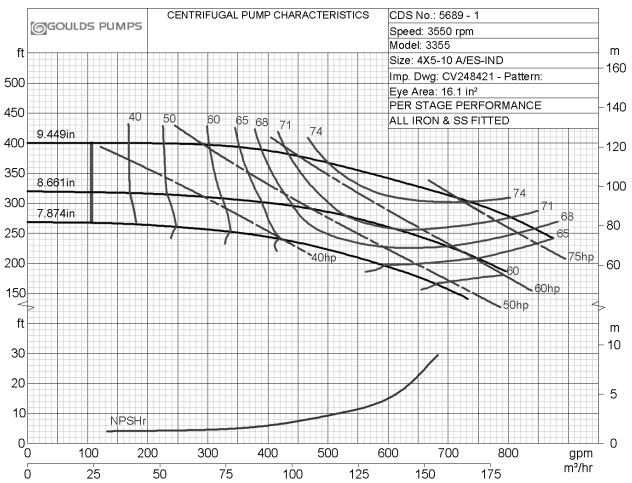
4X5-10 A/ES **1780rpm**



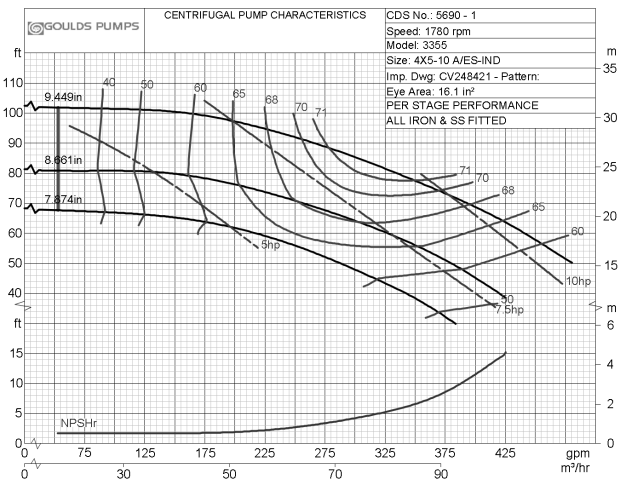
4X5-10 A/ES **3550rpm**



4X5-10 A/ES **1780rpm**



4X5-10 A/ES-IND **3550rpm**



4X5-10 A/ES-IND **1780rpm**

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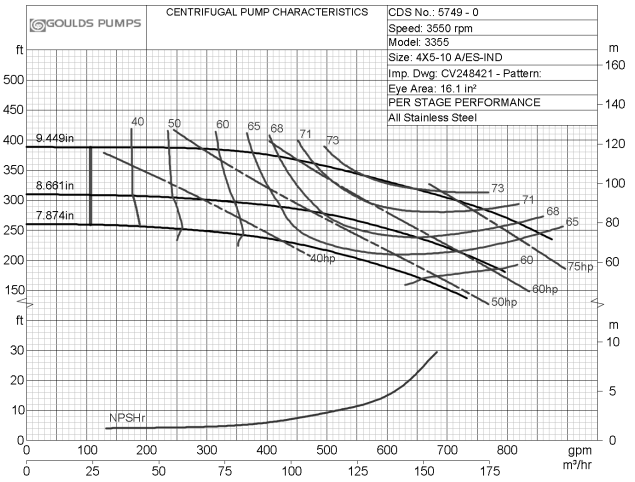
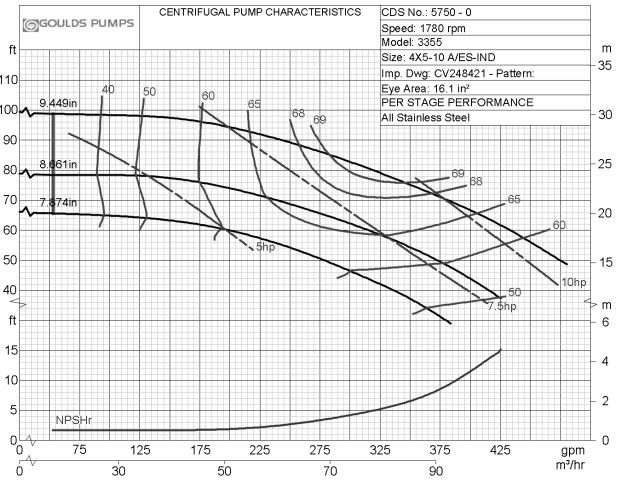
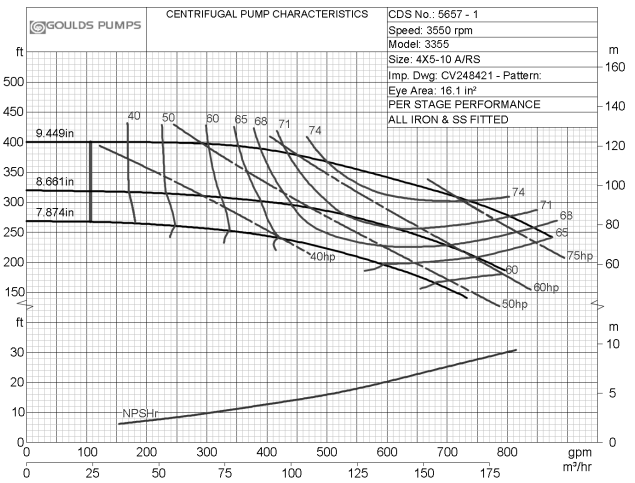


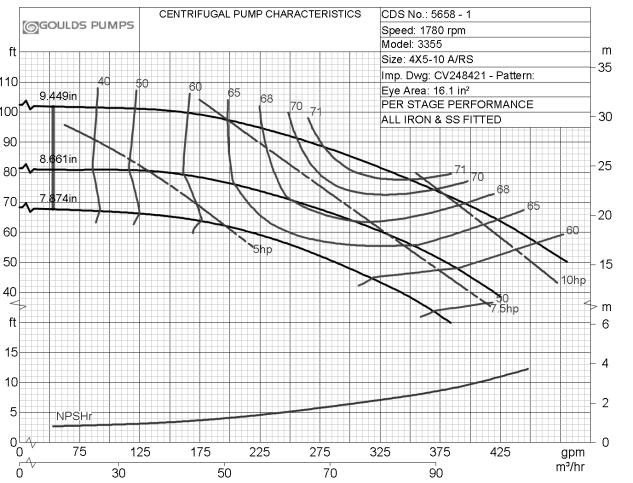
4X5-10 A/ES-IND **3550rpm**



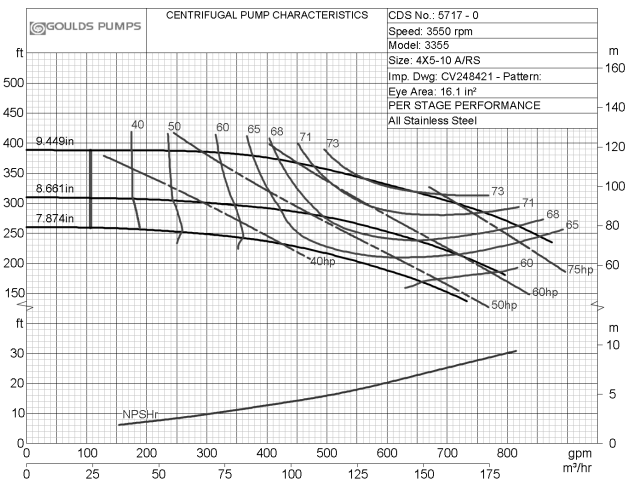
4X5-10 A/ES-IND **1780rpm**



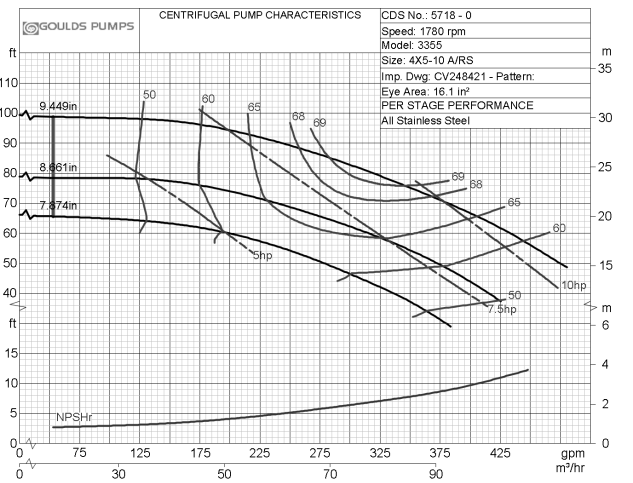
4X5-10 A/RS **3550rpm**



4X5-10 A/RS **1780rpm**



4X5-10 A/RS **3550rpm**



4X5-10 A/RS **1780rpm**

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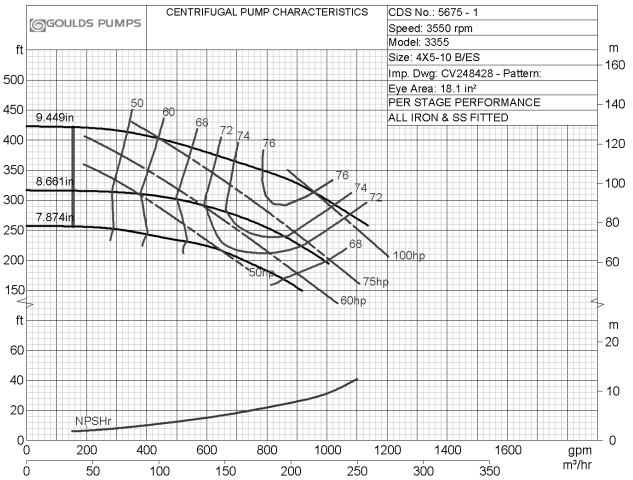
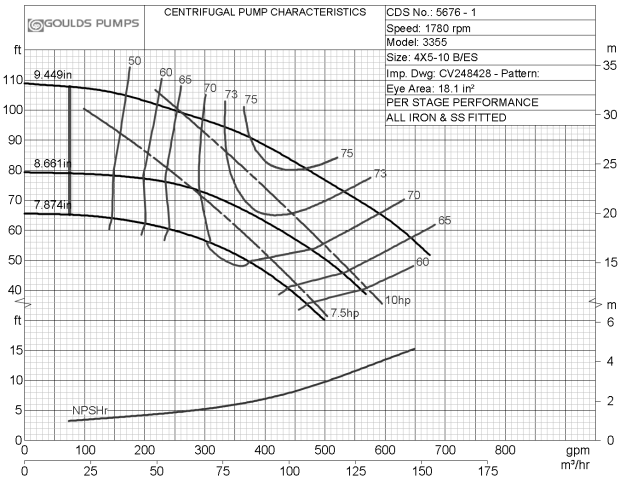
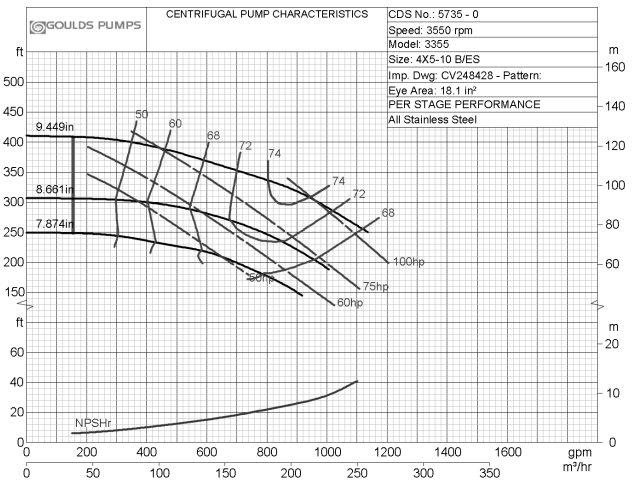


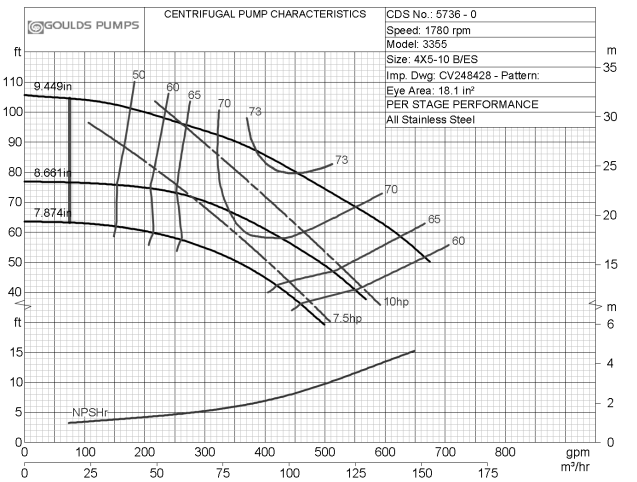
4X5-10 B/ES **3550rpm**



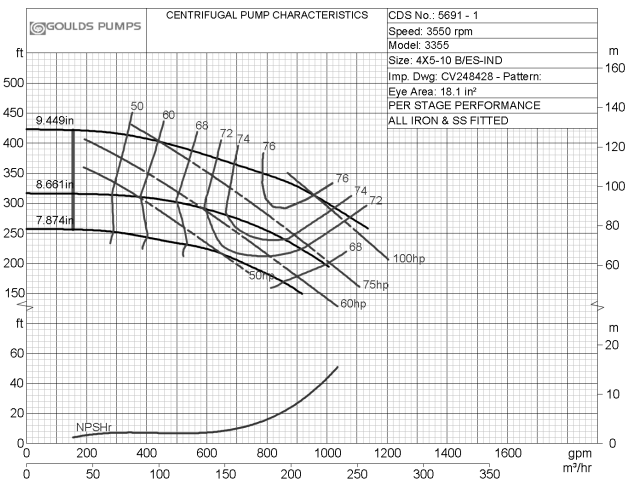
4X5-10 B/ES **1780rpm**



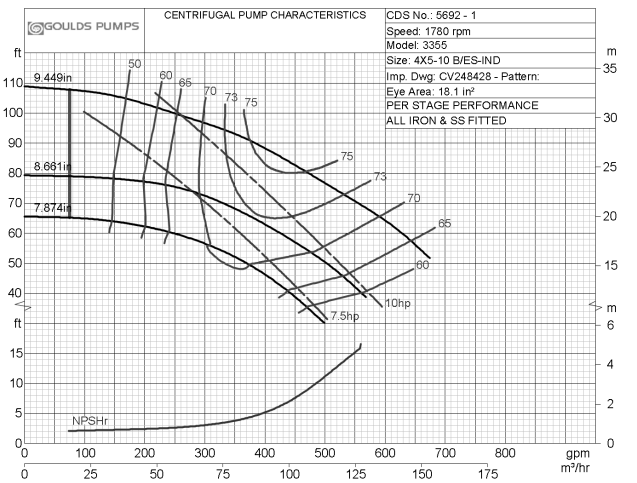
4X5-10 B/ES **3550rpm**



4X5-10 B/ES **1780rpm**



4X5-10 B/ES-IND **3550rpm**



4X5-10 B/ES-IND **1780rpm**

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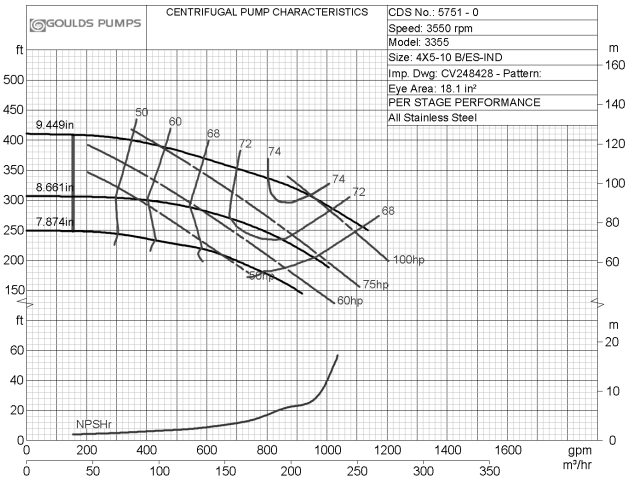
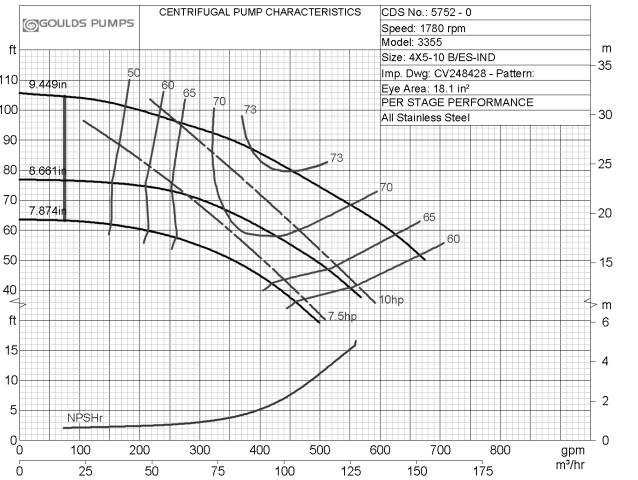
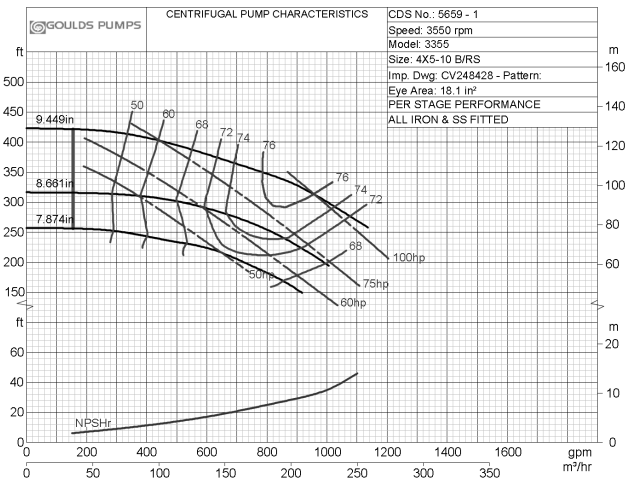


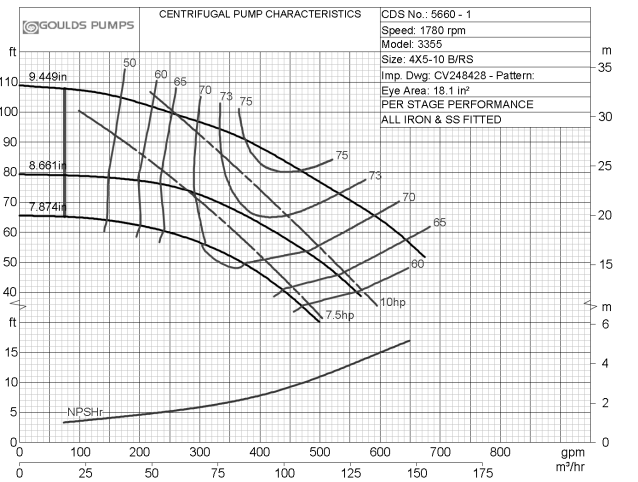
4X5-10 B/ES-IND **3550rpm**



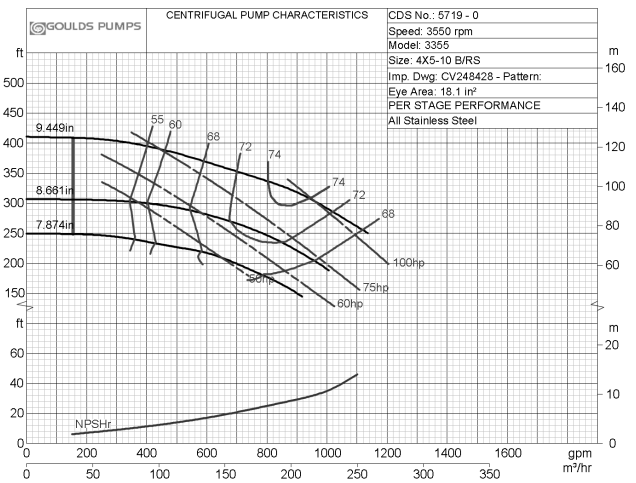
4X5-10 B/ES-IND **1780rpm**



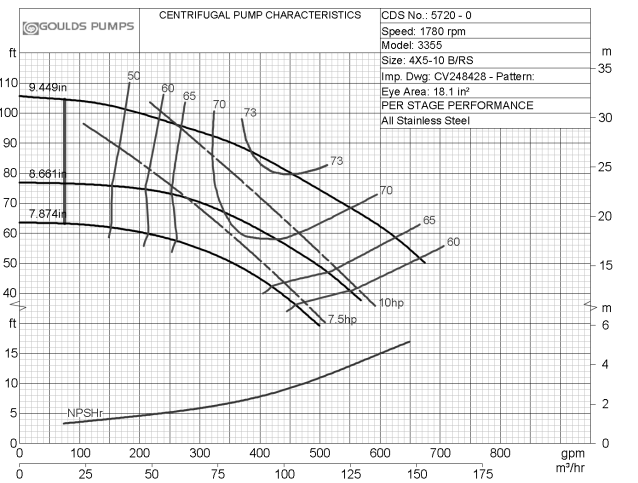
4X5-10 B/RS **3550rpm**



4X5-10 B/RS **1780rpm**



4X5-10 B/RS **3550rpm**



4X5-10 B/RS **1780rpm**

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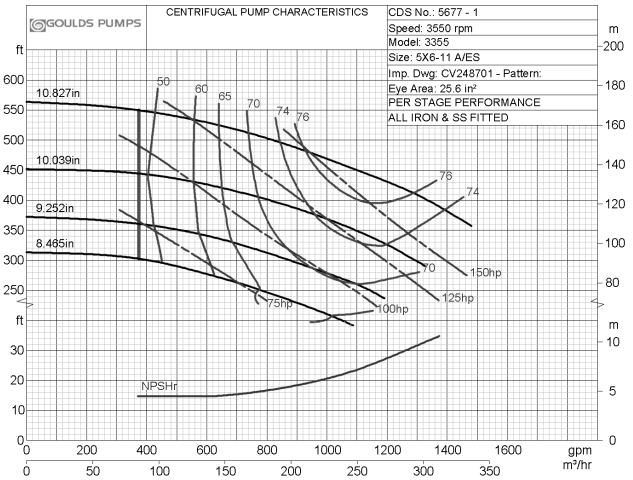
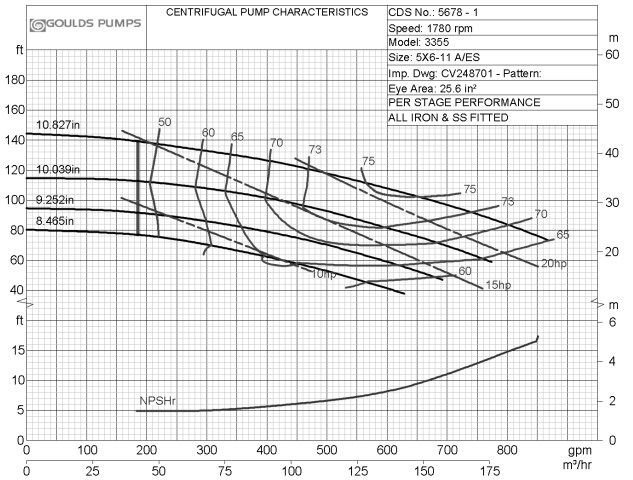
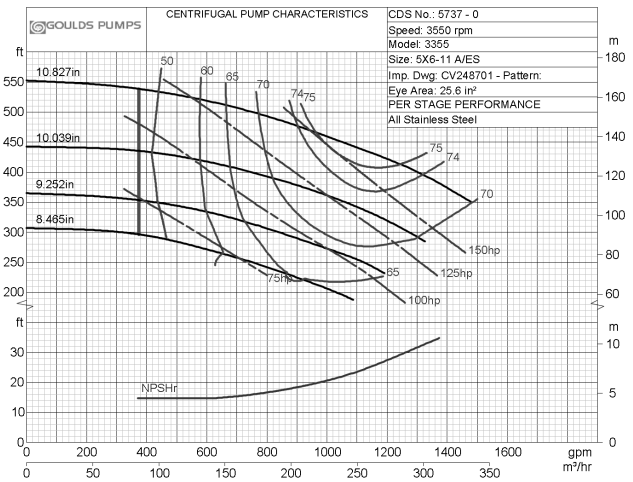


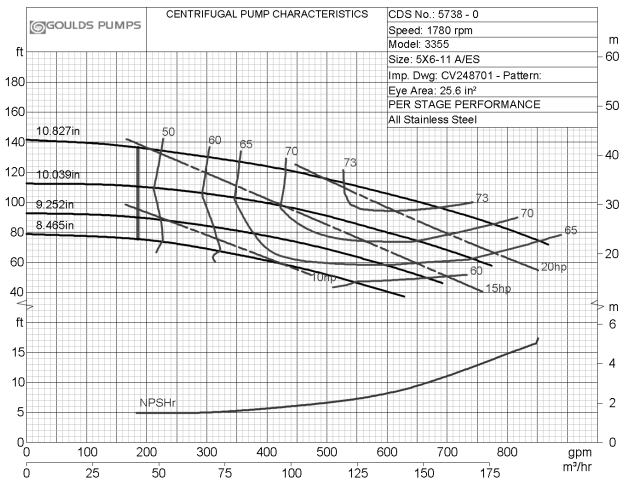
5X6-11 A/ES **3550rpm**



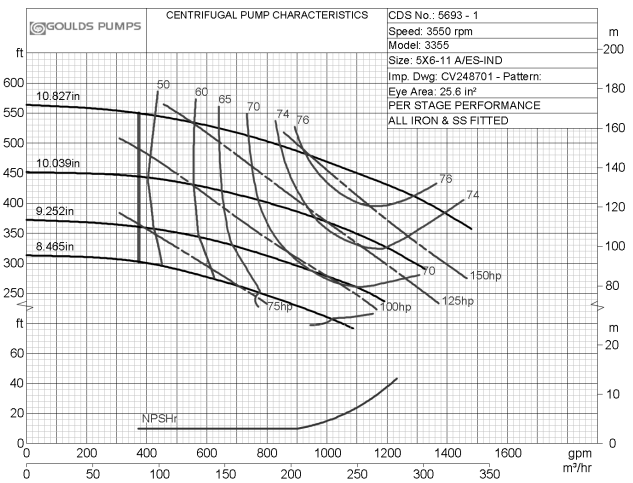
5X6-11 A/ES **1780rpm**



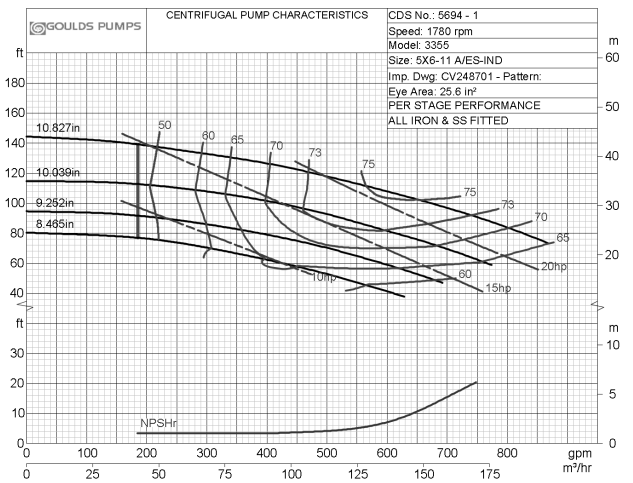
5X6-11 A/ES **3550rpm**



5X6-11 A/ES **1780rpm**



5X6-11 A/ES-IND **3550rpm**

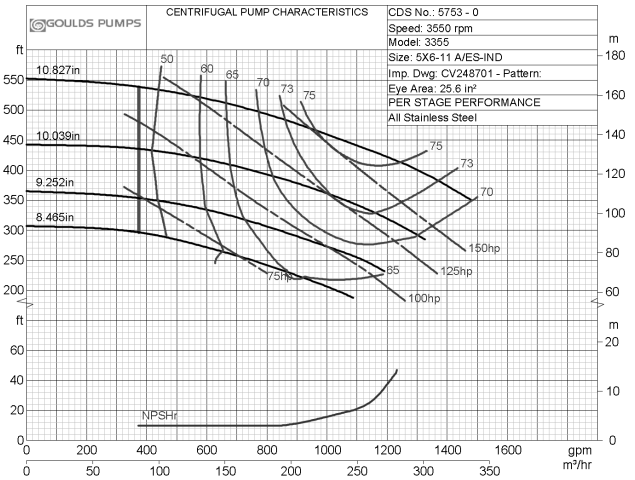


5X6-11 A/ES-IND **1780rpm**

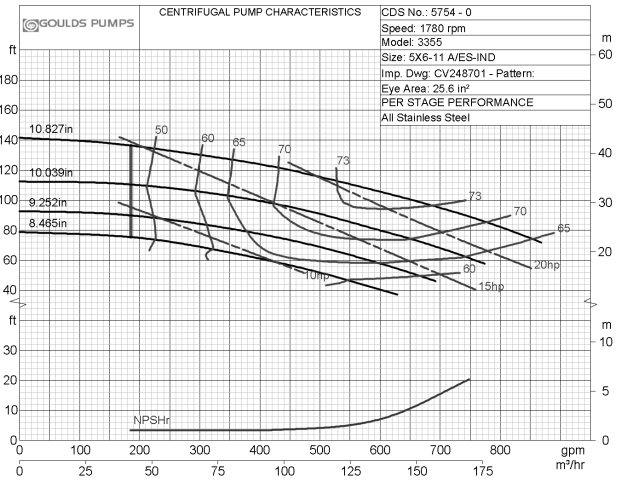
60Hz Curves

Model 3355

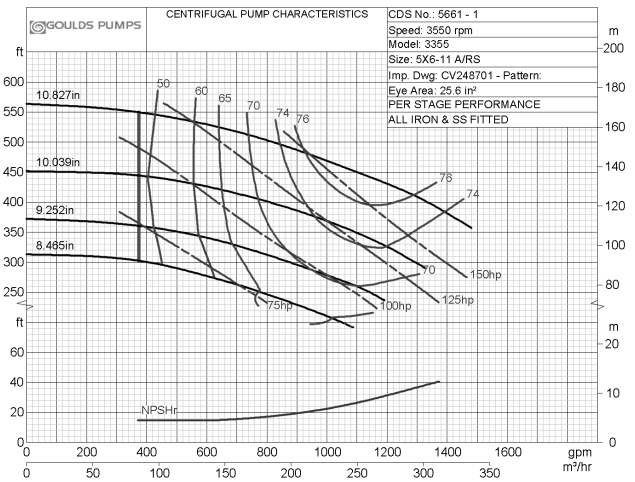
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



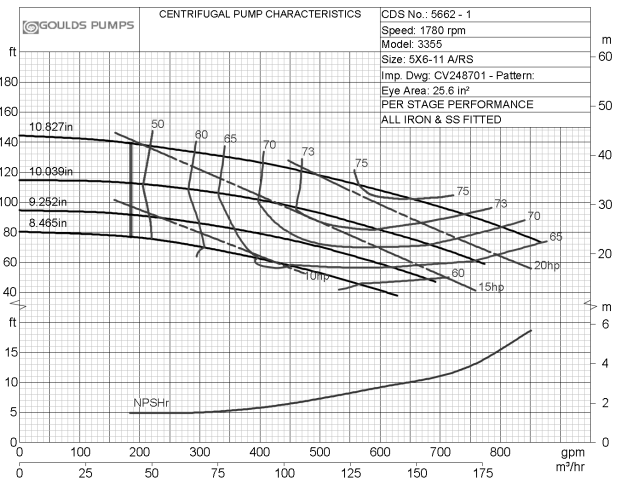
5X6-11 A/ES-IND **3550rpm**



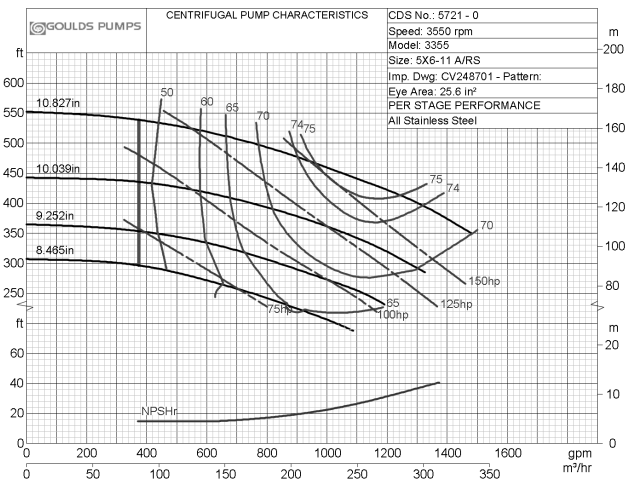
5X6-11 A/ES-IND **1780rpm**



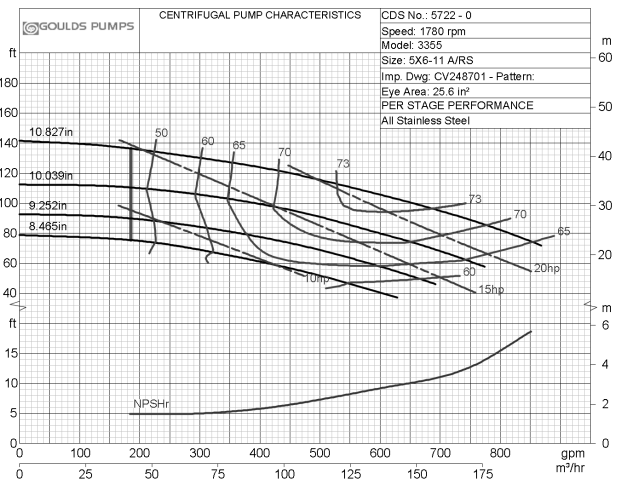
5X6-11 A/RS **3550rpm**



5X6-11 A/RS **1780rpm**



5X6-11 A/RS **3550rpm**



5X6-11 A/RS **1780rpm**

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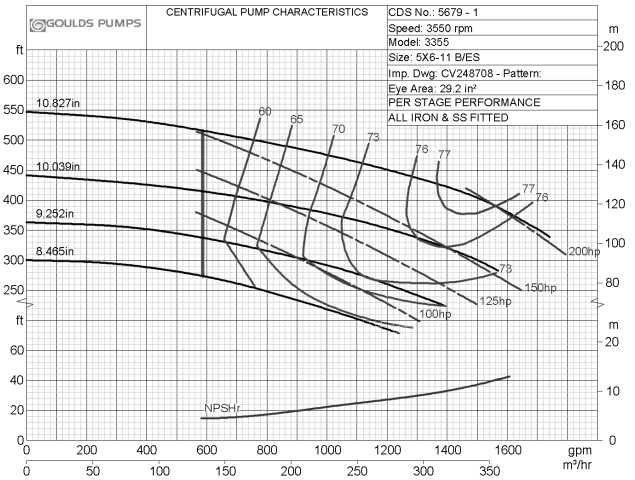
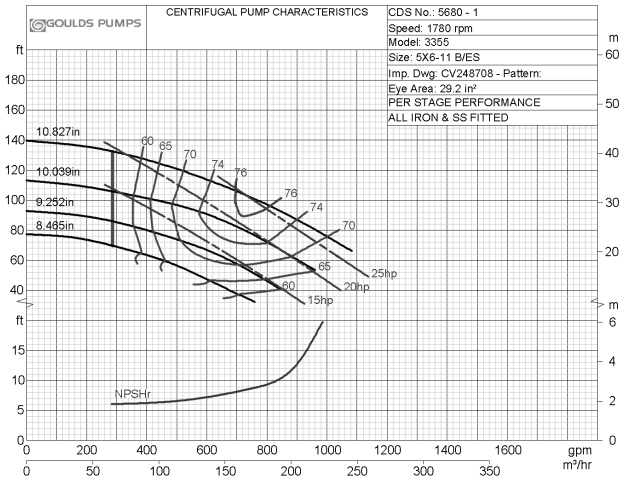
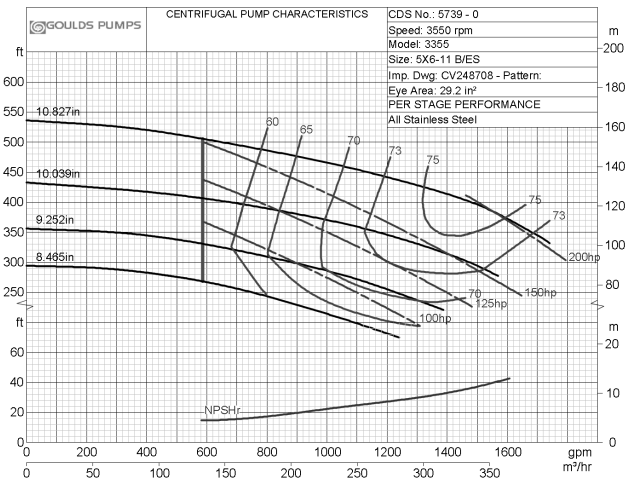


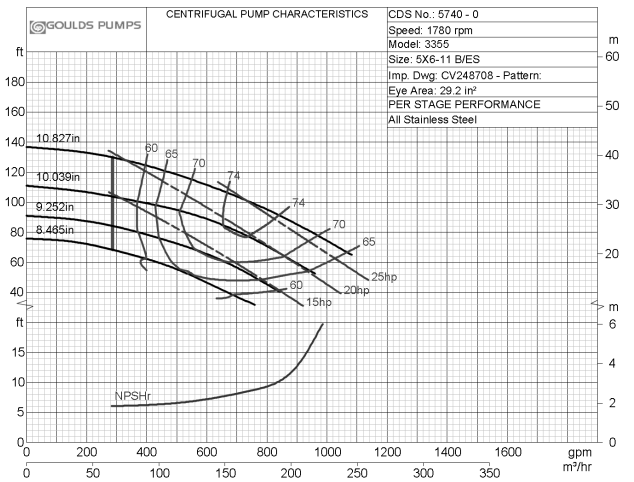
5X6-11 B/ES **3550rpm**



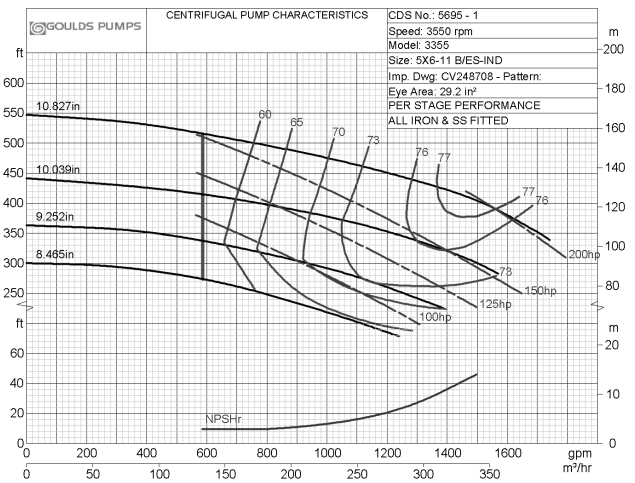
5X6-11 B/ES **1780rpm**



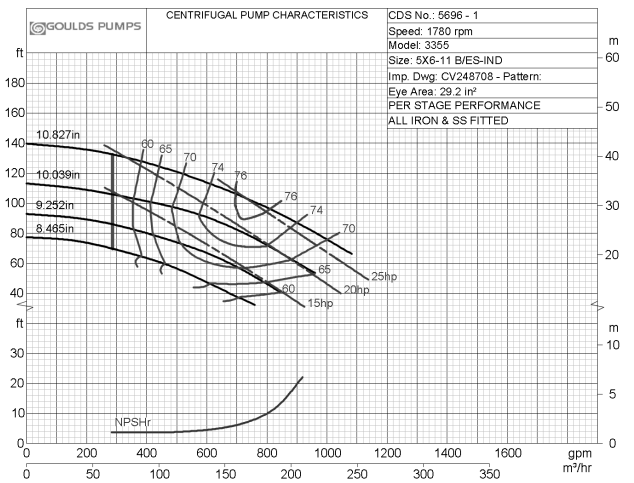
5X6-11 B/ES **3550rpm**



5X6-11 B/ES **1780rpm**



5X6-11 B/ES-IND **3550rpm**



5X6-11 B/ES-IND **1780rpm**

60Hz Curves

Model 3355

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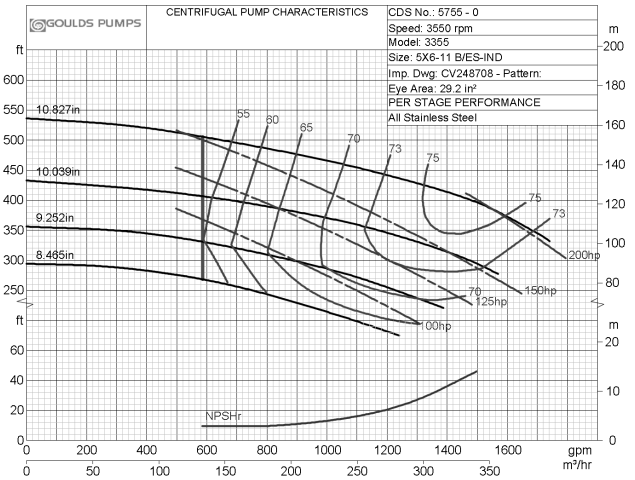
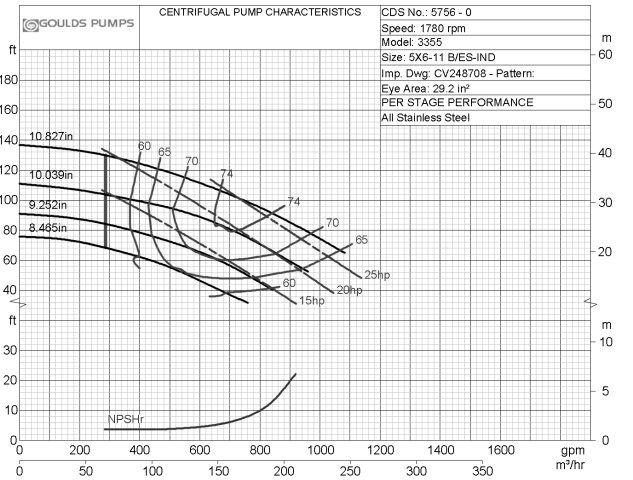
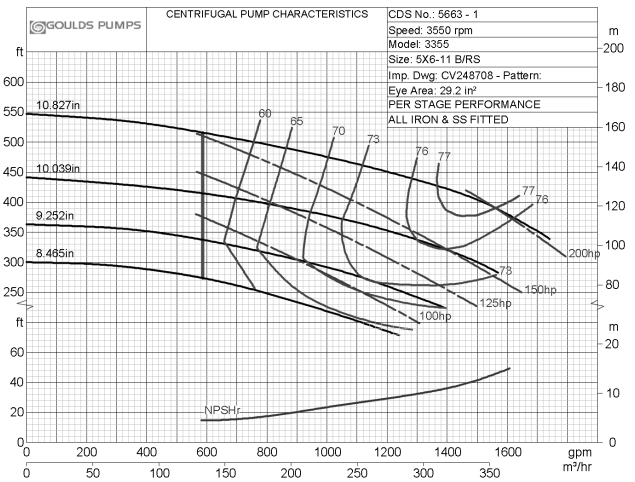


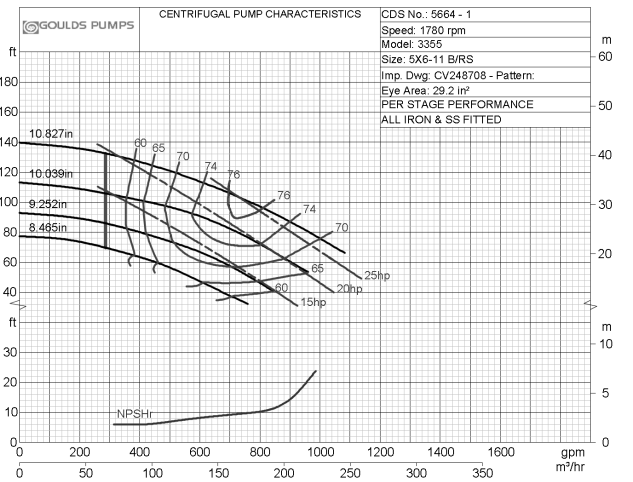
5X6-11 B/ES-IND **3550rpm**



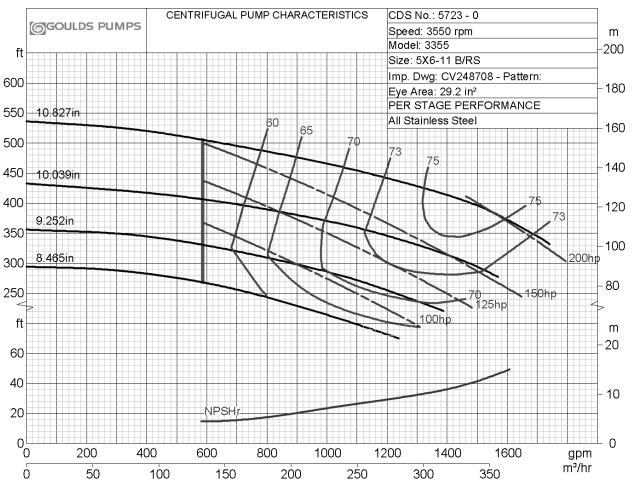
5X6-11 B/ES-IND **1780rpm**



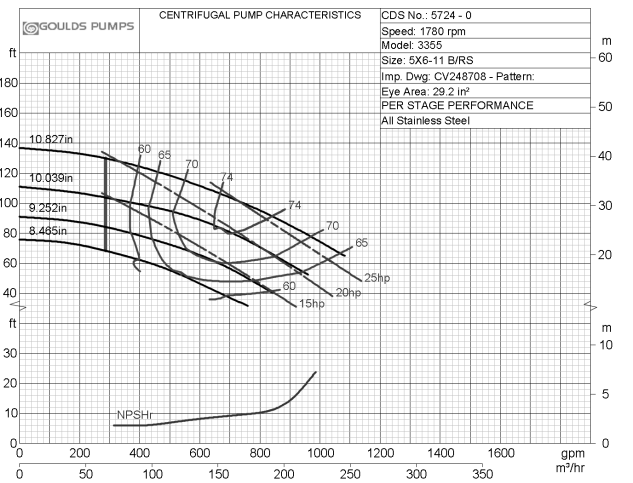
5X6-11 B/RS **3550rpm**



5X6-11 B/RS **1780rpm**



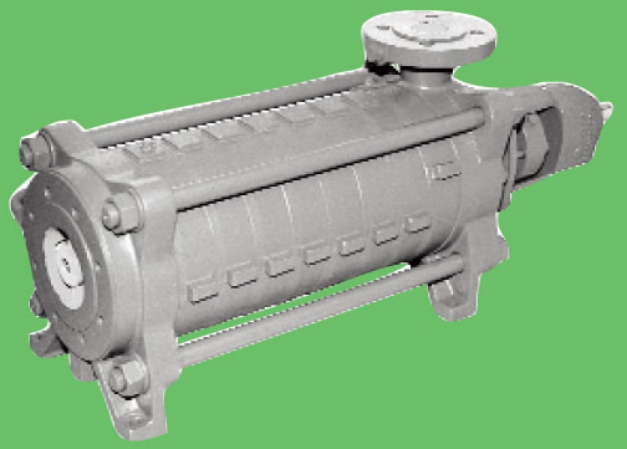
5X6-11 B/RS **3550rpm**



5X6-11 B/RS **1780rpm**

NOTES

NOTES



Goulds Model 3311

Multi-Stage Pumps Designed for a Wide Range of High Pressure Services

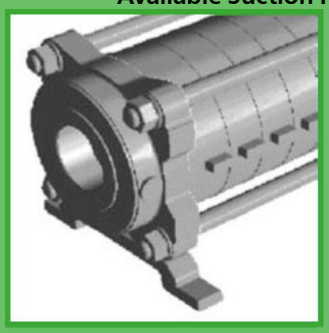
- Capacities to 1100 GPM (250 m3/hr)
- Heads to 5250 feet (1600 m)
- Temperatures to 356° F (180°C)
- Pressures to 2320 psig(160 bar)

- **3 Sizes**

Goulds Model 3311 is a radial split, segmented ring multi-stage pump... a proven state-of-the-art design for the most demanding high pressure services. The modular design and parts interchangeability reduce maintenance and inventory costs. Compact size and flexible nozzle positions reduce space and piping costs. High reliability, optimum efficiency, and simplified maintenance combined with low first cost and low operating costs make the 3311 a true world class pump.

Discharge Flange Orientation

Available Suction Flange Orientations



Design Features

High Efficiency Performance is achieved by utilizing multiple hydraulics for each pump size. Reduce running costs by operating in the best efficiency range.

Modular Design permits option flexibility, reduces lead-times, and maximizes interchangeability. Spare parts inventory is reduced.

Ease of Maintenance is assured as roller bearings, mechanical seal, and balance device can be serviced without disturbing piping or driver.

Balance Drum/Disc Combination balances axial thrust over the full range of performance.

Rotating Element is dynamically balanced after individual balancing of the impellers. First critical speed is always above maximum operating speed.

Multiple Nozzle Orientations to fit your piping configurations.

Services

Cogeneration
Boiler Feed
Shower
Pressure Boosting
High Pressure Cleaning
Mine De-watering

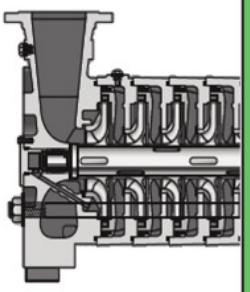
Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3311 High Pressure Multi-Stage Pumps

Rugged Design Features for a Wide Range of Services

RADIAL SUCTION CASING WITH PRODUCT LUBRICATIED BEARING

Suction Flange is located over pump foot to maximize nozzle load capacities.

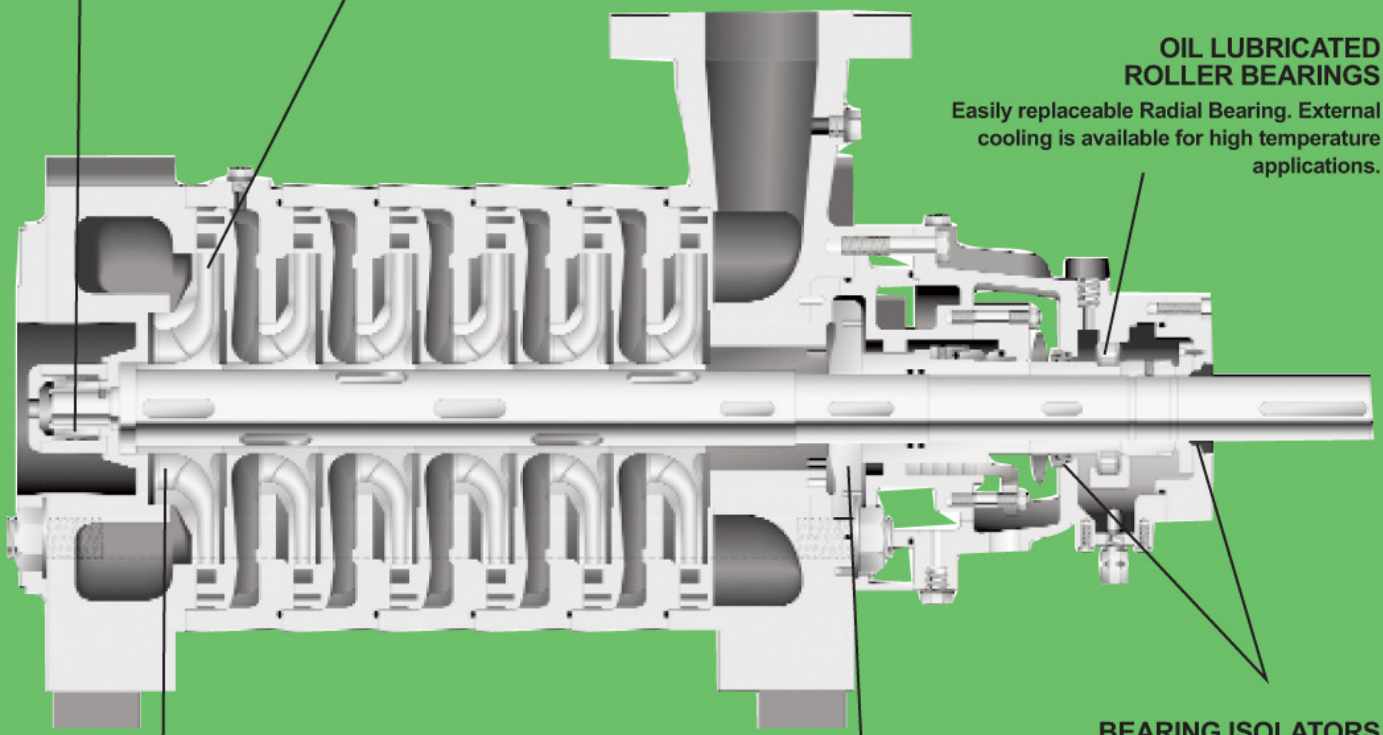


PRODUCT LUBRICATED BEARINGS

Self-aligning bearing for greater reliability.

HIGH EFFICIENCY HYDRAULICS

Multiple impellers and diffusers for each pump size optimizes efficiency for given conditions of service.



OIL LUBRICATED ROLLER BEARINGS

Easily replaceable Radial Bearing. External cooling is available for high temperature applications.

BEARING ISOLATORS

Extends bearing life by providing maximum bearing protection.

SUCTION IMPELLER

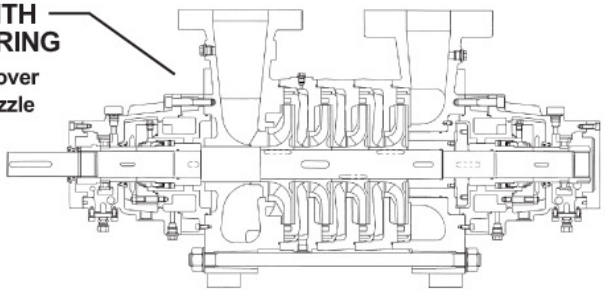
First stage suction impeller is designed with a large eye area to provide reliable operation in low NPSHA applications.

COMBINED BALANCE DRUM AND DISC

Axial thrust balancing is provided over the entire operating range.

RADIAL SUCTION WITH ANTI-FRICTION BEARING

Suction Flange is located over pump foot to maximize nozzle load capacities.



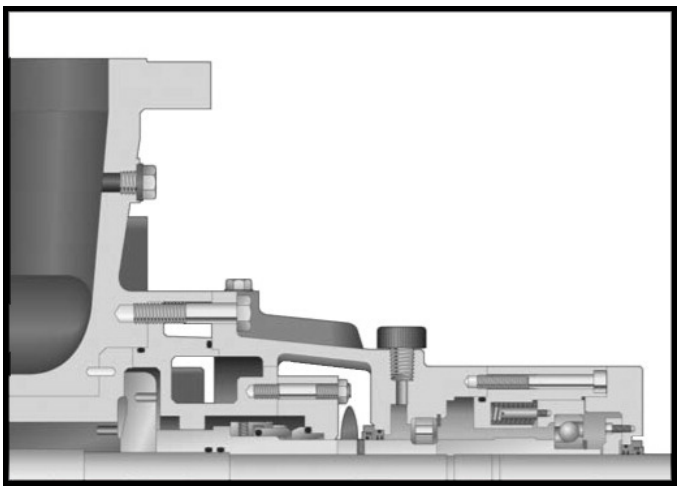
EASE OF MAINTENANCE

Service bearings, mechanical seal, and balance device without disturbing piping.

Other Features For Application Flexibility

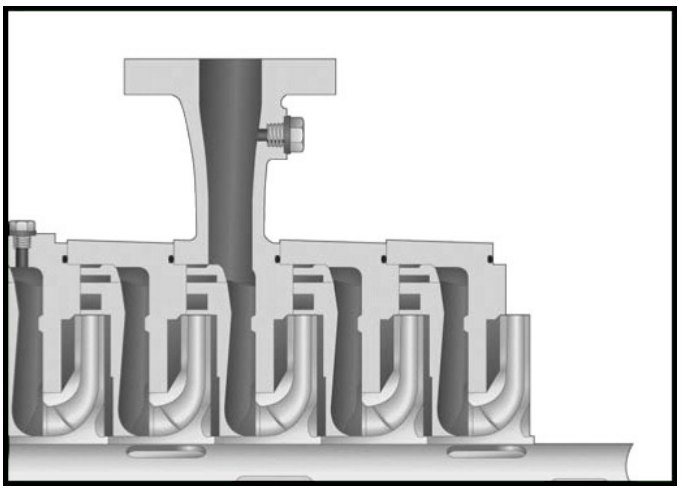
Balance Disc Lift-Off Device

Assures positive separation of balance disc for slow roll turning gear during low speed operation with variable speed drivers or services that require frequent daily starts.



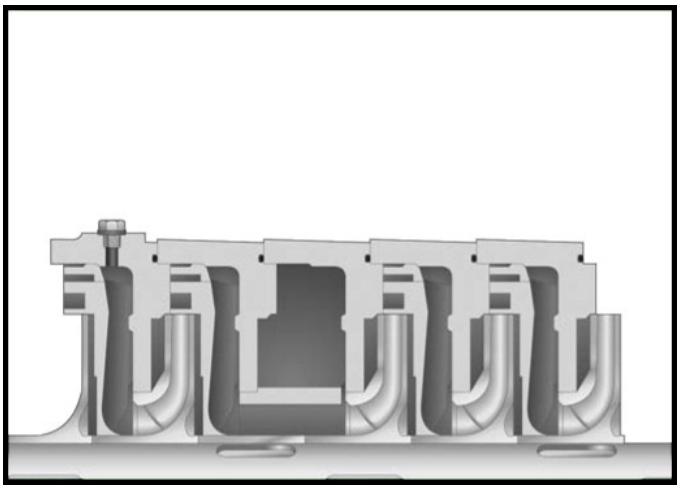
Interstage Bleed-Off

Connection can be provided for intermediate flow rates and pressures at any radial position between the tie bolts.



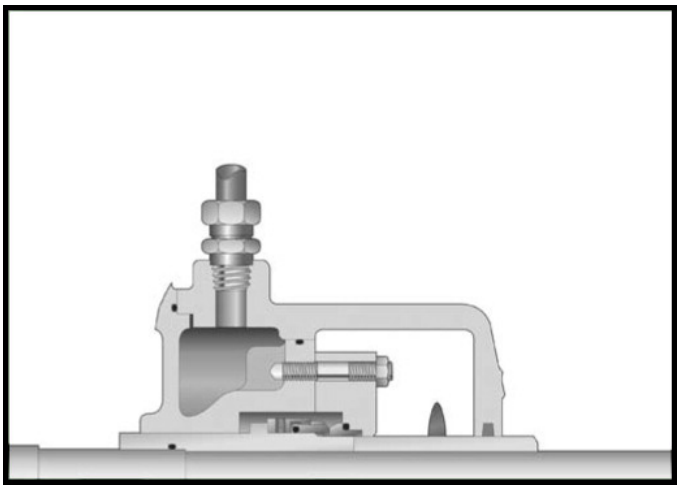
Destaging Device

Provides for future discharge pressure requirements - destaging parts can be easily replaced with active stage for higher pressure demand. No change to suction and discharge piping locations is required.



Seal Cooling Chamber

Seal cooling for high temperature services. In addition, a wide variety of mechanical seal piping plans are available.

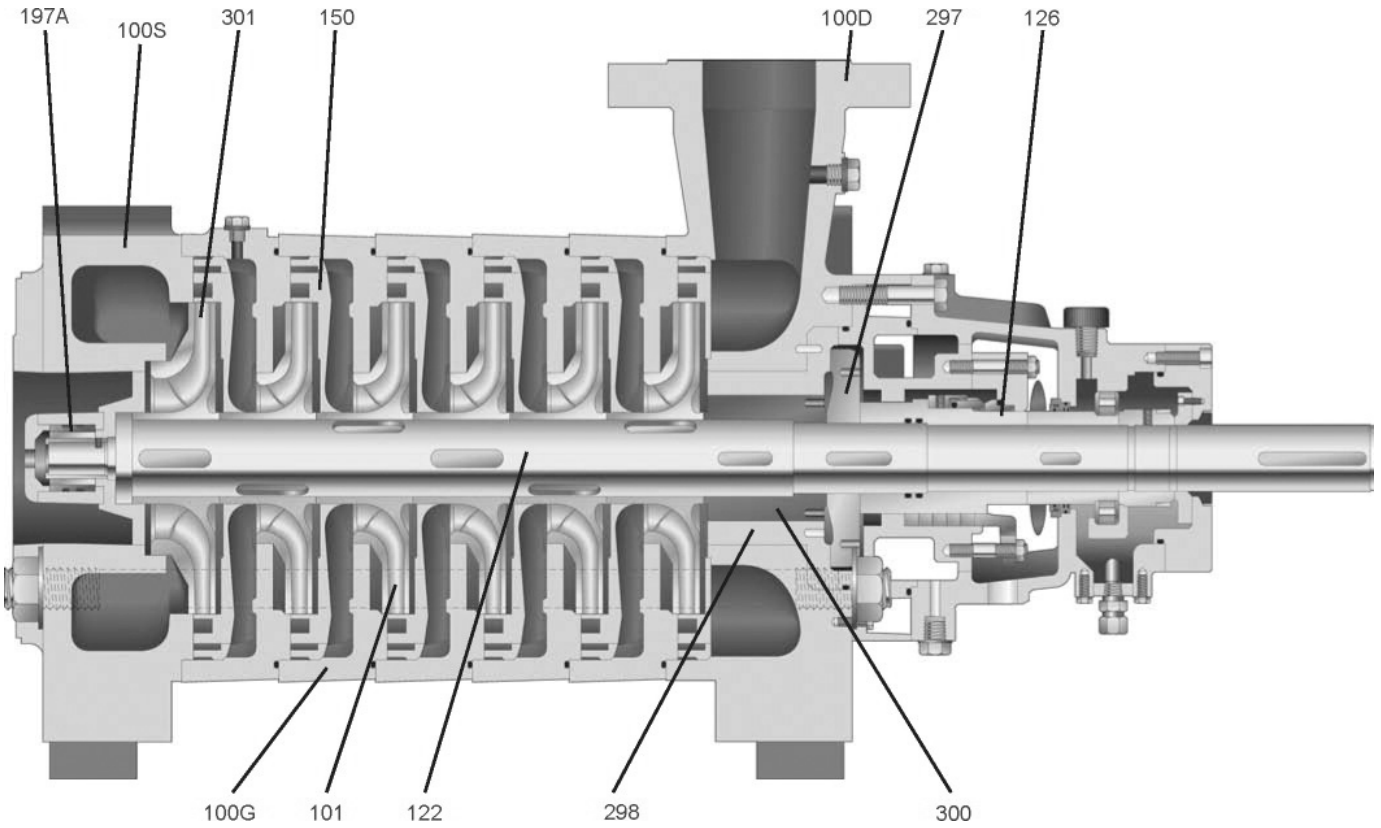


Construction Details

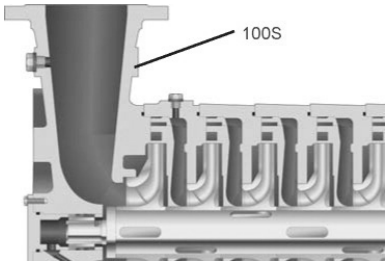
		English			Metric		
	Pump Size ►	2×3-7	2.5×4-8	4×5-11	2×3-7	2.5×4-8	4×5-11
Pump/Casing	Wt. - 3 Stage Pump - Lbs, kg	401	774	1069	182	351	485
	Wt. - Ea. Add'l Stage - Lbs, kg	13	24	42	6	11	19
	Min. Wall Thickness - in, mm	0.49	0.49	0.59	12.5	12.5	15
	Max. Allowable Suction Pressure	232 psi			16 bar		
	Max. Allowable Temperature	356° F			180° C		
	Max. Allowable Working Pressure	2320 psi			160 bar		
Stuffing Box	Stuffing Box Bore - in, mm	2.83	3.94	5.12	72	100	130
	Stuffing Box Depth - in, mm	1.81	2.17	2.68	46	55	68
	Packing Size - in, mm	0.39	0.39	0.49	10	10	12.5
	Packing ID/OD - in, mm	2.05/2.83	3.15/3.94	4.13/5.12	52/72	80/100	105/130
	No. of Packing Rings Ea. Stuffing Box	4	5	5	4	5	5
	Dia. Of Shaft Sleeve (pkg) - in, mm	1.77	2.76	3.74	45	70	95
Shaft/Bearings	Dia. Of Shaft at Impeller - in, mm	1.42	1.89	2.60	36	48	66
	Dia. Of Shaft at Sleeve - in, mm	1.18	1.65	2.32	30	42	59
	Dia. Of Shaft at Bearings - in, mm	1.77	2.17	2.95	45	55	75
	Dia. Of Shaft at Coupling - in, mm	1.10	1.50	2.20	28	38	56
	Max. (BHP, kW) per 100 RPM	5.36	20.12	44.25	4	15	33
	Bearing - Inboard	NU 1009	NU 1011	NU 1015	NU 1009	NU 1011	NU 1015
	Bearing - Outboard*	NU 1009	NU 1011	NU 1015	NU 1009	NU 1011	NU 1015

* Pumps with product lubricated bearing utilize a Silicon Carbide bearing.

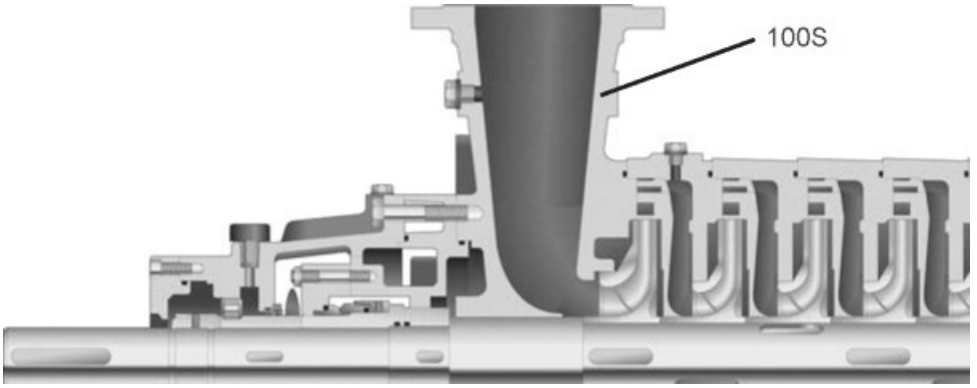
Sectional View Model 3311



End Suction



Radial Suction with Product Lubricated Bearing

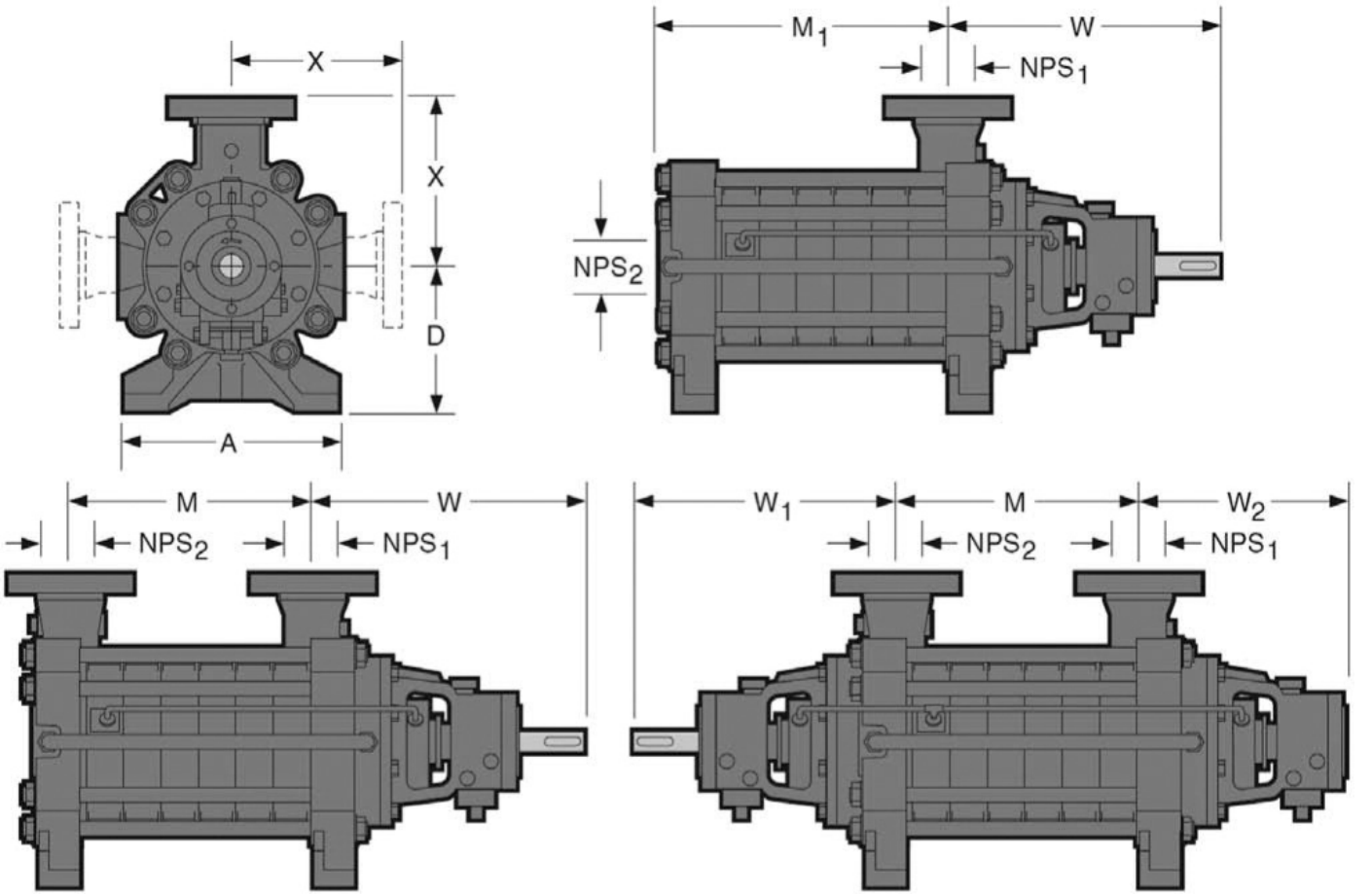


Radial Suction

Parts List and Materials of Construction

Part No.	Part Name	DIN Standard		ASTM Equivalent	
		Chrome Steel/ Cast Iron	All Chrome	Chrome Steel/Cast Iron	All Chrome
100D	Casing, Discharge	G-X8CrNi 13	G-X8CrNi 13	A743 CA-15	A743 CA-15
100G	Casing, Stage	G-X8CrNi 13	G-X8CrNi 13	A743 CA-15	A743 CA-15
100S	Casing,Suction	G-X8CrNi13	G-X8CrNi13	A743CA-15	A743CA-15
101	Impeller	GG-25	B-X2CrNiMo 1810	A48 Cl. 40B	A351 CF-3MN
301	Suction Impeller	B-X2CrNiMo 18 10	B-X2CrNiMo 18 10	A351 CF-3MN	A351 CF-3MN
122	Shaft	X4CrNi 13 4	X4CrNi 13 4	A473 410	A473 410
150	Diffuser	GG-25	B-X2CrNiMo 18 10	A48 Cl. 40B	A351 CF-3MN
126	Shaft Sleeve	X35CrMo17	X35CrMo17	17% Chr	17% Chr
197A	Product Lube Sleeve Bearing	Silicon Carbide	Silicon Carbide	Silicon Carbide	Silicon Carbide
297	Balance Disc	X46Cr13	X46Cr13	13% Chr	13% Chr
298	Balance Counter Disc	G-X170Cr18	G-X170Cr18	18% Chr	18% Chr
300	Balance Drum	X20Cr13	X20Cr13	A276 Gr. 420	A276 Gr.420

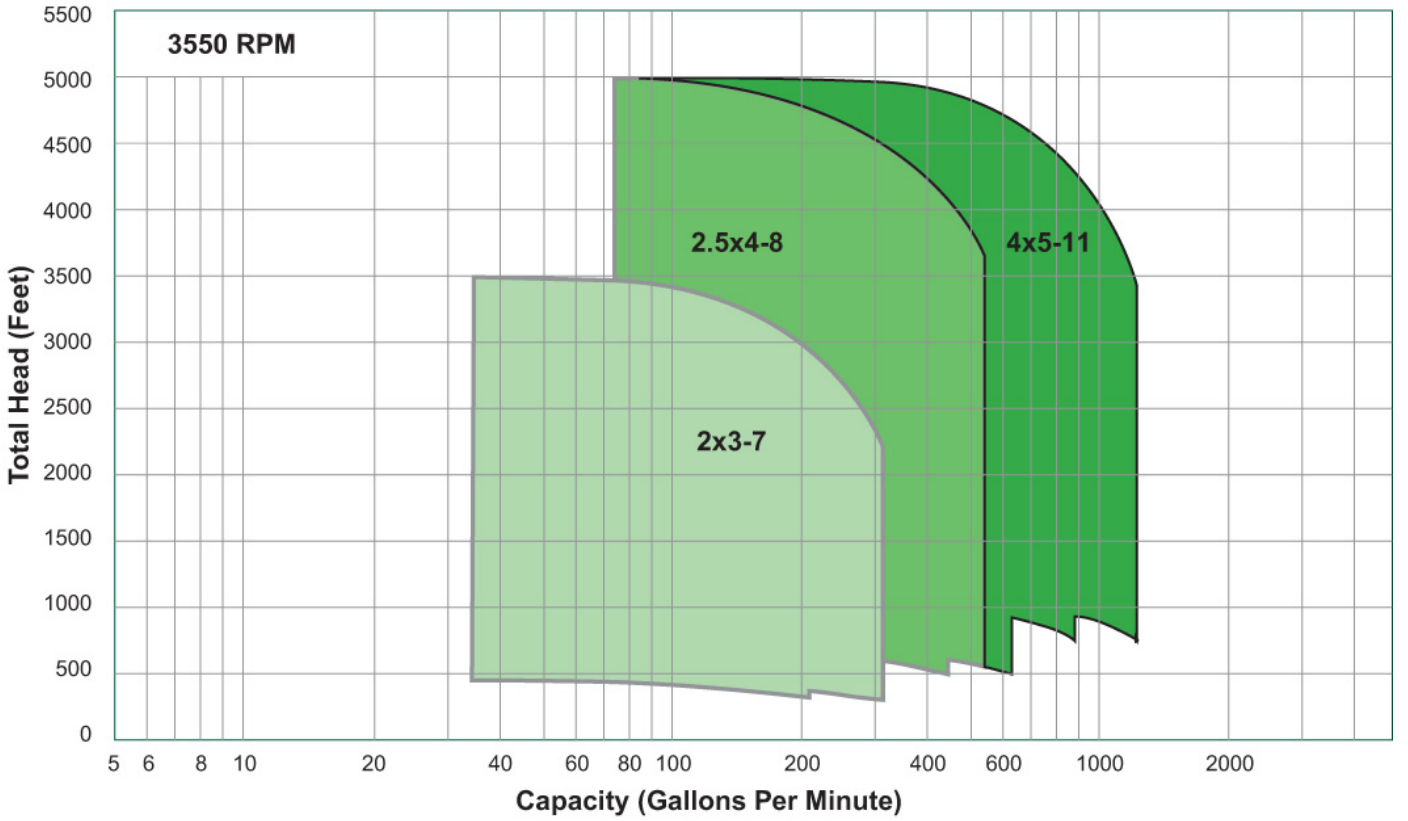
Dimensions Model 3311



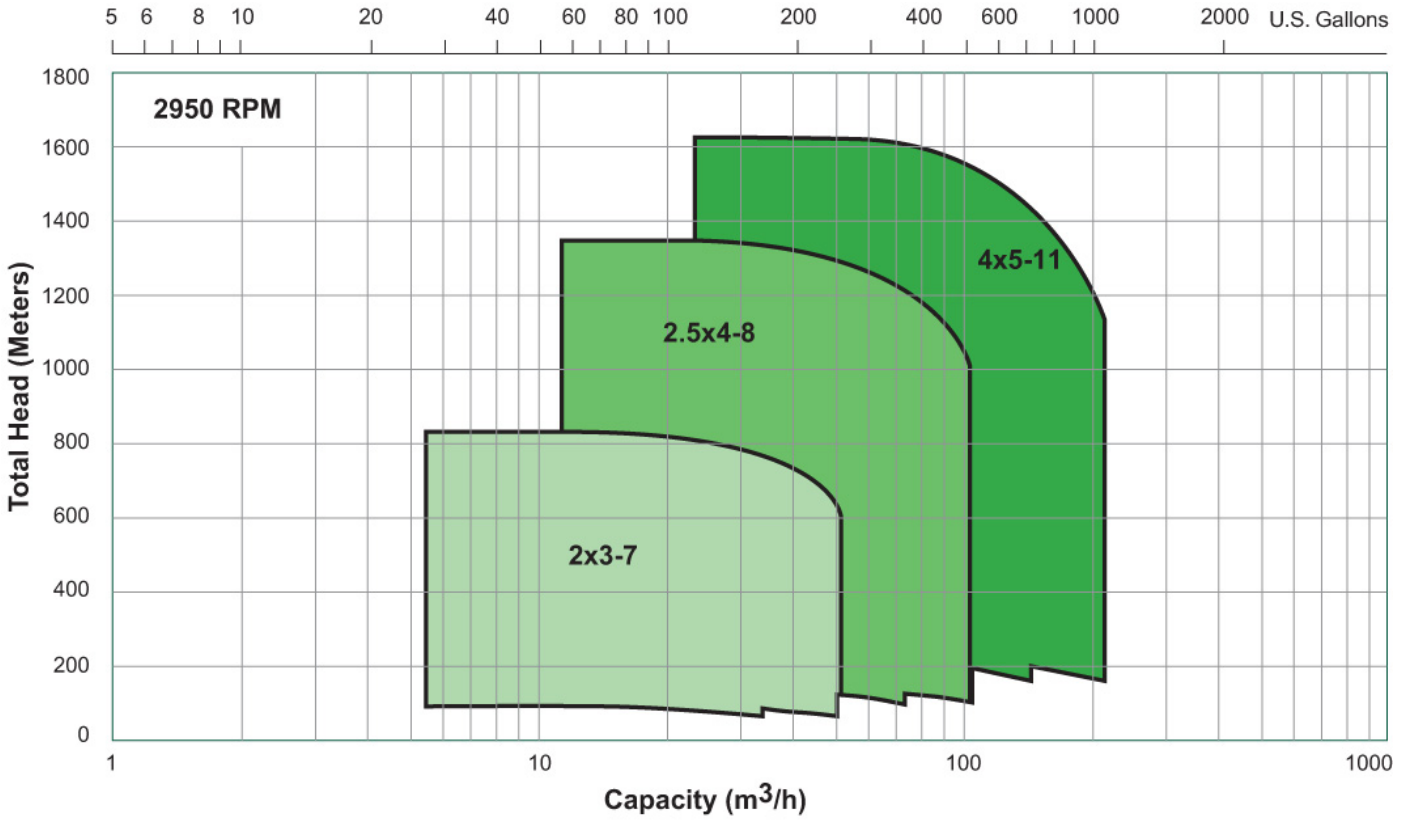
DIMENSIONS - (All dimensions in English)

Pump Size	NPS 2 End Suction	NPS 2 Radial Suction	NPS 1	X	D	A	W	W 1	W 2	M 3-Stage	M 1 3-Stage	Each Add'l Stage M & M 1
2 × 3-7	4	3	2	9.65	7.28	13.19	17.13	17.52	13.07	8.27	9.06	2.17
2.5×4-8	5	4	2.5	11.81	10.04	14.96	19.37	19.21	14.72	10.63	12.99	2.76
4×5-11	6	5	4	13.58	11.02	14.96	21.26	20.71	15.20	13.39	15.75	3.35

Hydraulic Coverage Model 3311 60 Hz



Hydraulic Coverage Model 3311 50 Hz



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves .

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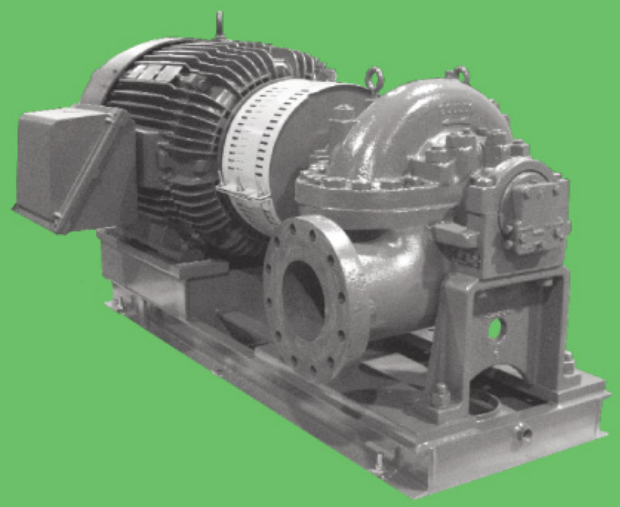
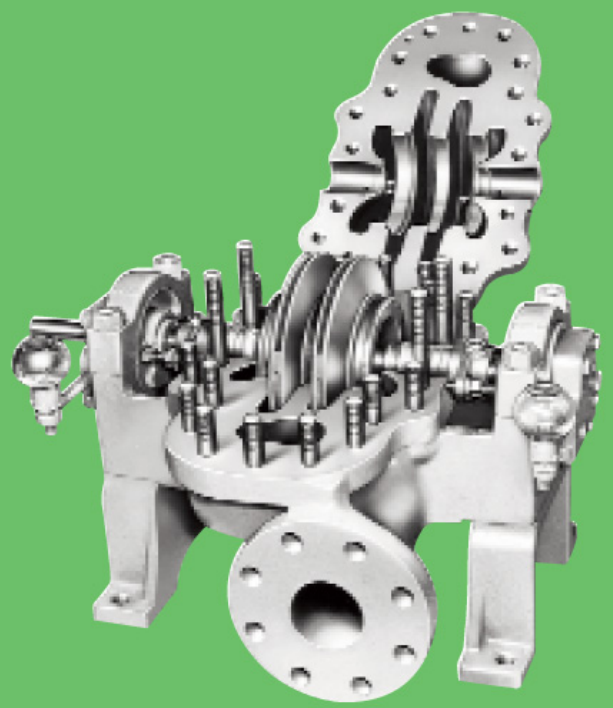


Goulds Model 3316

Two Stage, Horizontally Split Case Pumps Designed for Boiler Feed, Mine Dewatering and other Applications Requiring Moderately High Heads with a Wide Range of Service Conditions

- Capacities to 3000 GPM (681 m^3/h)
- Heads to 1000 feet (305 m)
- Temperatures to 350°F (177°C)
- Pressures to 550 PSIG (3792 kPa)



Design Features

- **Casing** Removal of upper half permits inspection, maintenance or removal of rotating element without disturbing piping or pump-to-motor alignment.
- **Impellers** Opposed impellers provide axial balance. Opposed cut-waters provide radial balance.
- **Wear Rings** Case rings are easily replaced and protect against casing wear. Impeller rings are optional.
- **Maximum Interchangeability** Reduces inventory requirements.
- **Duplex Thrust Bearing** Provides high thrust capability.
- **Materials of Construction** Available in all iron, all bronze, or bronze fitted. Most sizes available in steel and stainless steel.

Applications

- Boiler Feed
- Mine Dewatering
- Booster
- High Pressure Process
- Condensate
- High Pressure Cleaning

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3316 Two Stage, Horiz. Split Case Pumps

Heavy Duty Design Features for Wide Range of Services

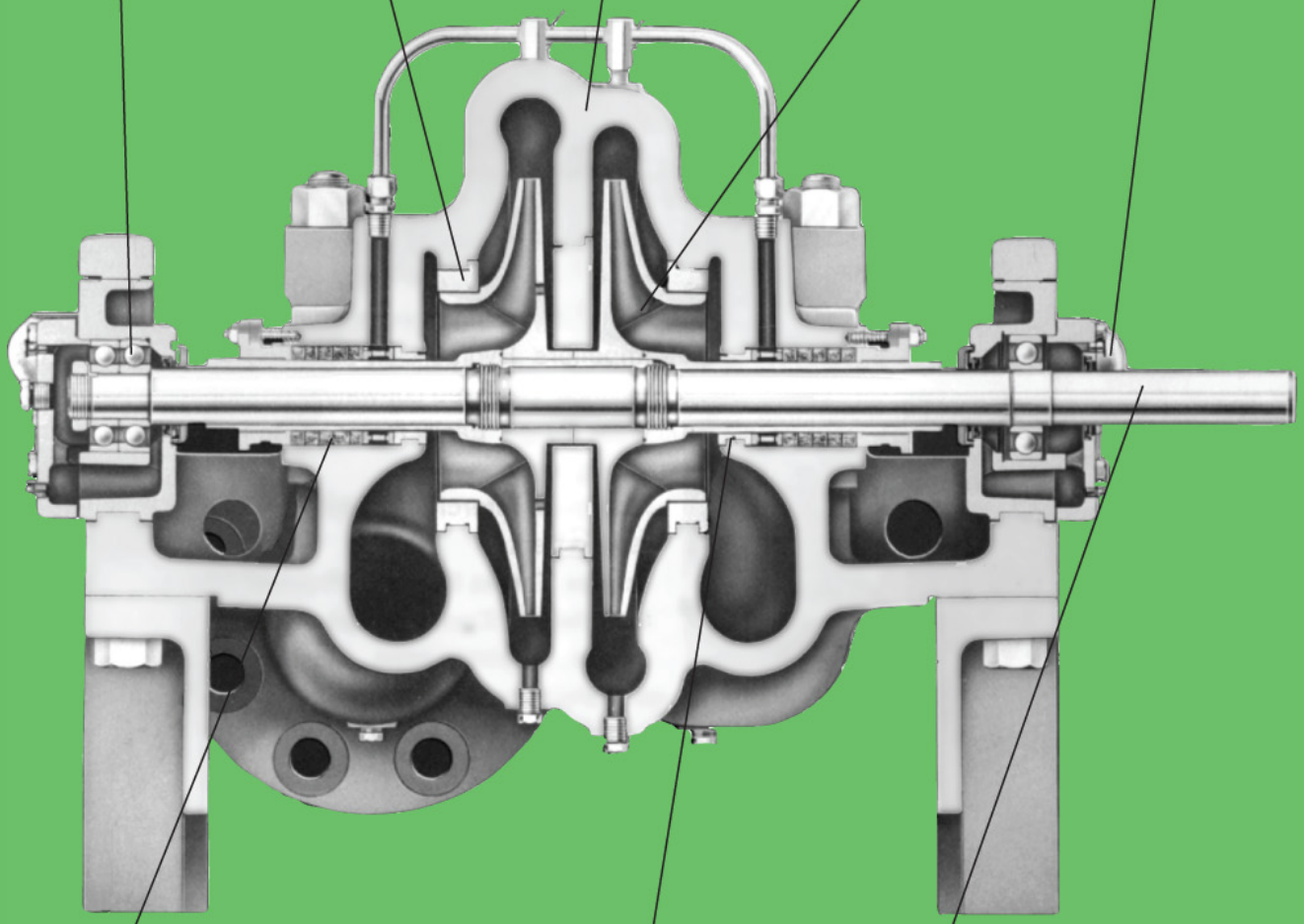
HIGH THRUST CAPABILITY
With duplex thrust bearing and shaft lock nut. Provides long trouble-free operation under the wide service conditions which these pumps are exposed.

RENEWABLE CASE WEAR RINGS
Permits easy maintenance of proper running clearances- protect against casing wear. Double lock in lower half casing to prevent rotation.

UPPER HALF CASING
Permits inspection, maintenance or removal of complete rotating element without disturbing piping or alignment.

HYDRAULICALLY BALANCED IMPELLERS
Axial thrust of one impeller is counterbalanced by the axial thrust of the other impeller. Opposed cutwaters balance radial reaction. Load on bearings is low.

OIL LUBRICATION STANDARD
Oil level maintained by constant level oiler. Sealed against containment. Grease and oil mist are available.



SHAFT SEALING FLEXIBILITY
Packed stuffing box or variety of mechanical seals available. Conversion of one to the other can be made in the field without machining. Equalizing piping keeps boxes at essentially suction pressure.

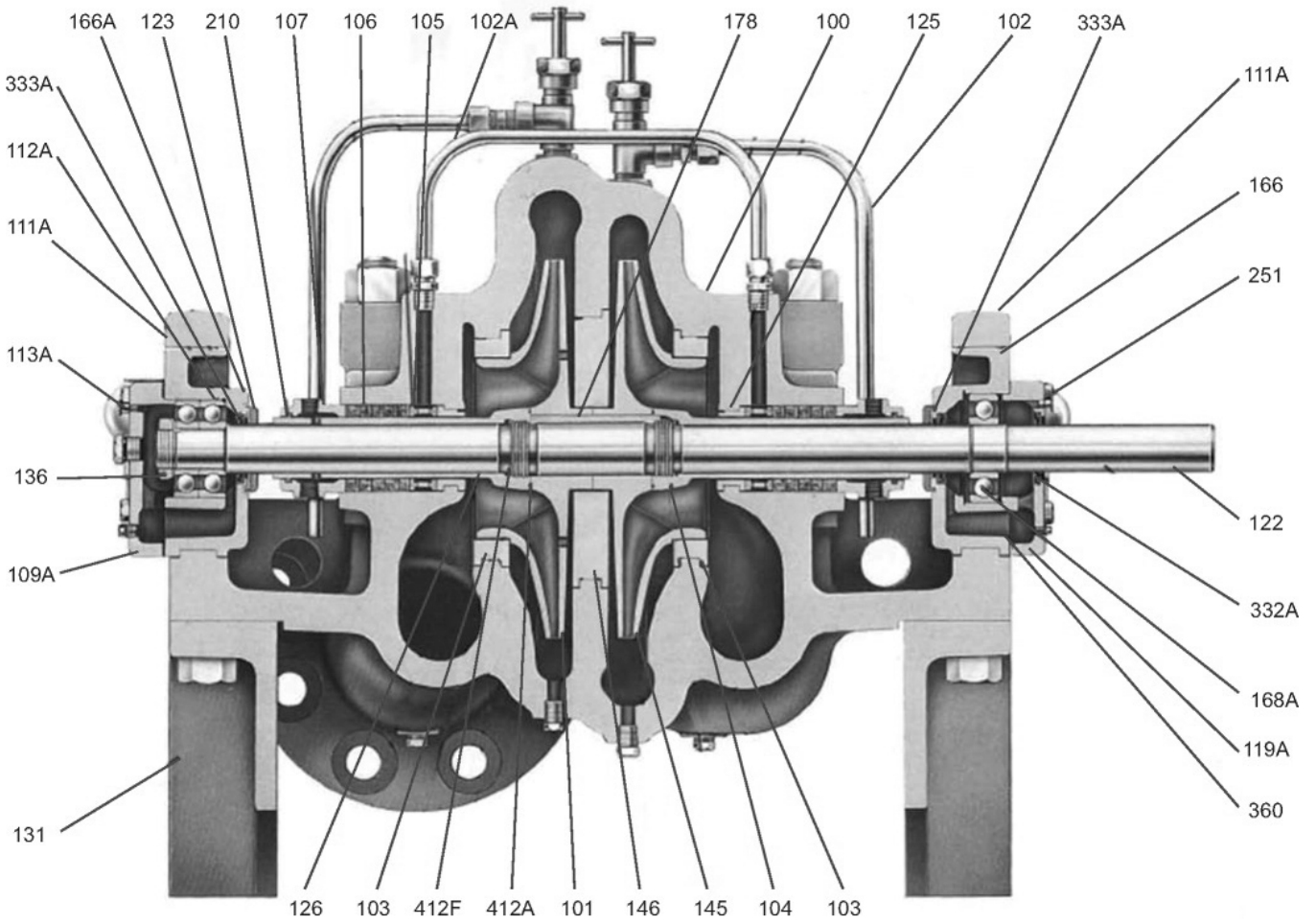
OPTIONAL IMPELLER WEAR RINGS
Can be mounted on impeller without additional machining of impeller. Locked on impeller hub with stainless steel set screws.

STUFFING BOX BUSHING
Limits stuffing box pressure. Protects casing from wear. Easily replaceable. Secured with double lock in lower half casing.

HEAVY DUTY SHAFT
Designed for toughest services. Renewable shaft sleeves fully protect shaft from pumpage.

MAXIMUM PARTS INTERCHANGEABILITY
Not only within the line but with Goulds Model 3405 single stage pumps. Keeps spare parts inventory to a minimum.

Sectional View Model 3316



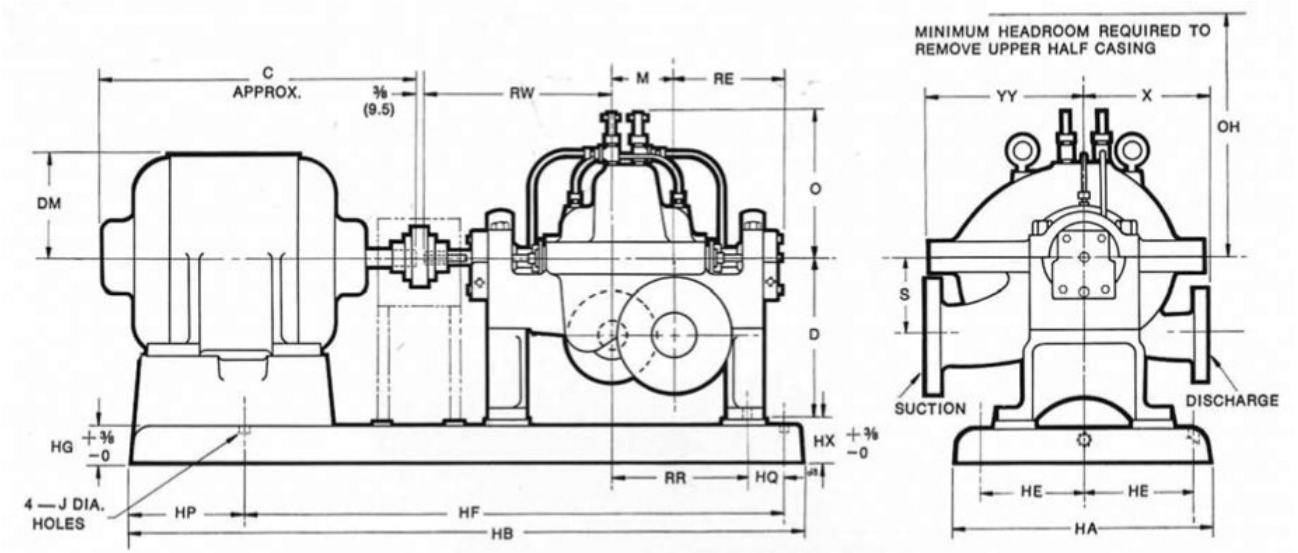
Parts List and Materials of Construction

Item Number	Part Name	Material			
		Bronze-Fitted	All Iron	All Bronze	All 316SS
100	Casing (Upper & Lower)	Cast Iron	Cast Iron	Bronze	316SS
101	Impeller–Suction, 1st Stage	Bronze	Cast Iron	Bronze	316SS
102A	Equalizing Tubing	Copper	Steel	Copper	316SS
103 [1]	Casing Wear Ring	Bronze	Cast Iron	Bronze	Nitronic 60
104	Shaft Sleeve–Locking	316SS	420SS [2]	316SS	
107	Stuffing Box Split Gland	316SS			
112A	Ball Bearing–Thrust	Steel			
122	Shaft	SAE 4340		316SS	
123	Deflector	Glass-Impregnated Nylon			
125	Stuffing Box Bushing	Bronze	Cast Iron	Bronze	316SS
126	Shaft Sleeve	316SS	420SS	316SS	
136	Bearing Locknut	Steel			
142	Impeller Wear Ring (Not Illustrated)	Bronze	Cast Iron	Bronze	316SS
145	Impeller–Discharge, 2nd Stage	Bronze	Cast Iron	Bronze	316SS
146	Diaphragm	Bronze	Cast Iron	Bronze	Nitronic 60
168	Ball Bearing–Coupling End	Steel			
251	Constant Level Sight Oiler	Steel & Glass			
320	Set Screw–Impeller Wear Ring	303SS			
332A/333A	Oil Seal	Synthetic Rubber			
351	Casing Gasket	Non-Asbestos			
412A	O-ring–Impeller	TEFLON ®			
412F	O-ring–Shaft	Buna Rubber			

1 Used when impeller is furnished without wear rings.
2 Flame hardened to 550 BHN.
® TEFLON is a registered trademark of DuPont.

Dimensions Model 3316

All dimensions in inches and (mm). Not to be used for construction. Right hand rotation illustrated.



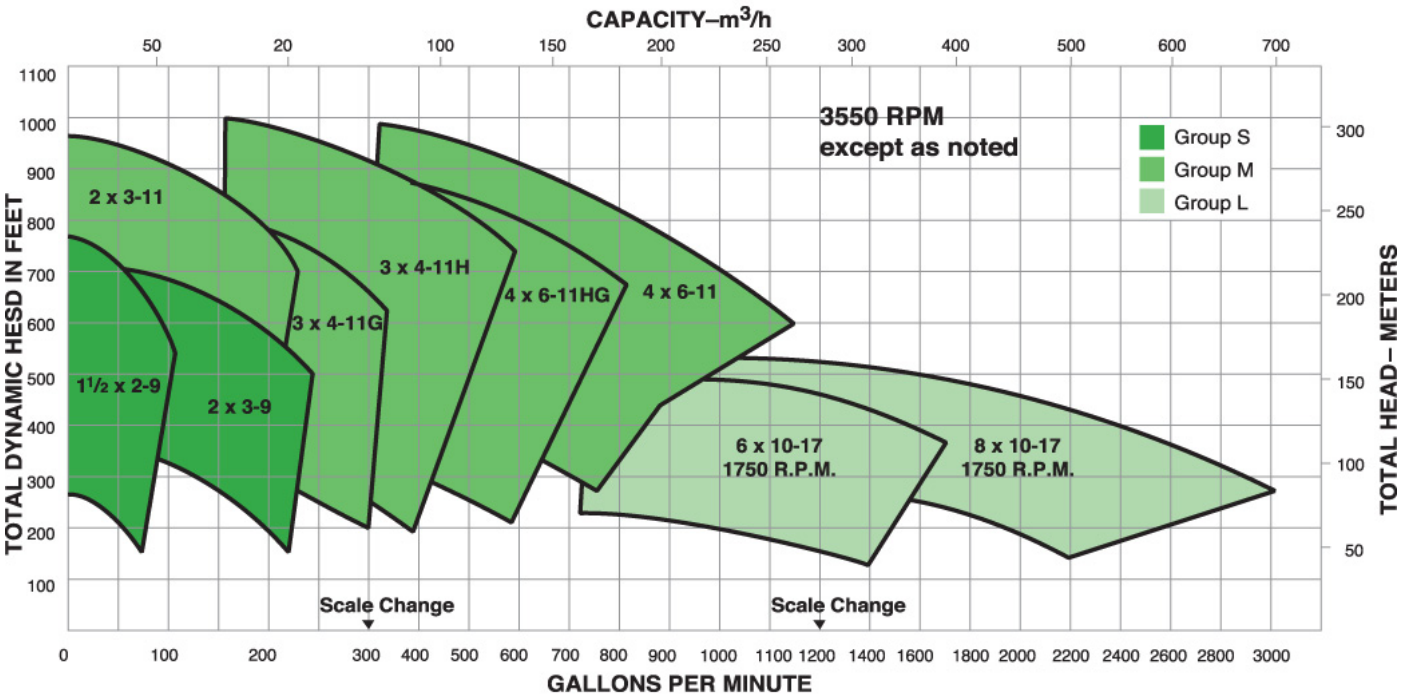
DIMENSIONS DETERMINED BY PUMP

Group	Disch. Size	Suct. Size	Casing Class	O	OH	D	X	YY	S	RR	RW	M	RE	Weight Lbs. (Kg)
S	1½ (38)	2 (51)	9	9½ (241)	15¼ (387)	11½	8¼ (210)	10 ⅛ (257)	4 ⅝ (117)	9 13/16 (249)	13 13/16 (351)	3½ (89)	8 15/16 (227)	325 (147)
	2 (51)	3 (76)	9	10 (254)	15¾ (400)	11½	8¾ (222)	11¼ (286)	5½ (140)	9 15/16 (252)	13 11/16 (348)	4 ⅜ (111)	9 1/16 (230)	400 (181)
M	2 (51)	3 (76)	11	11¼ (286)	17¾ (451)	16	10 (254)	12¼ (311)	4½ (114)	12 (305)	17 (432)	5 (127)	9¾ (248)	620 (281)
	3 (76)	4 (102)	11	11¾ (298)	18¼ (464)	16	11 (279)	13 (330)	5½ (140)	12 (305)	17 (432)	6 (152)	8¾ (222)	700 (318)
	4 (102)	6 (152)	11	12½ (318)	19 (483)	16	11½ (292)	16 (406)	6½ (165)	12 ⅝ (321)	16 ⅝ (416)	7 ⅛ (181)	8 ⅛ (206)	810 (367)
L	6 (152)	8 (203)	17	17¼ (438)	26¼ (667)	22	16 (406)	20½ (521)	9 (229)	16 3/16 (411)	18 11/16 (475)	9 13/16 (249)	9¼ (235)	1820 (826)
	8 (203)	10 (254)	17	18 ⅜ (467)	27 ⅜ (695)	22	17½ (445)	23½ (597)	10¼ (260)	16 ⅝ (422)	18¼ (464)	11 (279)	8½ (216)	2400 (1089)

DIMENSIONS DETERMINED BY MOTOR AND BASEPLATE

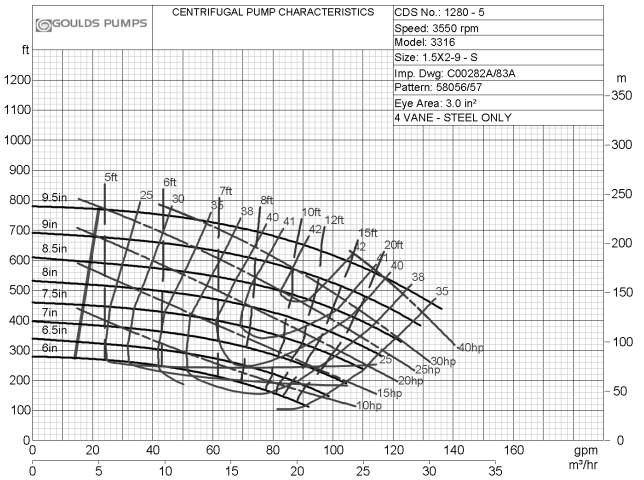
Group	Bedplate No.	Bedplate No.	C	HA	HB	HE	HF	HG	J	HP	HX	HQ	DM	Bedplate Weight Lbs. (Kg)
S	1	143T thru 215T	12½ to 19½ (318) to (495)	18 (457)	43½ (1105)	7 ⅞ (200)	38½ (978)	2½ (63.5)	¾ (19)	3¾ (95)	3 (76)	2 ⅜ (60)	3½ to 6 (89) to (152)	200 (91)
	2	154T thru 266T	22½ to 27 (572) to (686)		50½ (1283)		39¼ (997)			10 (254)			6½ to 7½ (165) to (191)	215 (98)
	3	324TS thru 265T	27 to 34 (686) to (864)	23 (584)	54½ (1384)	10¼ (260)	42¾ (1086)	3½ (89)		10½ (267)	4 (102)	2 11/16 (68)	9 to 9½ (229) to (241)	255 (116)
	4	404TST thru 405TS	34to36½ (864) to (902)		57¼ (1454)		44¾ (1137)			11¼ (286)			11 (279)	275 (125)
M	1	182T thru 266T	14½ to 27 (368) to (686)	24 (610)	57¼ (1454)	10½ (267)	50 (1270)	3½ (89)	⅞ (22)	5¾ (146)	4 (102)	3 1/16 (78)	5 to 7½ (127) to (191)	410 (186)
	2	324T thru 365T	27 to 34 (686) to (864)		61 (1549)		48¼ (1226)			11¼ (286)			9 to 9½ (229) to (241)	440 (200)
	3	404TS thru 447TS	34 to 46½ (864) to (1181)	26 (660)	69¾ (1772)	11½ (292)	53½ (1359)	4 (102)		14¾ (375)	4½ (114)		11 to 12½ (279) to (318)	580 (263)
L	1	254T thru 365T	22½ to 34 (572) to (864)	33 (838)	68 (1727)	14¾ (375)	55¼ (1403)	4½ (114)	1 (25)	11 (279)	5 (127)	3 ⅜ (86)	6½ to 9½ (165) to (241)	850 (386)
	2	404TS thru 447TS	34 to 46½ (864) to (1181)		76½ (1943)		59 13/16 (1519)			14 15/16 (379)			11 to 12½ (279) to (318)	1050 (476)
	3	447T	48 (1218)		79½ (2019)		61¾ (1568)			16 (406)			121/2 (318)	1200 (544)

Hydraulic Coverage Model 3316

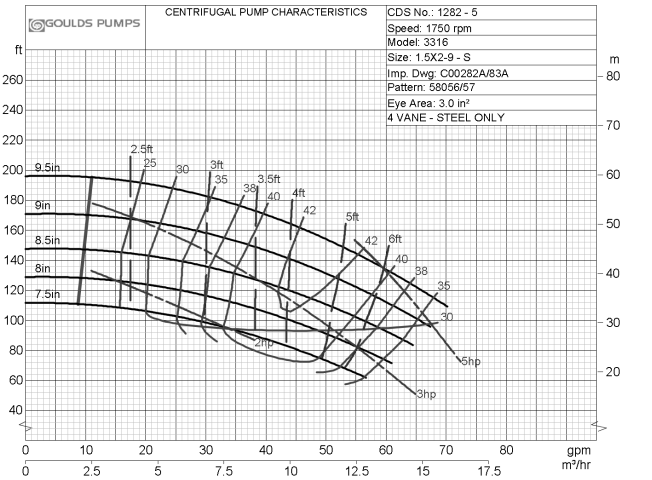


NOTES

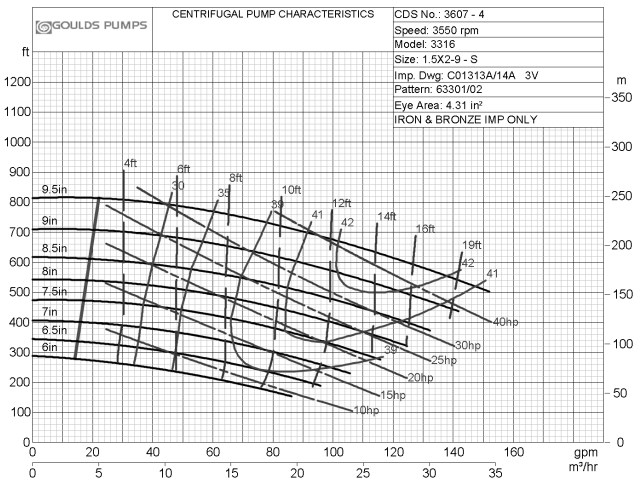
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



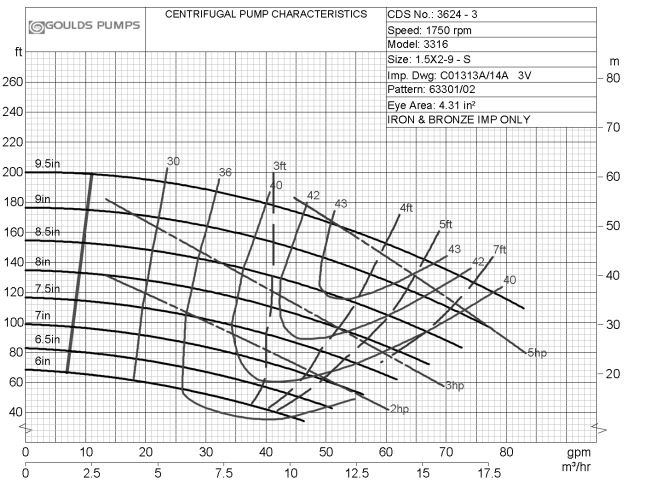
1.5X2-9 **3550rpm**



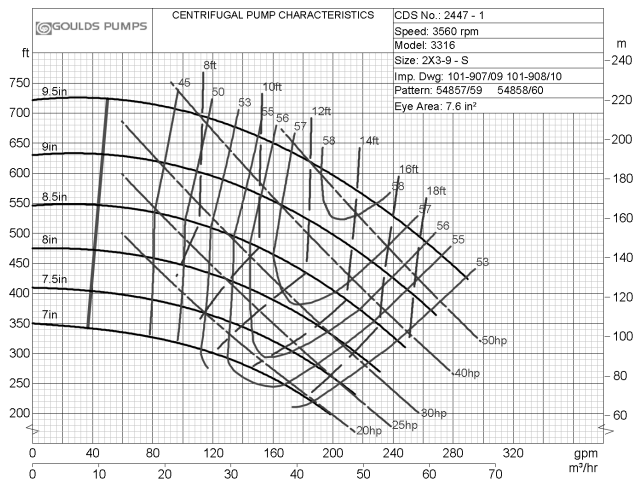
1.5X2-9 **1750rpm**



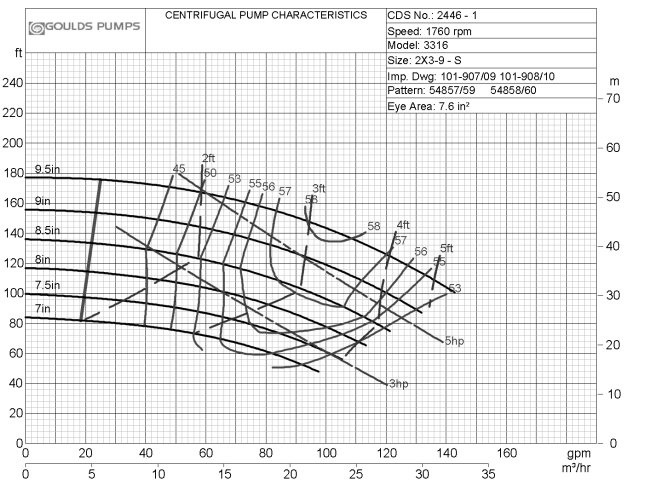
1.5X2-9 **3550rpm**



1.5X2-9 **1750rpm**



2X3-9 **3560rpm**

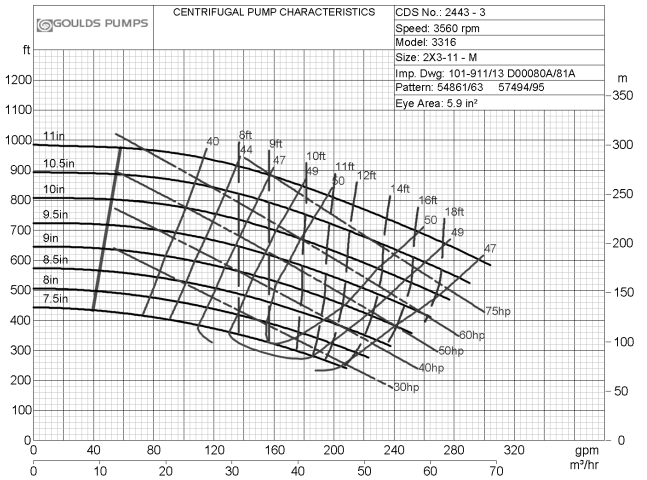


2X3-9 **1760rpm**

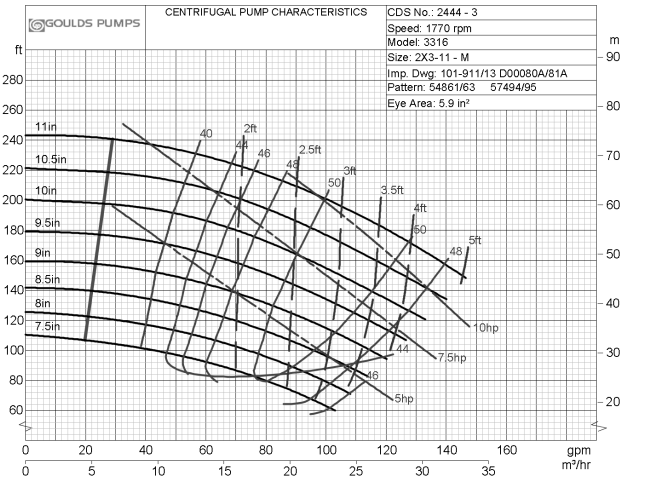
60Hz Curves

Model 3316

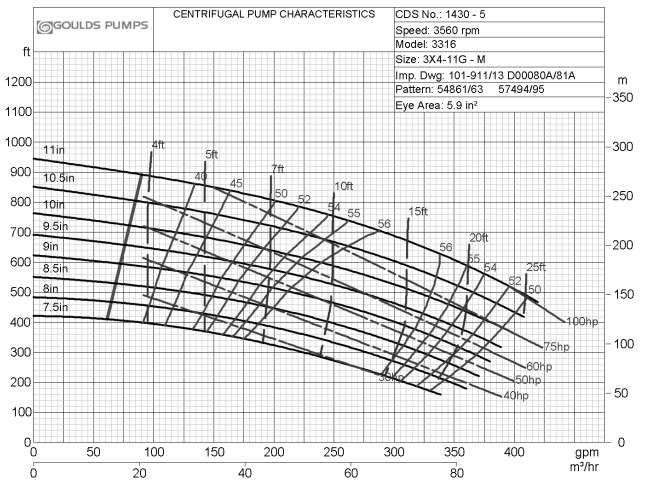
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



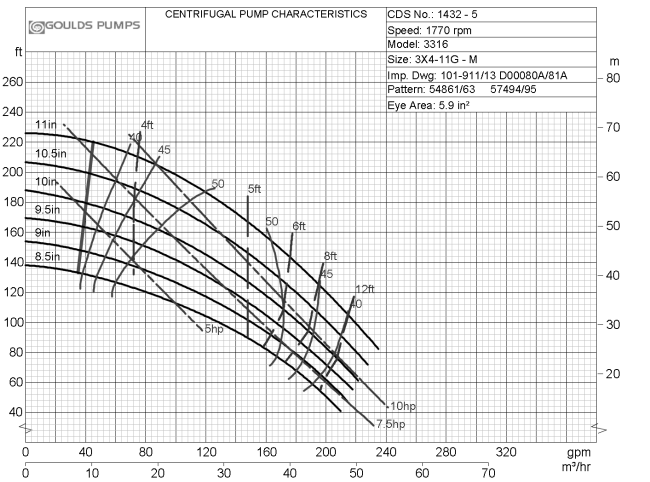
2X3-11 **3560rpm**



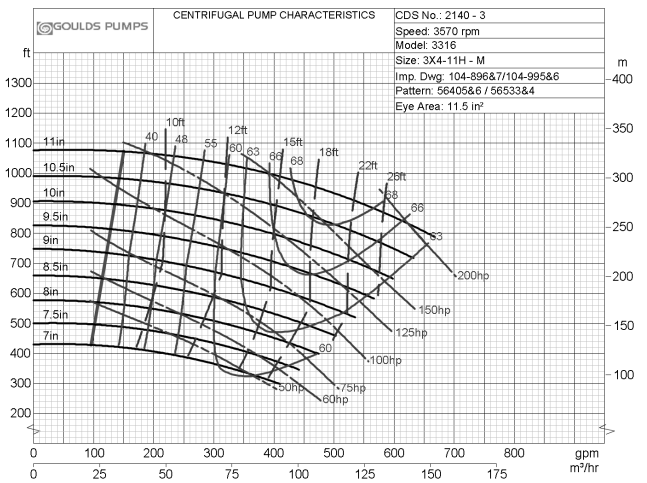
2X3-11 **1770rpm**



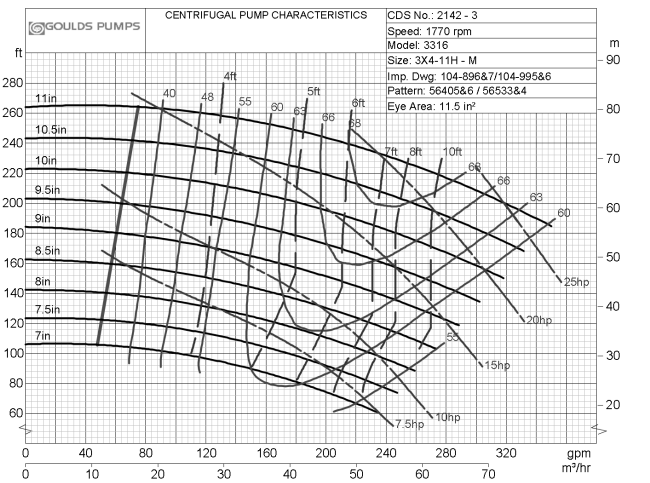
3X4-11G **3560rpm**



3X4-11G **1770rpm**

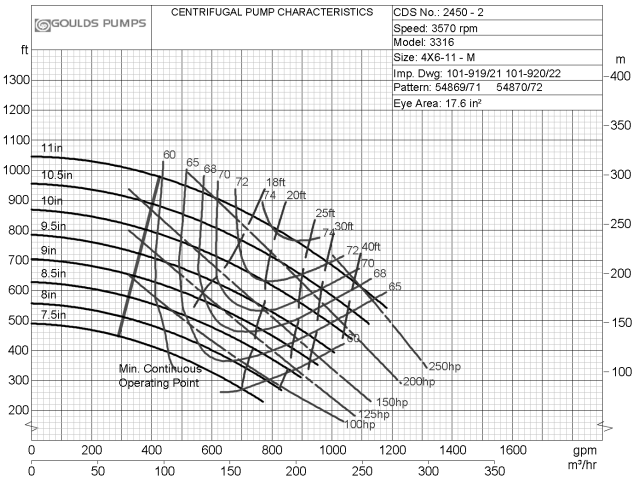


3X4-11H **3570rpm**

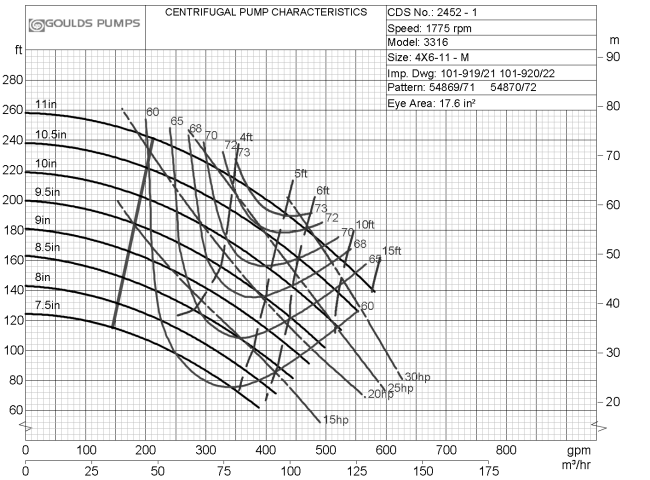


3X4-11H **1770rpm**

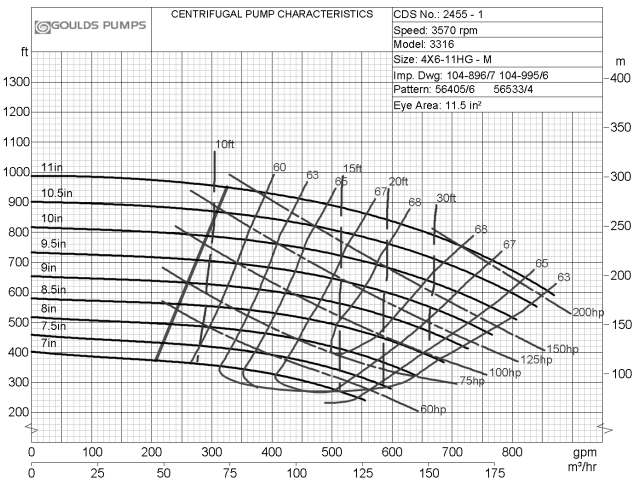
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



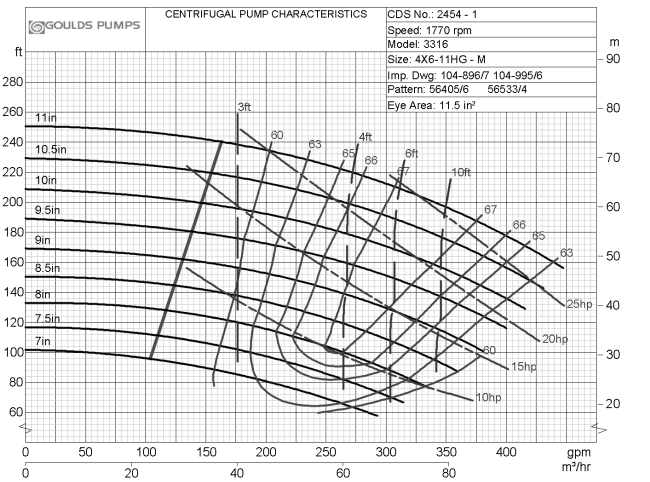
4X6-11 **3570rpm**



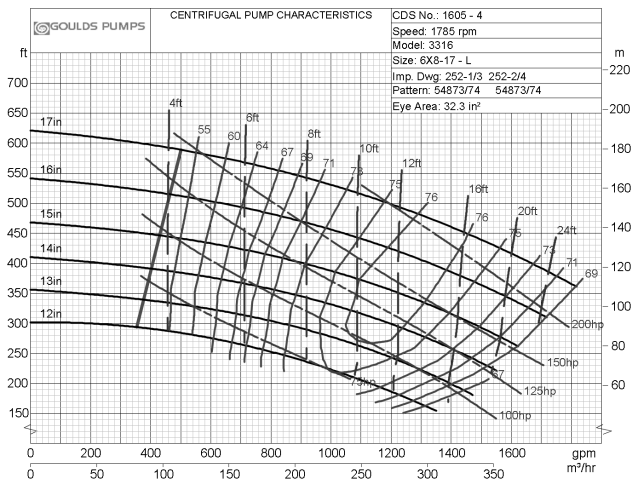
4X6-11 **1775rpm**



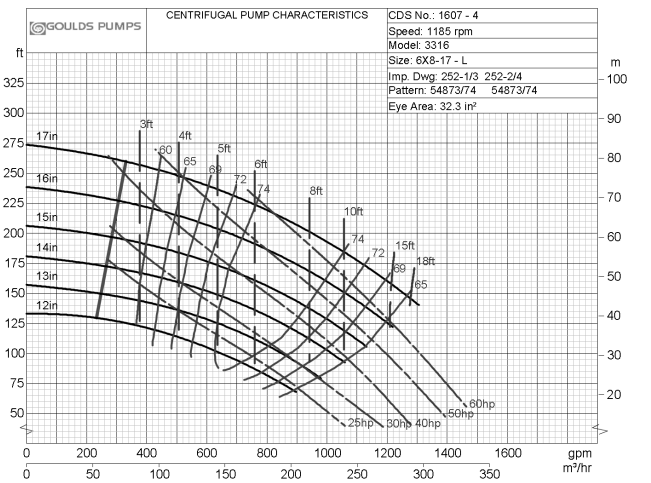
4X6-11HG **3570rpm**



4X6-11HG **1770rpm**



6X8-17 **1785rpm**

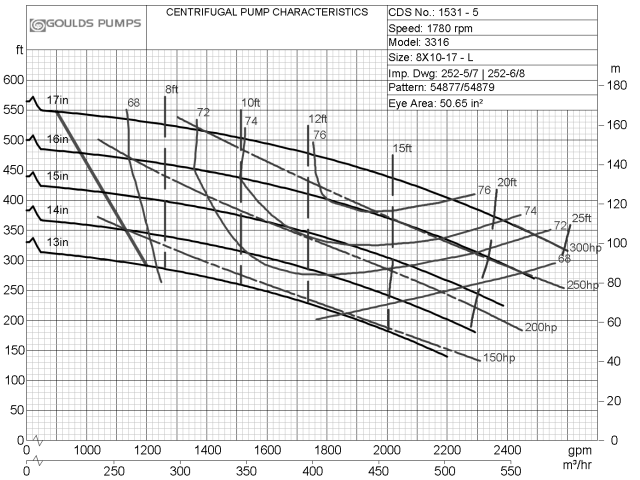


6X8-17 **1185rpm**

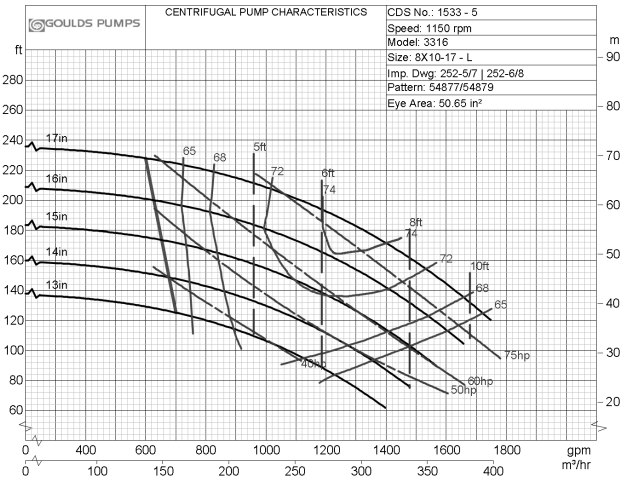
60Hz Curves

Model 3316

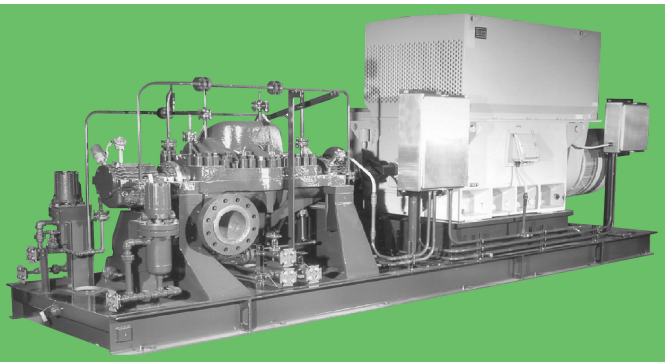
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



8X10-17 **1780rpm**



8X10-17 **1150rpm**



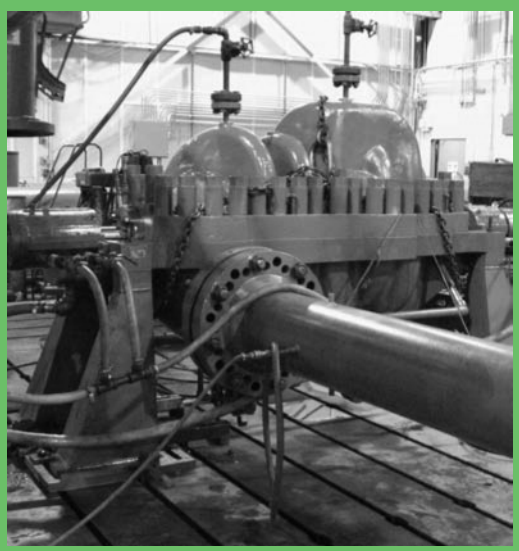
Goulds Model 3600

Heavy Duty Multi-Stage Pumps Designed for High Head/ High Capacity Services

Please Refer to Section API-1C

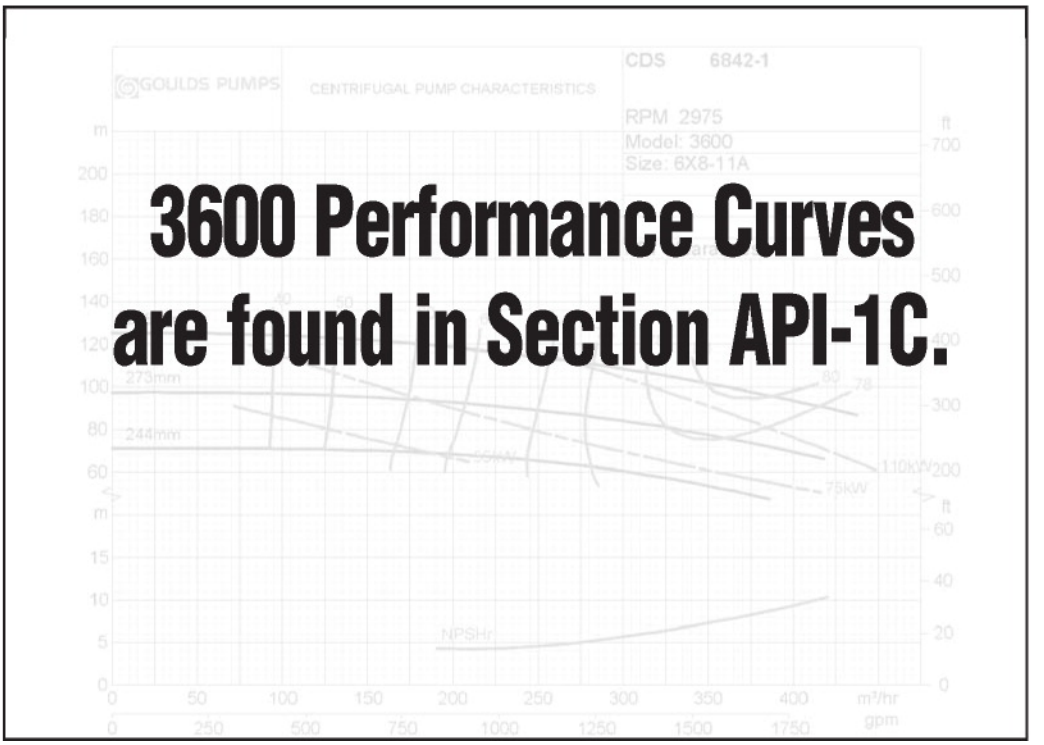
Proven Leadership

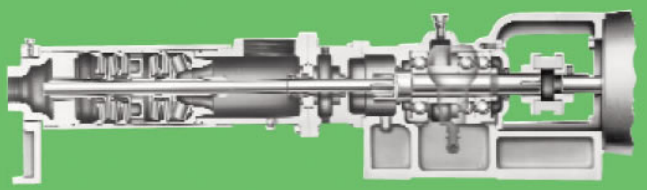
ITT Goulds Pumps is a proven leader in Multi-Stage and API Pumps with several thousand engineered multi-stage pumps sold and 40+ years of multi-stage pump expertise.



ITT Goulds Pumps offers proven engineering packaging expertise with highly complex specifications. We offer complex lube oil skids, seal flush piping plans, etc. to meet the toughest customer applications.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.


3600 Performance Curves
are found in Section API-1C.



Model 3935

Series BP Multi-Stage Diffuser Type Pumps for Wide Range of Low Flow-High Head Services

- Capacities to 125 GPM (28 m^3/h)
- Heads to 2600 feet (792 m)
- Temperatures to 400°F (204°C) with cooling 300°F (149°C) without cooling
- Pressures to 1500 PSIG (10340 kPa) *4 Sizes (up to 85 stages)*

Design Features

- **High Efficiency**
- **Low NPSH Required**
- **Quiet Operation** - minimum vibration and low maintenance
- **Few Wearing Parts** - performance remains essentially the same throughout pump life.
- **Steady Pressure** - no accumulators required to remove pulsation.
- **Easy Flow Regulation** - simple control systems required.
- **Simple Installation**
- **Space Saving**
- **Steep Performance Curves** - for stable operation.
- **No Relief Valves Required**
- **Low Initial Cost**
- **Threaded Connections Standard** - flanged construction available.

Applications

- Reverse Osmosis
- Boiler Feed
- Descaling
- High Pressure/High Temperature Cleaning
- Spraying Systems
- Hydraulic Systems
- Process Water
- Petrochemical and Hydrocarbon Services Transfer
- All Low Flow Applications—where efficiency is critical

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 3935

FOOT SUPPORT
Design allows for thermal expansion on high temperature services.

PRECISION HONED CASING
20-25 RMS finish on casing ID assures bowl alignment and permits easy assembly. Compressed metal-to-metal seal on bowl surfaces and auxiliary o-rings prevent leakage. Barrel type casing with dry buttress thread for high pressure containment.

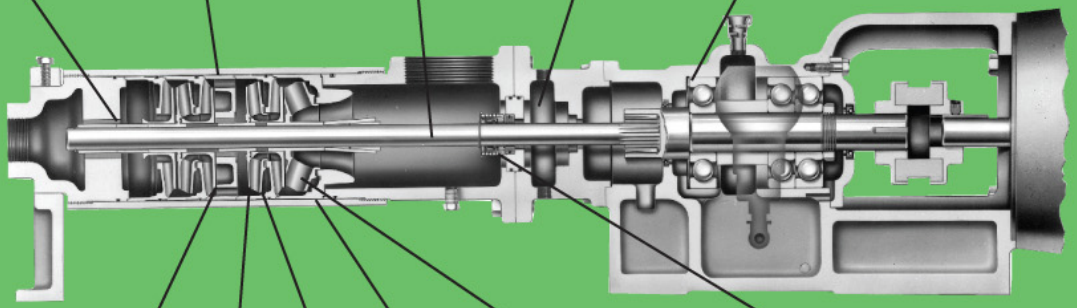
SEAL HOUSING AND COOLING JACKET
Exclusive chamber for installation of special seal arrangements and/or cooling flush systems. Precision machined to assure alignment between liquid and power end.

MOTOR
Standard NEMA C-face stocked by most motor manufacturers. C-flange mounting assures pump and motor shaft alignment. No coupling alignment required.

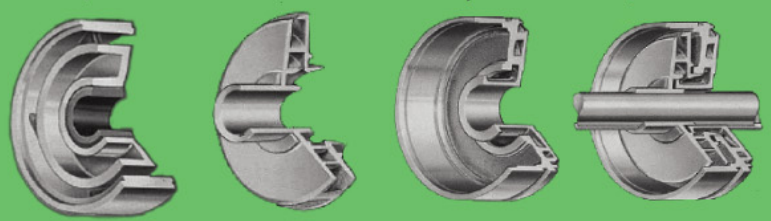
SPLINED DRIVE SHAFT
Splined drive shaft and mating pumpshaft allow smooth transmission of high horsepower.

TAIL BEARING
Provide complete shaft support.

SHAFT
Keyed alloy shaft, one piece throughout pump. No internal coupling

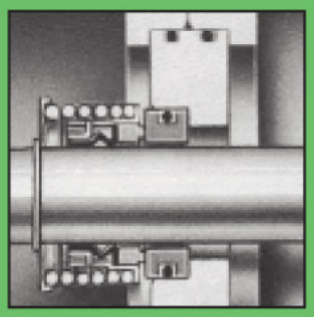


LOW NPSH FIRST STAGE IMPELLER
Standard mixed flow impeller provides low NPSH performance without the use of cavitating type inducer.



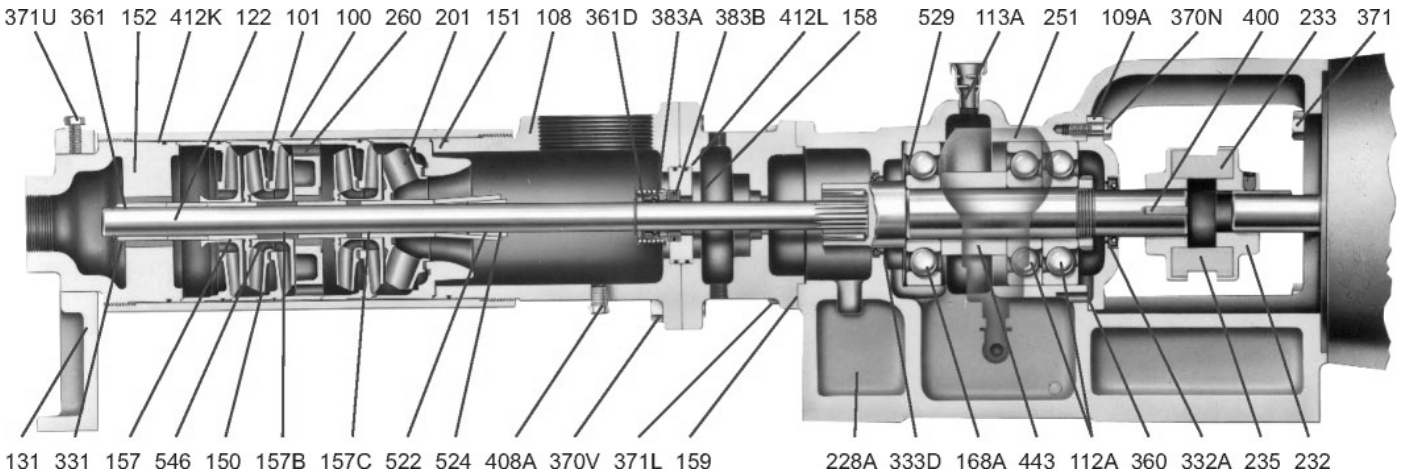
STEADY BEARING
Intermediate carbon shaft bearing self-lubricated by pumpage and lock-fitted for accurate permanent alignment. Bearings spaced at 1 foot (0.3 meters) intervals.

POSITIVE BOWL ALIGNMENT
Rabbet locks provide positive alignment.



MECHANICAL SEAL
The standard mechanical seal is of single spring design providing positive drive while compensating for seal face wear.

Sectional View Model 3935



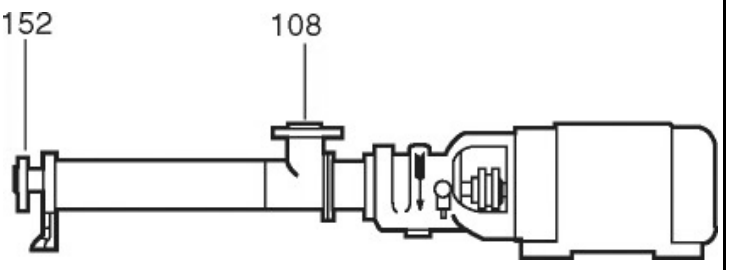
Parts List and Materials of Construction

Power End

Item Number	Part Name	Material	Grease Lubrication		Oil Lubrication			
			J	S	M	L	X	Y
112	Ball Bearing, Thrust	Steel	308SZZ	7308PDF	—	—	—	—
112A	Ball Bearing, Thrust	Steel	—	—	7408DT	7408DT	7408DT	7313DT
168A	Ball Bearing Coupling End	Steel	—	—	408S	408S	408S	313S
228	Frame—Grease Lube	Cast Iron	J	S	—	—	—	—
228A	Frame—Oil Lube	Cast Iron	—s	—	M	L	X	Y
332	Grease Seal-Bearing Cover	Buna-N	—	S	—	—	—	—
332A	Oil Seal—Bearing Cover	Buna-N	—	—	M	L	X	Y
333	Grease Seal—Frame	Buna-N	—	S	—	—	—	—
333D	Oil Seal—Frame	Buna-N	—	—	M	L	X	Y
380	Stub Shaft	Steel	J	S	M	L	X	Y
443	Bearing Spacer	Steel	—	—	M	L	X	Y

Liquid End

Item Number	Part Name	Material
100	Casing	Carbon Steel
101	Impeller	NI-Resist Type 1
108	Casing Adapter	NI-Resist Type 2
122	Shaft	K-Monel
150	Diffuser	NI-Resist Type 1
150A	Diffuser Blank (Not Shown)	NI-Resist Type 2
151	Suction Diffuser	NI-Resist Type 2
152	Discharge Head	NI-Resist Type 2
157	Spacer Sleeve	316SS
157B	Intermed. Brg. Shaft Sleeve	316SS
157C	1st Stage Shaft Sleeve	316SS
159	Seal Housing	NI-Resist Type 2
188*	Cooling Jacket (Not Shown)	NI-Resist Type 2
201‡	Impeller, First Stage	NI-Resist Type 1
260	Intermediate Bearing	NI-Resist Type 1 Carbon Insert
331	Shim	316SS
361	Retaining Ring, Shaft	303SS
412J*	O-Ring Cooling Jacket (Not Shown)	Viton
412K	O-Ring Casing	Viton
473*	Restricting Bushing (Cooling Jacket—Not Shown)	Carbon
522	Drive Collar	316SS
524	Split Collet	316SS

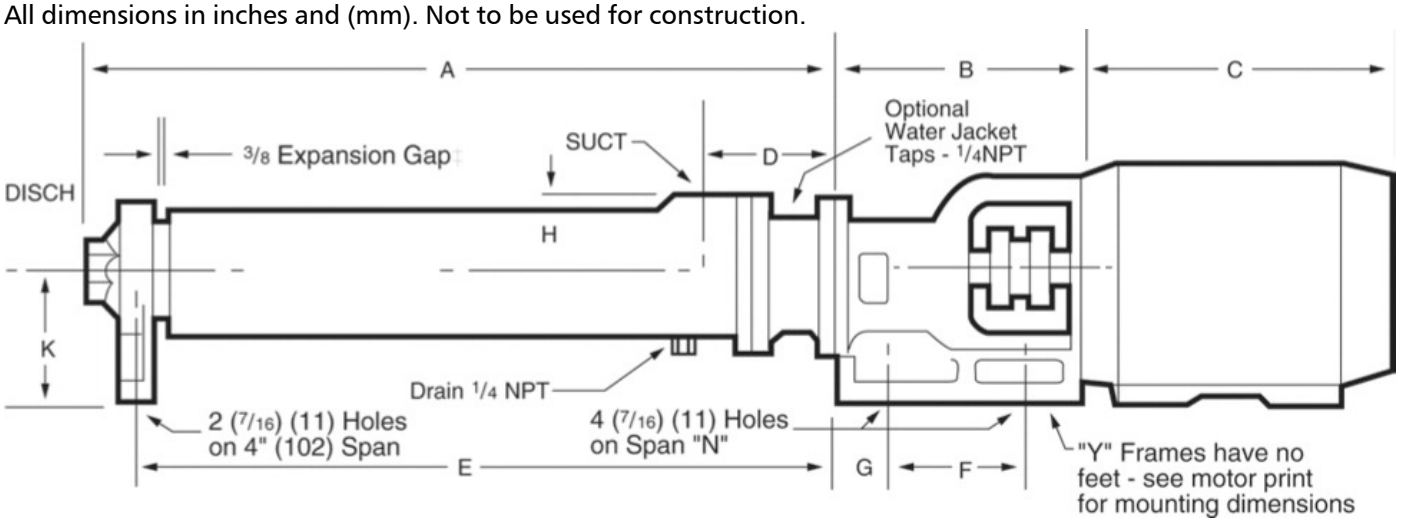


Optional Flanged Construction		
Item No	Part Name	Material
108	Casing Adapter	Cast Carbon Steel
152	Discharge Head	Cast Carbon Steel

*Optional ♦For 444TSC and 445TSC Motors Only ‡BP40, 70 & 100 Only **Steel on Y Frame

Dimensions Model 3935

All dimensions in inches and (mm). Not to be used for construction.



MAXIMUM & MINIMUM DIMENSIONS DETERMINED BY PUMP*

PUMP		A	C	D	E	H	K	Suct.	Disch.
BP20	Min Max	16⅝ 101	11 18¾	3⅞ 4 15/16	15⅝ 100¼	2¾	4½ 7	1½" NPT	1" NPT
BP40	Min Max	23 3/16 66 15/16	11 7/16 22¼	6 6	22 9/16 66 5/16	3 1/16	6¼ 11	3" NPT	1½" NPT
BP70	Min Max	24 15/16 84¾	13 1/16 22¼	6 6	24 5/16 84⅛	3 1/16	6¼ 11	3" NPT	1½" NPT
BP100	Min Max	26 7/16 98¼	13 1/16 26⅝	6 6	25 13/16 97⅝	3 1/16	6¼ 11	3" NPT	1½" NPT

*Pump length and number of stages varies with developed head at best efficiency point

DIMENSIONS DETERMINED BY FRAME

Frame	B	F	G	N
J	7½	5¼	1⅛	5
S	12⅛	8⅝	1¾	4
M & L	15⅞	8⅝	1¾	4
X	15⅞	8⅝	1¾	4
Y	19⅝	NA	NA	NA

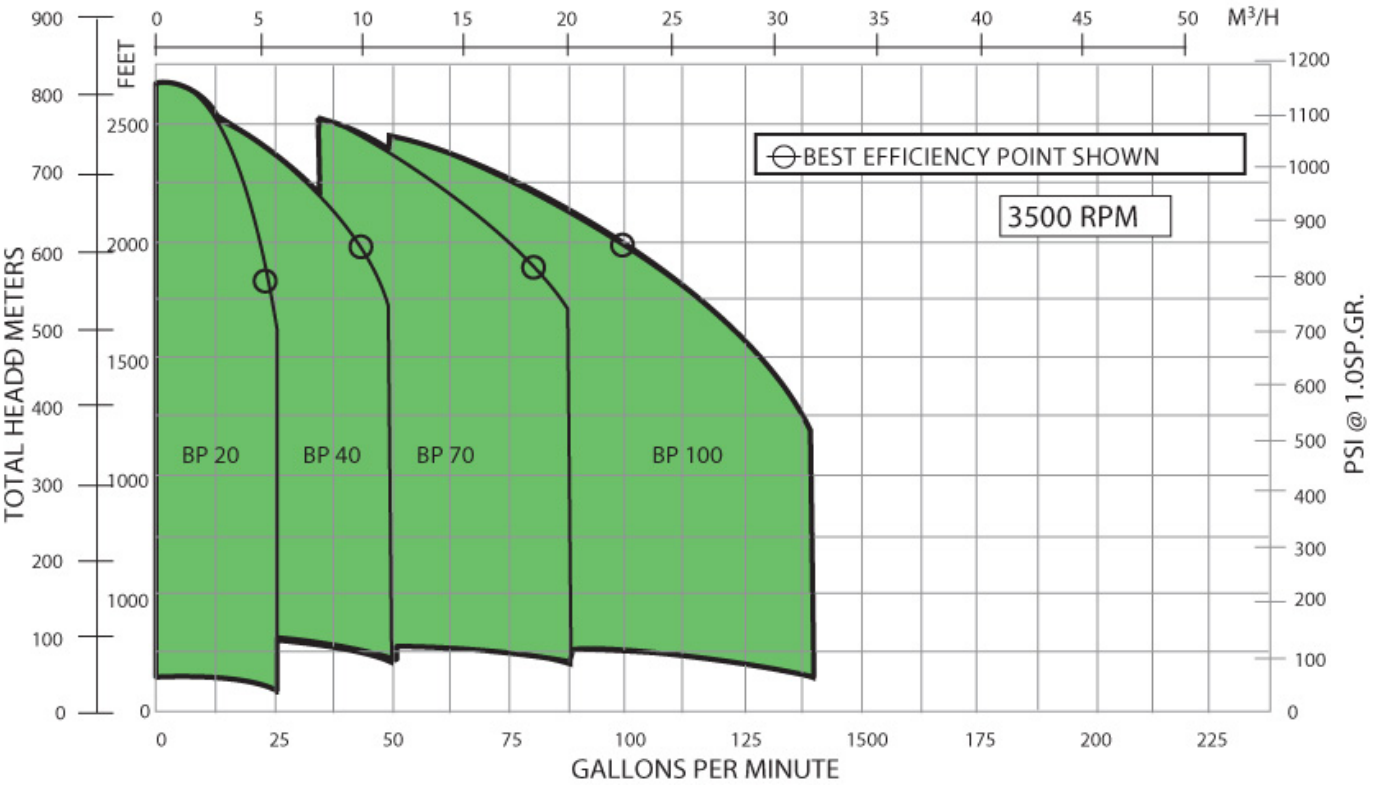
‡= Gap 1/8" on J frame only.

NOTES: : All 'C' dimensions are approximate for ODP motors.

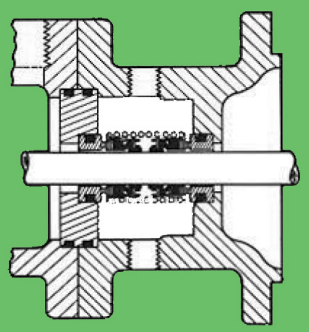
All 'A' dimensions based on ambient temperature.

Flanged suction and discharge connections available. Flanges are ANSI 600 lb. standard (¼ raised face) and will accept either 300 lb. or 600 lb. companion flanges (not illustrated above).

Hydraulic Coverage Model 3935

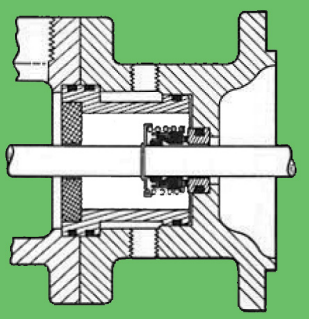


Maximum Sealing Flexibility



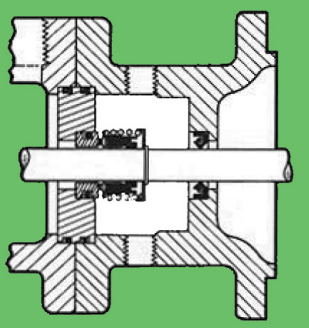
Double Unbalanced Seal

Used where it is desirable to keep mechanical seal out of pumpage. This arrangement can also be used on high vacuum service where sealing is essential.



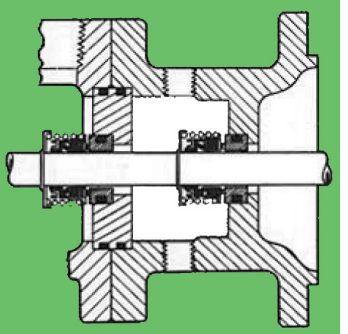
Cooling Chamber With Close Fitting Carbon Bushing

Used on hot services where pumping temperature exceeds the allowable limits of the mechanical seal.



Low Pressure Cooling and/or Flush

Used mostly on high temperature heat transfer fluids operating at low suction pressures for very effective cooling.



Tandem Seals

Used on toxic and highly flammable service with oil or other compatible fluid buffer.

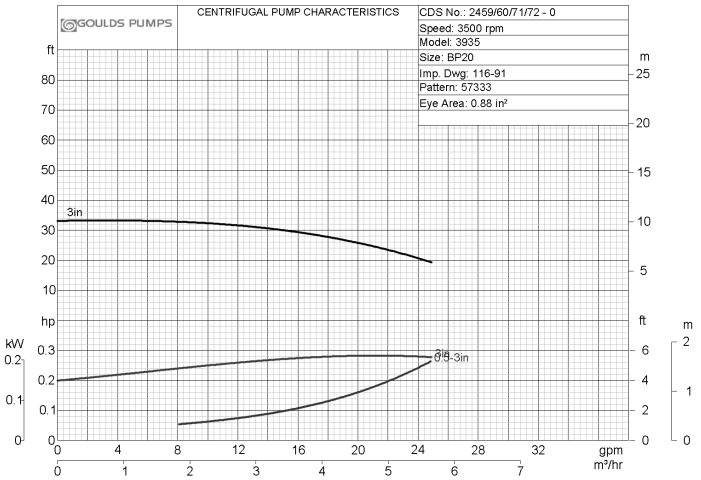
Quiet – Smooth Performance

The Centrifugal characteristics of Goulds Model 3935 assure quiet, smooth, low maintenance operation. High pitched noise inherent in high speed single stage designs and piston noise associated with reciprocating pumps are alleviated with the multi-stage diffuser design of the Model 3985.Therfore, the quiet, smooth-running 3935 easily meets the sound and vibration level requirements demanded by today's ecology minded industries.

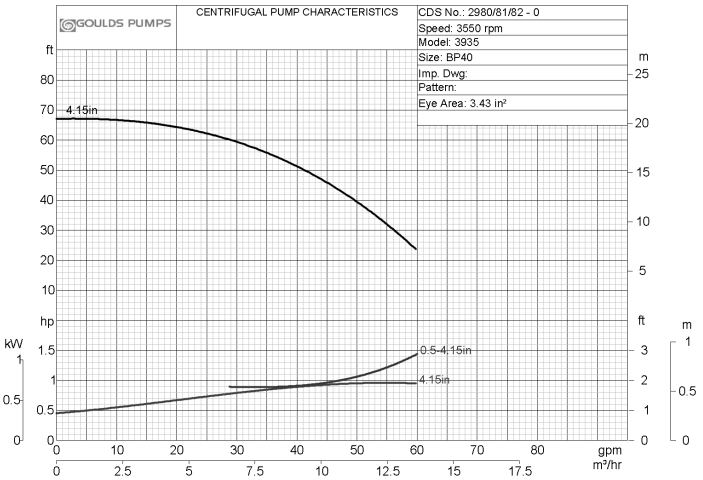
Radial Load On Impeller Is Equal and Balanced

NOTES

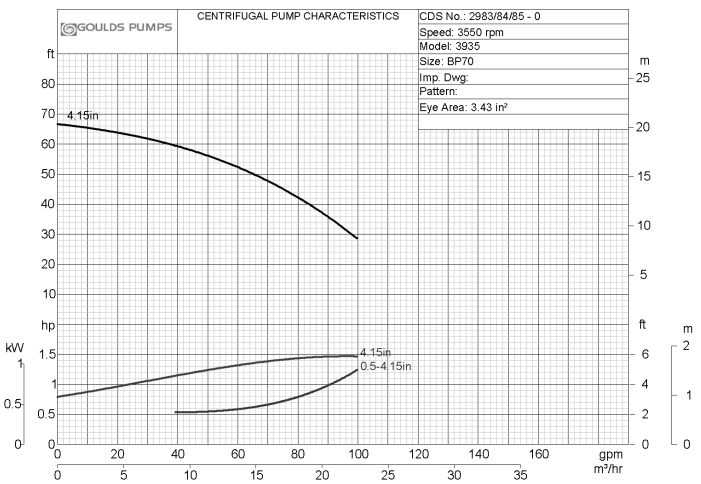
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



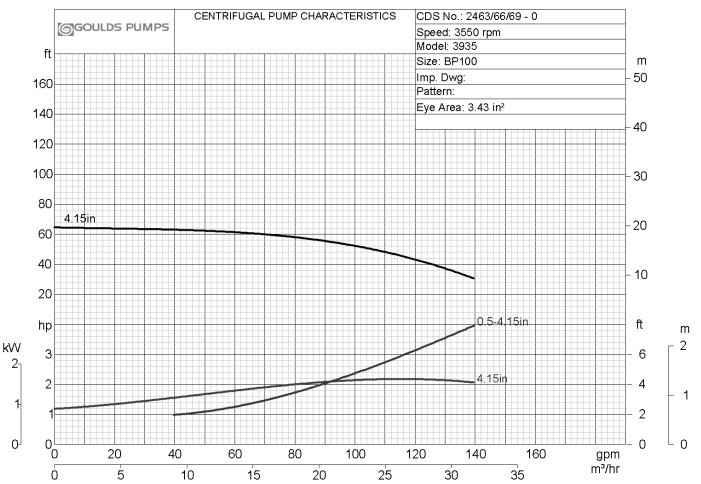
BP20 **3500rpm**



BP40 **3550rpm**



BP70 **3550rpm**

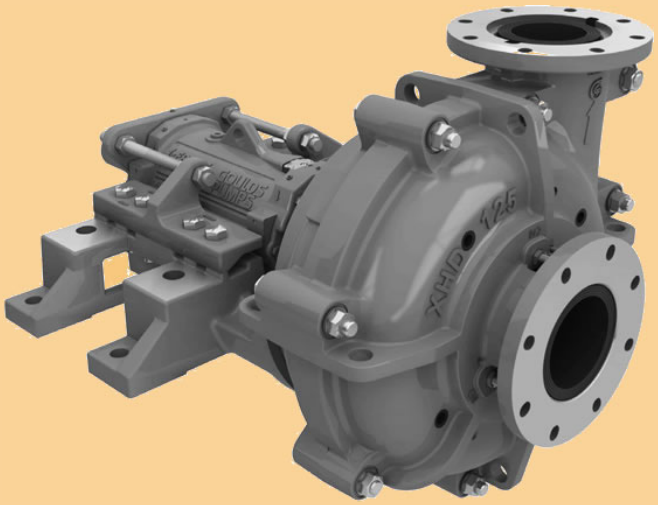


BP100 **3550rpm**

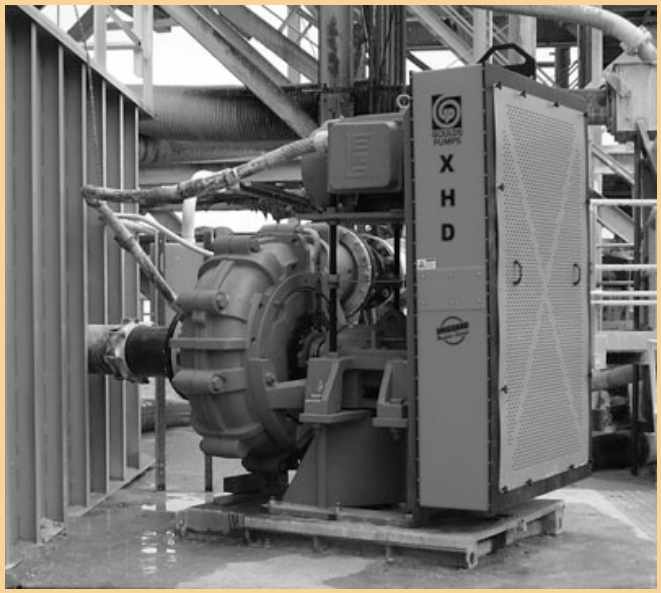
NOTES

6

Abrasive Slurry / Solids Handling



We know that only "up-time" yields money and is paramount to our customers. The XHD, engineered to maximize up-time, expands the breadth of our mineral processing solutions portfolio and further complements the complete solutions that our experienced team can provide. We maximize the performance of your processing plants from start to finish.



Model XHD

Extra Heavy Duty, Lined Slurry Pump

- Capacities to 13,000 GPM (2,950 m^3/h)
- Heads to 280 feet (85 m)
- Temperatures to 250°F (121°C)
- Pressures to 250 PSIG (17 bar)

Design Features:

- Bearing cartridge with machined rails for alignment. Easy to access dual rod adjustment allows you to adjust and maintain performance.
- Suction seal ring is adjustable while pump is in operation, allowing you to maintain peak efficiency and performance along with extending wear life. (Patent Pending)
- Split stuffing box and gland for quick and easy packing adjustment and replacement.
- Special tapered impeller thread to facilitate assembly and alignment. (Patent Pending)
- Extensive use of Computational Fluid Dynamics (CFD) analysis for optimal design to maximize efficiency and wear life.

Services

- **Primary Metals:** SAG/Ball Mill, Cyclone Feed, Tailings
- **Mineral Processing:** Slurry Transfer, Flotation Cells, Thickener Underflow
- **Non-Metallic Mining:** Heavy Media, Cyclone Feed, Raw Coal, Clay, Soda Ash and Phosphate Slurries, Slurry Heater, Slurry Digestion, Hydrate
- **Power:** Absorber Recycle, Gas Cooling, Filter Feed, Lime and Ash Slurries
- **Sand & Aggregate:** Sand Slurries, Tailings

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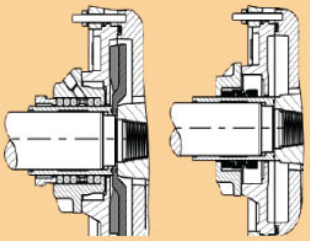
Model XHD Extra Heavy Duty, Lined Slurry Pump

Designed for the toughest slurry applications

Patented i-Alert™ vibration and bearing temperature monitor.



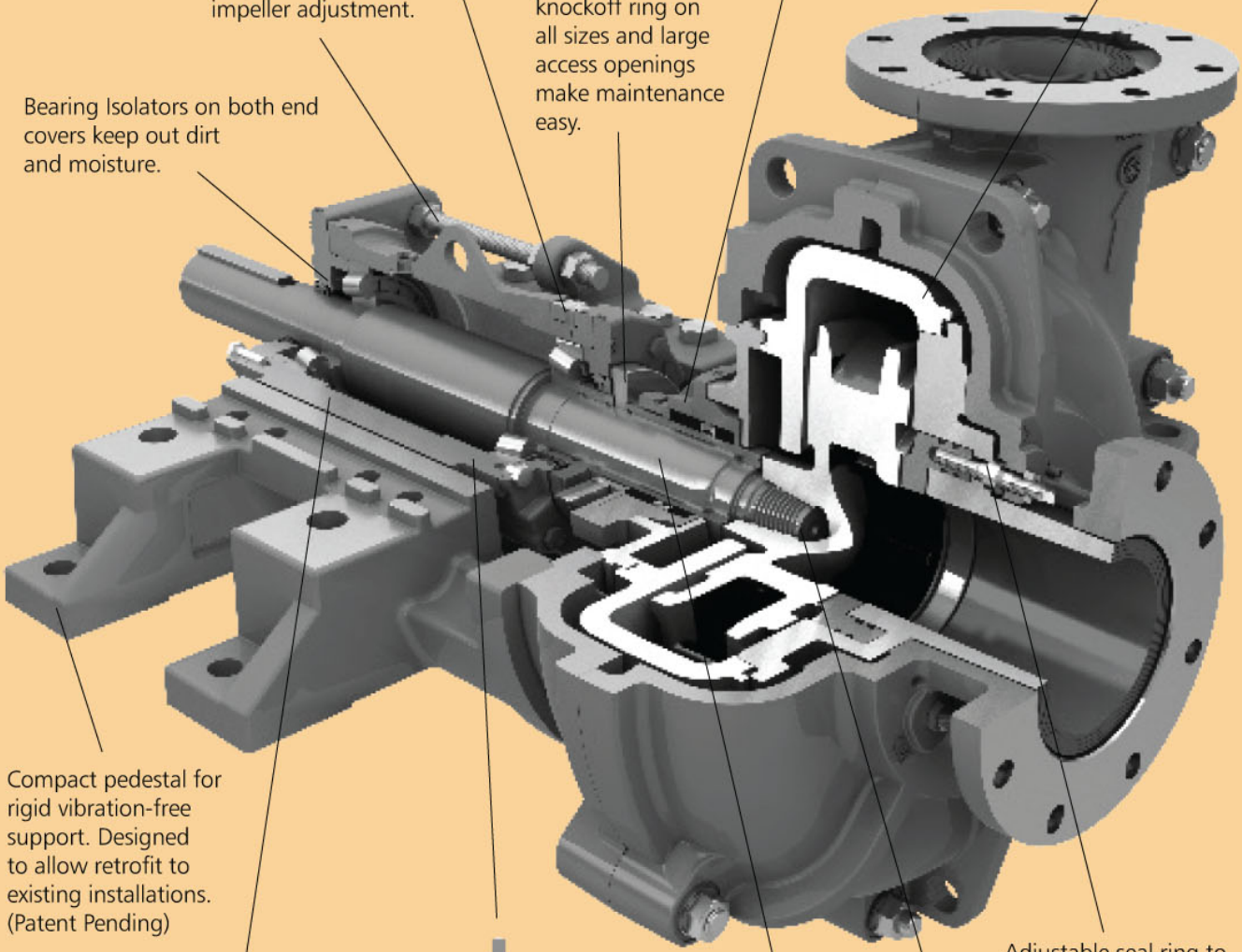
Split stuffing box and gland for easier packing maintenance. Choice of packing, expeller or mechanical seals.

Extra-thick, replaceable, hardened chrome iron liners for extended wear life.

Easy access dual rod impeller adjustment.

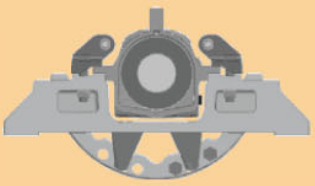
Standard impeller knockoff ring on all sizes and large access openings make maintenance easy.

Bearing Isolators on both end covers keep out dirt and moisture.



Compact pedestal for rigid vibration-free support. Designed to allow retrofit to existing installations. (Patent Pending)

Fully machined slide rails for accurate shaft and bearing cartridge alignment. Designed-in rebuild capability.



Critical frame alignment surfaces protected by frame clamps for years of maintainability, extending life in corrosive mineral processing environments.

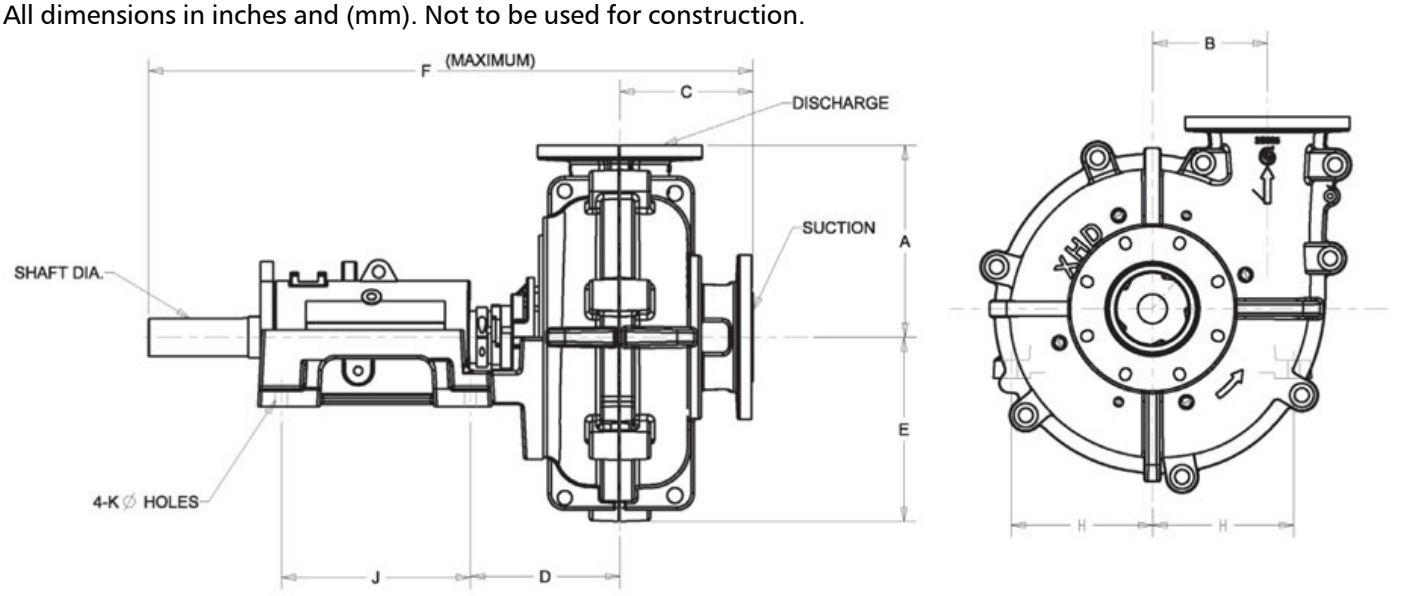
Large diameter shaft for low deflection.

Special tapered impeller thread to facilitate assembly and alignment. (Patent Pending)

Adjustable seal ring to maintain clearance for peak performance. Can be adjusted while in operation. (Patent Pending)

Dimensions Model XHD

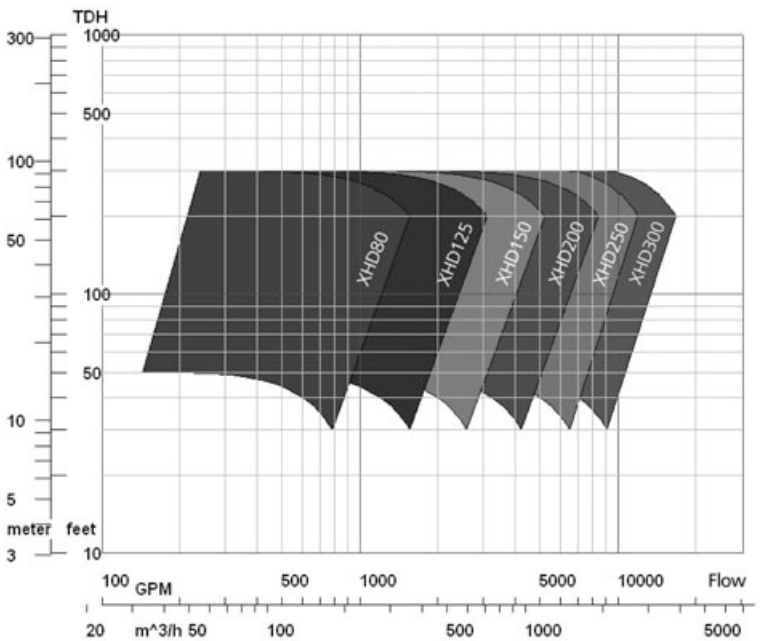
All dimensions in inches and (mm). Not to be used for construction.



Pump Size	Suction Size	Discharge Size	Frame Size	A	B	C	D	E	F	H (3)	J	Shaft Diameter
80	100 / 4"	75 / 3"	PF2	300	165	210	336	278	1017	350	227	60
125	150 / 6"	125 / 5"	PF3	400	240	275	393	394	1268	405	283	80
150	200 / 8"	150 / 6"	PF4	515	310	360	516	560	1760	502	420	100
200	250 / 10"	200 / 8"	PF4	650	400	435	546	710	1850			
250	300 / 12'	250 / 10'	PF5	725	490	500	667	720	2174	515	490	120
300	350 / 14"	300/ 12"	PF5	925	625	585	732	925	2285			

1 All Dimensions in mm
2 Not for construction, installation or application purposes
3 Pedestal width

Hydraulic Coverage Model XHD



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

NOTES

The Goulds Model SRL is the original rubber-lined slurry pump. It is the result of nearly a century of proven experience in the design, manufacture and field operation of slrry pumps. The SRL is built to stand up to the toughest services, while providing maximum reliability and extreme ease of maintenance. Available in a wide variety of natural and synthetic elastomers, the SRL, with its heavy duty design, extra thick liners and multiple impeller options, provides you with the right pump for your application along with the years of dependable service even under the most severe operating conditions.

Model SRL

Designed for the Most Severe and Abrasive Duties

- Capacities up to 20,000 GPM (4,542 m^3/h)
- Heads to 164 feet (50 m)
- Temperatures to 250°F (121°C)
- Pressures to 500 PSIG (3,447 kPa)

Design Features

Large Diameter Impeller

- Develops higher heads at lower operating speeds
- Open and closed designs to suit most applications
- Variety of elastomers and metal alloys available
- Shearpeller® for stringy and froth-laden slurries

Field Replaceable Liners

- Precision molded and bonded to metal skeleton
- FRP volute support to resist collapse. Sizes > 8" (200 mm)
- Extra thick rubber design for severe duties

Heavy Duty Mechanical Design

- Large-diameter shaft for low deflection and longer life
- Oil-lubricated cartridge bearing assembly
- Heavy-duty bearings for reliability and long life

Gland Seal Options

- Standard and low-dilution seal water, or mechanical seal
- Replaceable XH-800 shaft sleeve for maximum life

Services

- **Primary Metals:** SAG/ball mill discharge, cyclone feed and tailings
- **Mineral Processing:** Slurry transfer, float cells and thickener underflow
- **Non-Metallic Mining:** Clay slurries, phosphate, soda ash and potash
- **Sand & Gravel:** Sand and aggregate slurries, tailings
- **Power Utility:** Absorber recycle, gas cooling, fllter feed, flue gas desulfurization and gypsum tailings
- **Chemical:** Acid transfer, leach feed
- **Pulp & Paper:** Lime slurries and fly ash
- **General Industry:** Foundry sand, plant waste and ash slurries

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Bearing Assembly

- Cartridge design
- Precision machined cast iron bearing housing
- Large diameter AISI 1045 steel shaft
- Heavy-duty anti-friction bearings
- Minimum 5-year bearing L_{10} life
- Oil lubrication
- Taconite bearing protection with grease packed labyrinth and lip seals
- External oil level sight gauges on both sides

Shaft Sleeve

- Hard Ni-Cr coated XH-800 alloy sleeve
- 64 Rockwell C coating will not chip or crack
- Ground 6-8 RMS surface finish
- 316 SS base alloy for corrosion resistance
- Special alloys available

Suction Wearplate Liner

- Standard on SRL-XT models and SRL-C pumps with discharges 6" and larger
- Quick replacement of wear part
- Reduced downtime and replacement cost
- Choice of elastomers and polyurethanes
- Optional CRM wearplate available

Ceramic-Rubber Media (CRM) Liners

The primary circuit ball/SAG mill discharge is one of the most severe duties in mineral processing. The suction wearplate is subjected to rapid wear due to high solids concentration and coarse nature of the slurry. Goulds developed a proprietary process to locate and mold ceramic rods into the rubber liner for the optimum combination of hardness and resilience for extended wear life. Field trials confirmed CRM liner life of two to four times that of natural rubber alone. Because the CRM liner retains its shape longer, it also extends the life of the other wear parts for an even lower life cycle cost.

Bearing Cartridge Assembly

XH-800 Shaft Sleeves

Optional Natural Rubber CRM Wearplate

Rubber

The Goulds Model SRL utilizes a soft natural rubber blend which offers the best combination of resilience and tear resistance for maximum wear life in abrasive and corrosive slurries. Goulds offers a wide variety of natural and synthetic rubbers as well as polymers in a range of hardness to suit almost any slurry application.

FRP & Rubber Composite Hybrid Liners

All SRL model liners are molded to a metal skeleton and bolted to the casing for a secure fit. However, on larger pumps, the amount of unsupported rubber in the volute and discharge neck area can make them prone to collapse under adverse operating conditions period It can also be difficult to handle and install. Goulds molds a fiberglass (FRP) shell to the casing liners for added support on pump sizes 12×10-25 SRL-C and larger. This unique hybrid liner design is collapse resistant with improved fit for easy handling and assembly.

FRP & Rubber Composite Hybrid Liners

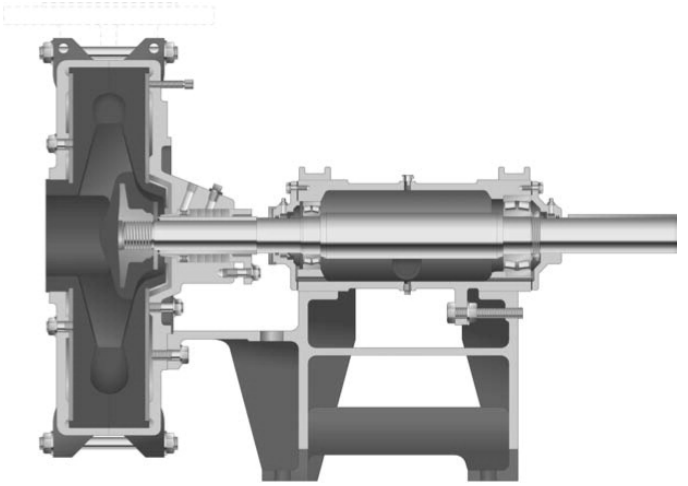
Elastomer Selections and Application Guide for SRL Pumps

Please use the following chart as a general guide only. Refer to factory for specific elastomer recommendations.
E = Excellent G = Good P = Poor

Elastomer Type	Hardness	Temperature		pH		Resistance to		
	Durometer Shore A	Maximum		Min.	Max.	Abrasion	Moderate Chemicals	Hydro-carbons & Oils
Natural Rubber	40	154°F	68°C	4.5	12	E	G (1)	P
Natural Rubber (Soft)	36	150°F	66°C	4.5	12	E	G (1)	P
Natural Rubber (Hard)	50	180°F	82°C	4.5	12	E	G (1)	P
Natural Rubber (Food Grade)	38	150°F	66°C	4.5	12	E	G (1)	P
Neoprene	60	212°F	100°C	3.0	12	G	G (1)	G
Nitrile (60)	60	220°F	105°C	3.5	12	G	G (1)	E
Chlorobutyl	50	250°F	121°C	1.0	12	G	E	P
Hypalon®	55	230°F	110°C	<1.0	14	G	E	G
Ethylene Propylene	70	230°F	110°C	1.0	12	G	E	P
Viton®	70	300°F	149°C	<1.0	14	P	E	E
Urethane	81	149°F	65°C	3.0	11	E (2)	G (1)	E
Urethane (Hi-Temp)	83	212°F	100°C	3.0	11	E (2)	G (1)	E

(1) Poor for oxidizing chemicals and strong acids
(2) Fine particles only (150 mesh or less)

Sectional View **Model SRL**



- Sizes: 2" to 6" (50mm-150mm)
- Flows to: 1,500 GPM (341m ^{3}/h)
- Heads to: 135 feet (41m)
- Solids to: ⅛" (3.2mm)
- Pressures to: 232 PSIG (1,600 kPa)

SRL Heavy-duty slurry pumps

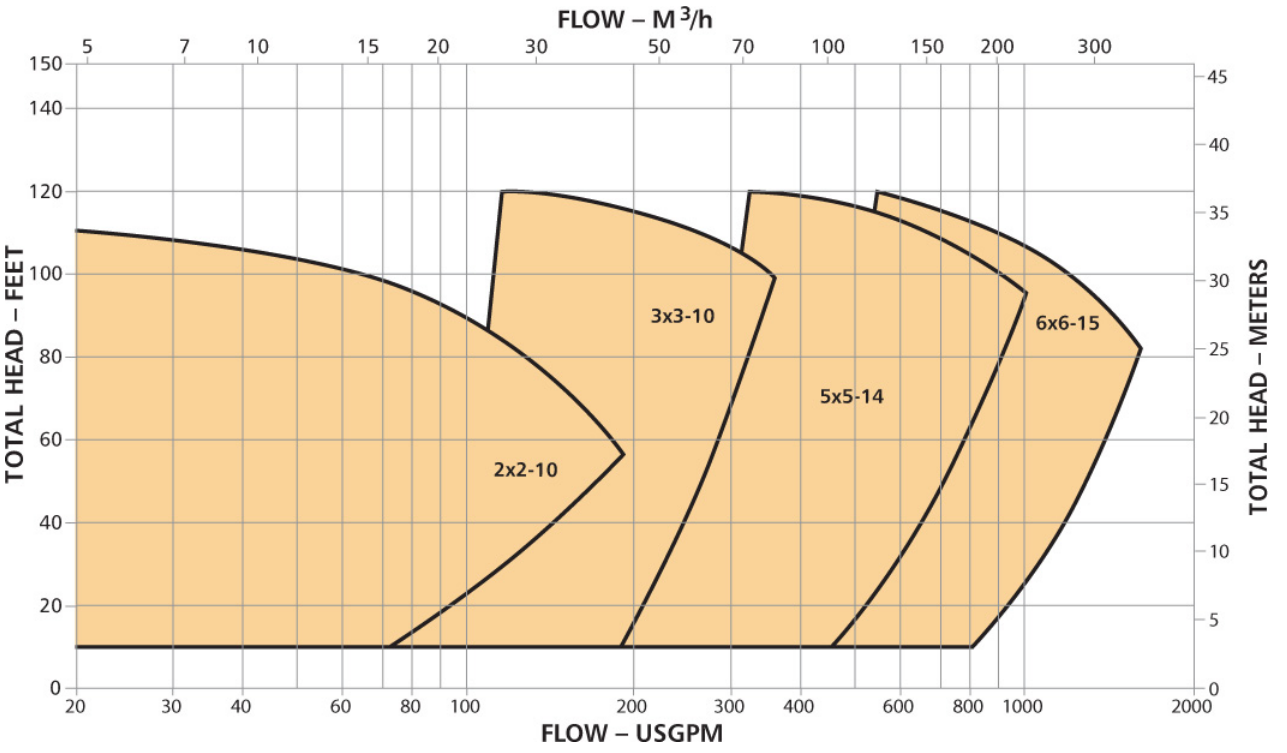
The SRL series rubber-lined horizontal slurry pumps are used in a variety of applications in mineral processing and general industry. The open impeller is designed to handle most types of slurry in abrasive and corrosive applications, including some containing air or froth.

It is typically used for slurries containing solids up to a nominal ⅛" (3.2mm) in diameter. A wide range of natural and synthetic elastomers are available to handle slurries containing a variety of chemicals.

Design Features and Benefits

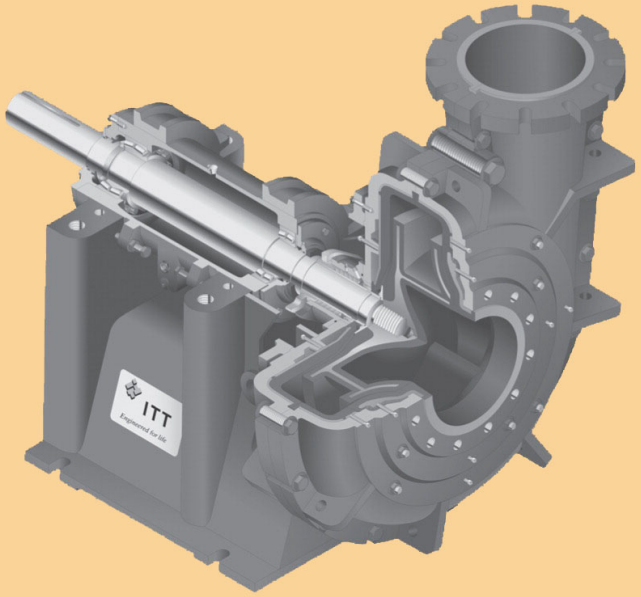
- Precision-molded, thick bolt-in liners
  Long-life and secure assembly in casing
- Large diameter semi-open impeller
  Low speeds and extended wear life
- Axially adjustable bearing assembly
  Maintains peak operating efficiency and life
- Short, rigid shaft and heavy-duty bearings
  Low deflections and reliable service
- Packed gland option or mechanical seal
  Standard, low, or no dilution arrangements
- Precision-machined cast iron frame
  Sturdy, vibration-free support
- Five discharge positions available
  Suitable for most piping arrangements

Hydraulic Coverage



Model SRL-C Heavy Duty Slurry Pumps

- Sizes: 3" to 20" (75mm-500mm)
- Flows to: 20,000 GPM (4,542 m3/h)
- Heads to: 164 feet (50 m)
- Solids to: ¼" (6.4 mm)
- Pressures to: 400 PSIG (2,758 kPa)



Model SRL-C 12 x 10-25

The SLR-C series rubber-lined horizontal slurry pumps utilize proven hydraulics to deliver high efficiencies for pumping abrasive and / or corrosive slurries. The closed impeller is designed to handle very abrasive slurries with high concentrations of solids in mining, mineral processing and general industry.

The Goulds SRL-C pump is typically used for slurries containing solids up to ¼" (6.4mm) in diameter and heavy concentrations of solids. A choice of natural and synthetic elastomers is available to suit most slurry applications.

SRL-C 20 x 18-40

Design Features and Benefits

- High-efficiency design
  Very low power costs
- Proven hydraulics for slurry service
  Extended parts wear life
- Thick bolt-in liners
  Positive assembly in casing for extended life
- Large liners reinforced with a fiberglass shell
  Resist liner collapse under adverse conditions
- Large-diameter closed impeller
  Lower speeds and extended wear life
- Replaceable suction wearplate available on 6" (150 mm) and larger pumps
  Provides reduced downtime and lower replacement cost
- Axially adjustable bearing assembly
  Maintains peak operating efficiency and life
- Short, rigid shaft and heavy-duty bearings
  Low deflections and reliable service
- Packed gland option or mechanical seal
  Standard, low, or no dilution arrangements
- Precision-machined cast iron frame
  Sturdy, vibration-free support
- Five discharge positions available
  Suitable for most piping arrangements

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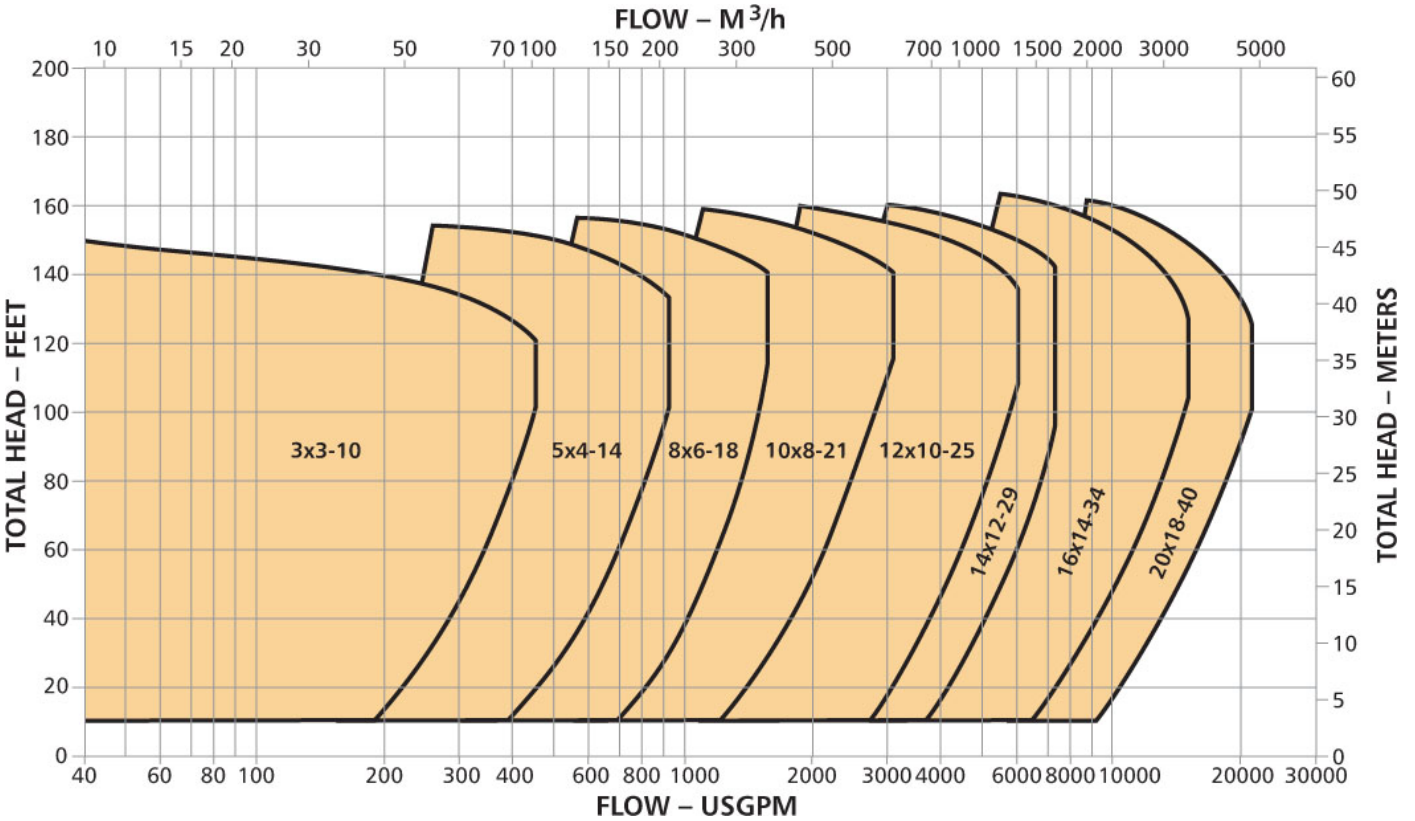
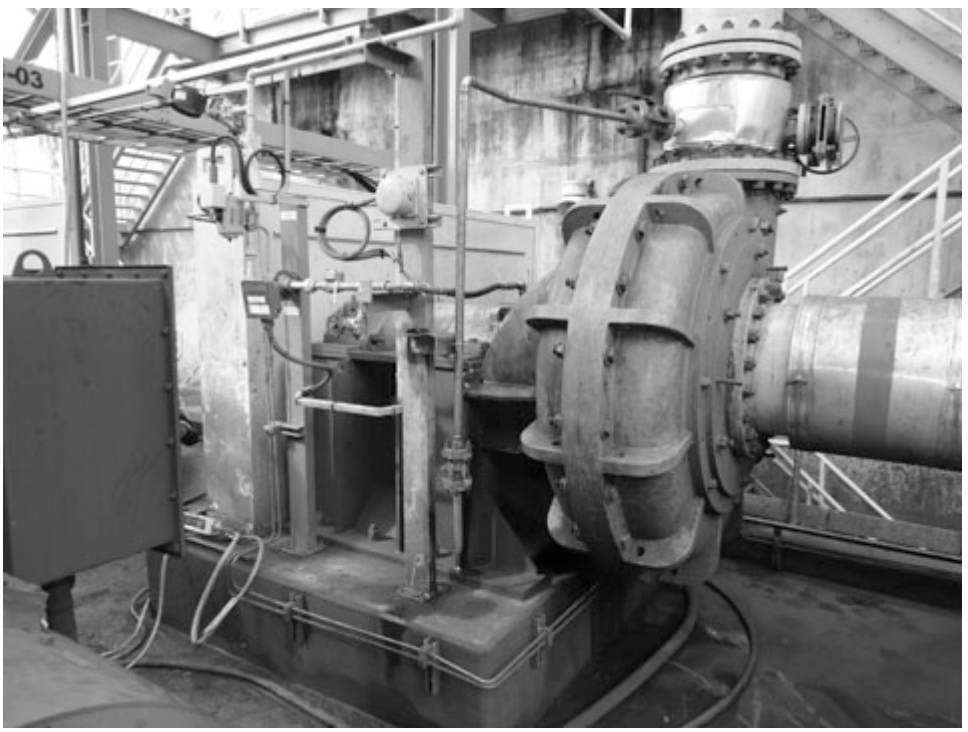
Hydraulic Coverage





SRL-C 20 x 18-40

Ball Mill

Sag Mill

The SRL-XT has extra-thick rubber components which are up to three times thicker than standard rubber-lined pumps. Its heavy duty design makes it ideal for the toughest applications, especially where coarser slurries are involved.

SRL-XT 14 × 12 - 36 on Ball Mill Discharge Service

Model SRL-XT

Designed with Extra-Thick Rubber for the Most Severe and Abrasive Applications

- Sizes: 6" (150 mm) to 12" (300 mm)
- Flows to: 10,000 GPM (2,270 m^3/h)
- Heads to: 140 feet (42 m)
- Solids to: ½" (13 mm)
- Pressures to: 250 PSIG (1,725 kPa))

Design Features and Benefits

Rubber up to three times the conventional thickness

- Handles coarse material with imporved abrasion resistance, longer wear life and less downtime

Precision molding of rubber-to-metal skeletons, bolt-in liners

- Greater dimensional accuracy; fast, easy replacement; reduced downtime

Tongue-and-groove fit between casing halves and liners

- Positive locking of liner into casing to prevent collapse

Front removal of suction wearplate

- Allows for inspection and ease of replacement without disturbing discharge
- Allows for rotation of suction wearplate to maximize efficiency and wear life

Large ACME impeller threads

- Allows for quick, easy removal of impeller, less downtime

Impeller release collar

- Relieves pressure on impeller allowing easy removal, less downtime

Heavy-duty oil lubricated bearing cartirdge with labyrinth style seals

- Maximum bearing and shaft life, less downtime
- External impeller adjustment maintains peak operating efficiency and maximizes life

Packed gland or mechanical seal options

- Standard full flush, low or no dilution available

Free-standing pump with rugged cast iron pedestal

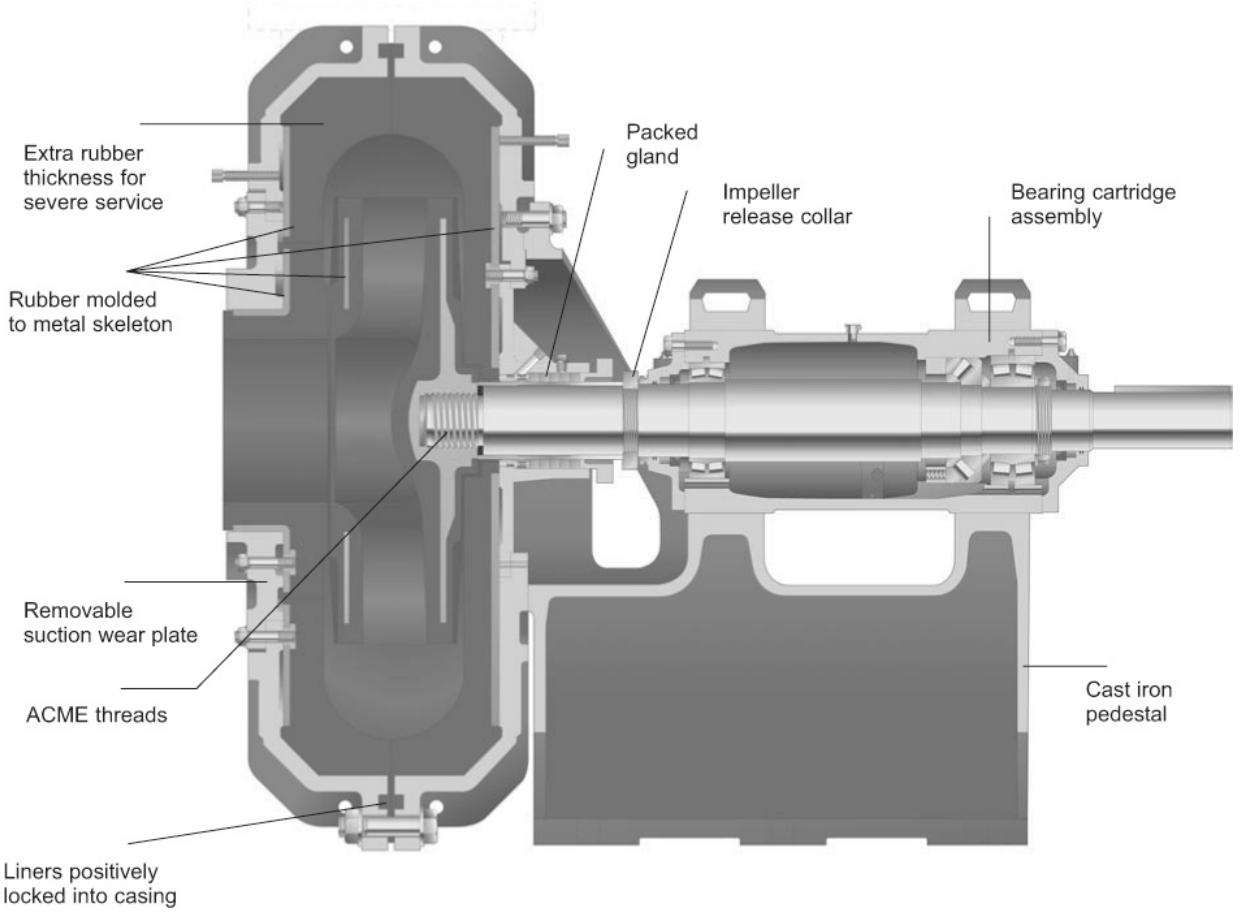
- Allows mounting of pump directly on concrete foundations
- Won't tip
- Allows for mounting of large motors overhead, saves space

Services

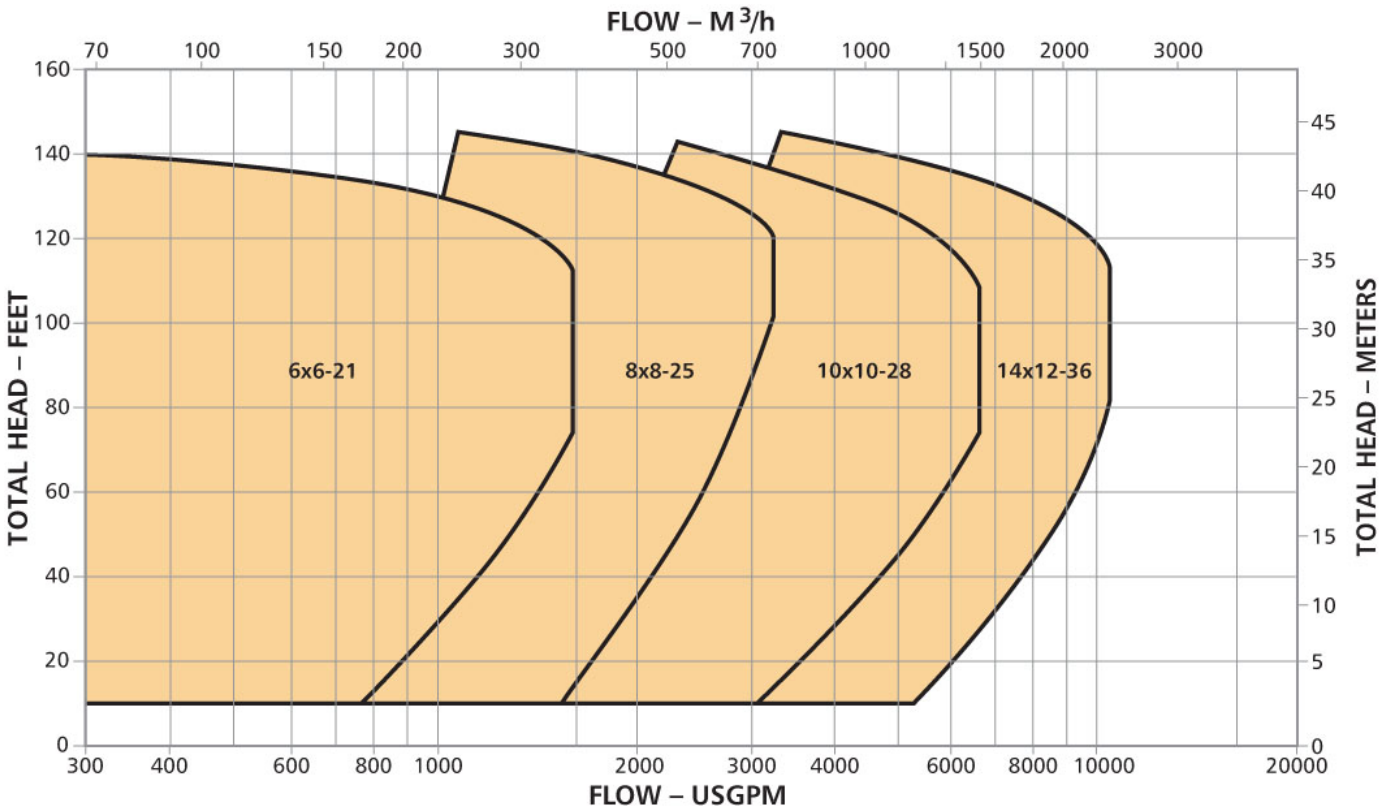
- Sag Mill
- Rod & Ball Mill
- Primary and Secondary Cyclone
- Thickener Feed
- Flotation Feed
- Tailings

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Sectional View **Model SRL-XT**



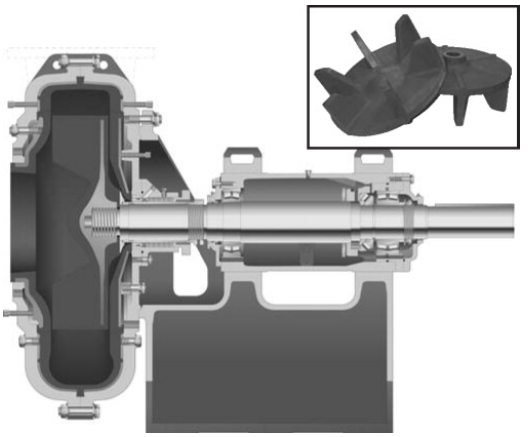
Hydraulic Coverage



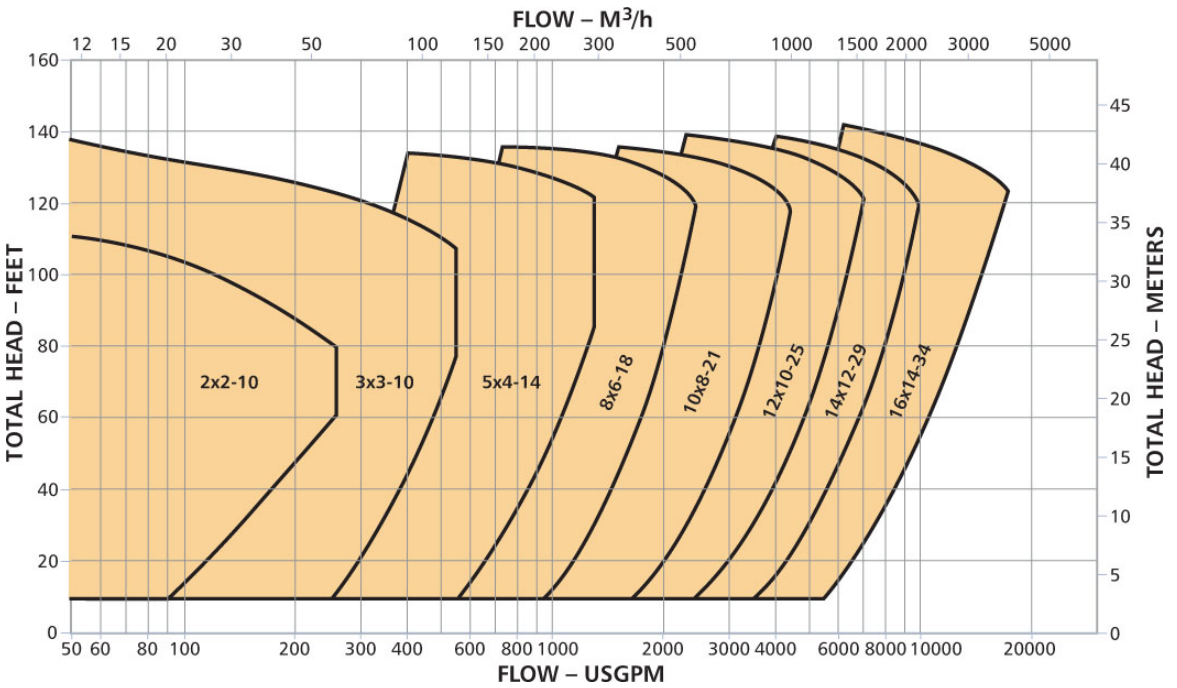
Sectional View **Model SRL-S**

The SRL-S Shearpeller® provides the solution for applications with entrained air, froth and stringy solids.

The Shearpeller's innovative patented design successfully handles large stringy solids. Also, due to its unique tapered radial vane design the SRL-S can handle up to a froth factor of 2.5 without oversizing the pump, providing significant cost savings. This design is also very effective in handling entrained air without air binding. Available on the 2×2-10 SRL and all sizes of the SRL-C up through the 16×14, the Shearpeller ® is completely interchangeable with the standard models.



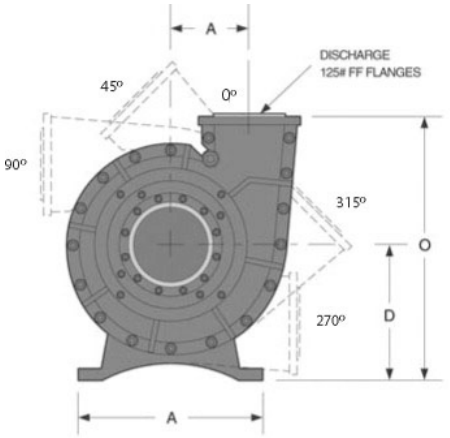
Hydraulic Coverage

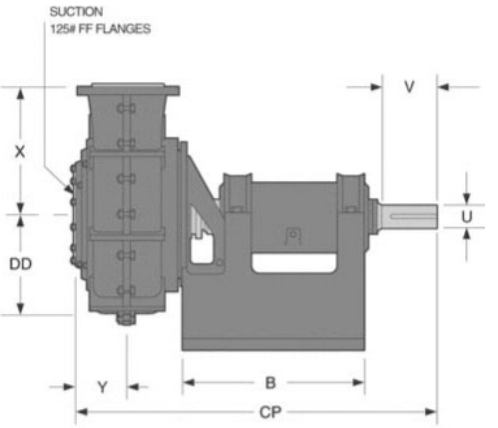


Engineering Data

Model	Size	Frame	Cartridge	Shearpeller	Suction Wearplate	Hybrid Liners	Maximum Working Pressure (PSI)							Weight Lbs. (Kg.)
							75	125	140	225	250	400	500	
SRL	2 × 2 – 10	0		X			X	X		X				380 (172)
SRL	3 × 3 – 10	1	X				X							500 (227)
SRL	5 × 5 – 14	2	X				X							1000 (436)
SRL	6 × 6 – 15	2	X				X			X				1300 (590)
SRL-C	3 × 3 – 10	1	X	X			X	X		X				650 (295)
SRL-C	5 × 4 – 14	2	X	X			X	X		X				1100 (499)
SRL-C	8 × 6 – 18	3	X	X	X		X	X		X				2850 (1293)
SRL-C	10 × 8 – 21	3	X	X	X		X	X		X	X			3400 (1542)
SRL-C	12 × 10 – 25	4	X	X	X	X			X		X			4300 (1950)
SRL-C	14 × 12 – 29	5	X	X	X	X			X		X	X		6700 (3039)
SRL-C	16 × 14 – 34	6	X	X	X	X			X		X		X	9100 (4127)
SRL-C	20 × 18 – 40	7	X		X	X			X		X	X		15300 (6938)
SRL-XT	6 × 6 – 21	3	X		X		X			X				3450 (1565)
SRL-XT	8 × 8 – 25	4	X		X			X			X			4900 (2222)
SRL-XT	10 × 10 – 28	5	X		X			X			X			7550 (3424)
SRL-XT	14 × 12 – 36	6/7	X		X			X			X			10420 (4725)

Dimensions Models SRL and SRL-C



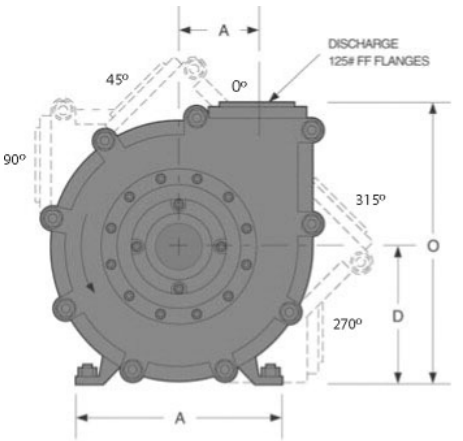


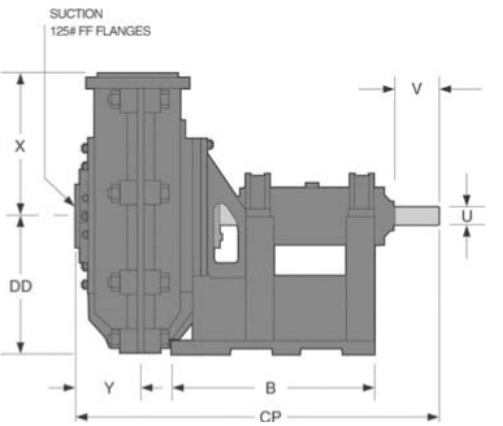
BARE PUMP DIMENSIONS														
Size and Type	Suct.	Disch.	No.	Frame A	B	CP	D	DD	O	U	V	X	Y	Z
2 × 2 - 10 SRL	2.0	2.0	0	9.5	12.2	27.7	9.0	8.2	17.1	1.1	3.4	3.1	2.3	5.5
3 × 3 - 10 SRL	3.0	3.0	1	12.4	15.2	34.8	12.5	10.1	21.2	1.6	5.0	6.7	3.1	6.2
5 × 5 - 14 SRL	5.0	4.0	2	15.0	17.1	41.1	15.5	12.7	30.0	2.2	7.4	14.5	3.9	9.5
6 × 6 - 15 SRL	6.0	6.0	2	15.0	17.1	43.3	15.5	14.0	31.5	2.2	7.4	16.0	5.1	9.7
3 × 3 - 10 SRL-C	3.0	3.0	1	12.4	15.2	36.9	12.5	11.6	22.5	1.6	5.0	10.0	4.6	7.9
5 × 4 - 14 SRL-C	5.0	4.0	2	15.0	17.1	42.2	15.5	12.0	30.0	2.2	7.4	14.5	4.6	8.5
8 × 6 - 18 SRL-C	8.0	6.0	3	18.5	29.3	61.4	20.5	15.7	36.5	3.3	11.4	16.0	7.4	11.5
10 × 8 - 21 SRL-C	10.0	8.0	3	18.5	29.3	64.2	20.5	17.6	38.5	3.3	11.4	18.0	8.9	15.0
12 × 10 - 25 SRL-C	12.0	9.75	4	34.0	34.0	65.5	22.0	20.7	48.2	4.0	9.6	24.2	8.5	14.7
14 × 12 - 29 SRL-C	14.0	11.75	5	41.0	42.0	72.9	28.0	25.7	53.0	4.7	12.0	25.0	9.4	19.6
16 × 14 - 34 SRL-C	16.0	13.2	6	49.5	39.5	80.4	34.0	31.1	61.5	4.9	14.0	27.5	10.9	23.7
20 × 18 - 40 SRL-C	20.0	17.0	7	48.0	55.5	93.7	37.0	32.7	69.7	5.5	9.7	32.7	13.4	27.2

NOTES:

1. All dimensions are in inches.
2. Discharge positions a,b,c,d and e are standard on all pump sizes.
3. Not for construction, installation or application purposes.
4. SRL-S dimensions are the same as the equivalent SRL-C pump sizes.

Model SRL-XT





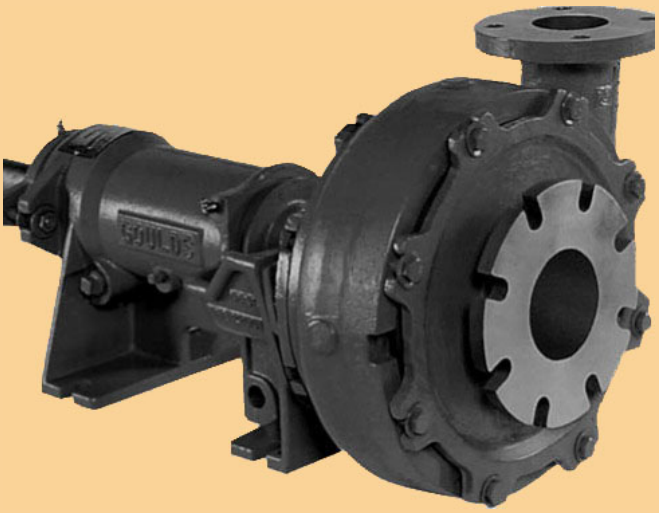
BARE PUMP DIMENSIONS													
Size and Type	Suct.	Disch.	A	B	CP	D	DD	O	U	V	X	Y	Z
6 × 6 - 21 SRL-XT	6.0	5.2	18.6	29.3	63.2	20.5	17.6	38.5	3.3	11.3	18.0	8.9	15.0
8 × 8 - 25 SRL-XT	8.0	8.0	34.0	34.0	68.7	22.0	25.1	46.7	4.0	9.6	24.7	11.2	14.0
10 × 10 - 28 SRL-XT	9.5	10.25	41.0	42.0	74.7	28.0	29.5	57.2	4.75	9.5	29.2	12.2	17.1
14 × 12 - 36 SRL-XT	13.38	12.0	49.5	39.5	81.1	34.0	34.7	68.0	5.5	12.5	34.0	13.2	22.1

NOTES:

1. All dimensions are in inches.
2. Discharge positions a,b,c,d and e are standard on all pump sizes.
3. Not for construction, installation or application purposes.

The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.

NOTES

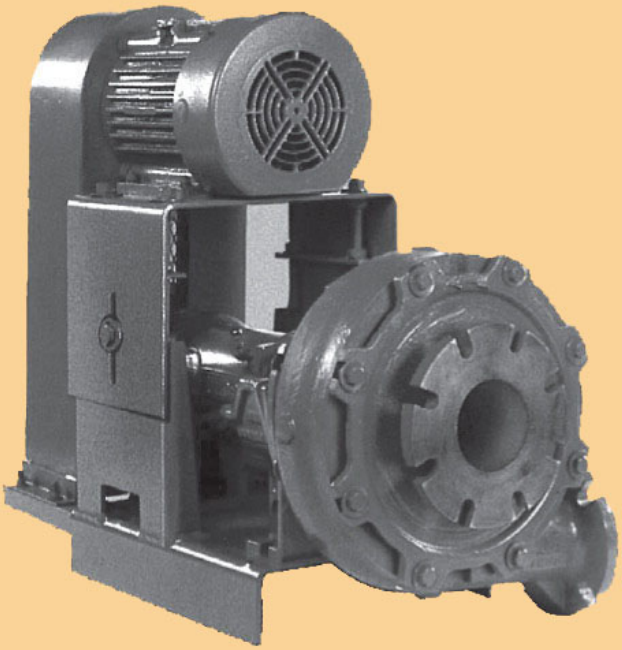


Goulds Model JC

Designed for Handling a Wide Range of Corrosive / Abrasive Slurries

- Capacities to 7,000 GPM (1,600 m^3/h)
- Heads to 240 feet (73 m)
- Temperatures to 250°F (121°C)
- Pressures to 127 PSIG (876 kPa)
- Spherical solids to 2¼ inches (57 mm)

Thousands of installations attest to the remarkable versatility of the Model JC Slurry pump. Sixteen sizes are available in a wide range of materials and configurations, making the JC ideal for most medium-duty abrasive and / or corrosive slurry services. Plus, it's designed for extreme ease of maintenance and long hours of reliable operation.



Design Features

- **Extra-Thick Wet End Components-**For extended wear life.
- **Replaceable Wear Liner**-Low maintenance cost.
- **Heavy-Duty Power End**-Increased mean time between failures.
- **External Impeller Adjustment**-Maintains original efficiency; simple and fast.
- **Maximum Parts Interchangeability**-Entire line uses just five power ends.
- **Sealing Flexibility**-Choice of packing, mechanical seals or Dynamic Seal.

Services

- Wet scrubber systems
- Waste sludge
- Fracing slurries
- Paper mill wastes and liquors
- Clay and sand slurries
- Dirty water
- Kaolin clay
- Carbon slurry
- Lime mud
- Precipitated $CaCO_3$

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model JC Medium Duty Slurry Pump

Design Features for Wide Range of Corrosive/Abrasive Services

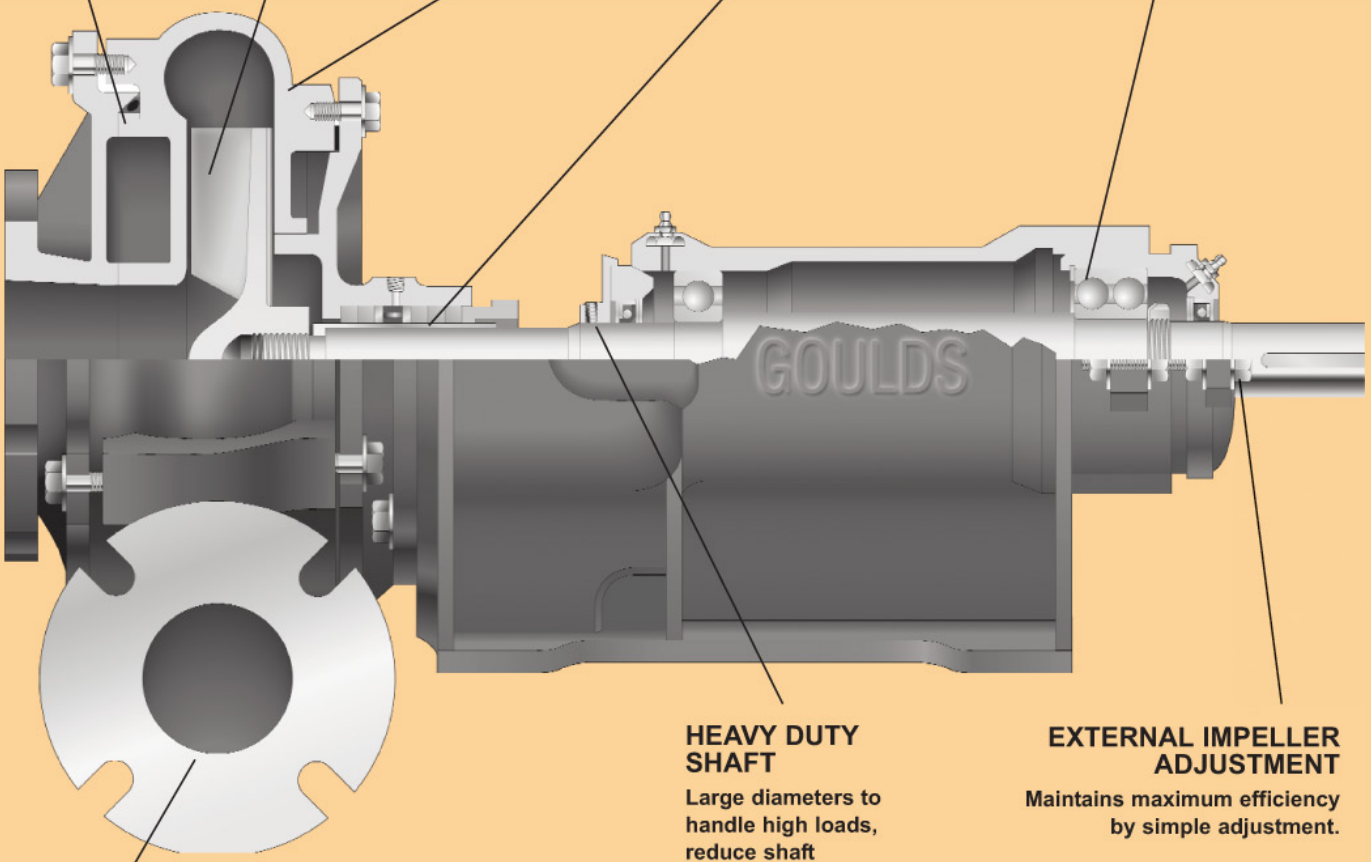
SUCTION COVER LINER
Replaceable part takes all wear on suction side of casing.

IMPELLER
Best design for slurry services/ proven by wear testing and field experience. Back pump-out vanes reduce stuffing box pressure, keep solids out of stuffing box.

CASING
Extra thick wall sections for extended wear life, reduced maintenance. Dual volute design where necessary to reduce radial loads.

SHAFT SLEEVE
Hook-type design with gasket for shaft protection.

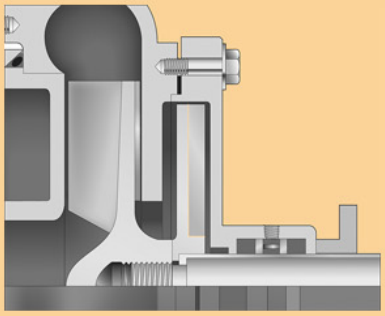
BEARINGS
Radial and thrust bearings are sized for 3-year life (25,000 hours). Grease or oil lubrication.



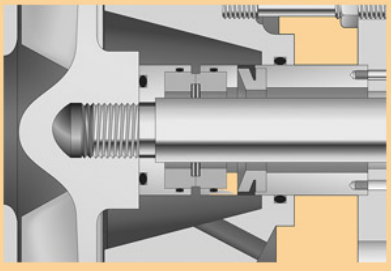
HEAVY DUTY SHAFT
Large diameters to handle high loads, reduce shaft deflection.

EXTERNAL IMPELLER ADJUSTMENT
Maintains maximum efficiency by simple adjustment.

DISCHARGE NOZZLE
May be rotated in field to any of eight positions.



DYNAMIC SEAL
Expeller option for absolute dry box sealing. No outside flush required.



MECHANICAL SEAL
A wide range of mechanical seals is available for sealing flexibility. Optional TaperBore™ seal chamber provides increased seal life.

Designed for Long Life, Reliable Operation

Pump End

Wet-end components feature extra metal thickness for extended wear. Replaceable suction cover liner takes all wear on suction side of casing; simplifies maintenance.

Efficient slurry design impeller for long life, optimum performance.

Components are fully-machined for positive alignment.

Stuffing Box Cover

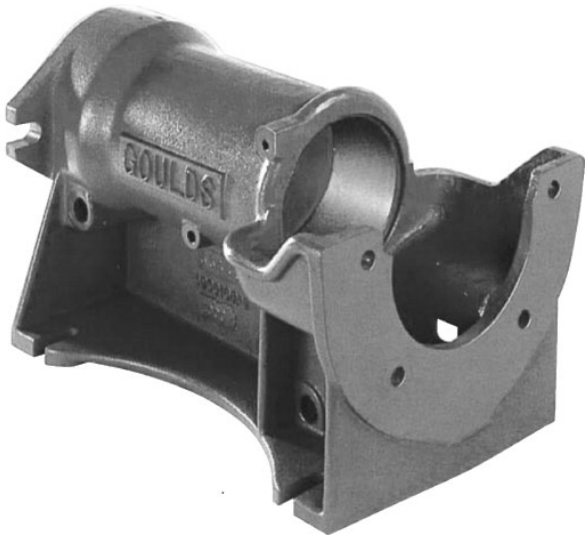
Casing

Impeller

Suction Cover Liner

Suction Cover

Power End



HEAVY-DUTY BEARING FRAME

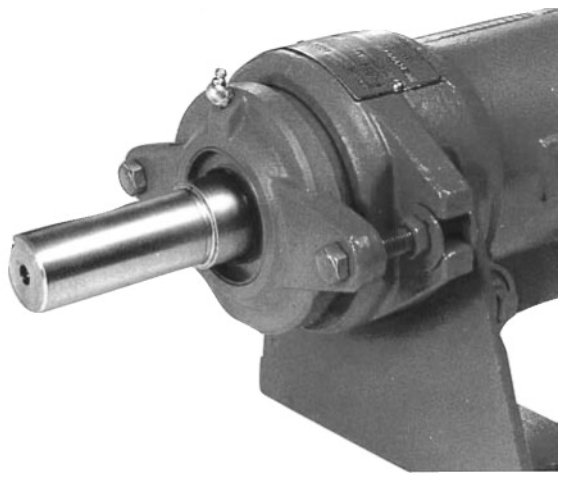
Rugged one-piece design with integral drip basin. Five frames accommodate fifteen pump sizes. Grease or oil lube.

RUGGED SHAFT ASSEMBLY

Designed for continuous service under the most severe operating conditions. Shaft designed for minimum deflection at maximum loads.

REPLACEABLE SHAFT SLEEVE

Hook-type sleeve protects shaft from pumpage.



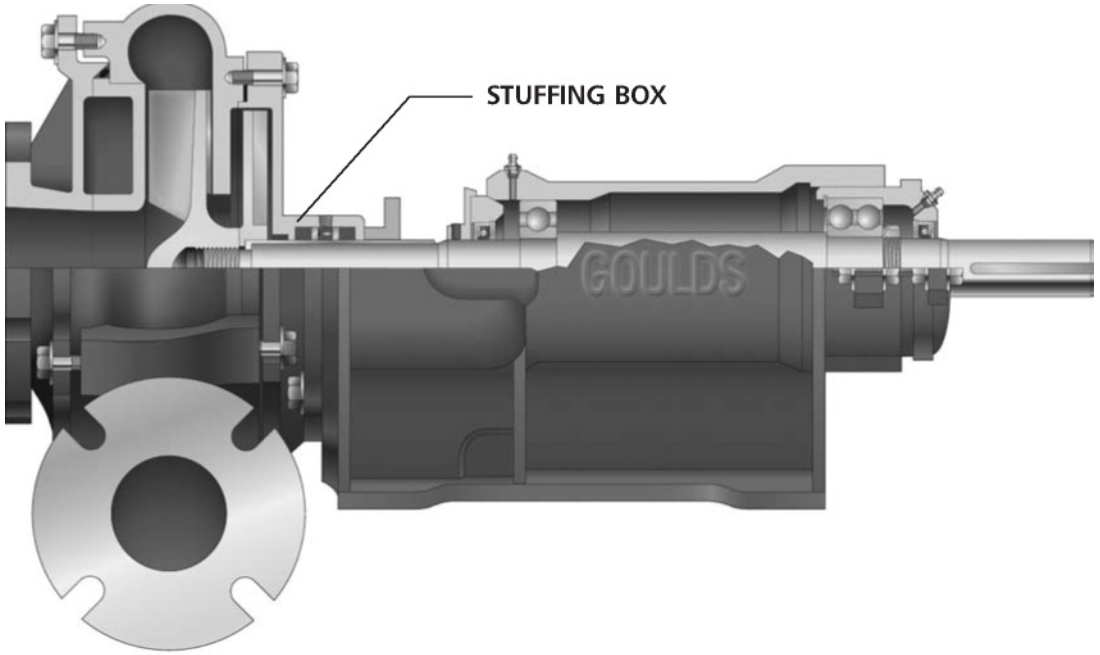
EXTERNAL IMPELLER ADJUSTMENT

Original performance easily maintained by adjustable jacking screws without disassembly of pump.

Sealing Flexibility

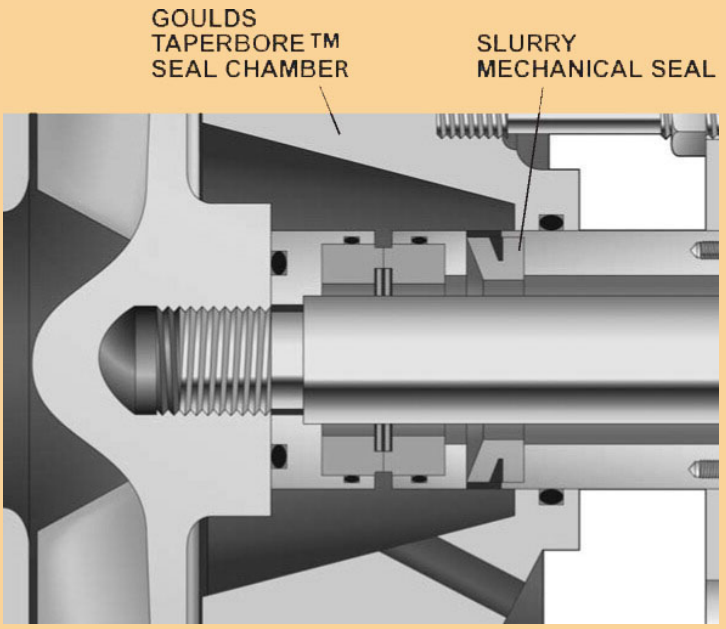
Goulds Dynamic Seal option is ideally suited to handle the tough applications where mechanical seals or packing require outside flush and constant /costly attention. An expeller between the stuffing box cover and impeller pumps liquid from the stuffing box.

For most applications, external seal water is not required- eliminating leakage, pumpage contamination, product dilution and problems associated with piping from a remote source.



Mechanical Seal

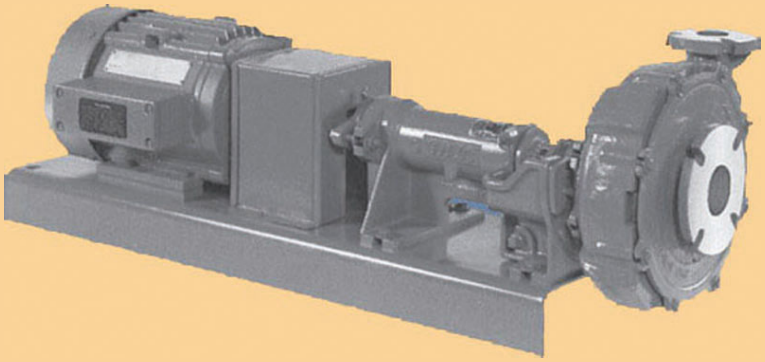
Goulds offers a variety of mechanical seals for applications flexibility including special slurry seals for tough services. In addition, a special enlarged seal chamber is offered for improved lubrication and cooling of the mechanical seal. The tapered throat keeps solids away from seal faces and from building up in the chamber. Seal life is remarkably extended.

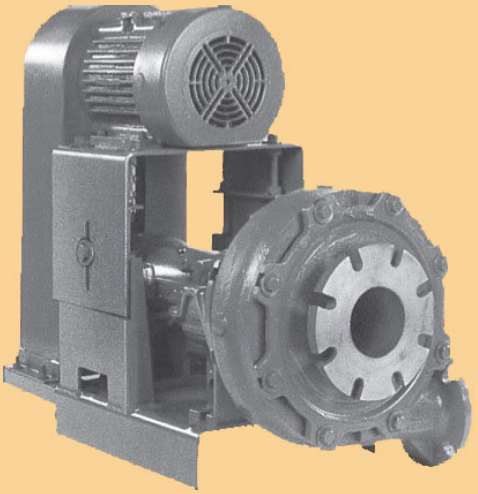


Application Flexibility

The Model JC is extremely versatile. A variety of drive arrangements can be supplied for application flexibility.

DIRECT DRIVE UNIT





OVERHEAD BELT DRIVE
Also available mounted side-by-side.

For Sump Pumping Applications

When the Model JC's performance and features are required for sump services, you can choose either a Model JCU submersible or Model VJC cantilever for extended service in abrasive slurry applications.

Model JCU Submersible Slurry Pump

- Capacities to 4,000 GPM (910 m^3/h)
- Heads to 210 feet (65m)
- Temperatures to 194F (90˚C)
- Solids to 2 inches (50 mm)

Features

- Replaceable Suction Liner
- Permanently lubricated bearings
- Automatic reset thermostats
- Tandem mechanical seals
- Optional slide rail assembly

Model VJC Vertical Cantilever Slurry Pump

- Capacities to 7,500 GPM (1,703 m^3/h)
- Heads to 240 feet (73 m)
- Temperatures to 200˚F (93˚C)
- Pit depths to 11 feet (3.4 m)
- Solids to 2 ¼ inches (57 mm)

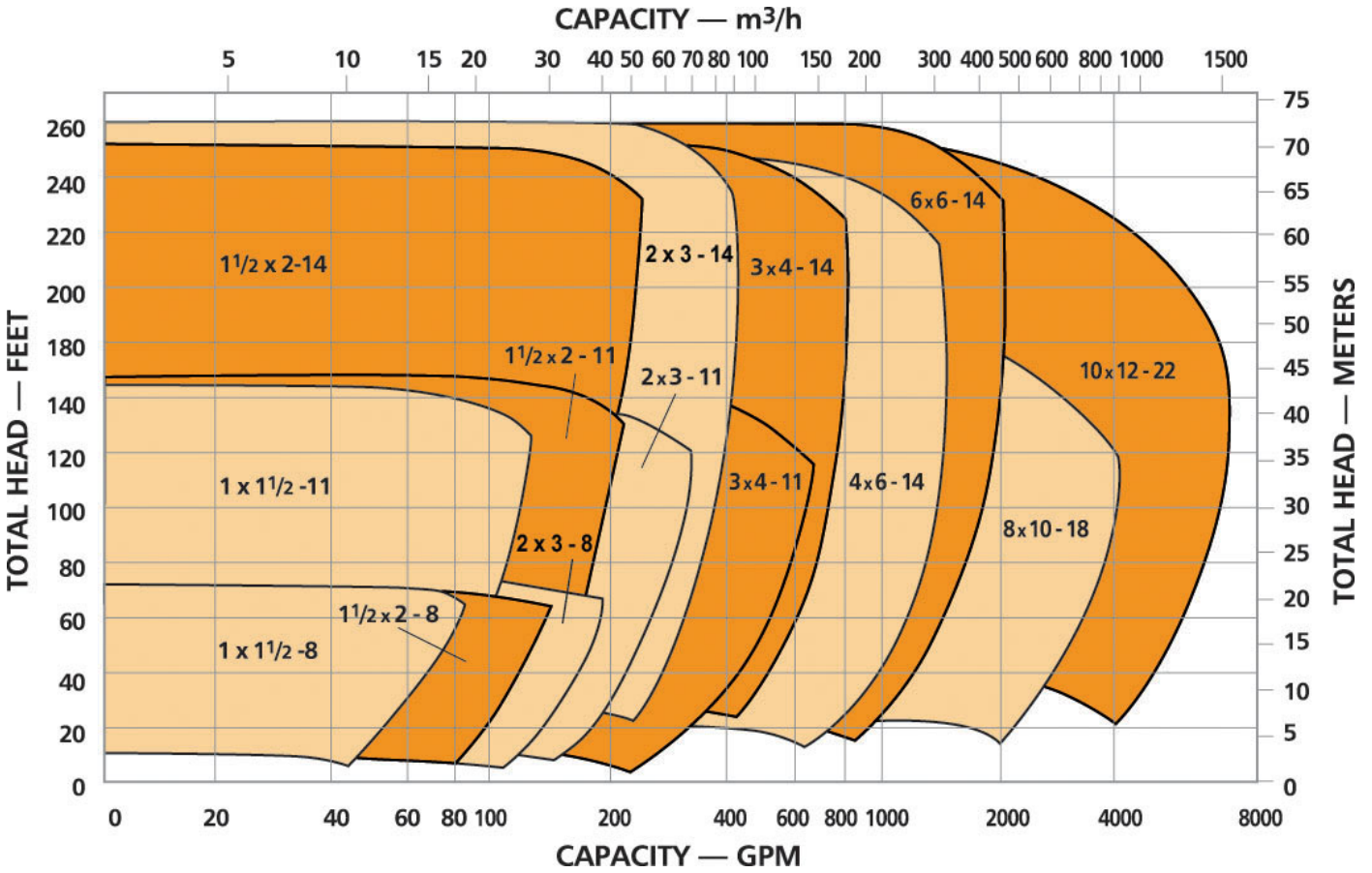
Features

- Cantilever design
- External impeller adjustment
- Heavy-duty bearings
- Bottom suction
- Replaceable suction liner

Model JCU

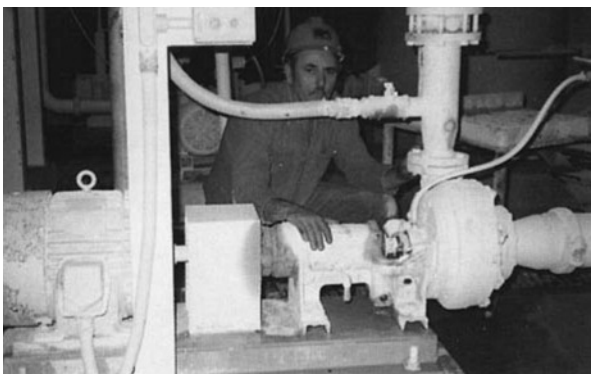
Model VJC

Hydraulic Coverage **Model JC**



Proven Performance

Goulds Model JC is in use by many industries on the most demanding slurry pump applications. The versatility of the product combined with rugged design and ease of maintenance have satisfied thousands of users' requirements for a pump that has it all.



Materials of Construction

Item Number	Description	Material			
		HC600	EnduraChrome™	316SS	CD4MCu
100	Casing	HC600	EnduraChrome™	316SS	HC600
100B	Suction Cover Liner	HC600	EnduraChrome™	316SS	HC600
101	Impeller	HC600	EnduraChrome™	316SS	HC600
105	Lantern Ring	Teflon *			
106	Padding	Graphitized Polymer Fiber			
107	Gland	316SS			
112	Thrust Bearing	Steel			
122	Shaft	Steel 1144			
123	Deflector	Cast Iron			
126	Shaft Sleeve	416SS	316SS		A-20
134	Bearing Housing	Cast Iron			
168	Radial Bearing	Steel			
182	Suction Cover	Cast Iron	EnduraChrome™	316SS	CD4MCu
184	Stuffing Box Cover	Cast Iron	EnduraChrome™	316SS	CD4MCu
184	Stuffing Box Cover (Expeller)	HC600	EnduraChrome™	316SS	CD4MCu
184A	TaperBore Seal Chamber	Cast Iron	EnduraChrome™	316SS	CD4MCu
332	Grease Seal (Outboard)	Buna-N			
333	Grease Seal (Inboard)	Buna-N			
228	Bearing Frame	Cast Iron			
262	Expeller	HC600	EnduraChrome™	316SS	CD4MCu
353	Mechanical Seal	As Required			
351	Gasket	Buna-N			
412	O-ring, Suction Cover to Casing	Buna-N			

* E.I. DuPont® Trademark

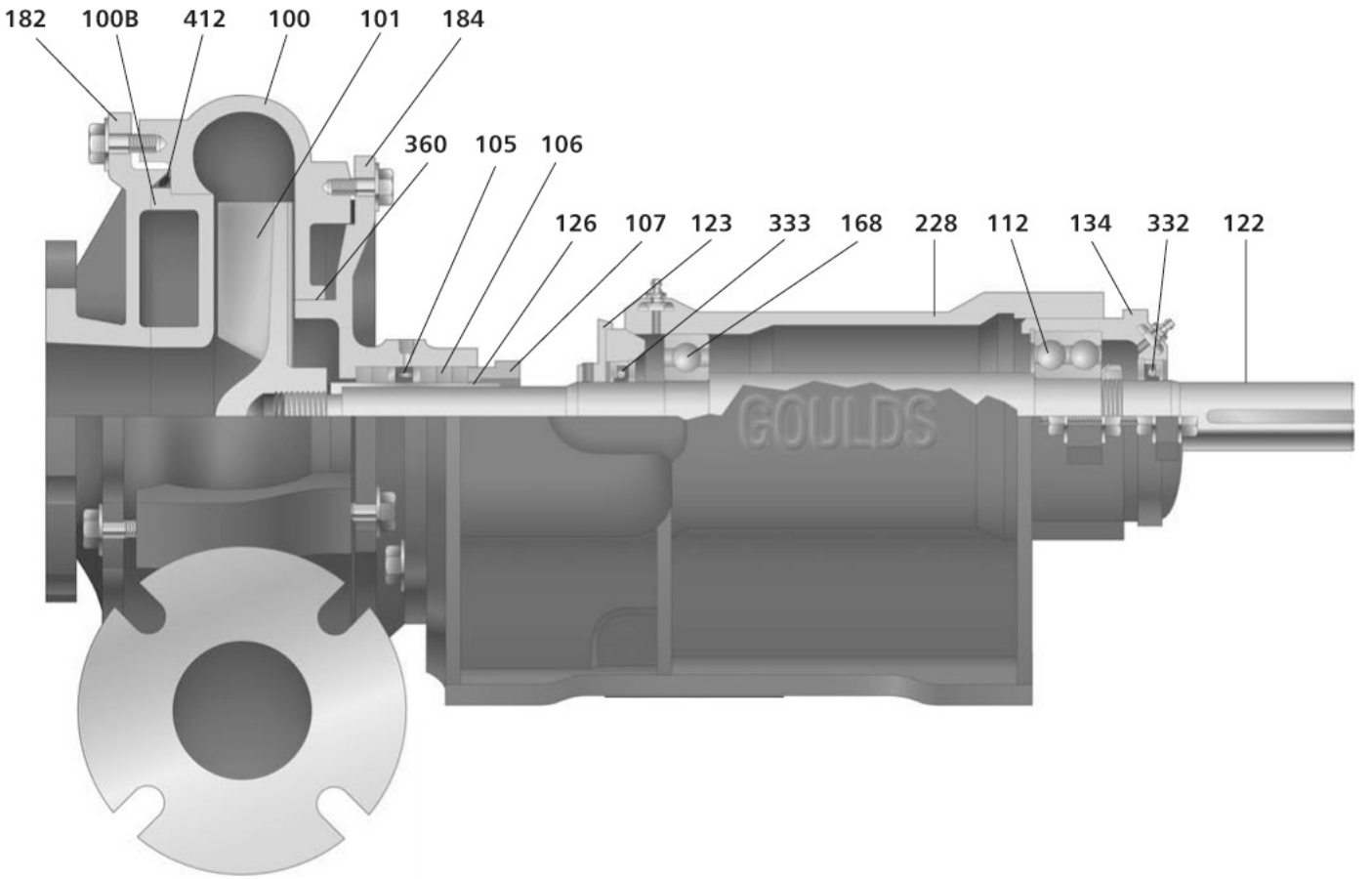
Materials of Construction

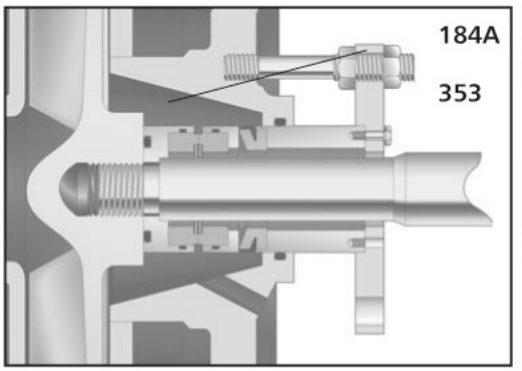
Description	Specification
Cast Iron	ASTM A48
HC600	ASTM A532 Class III Type A Hardened
EnduraChrome™	Modified ASTM A532 Class III Type A Hardened
316SS	ASTM A743 CF8M
416SS	AISI 416
CD4MCu	ASTM A743 CD4MCu
C-20	ASTM A296 CN7N

Construction Details All dimensions in inches and (mm).

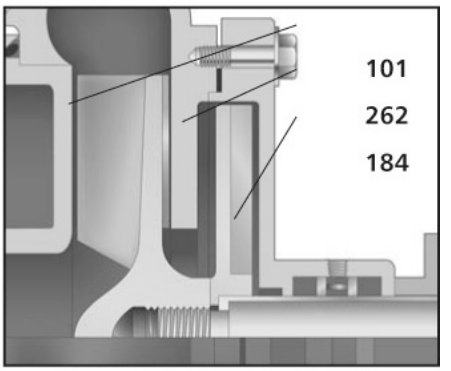
Pump Size	Frame	Pump						Stuffing Box						
		Max. Casing Thickness	Max. Solids Size	Working Pressure Cast Iron	Working Pressure HC600 &316SS	Max. HP (kW)	Shaft Dia. At Coupling	Bore	Depth	Sleeve OD	Shaft Dia. under Sleeve	Packing Size	No. of Rings	Seal Water Req'd
1 × 1½ - 8	1J	.375 (10)	.5 (12)	110 PSIG (758 kPa)	127 PSIG (876 kPa)	25 (19)	1.375 (35)	2.625 (67)	2.938 (75)	1.875 (48)	1.437 (37)	⅜ (9.5)	5	.5 GPH
1 × 1½ - 11														
1½ × 2 - 8			.75 (19)											
1½ × 2 - 11														
2 × 3 - 8		.56 (15)	.875 (22)											
2 × 3 - 11														
1½ × 2 - 14	2J	.375 (10)	.75 (19)			60 (45)	1.625 (41)	2.94 (75)	2.938 (75)	2.125 (54)	1.75 (45)	⅜ (9.5)	5	.5 GPH
2 × 3 - 14		.56 (15)	.875 (22)											
3 × 4 - 11		.62 (16)	1.125 (28)											
3 × 4 - 14	3J					125 (93)	2.125 (54)	3.5 (89)	2.938 (75)	2.75 (70)	2.25 (57)	⅜ (9.5)	5	.75 GPH
4 × 6 - 14			1.38 (35)											
6 × 6 - 14 (LS)			1.5 (38)											
6 × 6 - 14 (HS)	4J					200 (150)	2.625 (67)	4.375 (111)	3.75 (95)	3.375 (86)	2.94 (75)	½ (13)	5	1 GPH
3 × 6 – 18		.75 (19)	.62 (16)											
8 × 10 - 18			2.25 (57)			400 (300)	3.00 (76)	5.375 (137)	4.5 (245)	4.125 (105)	3.44 (88)	⅝ (16)	5	1.5 GPH
10 × 12 - 22	5J													

Sectional View **Model JC**





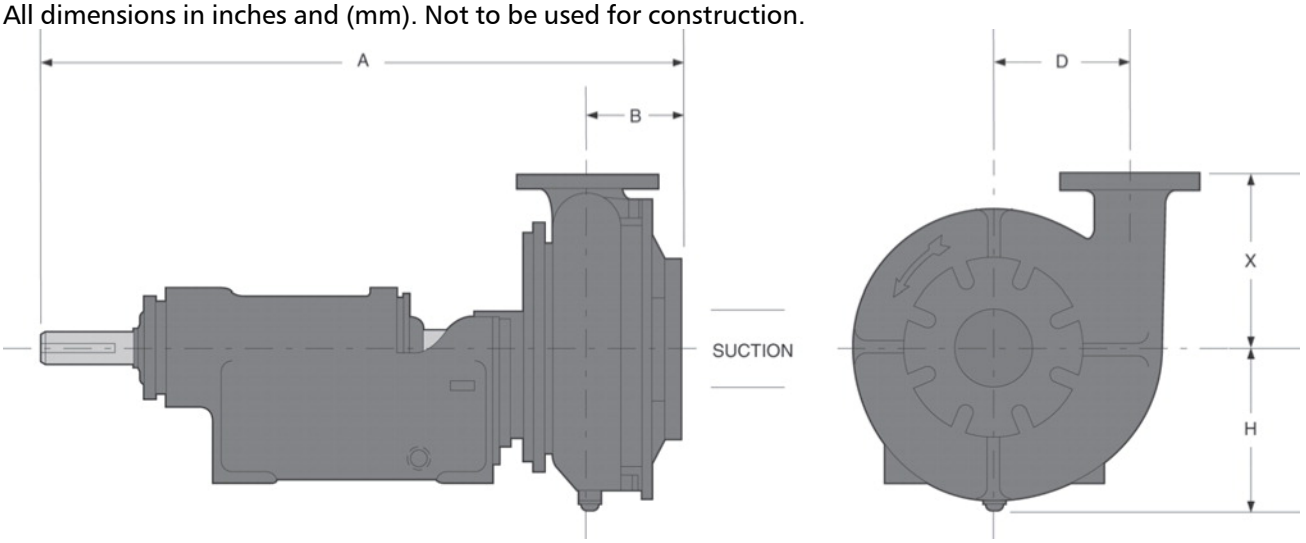
Mechanical Seal with TaperBore™
PLUS *Seal Chamber*



Dynamic Seal

Dimensions Model JC

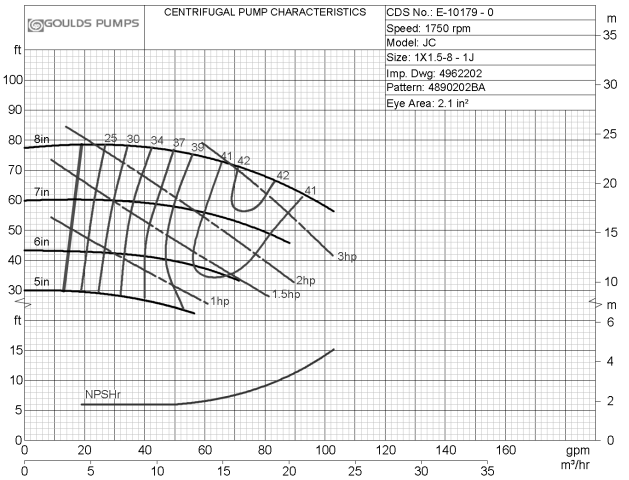
All dimensions in inches and (mm). Not to be used for construction.



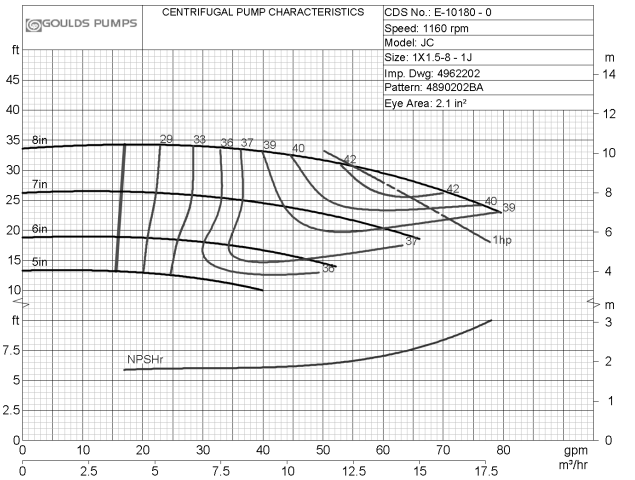
DIMENSIONS							
Pump Size	Frame	A	B	D	H	X	Weight Lbs./(kg)
1 × 1½-8	1J	31.00 (787)	3.00 (76)	4.44 (113)	5.75 (146)	6.25 (159)	190 (870)
1 × 1½-11		31.00 (787)	3.00 (76)	5.88 (149)	6.25 (159)	7.00 (178)	220 (100)
1½ × 2-8		31.50 (800)	3.50 (89)	5.00 (127)	6.38 (162)	6.50 (165)	195 (89)
1½ × 2-11		31.50 (800)	3.50 (89)	6.44 (164)	7.88 (200)	7.50 (191)	230 (105)
2 × 3-8		32.00 (813)	4.00 (102)	5.13 (130)	6.75 (171)	6.88 (175)	205 (94)
2 × 3-11		32.00 (813)	4.00 (102)	6.56 (167)	8.75 (222)	8.00 (203)	245 (112)
1½ × 2-14	2J	31.50 (800)	3.50 (89)	7.88 (200)	9.38 (238)	8.25 (210)	315 (144)
2 × 3-14		32.00 (813)	4.00 (102)	8.06 (205)	8.25 (210)	9.00 (229)	330 (150)
3 × 4-11		32.75 (832)	4.75 (121)	6.88 (175)	9.12 (232)	8.63 (219)	300 (137)
3 × 4-14	3J	36.75 (933)	4.75 (121)	8.38 (213)	10.62 (270)	9.25 (235)	440 (200)
4 × 6-14		37.25 (946)	5.25 (133)	9.13 (232)	11.62 (295)	10.50 (267)	475 (216)
6 × 6-14 (LS)		38.38 (975)	5.63 (143)	9.50 (241)	13.62 (346)	12.50 (318)	590 (269)
3 X 6-18	4J	42.26 (1073)	6.00 (152)	11.50 (292)	12.19 (310)	12.00 (305)	805 (366)
6 × 6-14 (HS)		42.12 (1070)	5.63 (143)	9.50 (241)	13.62 (346)	12.50 (318)	710 (323)
8 × 10-18		46.38 (1178)	9.63 (245)	13.00 (330)	18.00 (457)	16.50 (419)	1020 (464)
10 × 12-22	5J	50.62 (1286)	9.63 (245)	17.00 (432)	21.88 (556)	20.00 (508)	1800 (819)

NOTES

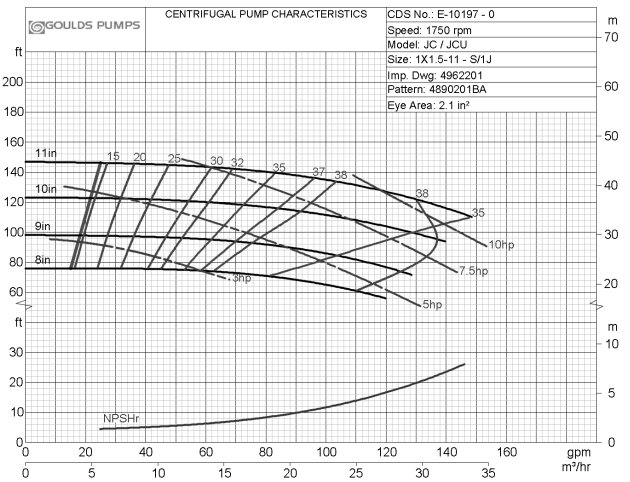
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



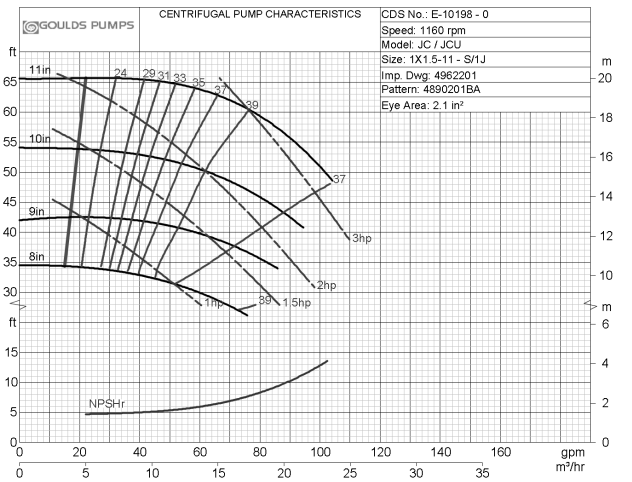
1X1.5-8 **1750rpm**



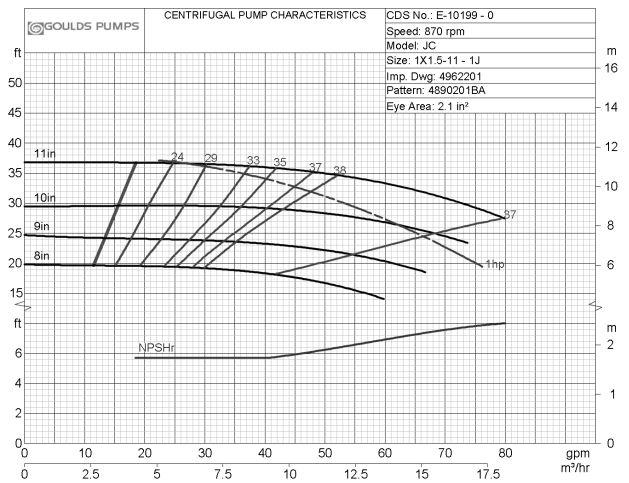
1X1.5-8 **1160rpm**



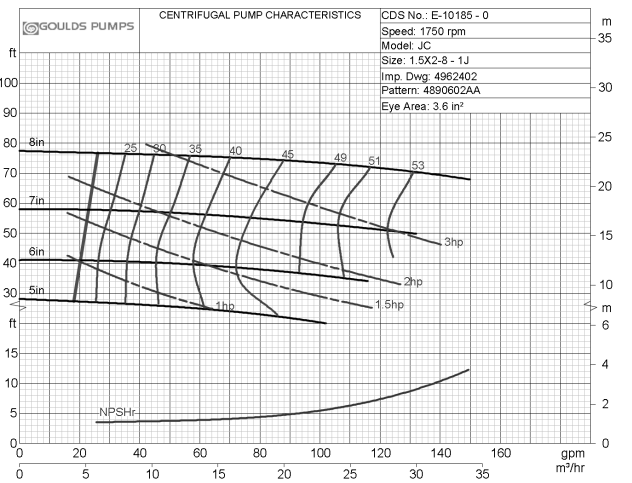
1X1.5-11 **1750rpm**



1X1.5-11 **1160rpm**

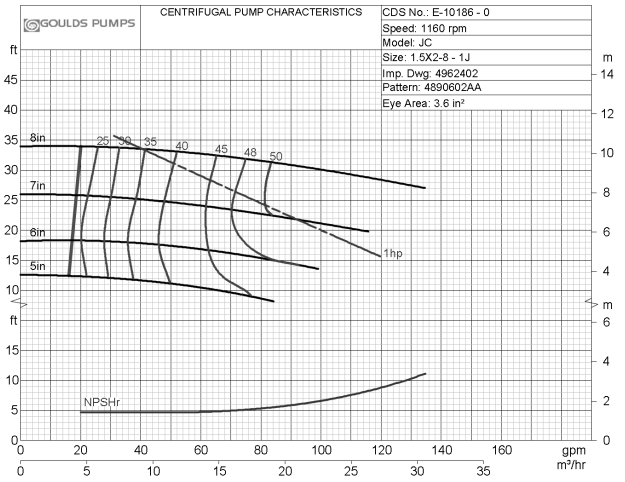


1X1.5-11 **870rpm**

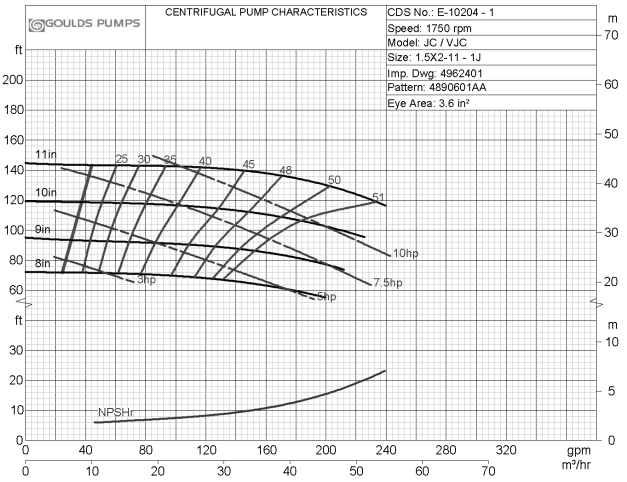


1.5X2-8 **1750rpm**

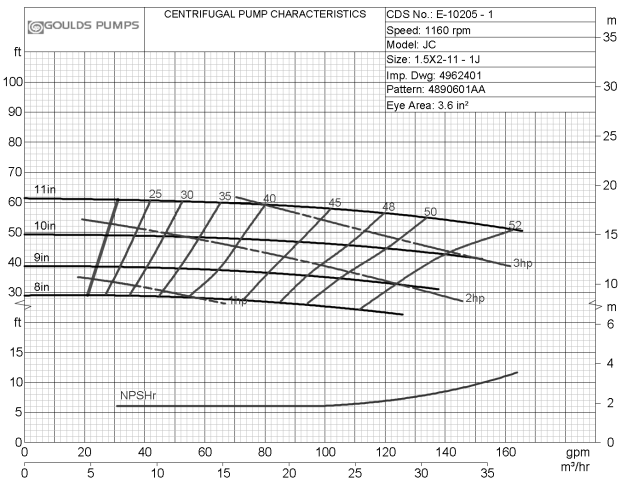
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



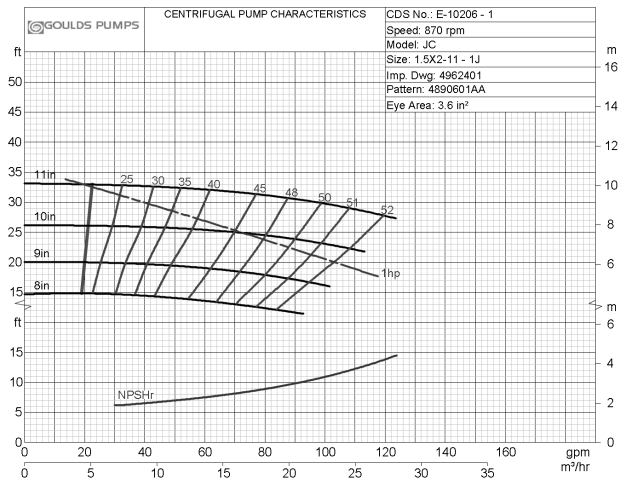
1.5X2-8 **1160rpm**



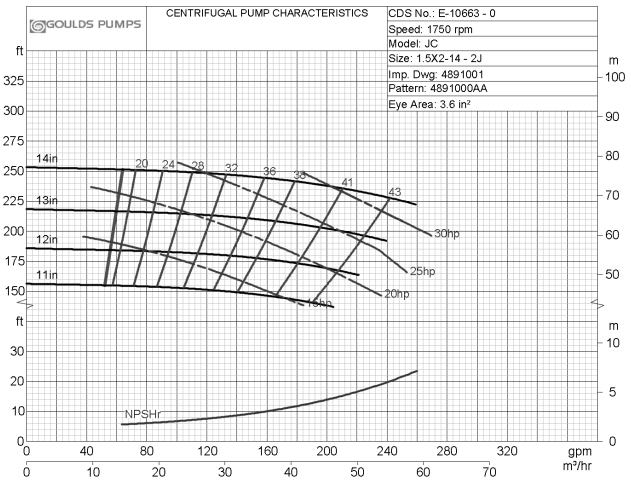
1.5X2-11 **1750rpm**



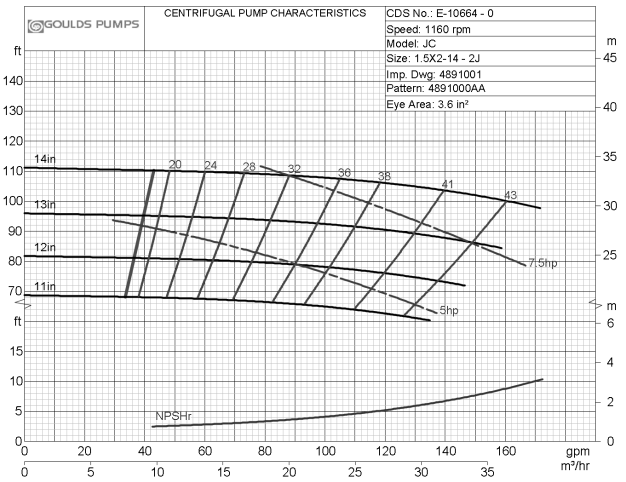
1.5X2-11 **1160rpm**



1.5X2-11 **870rpm**

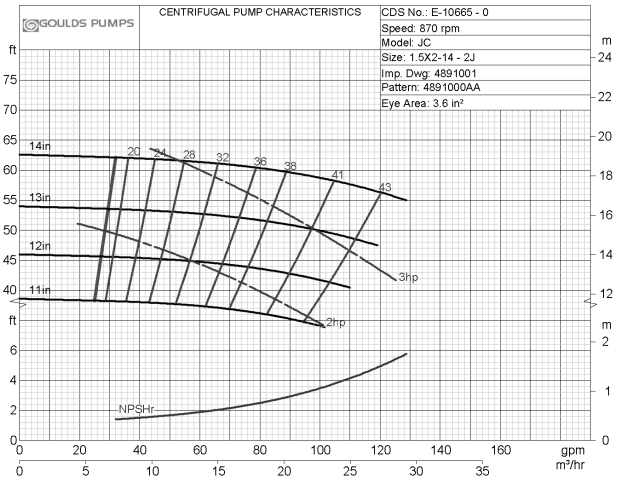


1.5X2-14 **1750rpm**

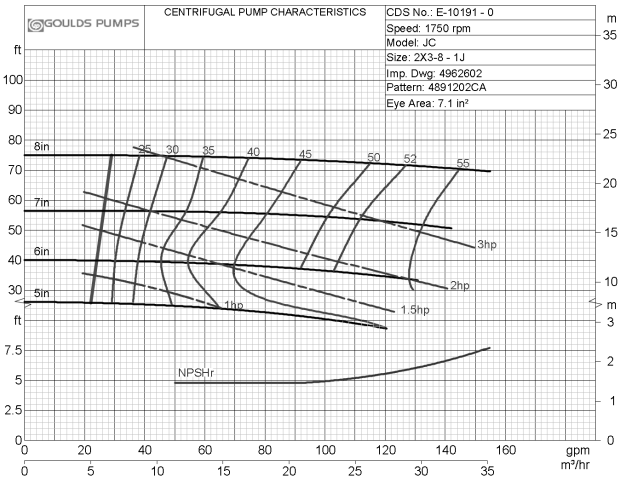


1.5X2-14 **1160rpm**

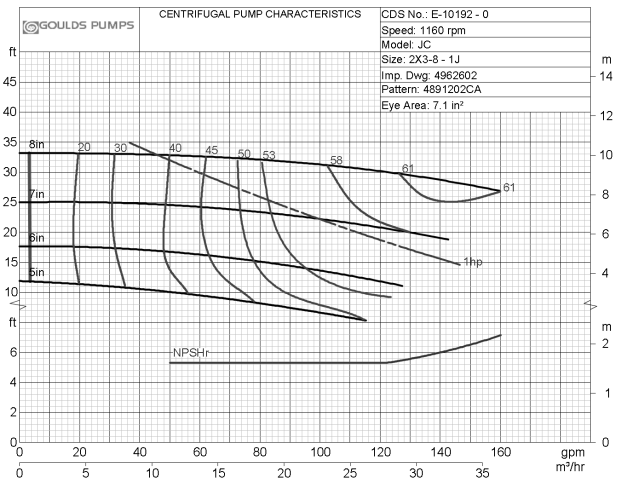
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



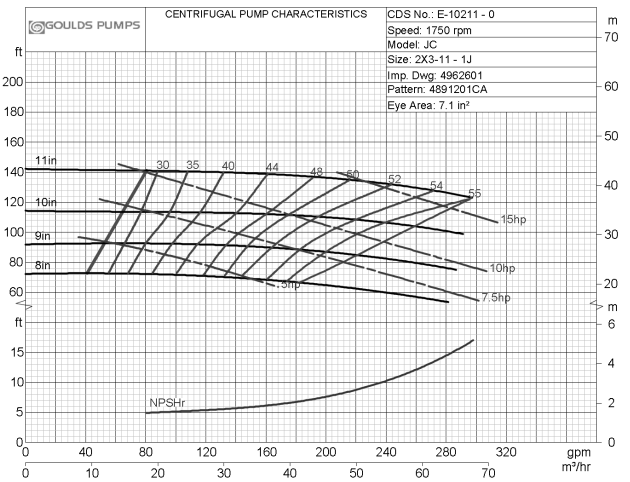
1.5X2-14 **870rpm**



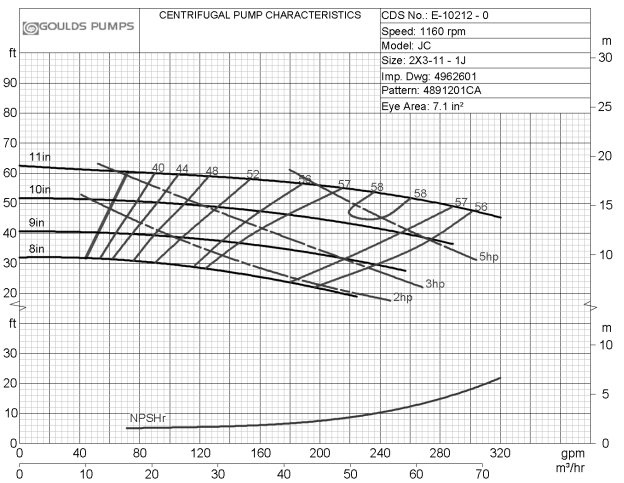
2X3-8 **1750rpm**



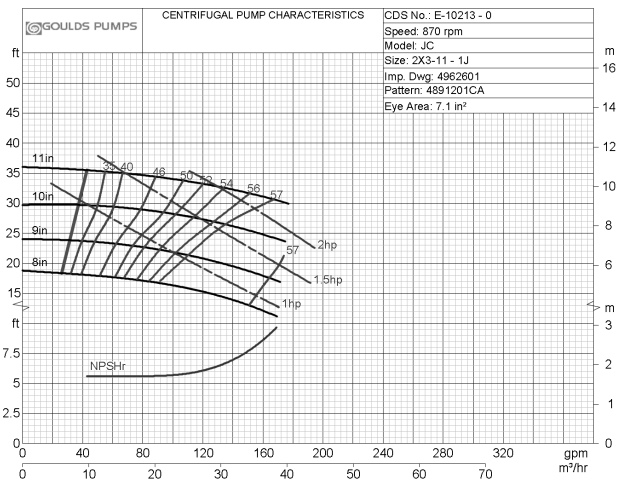
2X3-8 **1160rpm**



2X3-11 **1750rpm**

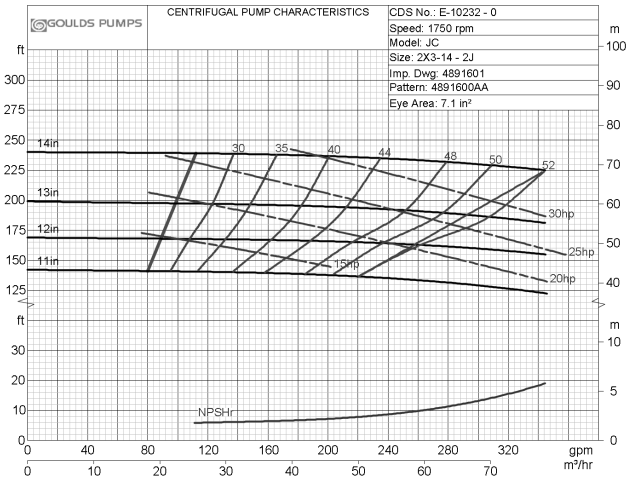


2X3-11 **1160rpm**

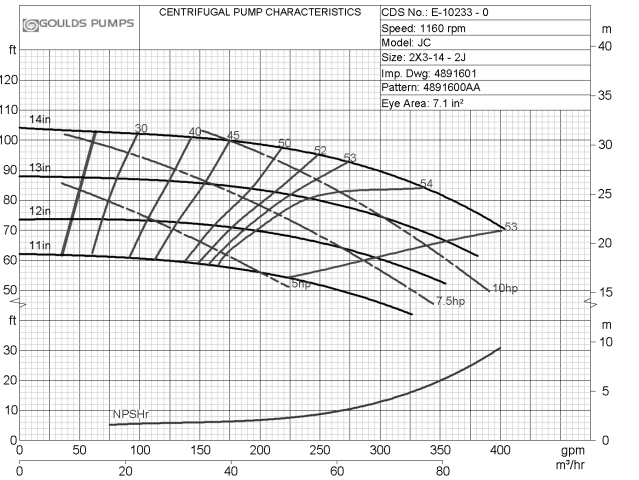


2X3-11 **870rpm**

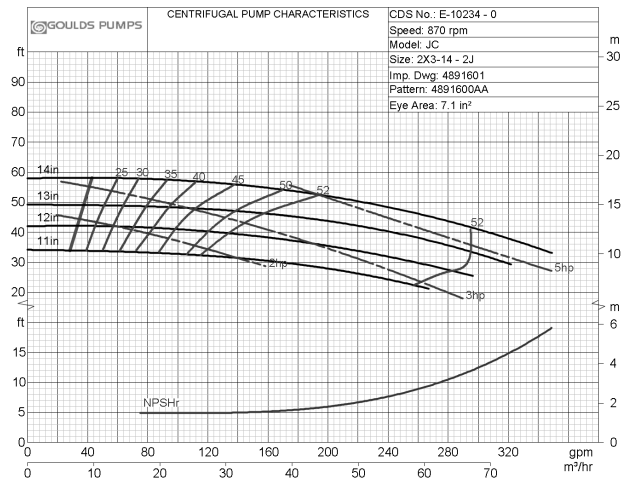
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



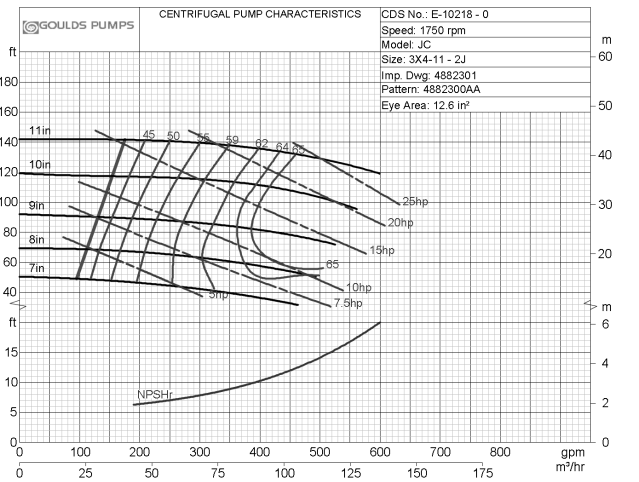
2X3-14 **1750rpm**



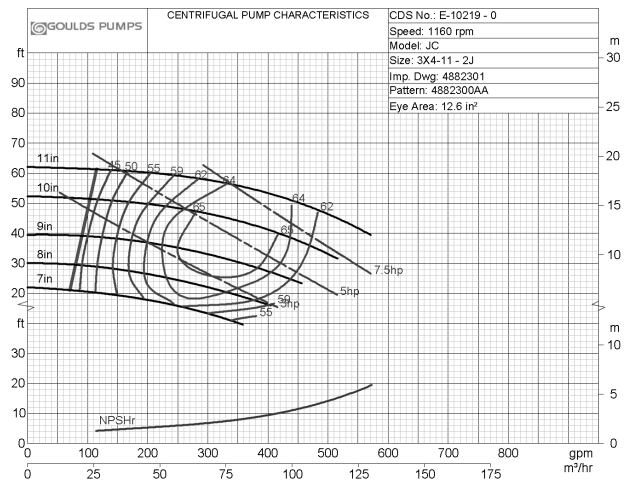
2X3-14 **1160rpm**



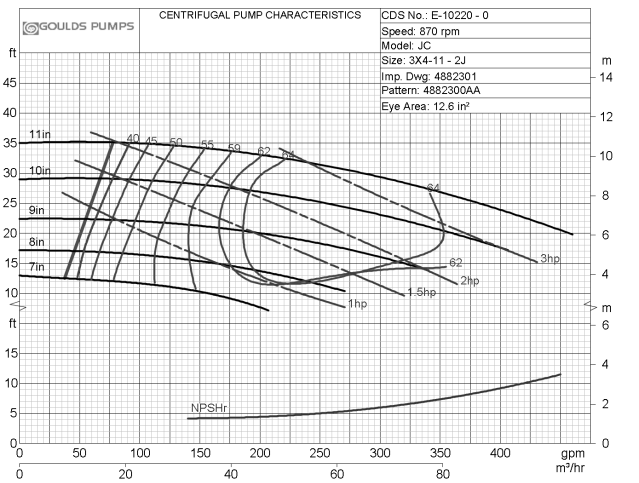
2X3-14 **870rpm**



3X4-11 **1750rpm**

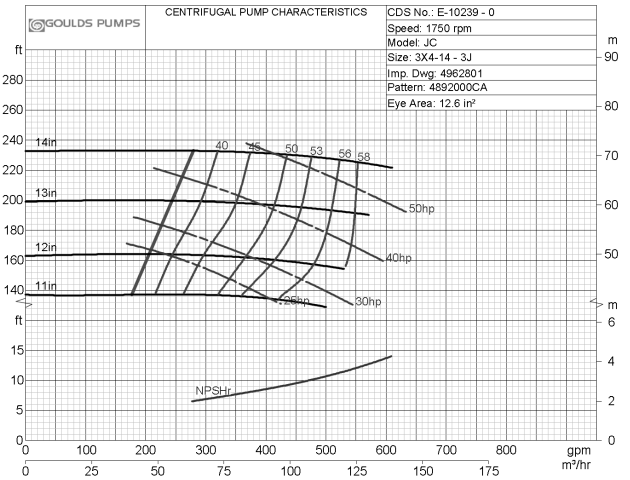


3X4-11 **1160rpm**

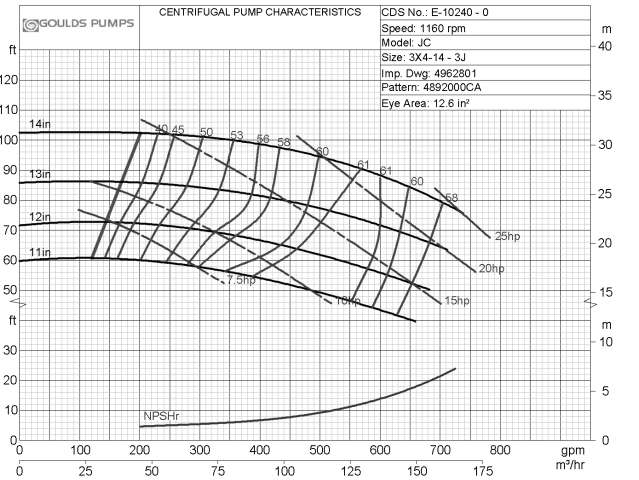


3X4-11 **870rpm**

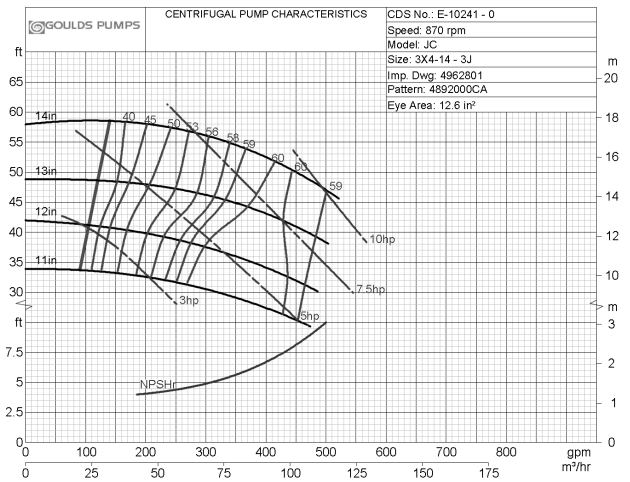
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



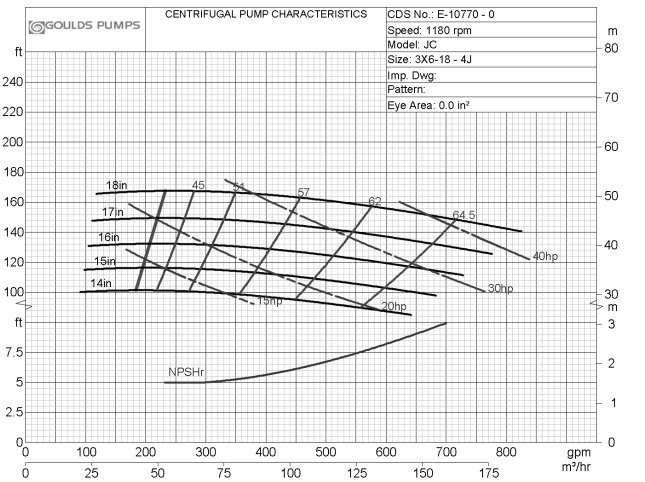
3X4-14 **1750rpm**



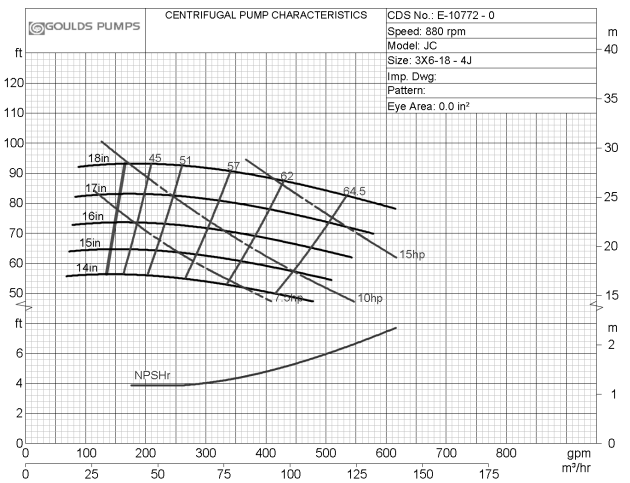
3X4-14 **1160rpm**



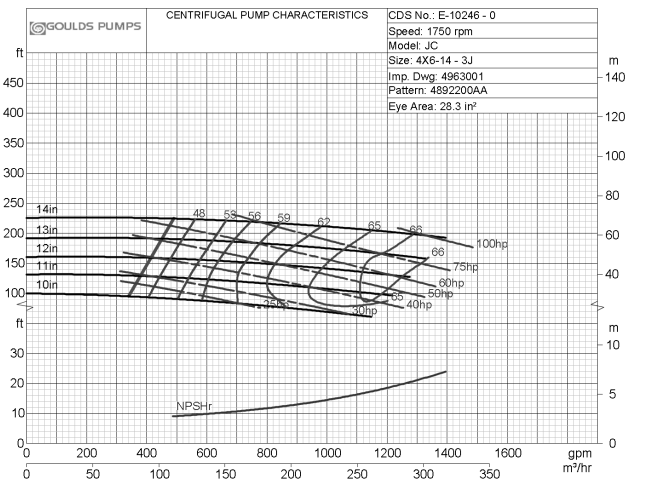
3X4-14 **870rpm**



3X6-18 **1180rpm**



3X6-18 **880rpm**

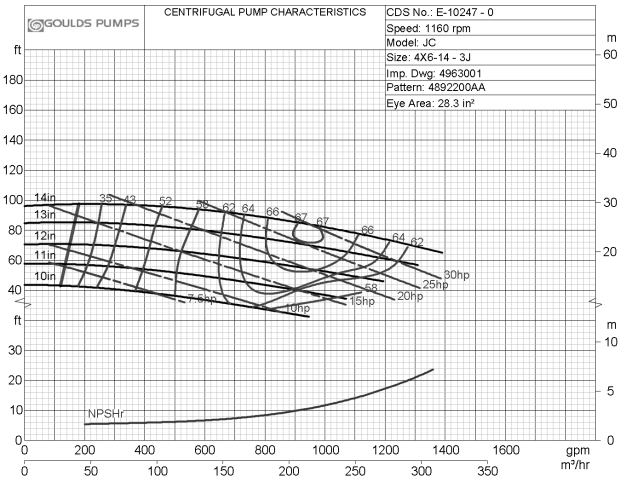


4X6-14 **1750rpm**

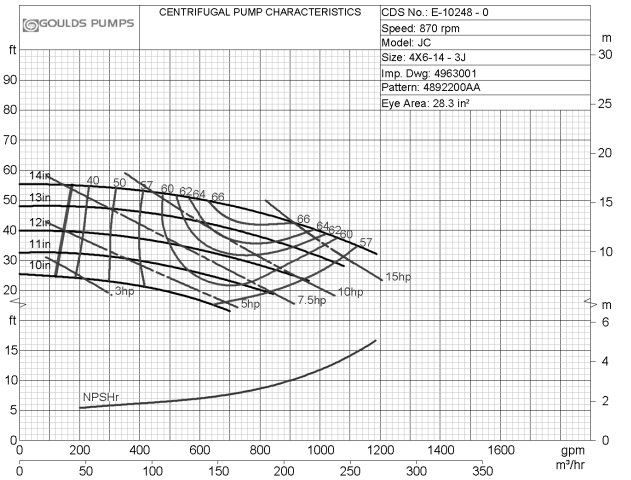
60Hz Curves

Model JC

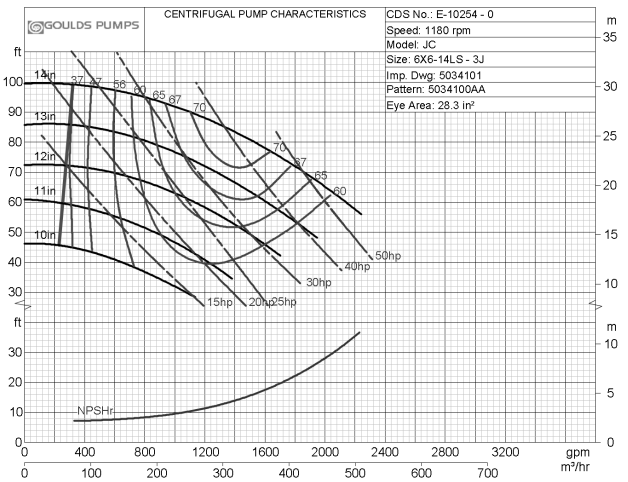
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



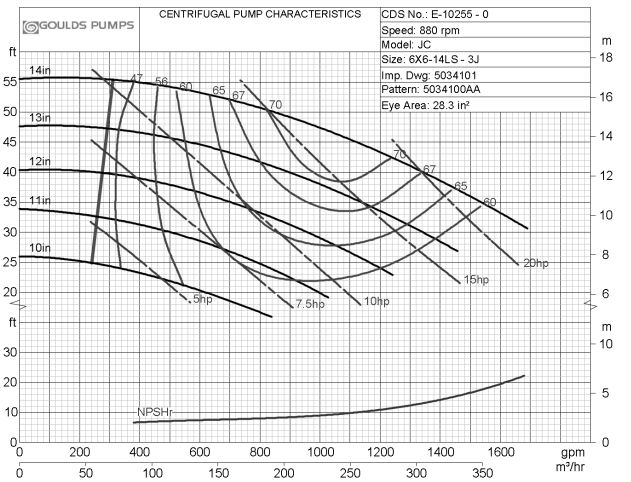
4X6-14 **1160rpm**



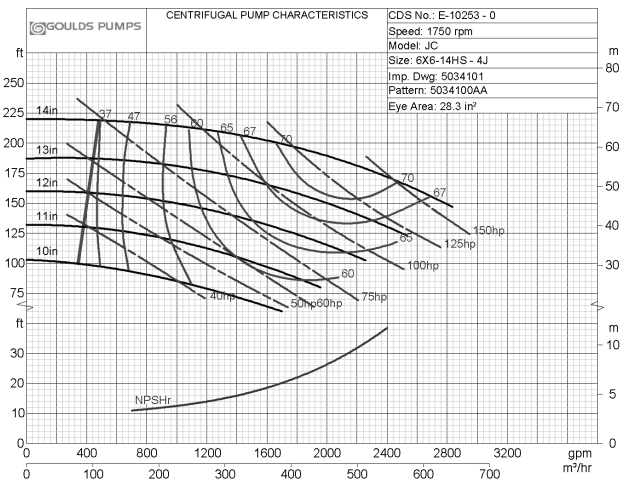
4X6-14 **870rpm**



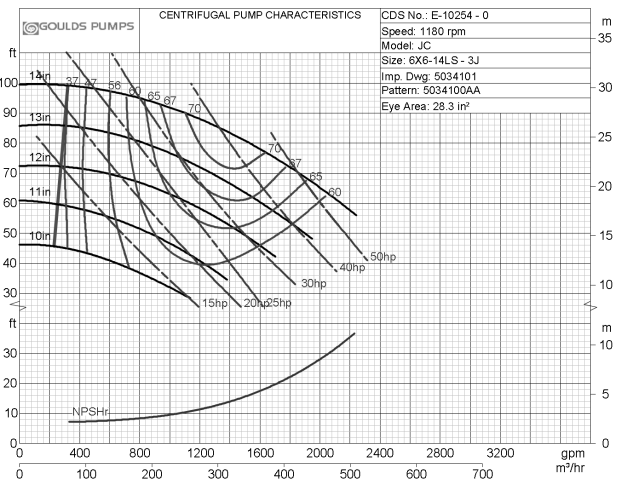
6X6-14LS **1180rpm**



6X6-14LS **880rpm**

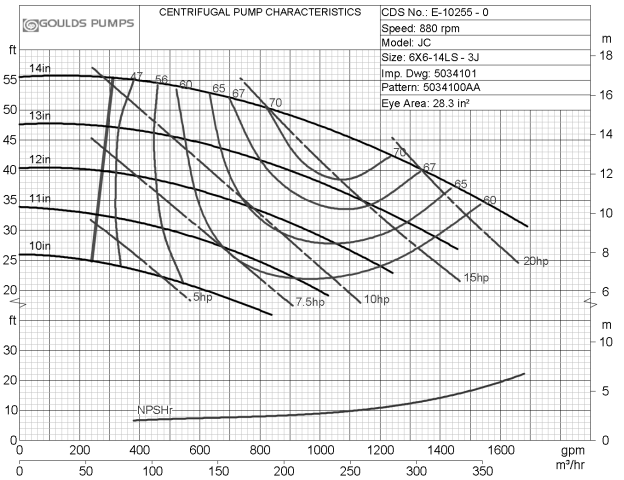


6X6-14HS **1750rpm**

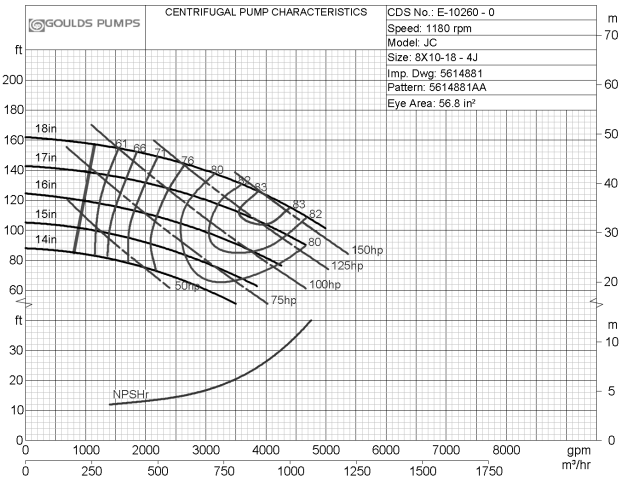


6X6-14LS **1180rpm**

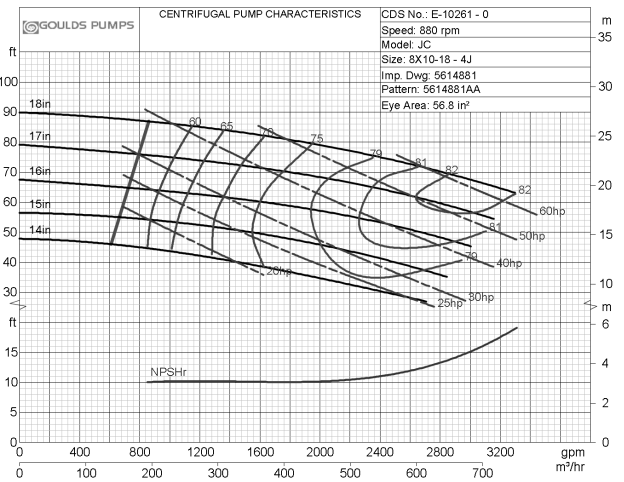
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



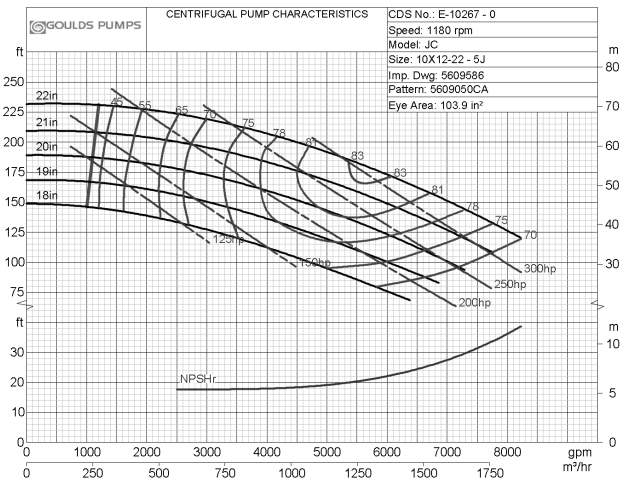
6X6-14LS **880rpm**



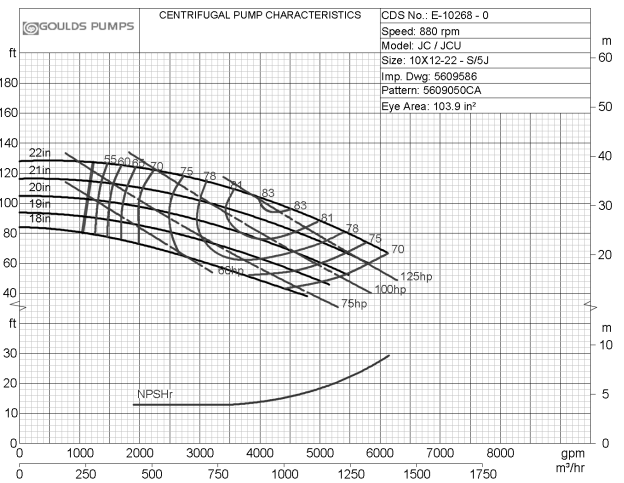
8X10-18 **1180rpm**



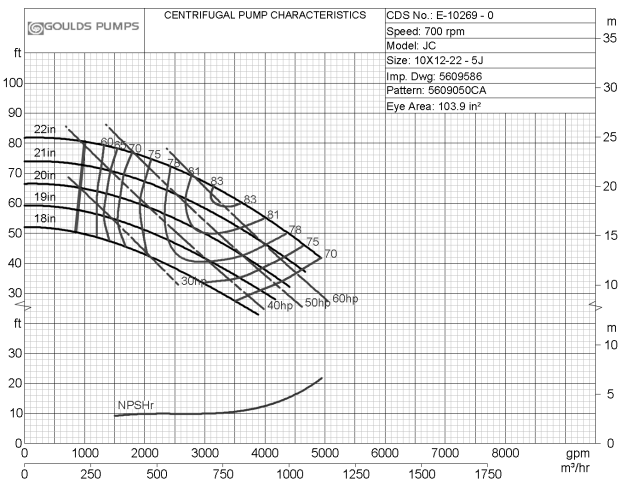
8X10-18 **880rpm**



10X12-22 **1180rpm**

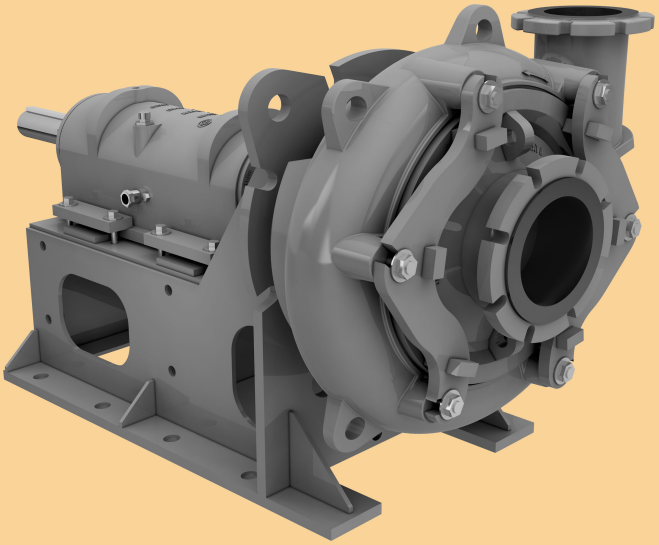


10X12-22 **880rpm**

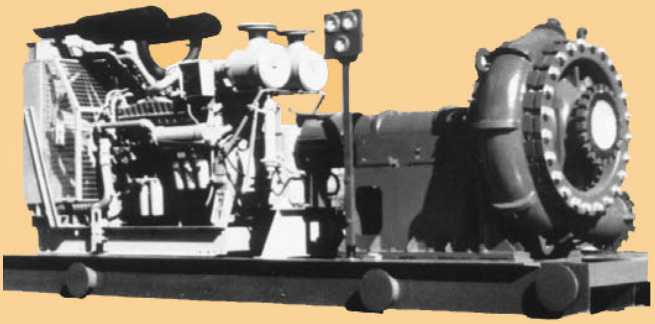


10X12-22 **700rpm**

NOTES



Goulds Model 5500 is the result of many years of experience designing and building severe duty slurry pumps. It's not only built to stand up to the toughest abrasive slurry services, but also is designed for extreme ease of maintenance and safety. A heavy duty bearing frame and shaft, extra thick wall sections, and easily replaceable wear parts add up to many years of service even under the severest operating conditions.



Portable diesel driven Model 5500 for pumping fly ash in major power plant.

Goulds Model 5500

Designed to Handle the Severest Abrasive Slurries

- Capacities to 17,000 GPM (3,861 m^3/h)
- Heads to 425 feet (130 m)
- Temperatures to 250°F (121° C)
- Pressures to 500 PSIG (3,448 kPa)
- Solids to 5 inches (127 mm)

Design Features

- **Large Diameter Impeller:** Develops higher heads at lower operating speeds.
- **Extra Heavy Duty Shaft:** Assures minimum shaft deflection while handling pulsating loads associated with high specific gravity slurries.
- **Simplified Mechanical Design:** For ease of installation and maintenance.
- **Extra Thick Wet End Components:** For extended wear life.
- **Sealing Flexibility:** Choice of packing, mechanical seal or dynamic seal.

Services

- **Primary Metals:** Ball Mill Discharge, Sag Mill Discharge, Tailings, Cyclone Feed
- **Coal Preparation:** Heavy Media, Hydrocyclone, Cyclone Feed, Thickener Underflow
- **Non-Metallic Mining:** Clay Slurries, Phosphate Slurries, Soda Ash, Potash
- **Sand and Gravel:** Sand and Aggregate Slurries, Tailings
- **Power Utility:** Ash Slurries, Lime Slurries
- **Wet Process Cement:** Clay Wash, Clay Storage, Kiln Feed, Raw Grind Feed, Screenings
- **Pulp & Paper:** Black Liquor, Sand Slurries, Mill Waste, Sludge, Scrubber Water, Fly Ash
- **General:** Foundry Sand, Plant Waste, Mill Scale, Sand Slurries, Lime Slurries, Ash Slurries

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model 5500 Severe Duty Slurry Pumps

Extra Heavy Duty Features for Handling Severest Abrasive Slurries

EXTRA HEAVY DUTY SHAFT
Long bearing span and large diameters reduce shaft deflection, extend bearing and packing life. Ideally suited for mounting large motors overhead.

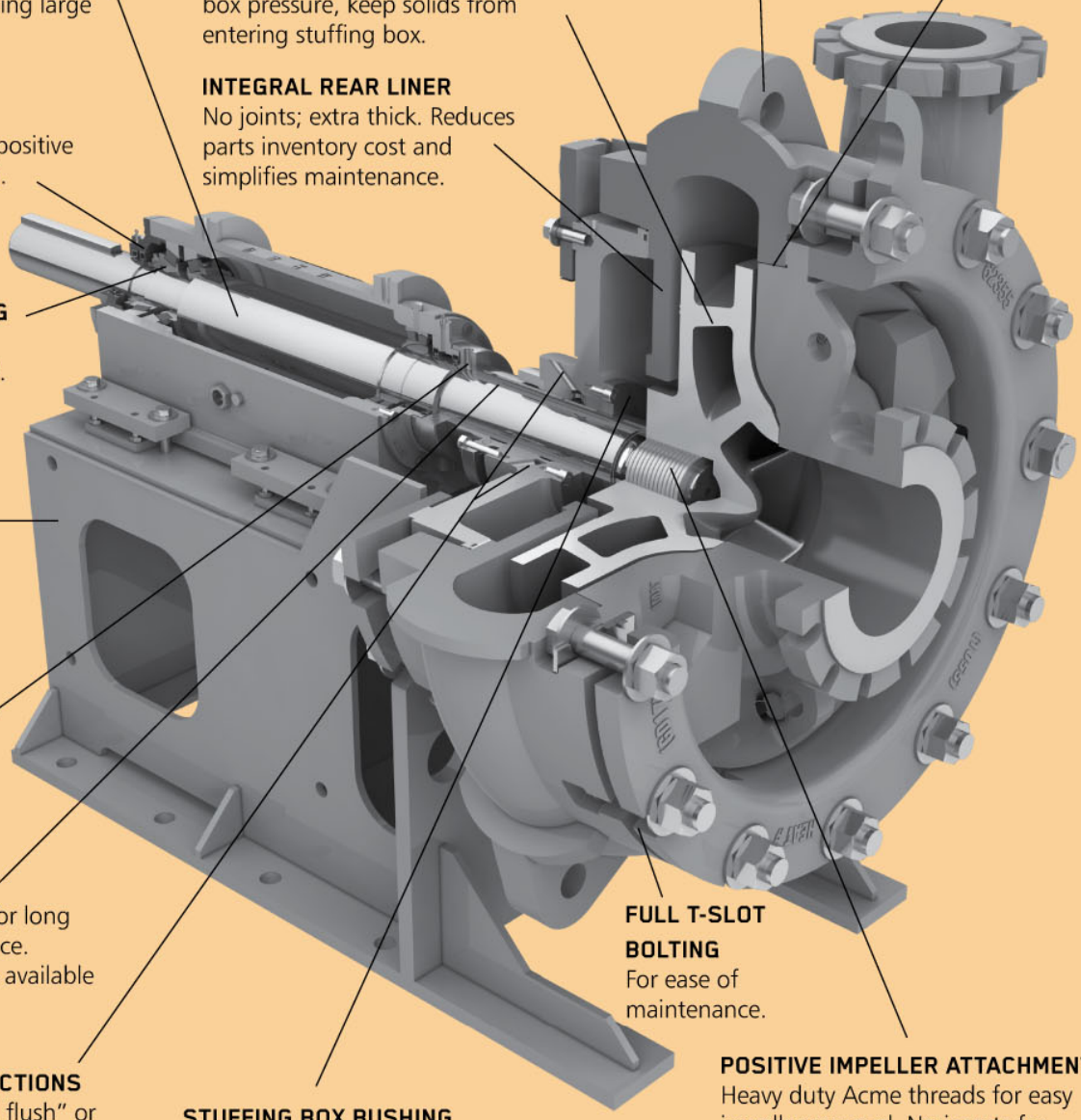
LARGE DIAMETER IMPELLER
Higher heads at lower operating speeds. Extra thick wall sections. Back pump-out vanes reduce stuffing box pressure, keep solids from entering stuffing box.

CAST IN LIFTING LUGS
Provides safe, ease of handling.

TAPER FIT
For ease of disassembly, reassembly.

INTEGRAL REAR LINER
No joints; extra thick. Reduces parts inventory cost and simplifies maintenance.

DOUBLE LIP SEALS
With grease barrier for positive bearing housing sealing.



DOUBLE ROW BEARING
Simple, rugged design. Oil lubrication standard.

FREE STANDING FABRICATED STEEL FRAME
For safe and easy installation; no cracking.

KNOCK-OFF DEFLECTOR
For easier impeller removal and added bearing protection.

SHAFT SLEEVE
Hook-type, extra thick for long life, reduced maintenance. Optional ceramic sleeve available for severe services.

FULL T-SLOT BOLTING
For ease of maintenance.

STUFFING BOX CONNECTIONS
Standard for either "full flush" or "low dilution." Customer selects best choice for service.

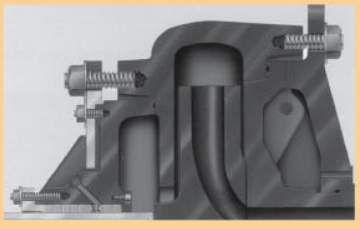
STUFFING BOX BUSHING
Allows easy clearance renewal without replacing stuffing box.

POSITIVE IMPELLER ATTACHMENT
Heavy duty Acme threads for easy impeller removal. No inserts for trouble-free operation.

THICK METAL SECTIONS
Casing, suction cover and impeller have extra thick wall sections for extended wear life, reduced maintenance.

EXTERNAL IMPELLER ADJUSTMENT
Easy access and adjustment allows sustained performance. Up to 8 inches of axial adjustment extends useful life of parts and allows easy access to impeller for maintenance.

MODEL 5500 HP
Special heavy duty casing, two-piece suction cover and liner, 400 lb. flanges for high pressure slurry pumping.



OPTIONAL CERAMIC SUCTION COVER INSERT
For extended wear life in severest services.

Designed for Ease of Maintenance

T-Slot Bolting

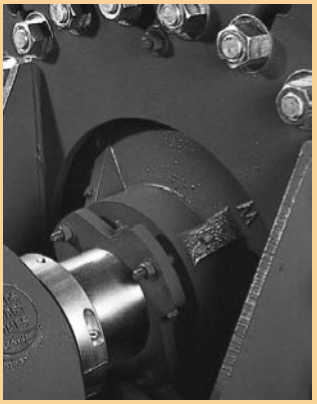
Individual bearings are contained in a single cartridge assembly.

Cast-In Lifting Lugs

On all major wet-end components facilitates handling for less downtime, greater safety and lower maintenance cost. No special tools required.

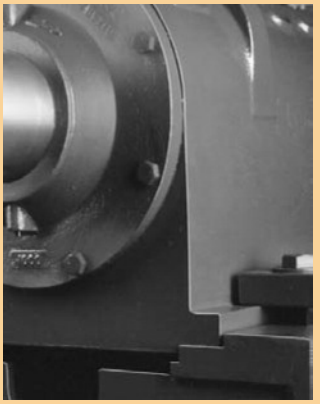
Knock-Off Deflector

Protects bearings; facilitates threaded impeller removal. Less maintenance time, lower maintenance costs.



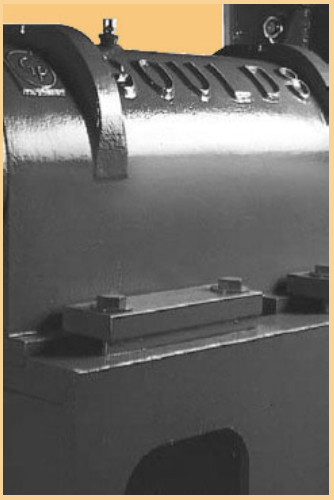
Flat Bottom Bearing Housing

Double register fit assures positive alignment and perfect fit with no shimming. Less maintenance and downtime.



Bearing Housing Hold-Down Bolts

Accessible from the top, facilitates impeller end clearance adjustment; simplifies power end removal. Less downtime, low maintenance cost.



Other Features

Optional Impeller Hook Allows fast, easy, safe removal of impeller; less downtime.

Bottom Oil Drain Speeds oil changes—less downtime, lower maintenance cost.

Dead-Set Bearings No shims, adjusting rings or springs. Simple, accurate—less downtime, lower maintenance cost.

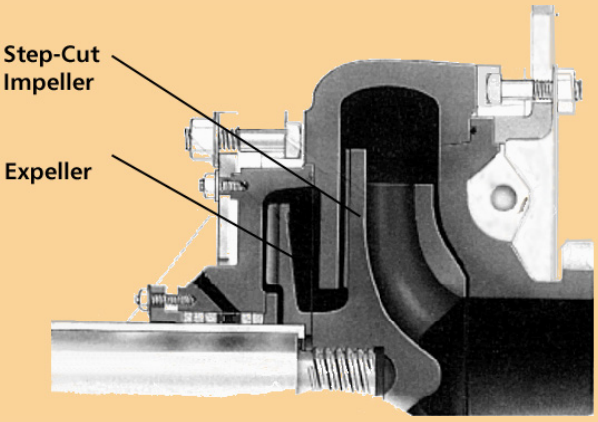
Generous Access To Stuffing Box Facilitates servicing stuffing box for extreme ease of maintenance; less downtime.

Dynamic Seal

Expeller Option For Absolute Dry Box Sealing

Expeller and step-cut impeller engineered for positive stuffing box sealing. No outside flush required. Saves water, piping costs; eliminates product loss.

All sizes performance tested.



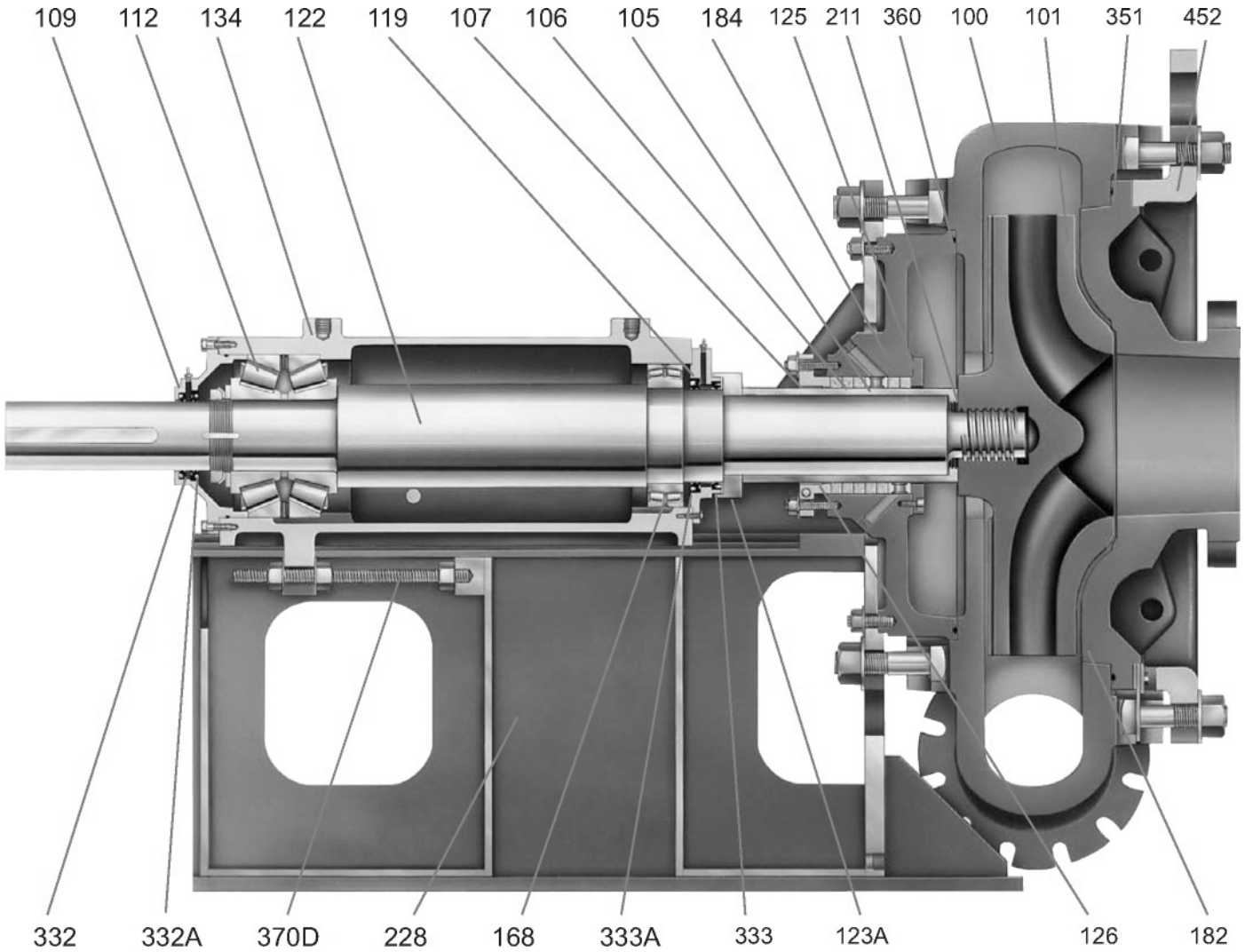
Parts List and Materials of Construction

Part Number	Description	Material		
		HC600 (High Chrome Iron)	EnduraChrome™ (High Chrome Iron)	CD4MCu
100	Casing	HC600	EnduraChrome™	CD4MCu
101	Impeller	HC600	EnduraChrome™	CD4MCu
105	Lantern Ring Teflon	Teflon		
106	Packing Graphite Synthetic	Graphite Synthetic		
107	Gland	Cast Iron		316SS
109	Outboard End Cover	Cast Iron		
112	Outboard Bearing	Tapered Roller		
119	Inboard End Cover	Cast Iron		
122	Shaft	Steel		
123A	Knock-Off Deflector	Steel		
125	Stuffing Box Bushing	HC600	EnduraChrome™	CD4MCu
126	Shaft Sleeve	420 Stainless Steel (Hardened)		CD4MCu
134	Bearing Housing	Cast Iron		
168	Inboard Bearing	Spherical or Tapered Roller		
182	Suction Cover	HC600	EnduraChrome™	CD4MCu
182HP	Suction Cover Liner	HC600	EnduraChrome™	CD4MCu
184	Stuffing Box Cover	Ductile Iron	EnduraChrome™	CD4MCu
184	Stuffing Box Cover (Expeller Option)	HC600	EnduraChrome™	CD4MCu
184A	Slurry Seal Chamber	HC600	EnduraChrome™	CD4MCu
211	Gasket—Impeller to Sleeve	Fiber		
228	Frame	Steel		
262	Expeller (Optional)	HC600	EnduraChrome™	CD4MCu
332	Outboard Oil Seal (Outside)	Buna Rubber		
332A	Outboard Oil Seal (Inside)	Buna Rubber		
333	Inboard Oil Seal (Outside)	Buna Rubber		
333A	Inboard Oil Seal (Inside)	Buna Rubber		
351	351 O-ring—Suction Cover/Casing	Buna Rubber		
353	Mechanical Seal As Required	As Required		
360	O-ring—Stuffing Box/Casing	Buna Rubber		
370D	Impeller Adjusting Screw	316 Stainless Steel		
452	Suction Cover Clamp	Ductile Iron		
452HP	Suction Cover	Ductile Iron		

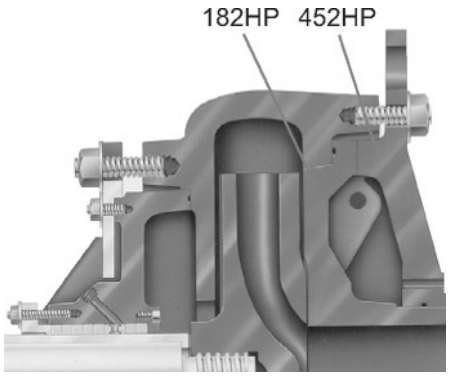
Materials of Construction

Description	Specification
HC600	ASTM A532, Class III Type A Hardened
EnduraChrome™	Modified ASTM A532, Class III Type A Hardened
Cast Iron	ASTM A48, Class 25
Steel	AISI 1141
420 Stainless Steel	ASTM A743 Grade CA-40
Ductile Iron	ASTM A536 Grade 80-55-06
CD4MCu	ASTM A743 Grade CD4MCu
316 Stainless Steel	ASTM A276 Type 316

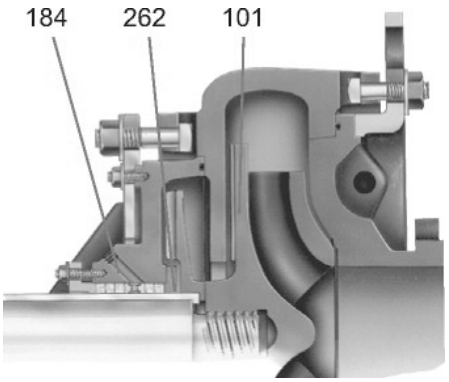
Sectional View Model 5500



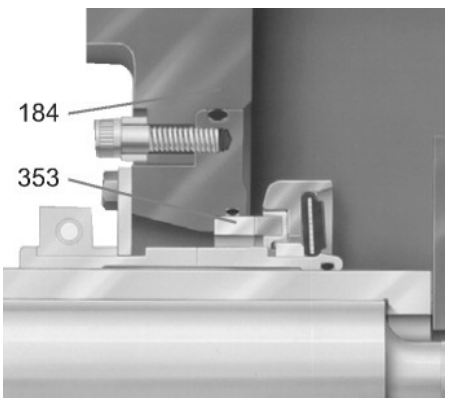
MODEL 5500 HP (HIGH PRESSURE PUMP)



DYNAMIC SEAL (EXPELLER OPTION)

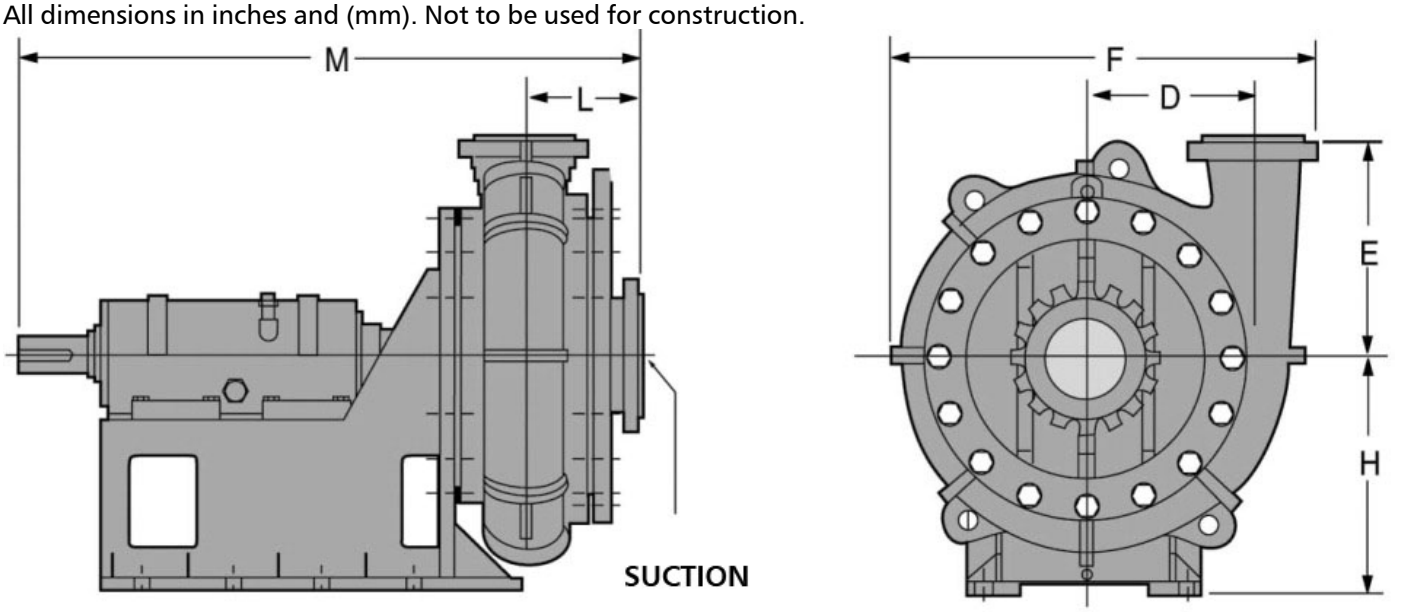


SLURRY MECHANICAL SEALWITH SLURRY SEAL CHAMBER



Dimensions Model 5500

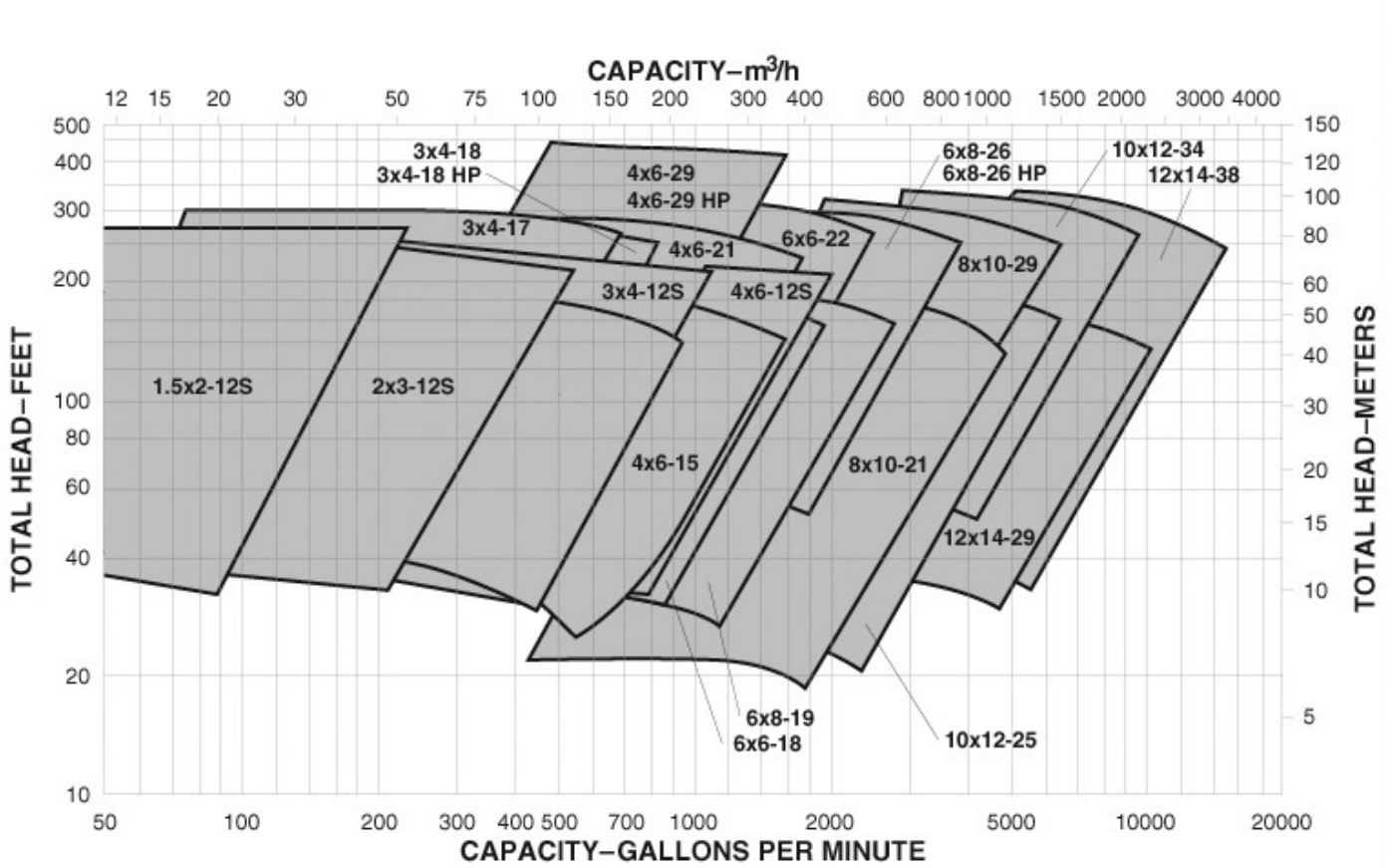
All dimensions in inches and (mm). Not to be used for construction.



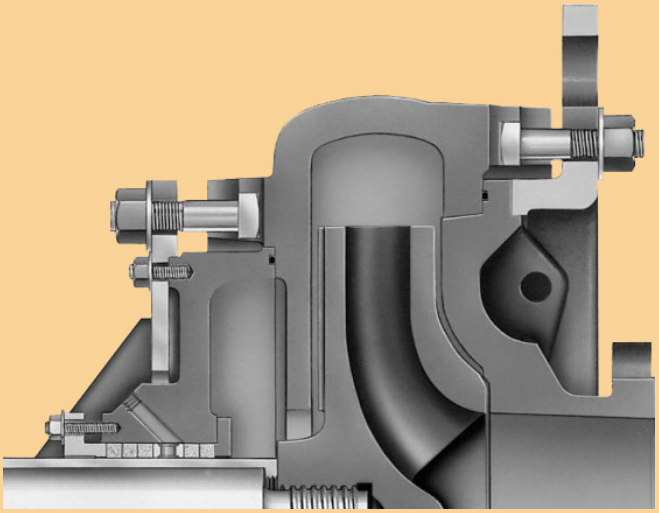
DIMENSIONS
Inches - (mm)

Pump	Frame	D	E	F	H	L	M	Weight Lbs./(kg)
1.5×2-12S	S2	8.06 (205)	11.00 (280)	19.40 (493)	12.50 (318)	4.75 (121)	38.00 (965)	1223 (556)
2×3-12S	S2	7.94 (202)	10.50 (267)	19.60 (498)	15.50 (394)	5.50 (140)	40.00 (1016)	1223 (556)
3×4-12S	S2	8.13 (207)	10.25 (260)	19.75 (502)	15.50 (394)	6.00 (152)	40.88 (1038)	1223 (556)
3×4-17	B2	11.00 (279)	16.00 (406)	29.00 (737)	18.00 (457)	8.00 (203)	58.00 (1473)	1895 (861)
3×4-18	B2	11.00 (279)	16.00 (406)	28.38 (721)	18.00 (457)	8.25 (210)	58.50 (1486)	1930 (877)
3×4-18HP	B2	11.00 (279)	16.00 (406)	28.50 (724)	18.00 (457)	8.25 (210)	59.12 (1502)	2145 (975)
4×6-12S	S2	8.13 (207)	11.75 (298)	21.65 (550)	15.50 (394)	6.50 (165)	41.88 (1064)	1223 (556)
4×6-15	B2	10.00 (254)	12.75 (324)	27.06 (687)	18.00 (457)	9.00 (229)	59.00 (1497)	1600 (727)
4×6-21	B2	14.00 (356)	18.00 (457)	36.00 (914)	22.00 (559)	10.00 (254)	60.12 (1527)	2944 (1338)
	B3	14.00 (356)	18.00 (457)	36.00 (914)	22.00 (559)	10.00 (254)	68.25 (1734)	3211 (1460)
4×6-21HP	B3	14.00 (356)	18.00 (457)	36.00 (914)	22.00 (559)	10.00 (254)	69.86 (1749)	3757 (1708)
4×6-29	B3	19.12 (486)	24.50 (622)	47.62 (1209)	30.00 (762)	10.50 (267)	70.22 (1784)	4410 (2005)
	B4	19.12 (486)	24.50 (622)	47.62 (1209)	30.00 (762)	10.50 (267)	77.78 (1976)	5400 (2455)
4×6-29HP	B4	19.12 (486)	24.50 (622)	47.62 (1209)	30.00 (762)	10.50 (267)	78.92 (2000)	6100 (2773)
6×6-18	B2	12.33 (313)	15.00 (381)	32.00 (813)	22.00 (560)	8.75 (222)	59.10 (1501)	2423 (1101)
	B3	12.33 (313)	15.00 (381)	32.00 (813)	22.00 (560)	8.75 (222)	67.17 (1706)	2690 (1223)
6×8-19	B2	13.59 (345)	15.00 (381)	34.25 (870)	22.00 (560)	9.00 (229)	59.41 (1509)	2513 (1142)
	B3	13.59 (345)	15.00 (381)	34.25 (870)	22.00 (560)	9.00 (229)	67.48 (1714)	2780 (1263)
6×6-22	B2	14.88 (378)	20.00 (508)	38.63 (981)	22.00 (560)	10.00 (254)	60.12 (1527)	3037 (1380)
	B3	14.88 (378)	20.00 (508)	38.63 (981)	22.00 (560)	10.00 (254)	68.25 (1734)	3304 (1502)
6×8-26	B3	18.25 (464)	21.00 (533)	46.50 (1181)	30.00 (762)	12.25 (311)	71.38 (1813)	5300 (2409)
	B4	18.25 (464)	21.00 (533)	46.50 (1181)	30.00 (762)	12.25 (311)	78.94 (2005)	6050 (2750)
6×8-26HP	B4	18.25 (464)	21.00 (533)	46.50 (1181)	30.00 (762)	12.25 (311)	79.19 (2011)	6420 (2918)
6×12-25	B3	18.25 (464)	21.00 (533)	46.50 (1181)	30.00 (762)	10.94 (278)	70.07 (1780)	5300 (2409)
	B4	18.25 (464)	21.00 (533)	46.50 (1181)	30.00 (762)	10.94 (278)	77.63 (1972)	6050 (2750)
8×10-21	B2	16.81 (427)	17.38 (441)	42.50 (1080)	25.00 (635)	10.50 (267)	61.00 (1549)	3123 (1420)
	B3	16.81 (427)	17.38 (441)	42.50 (1080)	25.00 (635)	10.50 (267)	69.06 (1754)	3390 (1541)
8×10-29	B3	21.00 (533)	24.50 (622)	53.00 (1346)	30.00 (762)	13.38 (340)	73.06 (1856)	5850 (2659)
	B4	21.00 (533)	24.50 (622)	53.00 (1346)	30.00 (762)	13.38 (340)	80.62 (2048)	6840 (3109)
10×12-25	B3	20.00 (508)	23.00 (584)	53.00 (1346)	30.00 (762)	11.25 (286)	70.25 (1784)	4375 (1989)
	B4	20.00 (508)	23.00 (584)	53.00 (1346)	30.00 (762)	11.25 (286)	77.81 (1976)	5125 (2330)
10×12-34	B4	24.75 (629)	27.00 (686)	62.50 (1588)	35.00 (889)	14.50 (368)	82.31 (2091)	8700 (3954)
	B5	24.75 (629)	27.00 (686)	62.50 (1588)	35.00 (889)	14.50 (368)	93.31 (2370)	10300 (4682)
12×14-29	B3	23.38 (594)	25.00 (635)	60.88 (1546)	35.00 (889)	12.50 (318)	72.44 (1840)	5740 (2609)
	B4	23.38 (594)	25.00 (635)	60.88 (1546)	35.00 (889)	12.50 (318)	80.00 (2032)	6730 (3059)
12×14-38	B4	26.50 (673)	34.00 (864)	67.75 (1721)	37.00 (940)	18.25 (464)	88.06 (2237)	12200 (5545)
	B5	26.50 (673)	34.00 (864)	67.75 (1721)	37.00 (940)	18.25 (464)	98.62 (2505)	13800 (6273)

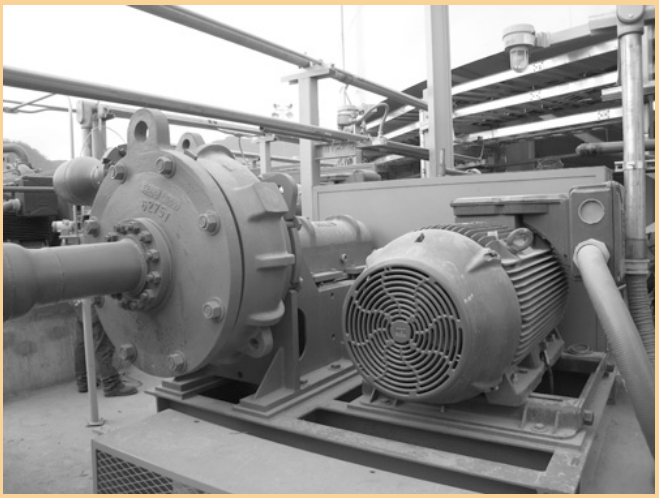
Hydraulic Coverage 50/60 Hz



NOTES



Goulds Model 5500 HP is designed to handle tough *staged* or *series* pumping. It's built with all the proven features of the standard 5500 making it the most reliable and maintenance-friendly pump in the industry.



Model 5500 HP

High Pressure, Heavy Duty Slurry Pump

- Capacities to 4,000 GPM (908 m^3/h)
- Heads to 425 feet (130 m)
- Pressures to 500 PSIG (3448 kPa)
- Temperatures to 200°F (93° C)
- Solids to 21/2 inches (64 mm)

Features

- **Heavy Duty Casing**
  For high pressures and abrasive services.
- **Two-Piece Suction Cover and Liner**
  Provides temporary secondary containment; pump will operate until shut down for repair.
- **400 Lb. Flanges**
  For high pressure pumping.
- **Maximum Interchangeability With 5500**
  For minimum inventory.

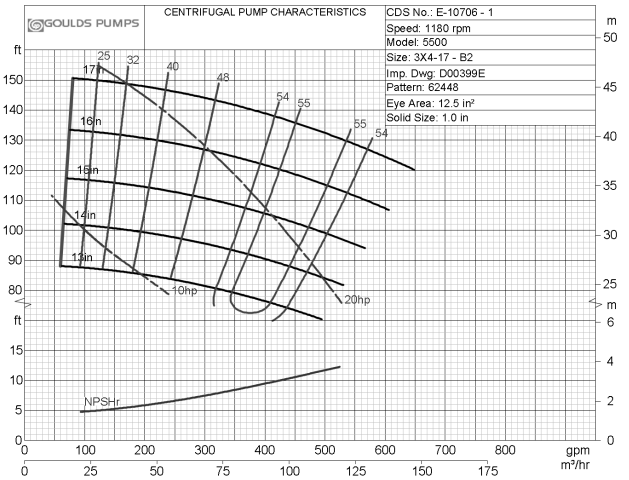
Services

- Tailings
- Thickener Underflow
- Pipeline
- Potash
- Mud Disposal

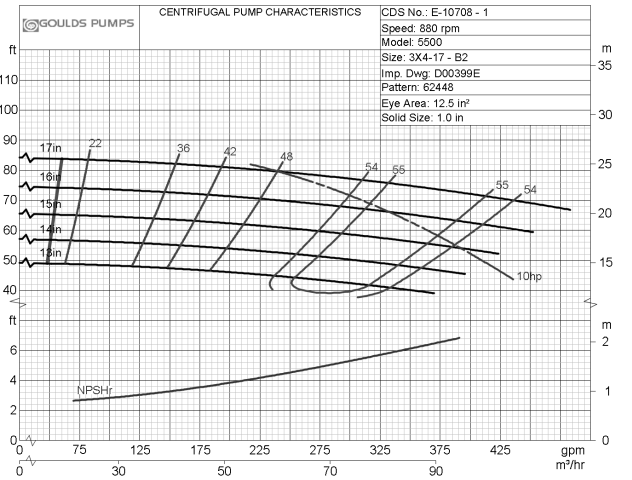
Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

NOTES

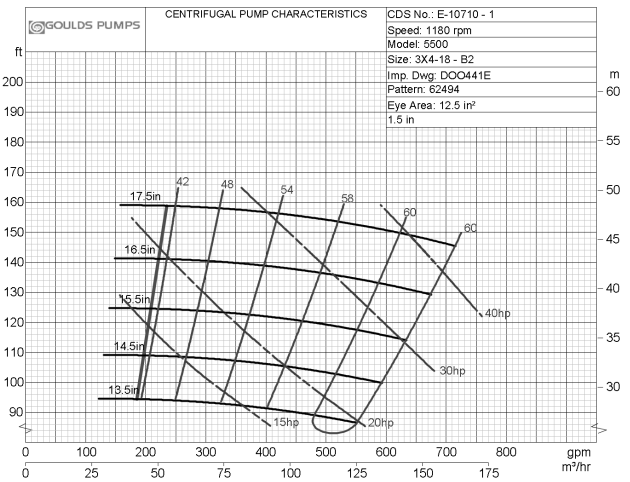
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



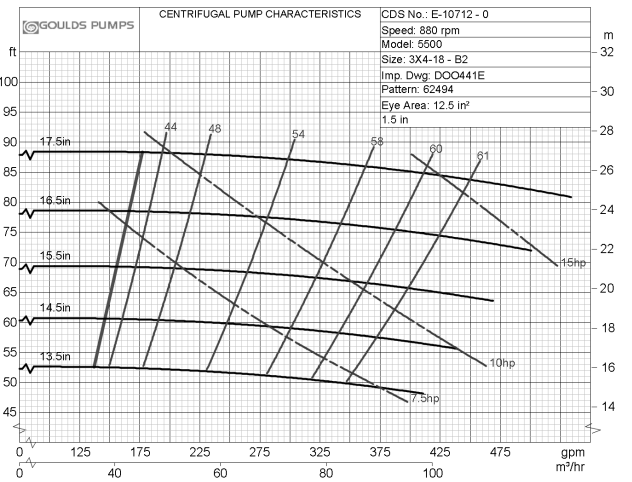
3X4-17 **1180rpm**



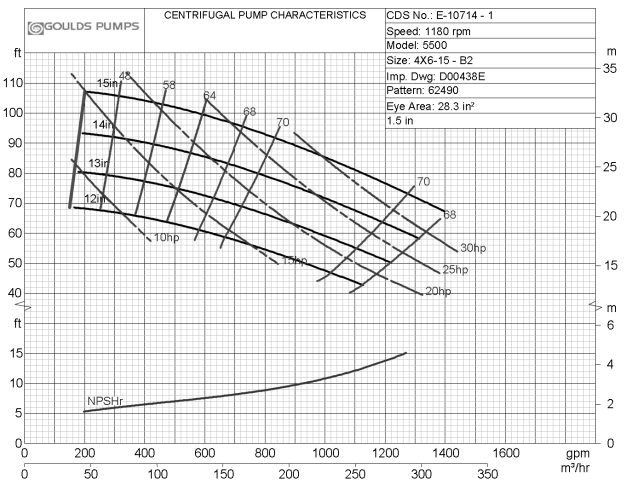
3X4-17 **880rpm**



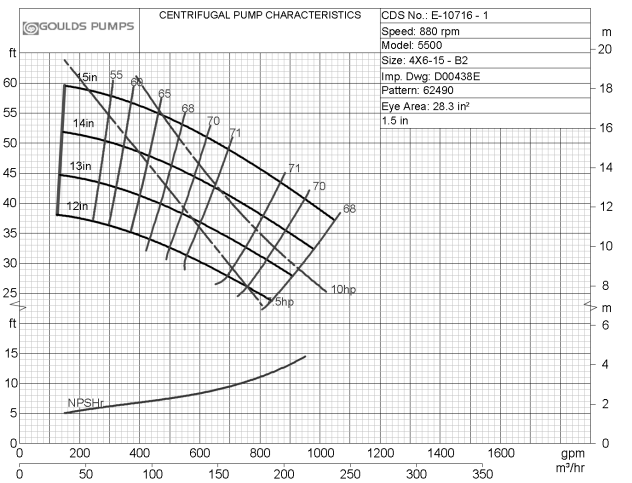
3X4-18 **1180rpm**



3X4-18 **880rpm**



4X6-15 **1180rpm**

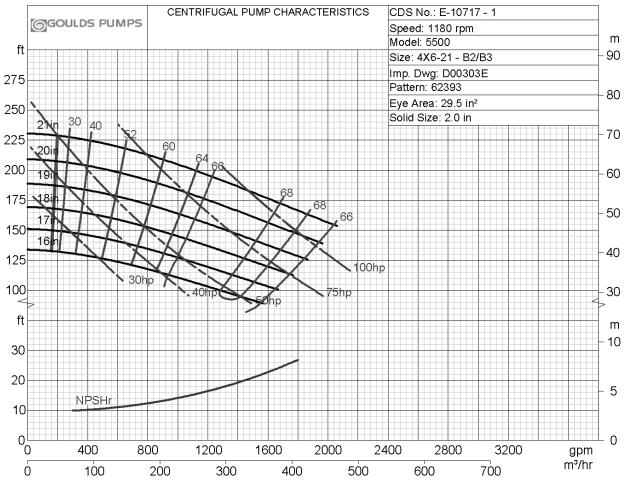


4X6-15 **880rpm**

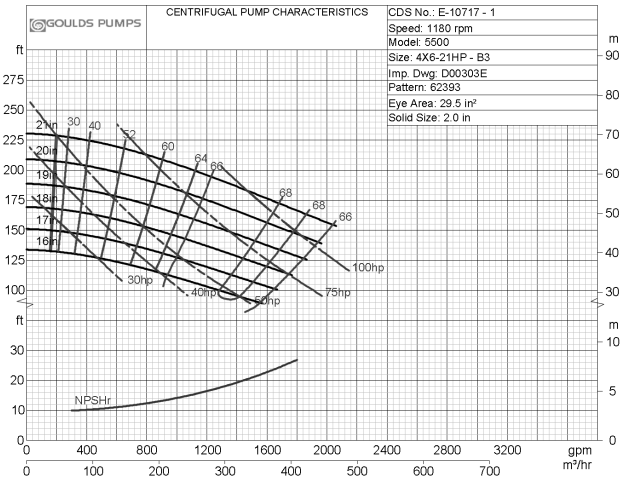
60Hz Curves

Model 5500

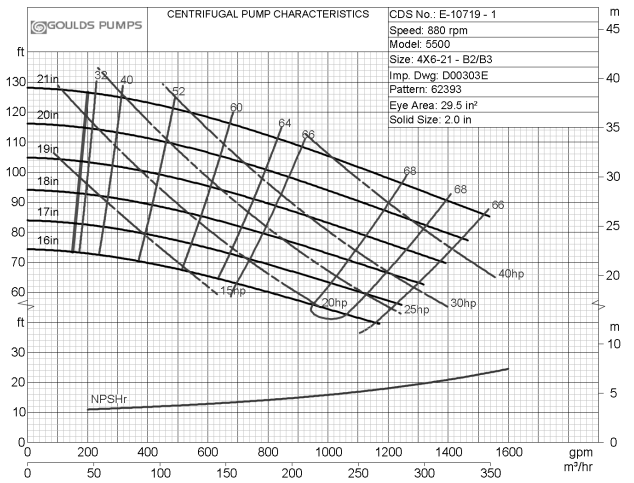
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



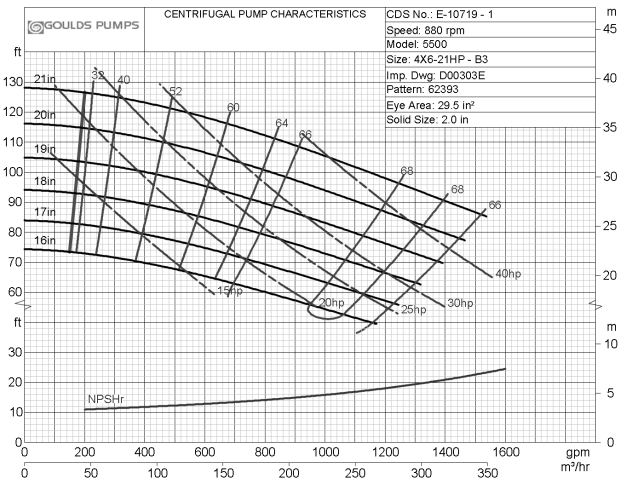
4X6-21 **1180rpm**



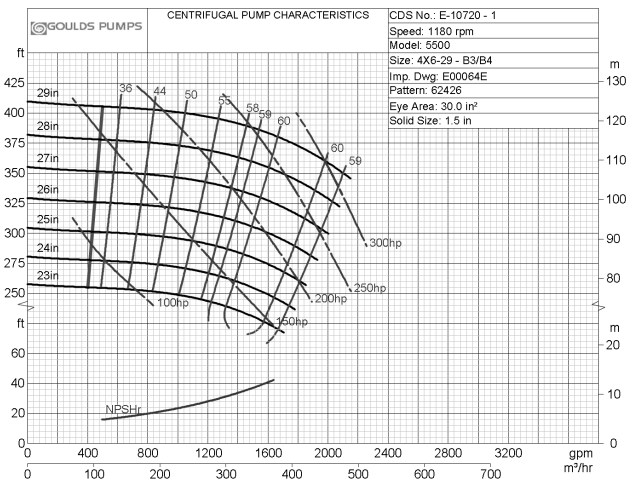
4X6-21HP **1180rpm**



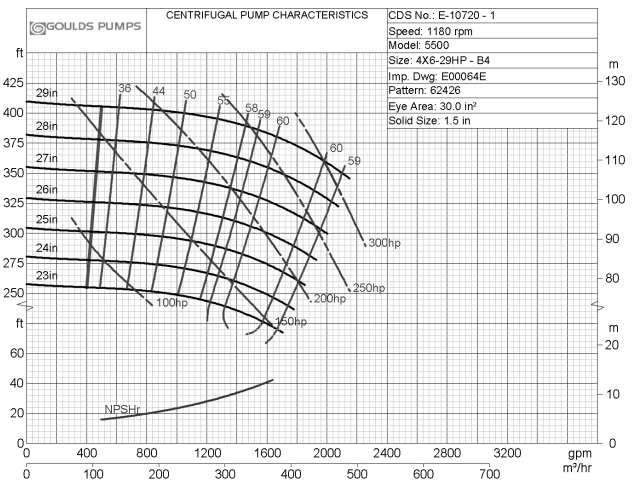
4X6-21 **880rpm**



4X6-21HP **880rpm**

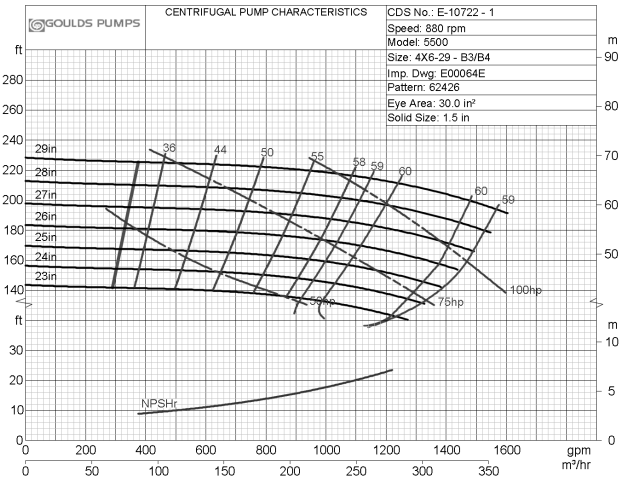


4X6-29 **1180rpm**

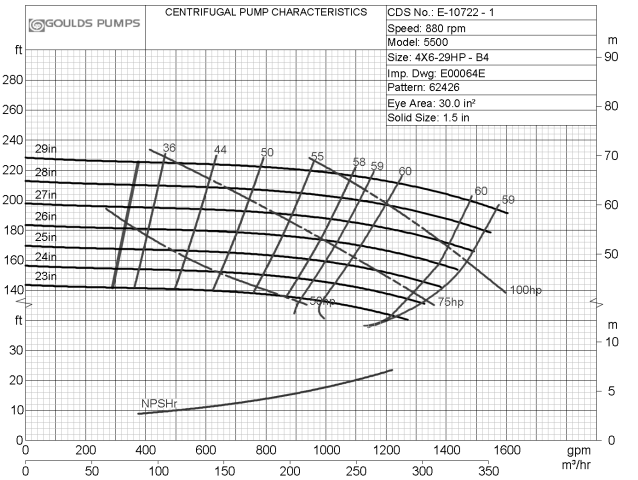


4X6-29HP **1180rpm**

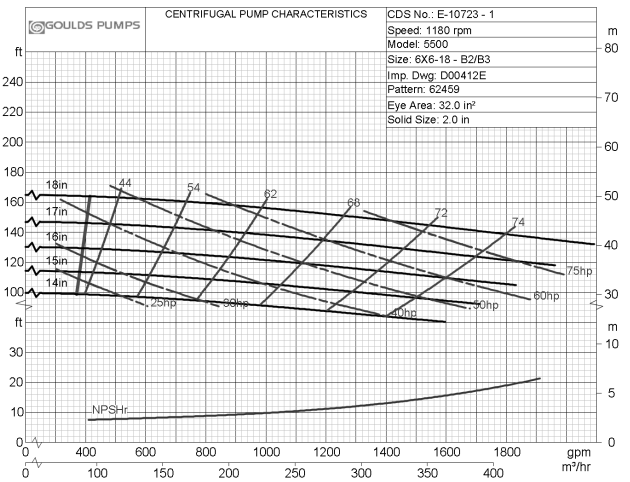
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



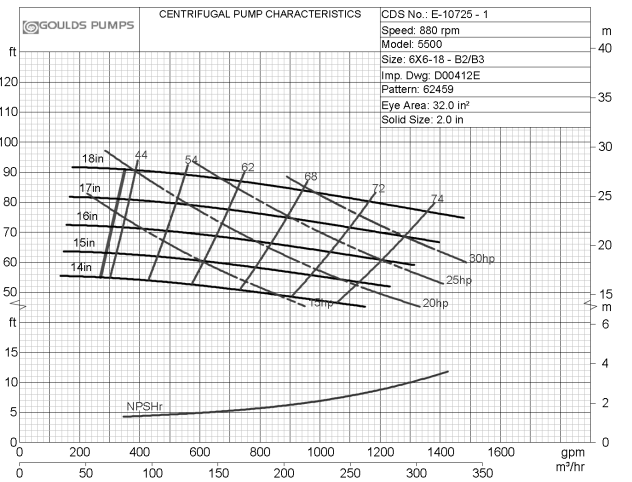
4X6-29 **880rpm**



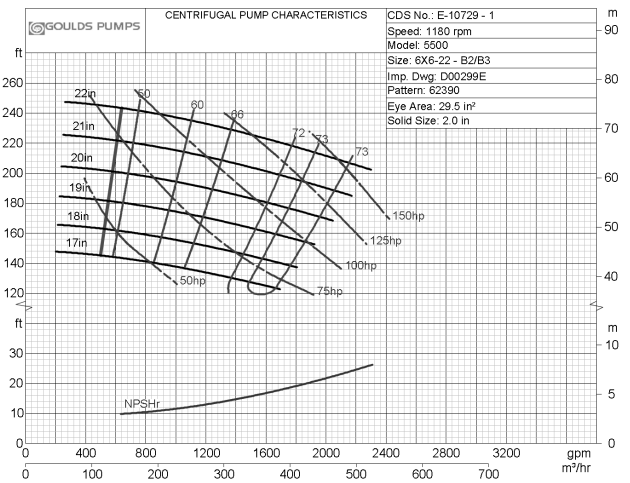
4X6-29HP **880rpm**



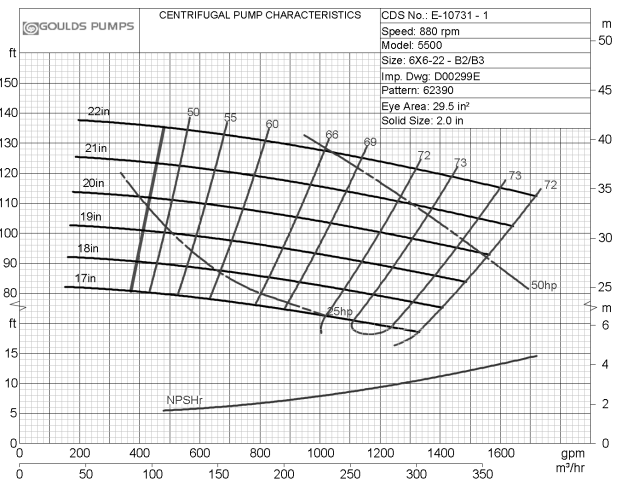
6X6-18 **1180rpm**



6X6-18 **880rpm**



6X6-22 **1180rpm**

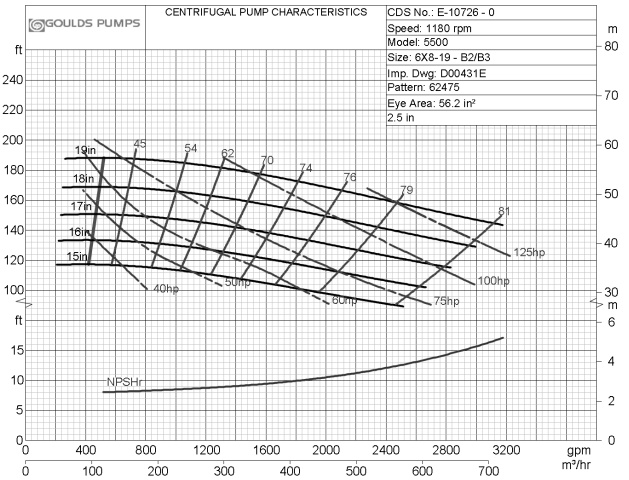


6X6-22 **880rpm**

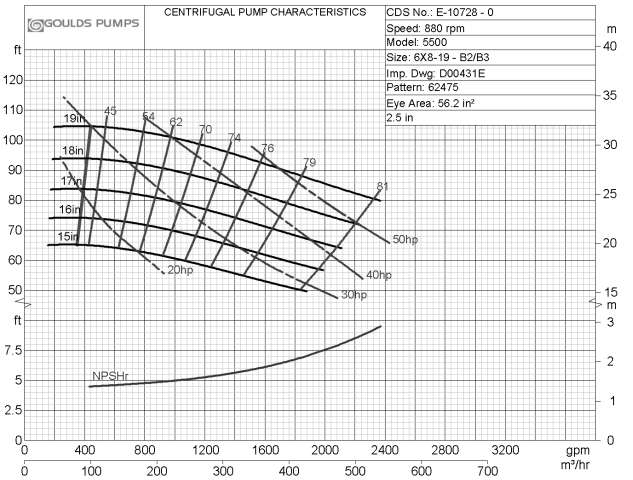
60Hz Curves

Model 5500

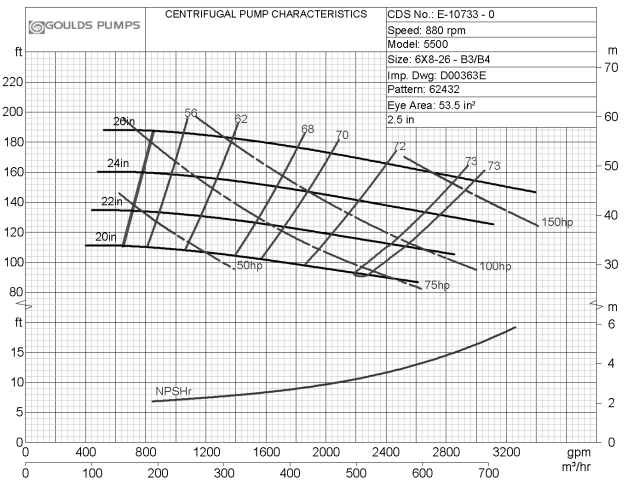
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



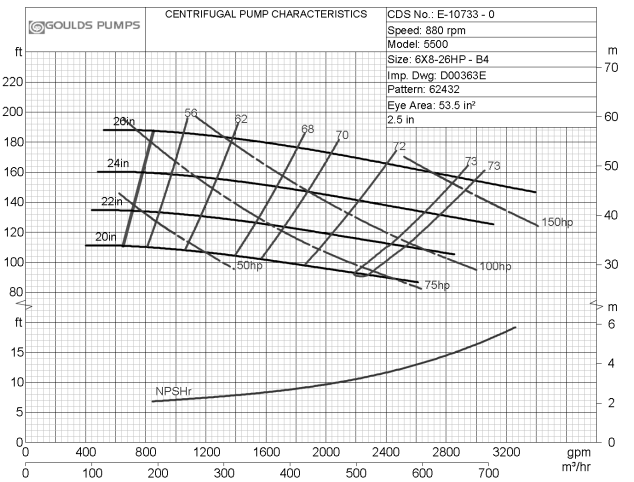
6X8-19 **1180rpm**



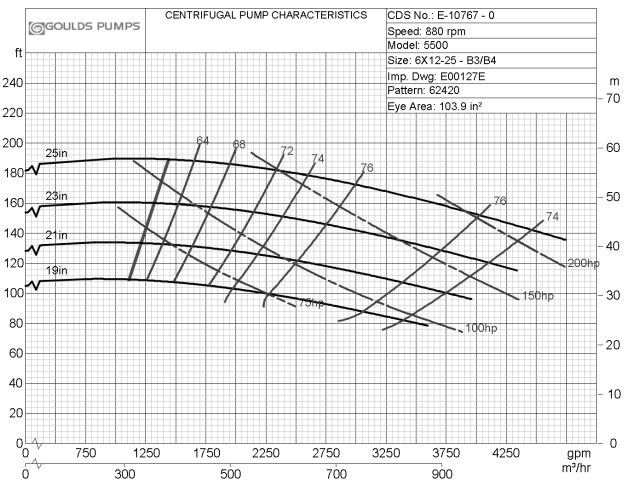
6X8-19 **880rpm**



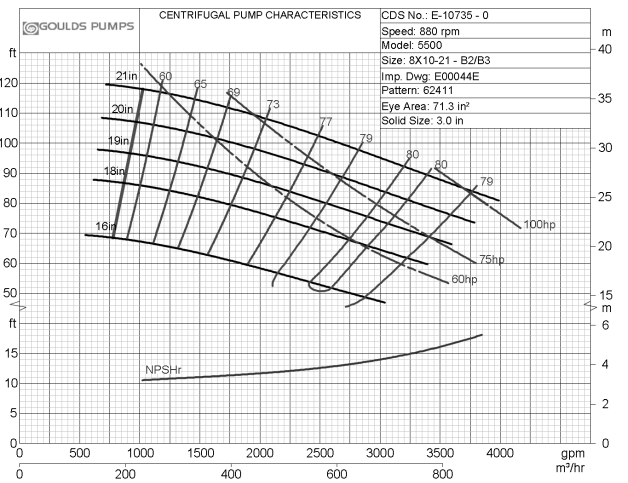
6X8-26 **880rpm**



6X8-26HP **880rpm**

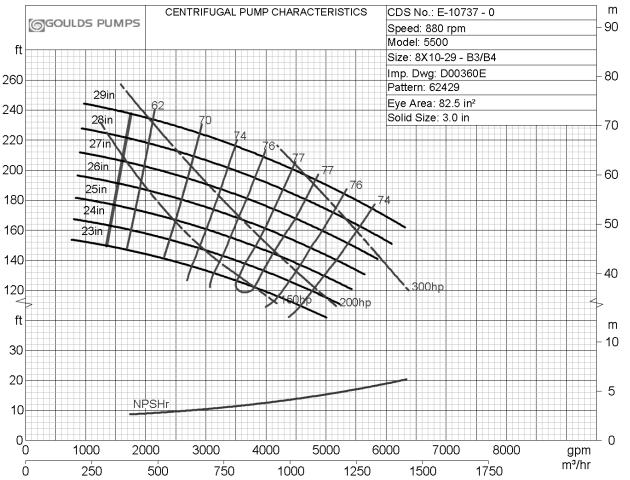


6X12-25 **880rpm**

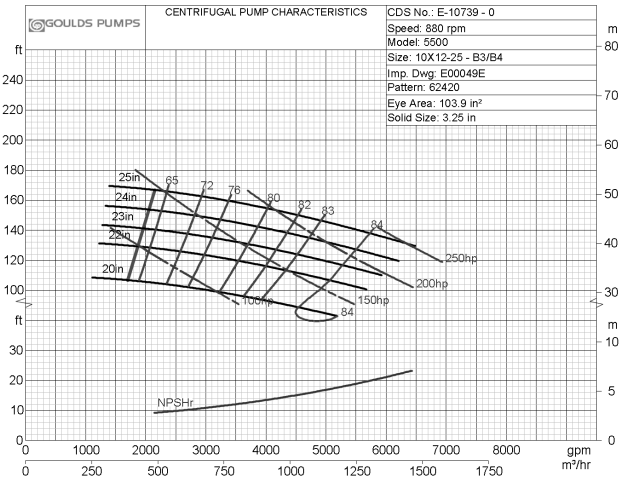


8X10-21 **880rpm**

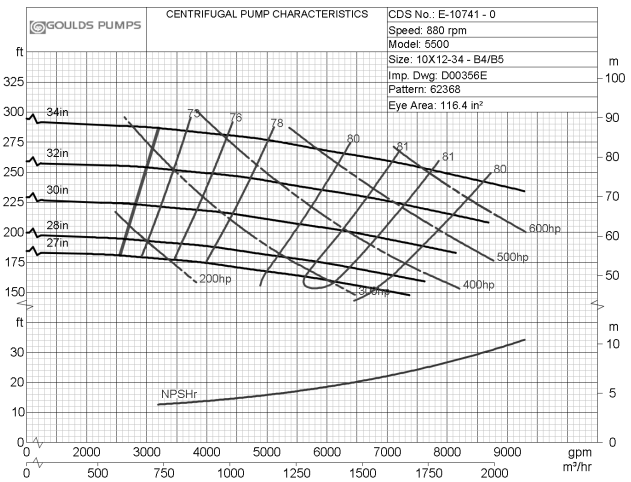
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



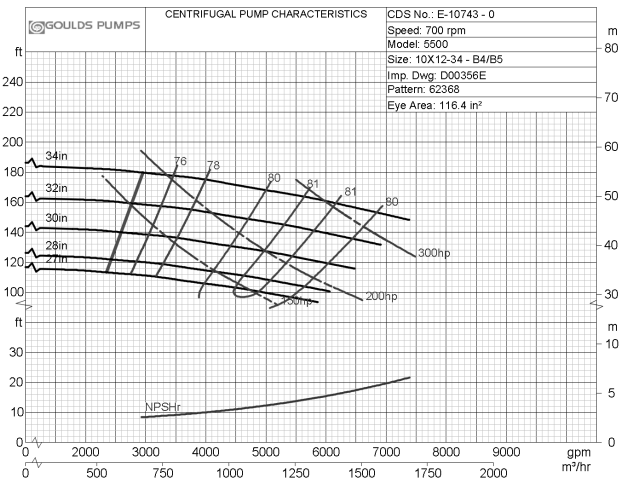
8X10-29 **880rpm**



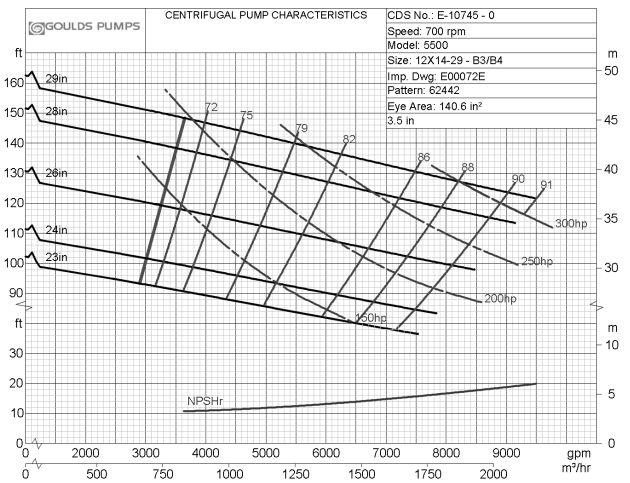
10X12-25 **880rpm**



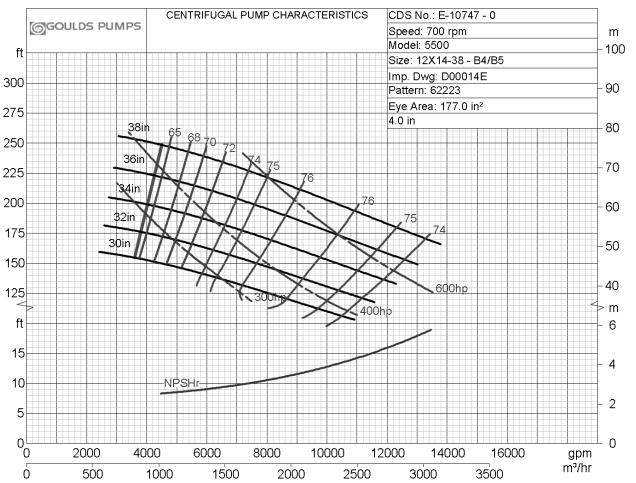
10X12-34 **880rpm**



10X12-34 **700rpm**

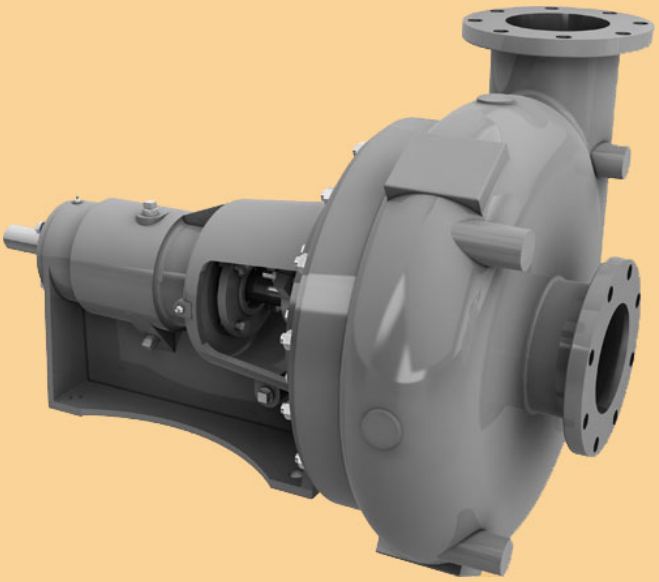


12X14-29 **700rpm**



12X14-38 **700rpm**

NOTES



Model HS
Horizontal
Hydro-Solids Pump

This Model HS eliminates clogging problems encountered with conventional centrifugal pumps. The recessed impeller design handles large particle solids and fibrous/stringy materials. Any spherical solids that will enter the suction (up to 10") will pass through the discharge.

Solves Material Transfer Problems

The elimination of clogging problems encountered with conventional centrifugal pumps is one of the outstanding features of the Goulds HS Hydro-Solids pump. Because of its design the HS is particularly well adapted to handling large particle solids and fibrous materials in liquid suspension.

With its impeller completely recessed the Hydro-Solids pump operates on the "induced flow" principle. A specially designed impeller at the suction inlet and a higher pressure at the periphery.

Since its impeller is clear of the pump casing, solids passage is not dependent upon vane or shroud spacing as it is in conventional centrifugal pump. Anything that will enter the suction inlet will be expelled through the pump discharge.

Built for the most solids handling applications, the HS line reflects Goulds' traditional emphasis on ruggedness of design, for maximum reliability and minimum maintenance over the life of the pump. Offered in 2, 3, 4, 6, 8 and 10-inch sizes, the HS model may be furnished in either cast iron, 28% chrome iron, or 316 stainless steel construction.

Goulds Model HS

Recessed Impeller Pump Designed for Handling Large Solids Entrained Air, and Fibrous Materials

- Capacities to 7,000 GPM (1,590 m^3/h)
- Heads to 140 feet (43 m)
- Temperatures to 200°F (93°C)
- Pressures to 100 PSIG (690 kPa)
- Solids to 10" (254 mm)

Design Features

- Recessed, Non-Clog Impeller
- Back Pull-Out Design
- Extra Thick Casing and Impeller
- Available in Cast Iron, High Chrome Iron, and 316 SS.

Services

Waste Treatment

- Raw Sewage
- Sewage Sludge
- Water, Resin, and Fiber
- Water and Ashes
- Textile Mill Effluent

Pulp and Paper

- Paper Stock
- Plant Effluent
- Black Liquor
- Filtrate

Food Processing

- Beet Pulp
- Dirty Water
- Vegetable Refuse
- Lemons
- Tomato Wash Water

Foundries and Steel Mills

- Mill Scale
- Water and Slag
- Grit

Agriculture

- Liquid Manure
- Drainage
- Mulch, Seed, and water
- Cane Wash
- Sprigs, Wood, and Fiber

Manufacturing

- Paint Sludge
- Plant Sewage and Sludge
- Floor Wash
- Clay Slip
- Clarifier Sludge

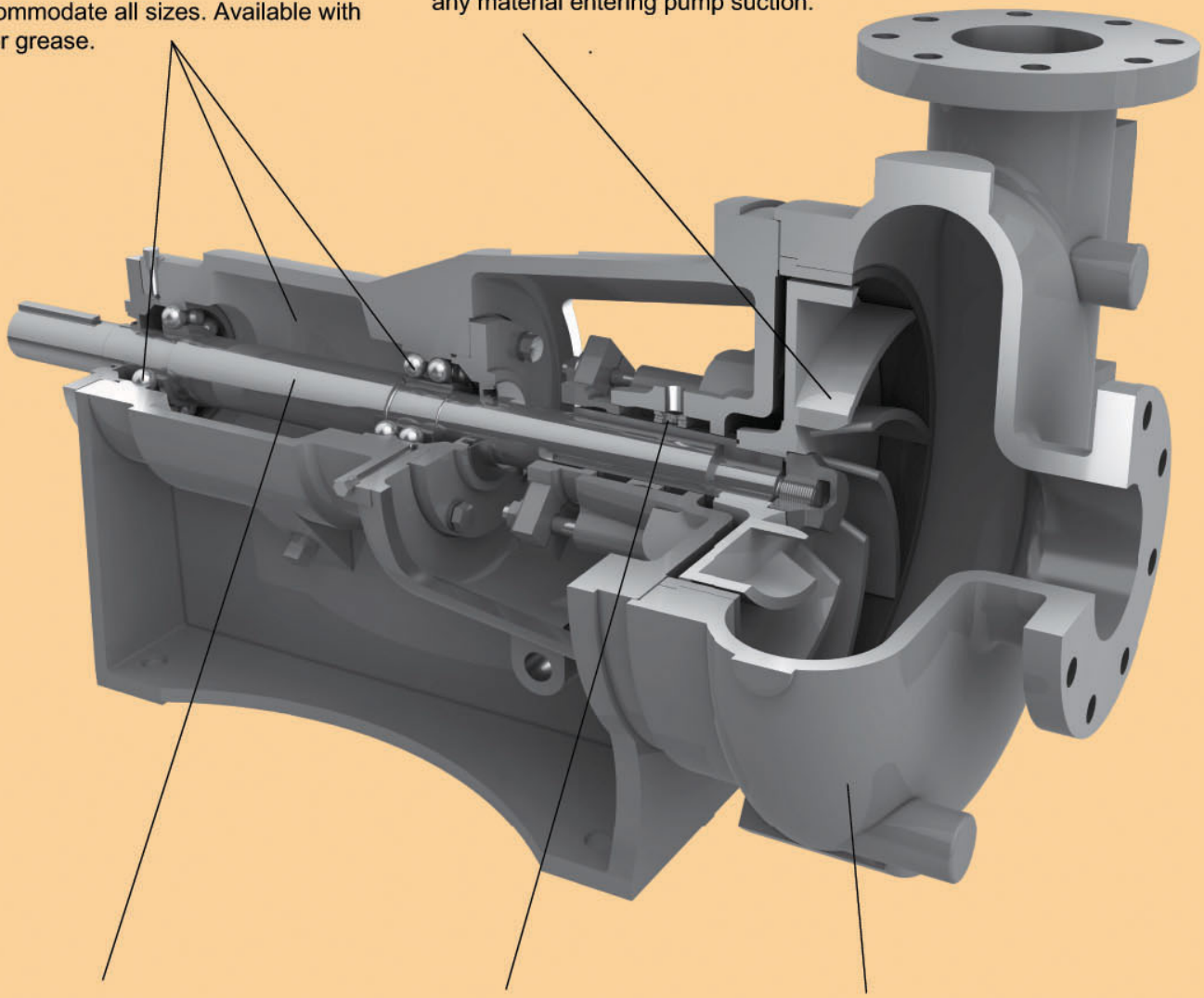
Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Model HS Hydro-Solids Pumps

Design Features for Solids Handling Services

BEARINGS AND FRAME
Rigidly maintains alignment between bearing frame and casing. Four frames accommodate all sizes. Available with oil or grease.

IMPELLER
Fully recessed, for handling large, stringy, fibrous solids. Pump will pass any material entering pump suction.

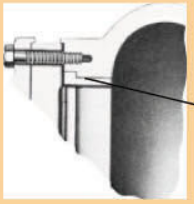


SHAFT AND SHAFT SLEEVE
Full length hook-type sleeve protects shaft from abrasive slurry.

STUFFING BOX
Easily accessible for service. Accommodates packing or mechanical seals.

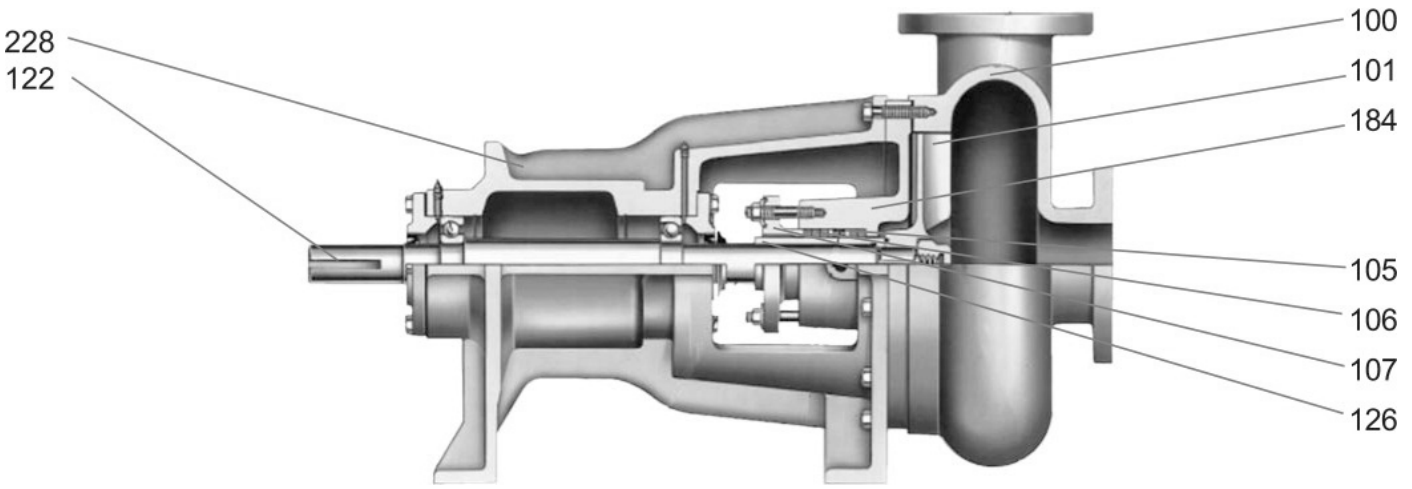
CASING
Heavy duty concentric casing virtually eliminates radial shaft loading and extends bearing life.

PUMP SIZES
Designed to provide optimum combination of solids handling capability wear resistance, and pump efficiency. Available in sizes from 2" (50mm) to 10" (250mm) in a variety of materials.



WEAR RING (OPTIONAL)
Replaceable wearing provides the extra protection for the casing which may be need in pumping the more abrasive materials.

Sectional View Model HS



Parts List and Materials of Construction

Part No.	Part Name	Material		
		Cast Iron	High Chromium Iron	316 Stainless Steel
100	Casing	Cast Iron	Chrome Iron	316 SS
101	Impeller	Cast Iron	Chrome Iron	316 SS
105	Lantern Ring	TEFLON®	TEFLON®	TEFLON®
106	Packing	Lubricated Polymer	Lubricated Polymer	Lubricated Polymer
107	Gland	Cast Iron	Cast Iron	Cast Iron
122	Shaft	Steel	Steel	Steel
126	Shaft Sleeve	416 SS	416 SS	316 SS
184	Stuffing Box Cover	Cast Iron	Chrome Iron	316 SS
228	Bearing Frame	Cast Iron	Cast Iron	Cast Iron

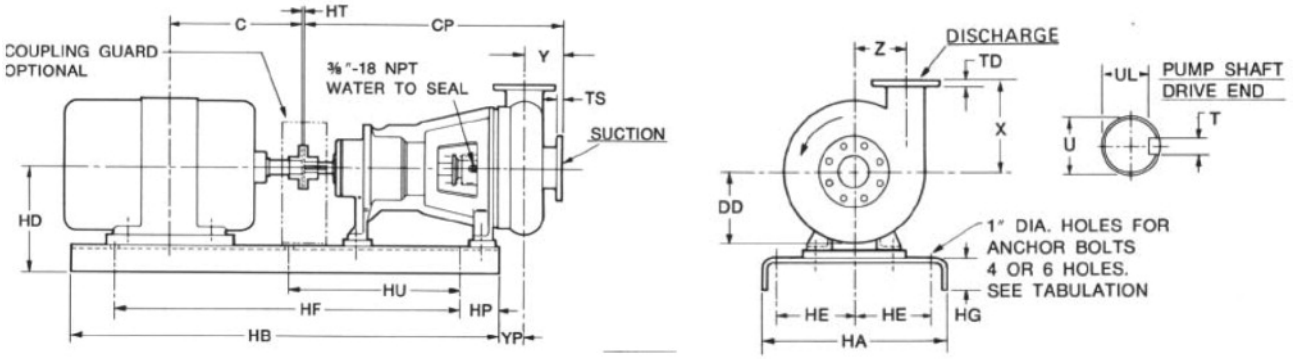
® TEFLON is a registered trademark of DuPont.

Construction Details

	2 x 2-8	3 x 3-10	4 x 4-12	6 x 6-12	6 x 6-18	8 x 8-22	10 x 10-26
Pump Weight–Lbs. (kg)	285 (130)	350 (160)	425 (195)	540 (245)	700 (320)	1025 (465)	1350 (615)
Maximum Solid Size–in. (mm)	2 (51)	3 (76)	4 (102)	6 (152)		8 (203)	10 (254)
Working Pressure–PSIG (kPa)	100 (690)				70 (483)		
Maximum Horsepower (kW)	60 (45)	60 (45)	200 (149)	200 (149)	165 (123)	250 (187)	250 (187)
Bearing Frame	2HM		3HM		3HM-18	4HM	
Outboard Bearing	MRC 7208 DU		MRC 7310 PDU			MRC 7316 PDU	
Inboard Bearing	MRC 208 M		MRC 310 M			MRC 316 M	

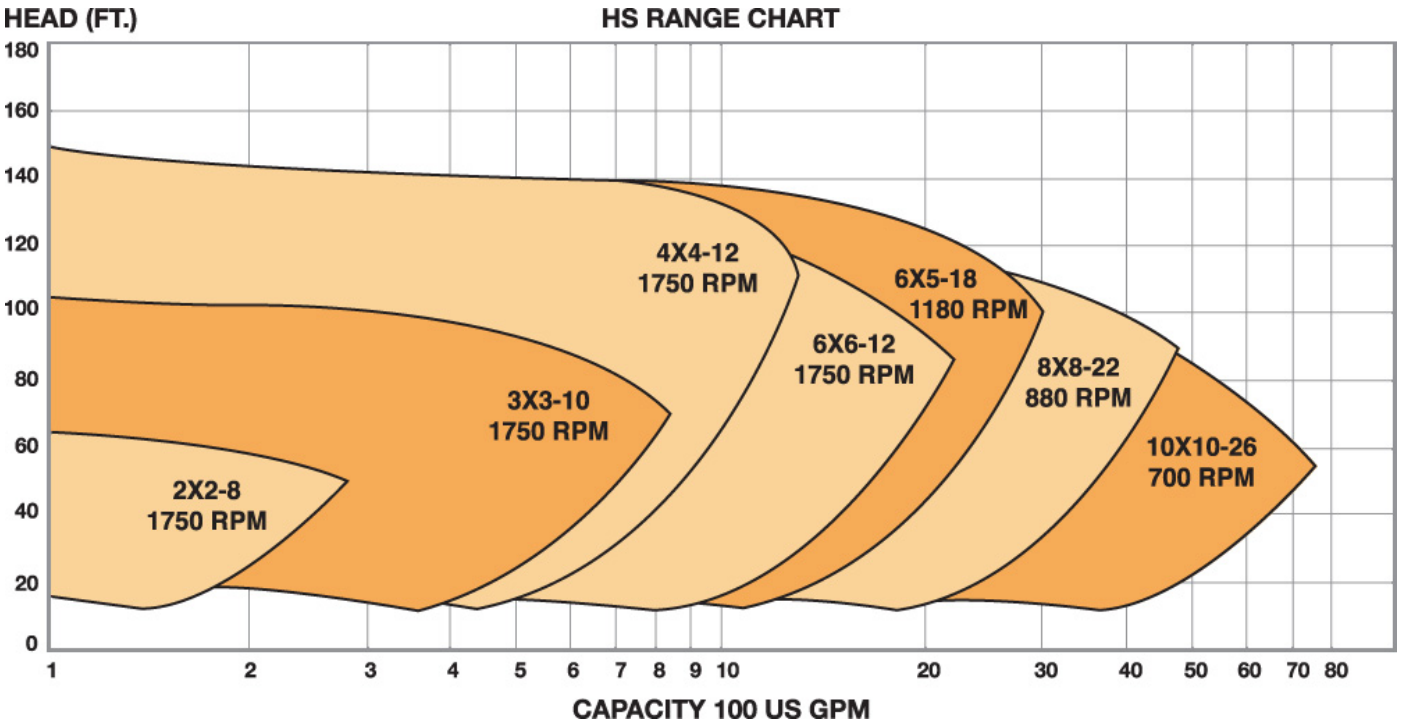
Dimensions Model HS

All dimensions in inches and (mm). Not to be used for construction.



BARE PUMP DIMENSIONS								
Pump Size	Bearing Frame	CP	HL	YP	BD	X	Z	D
2 × 2-8	2 HM	29 $^{9}/_{16}$ (751)	3 (76)	5 $^{1}/_{16}$ (129)	5 ¾ (146)	7 ¾ (197)	4 ⅜(111)	4 (102)
3 × 3-10	2 HM	32 ¼ (819)	4 ½ (114)	6 ¼ (159)	7 $^{7}/_{16}$ (189)	9 ⅝ (245)	5 ½ (140)	4 (102)
4 ×4-12	3 HM	37 ⅜ (950)	5 ½ (140)	7 (178)	9 (229)	11 ½ (292)	6 ½ (165)	4.25 (108)
6 × 6-12	3 HM	40 ⅞ (1038)	7 ½ (191)	8 ½ (216)	10 ⅛ (257)	13 (330)	6 ½ (165)	4.25 (108)
6 × 6-18	3 HM18	41 ⅞ (1064)	7 ½ (191)	9 ½ (241)	13 ¼ (337)	16 (406)	9 ⅝ (245)	4.25 (108)
8 × 8-22	4 HM	50 ¼ (1276)	9 (229)	11 ¼ (286)	16 ¾ (425)	20 ½ (521)	12 (305)	5.75 (146)
10 × 10-26	4 HM	53 ⅜ (1356)	10 ½ (267)	13 ⅜ (340)	19 ⅞ (505)	24 (610)	14 (356)	5.75 (146)

Hydraulic Coverage Model HS



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

Specifications

General Available in 2" through 10" discharge. Recessed impeller design handles large solids and fibrous material without clogging and is capable of passing any solid that will enter the suction inlet. Back pull-out enables rotating assembly removal without disturbing suction or discharge piping.

Casing One piece casting with integral suction and discharge ANSI Class 125 flange connections. Completely open from suction to discharge with internal impeller clearance equal to I.D. of suction and discharge.

Impeller Semi-open type, keyed to the shaft and held securely by a capped threaded locknut. O-ring seal is provided to protect the shaft from the pumpage.

Rotation Impeller rotation is clockwise as viewed from the driven end of this pump.

Stuffing Box Cover Designed to provide a self-centering fit with casing. Functions as a replaceable hub disc. Designed large enough to allow back pull-out of rotation element. Accommodates a separate lantern ring with five rings of packing, mechanical seal.

Shaft and Shaft Sleeve Machined shoulders for positive bearing location. Suitably turned round and polished high grade steel. Protected in the stuffing box area by a renewable hardened stainless steel shaft sleeve.

Bearings and Bearing Frame Bearings contained in a removable cast iron bearing frame. Frame is horizontally split for ease of maintenance. Radial and thrust bearings are anti-friction type with a 3 year minimum B-10 life..

Materials of Construction Standard materials of construction - cast iron, high chromium iron and 316 stainless steel. Other materials available on request.

The HS Family Provides Pumping Versatility

HSUL Submersible Hydro Solids Model

Designed specifically for sump clean-out operations, sewage wet wells and general industrial applications. Available with completely submersible motors designed for hazardous environments... some of which are suitable for continuous in-air operation as well.

VHS Vertical Cantilever Model

Especially designed for wet pit installation. Unlike standard vertical wet pit pumps, NO bearings or sealing devices are required below the floor plate. Problems of lubrication, sealing, and maintenance are eliminated. Available in settings up to 8 feet.

Other Recessed Impeller Pumps

Besides the Model HS horizontal, Goulds makes other recessed impeller pumps for non-clog solids handling services including:

- Model CV 3196 horizontal process pumps (Section CHEM-1D)
- Models HSU submersible pumps (Section AS-1L)
- Model CV 3171 recessed impeller sump pump (Section CHEM-4B)

NOTES

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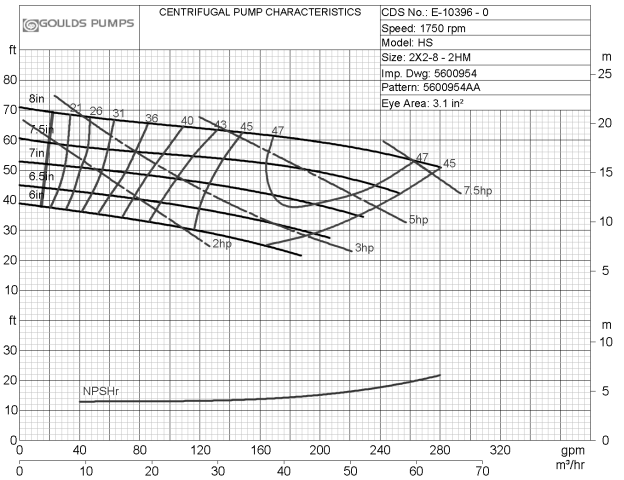
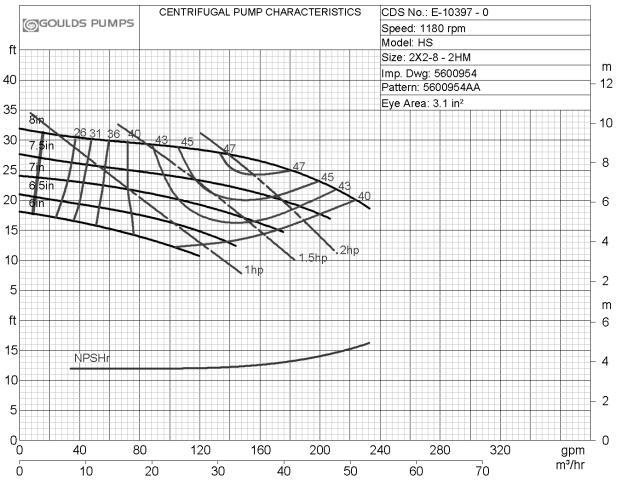
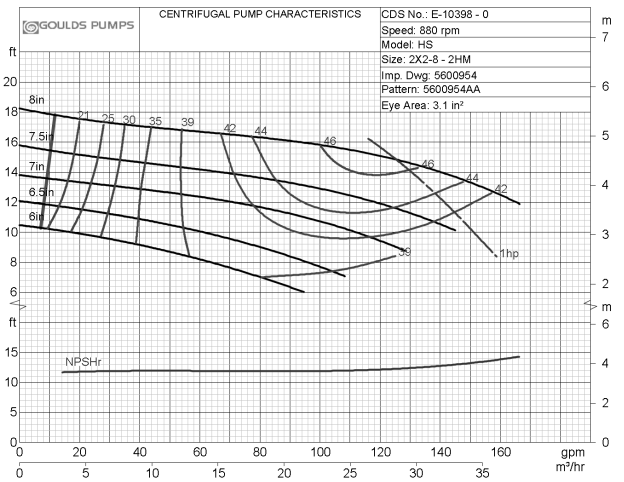


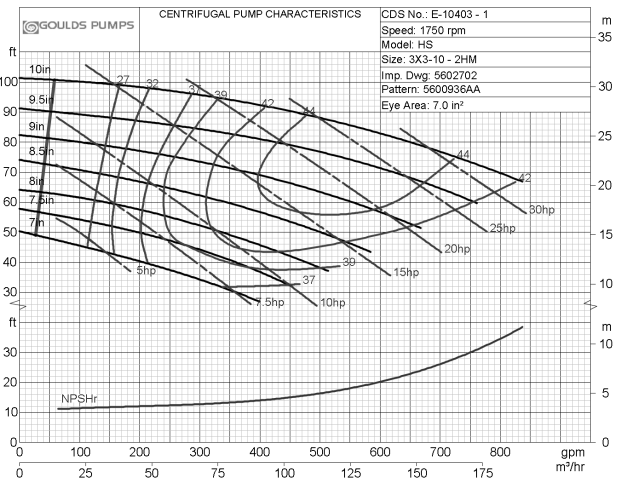
2X2-8 **1750rpm**



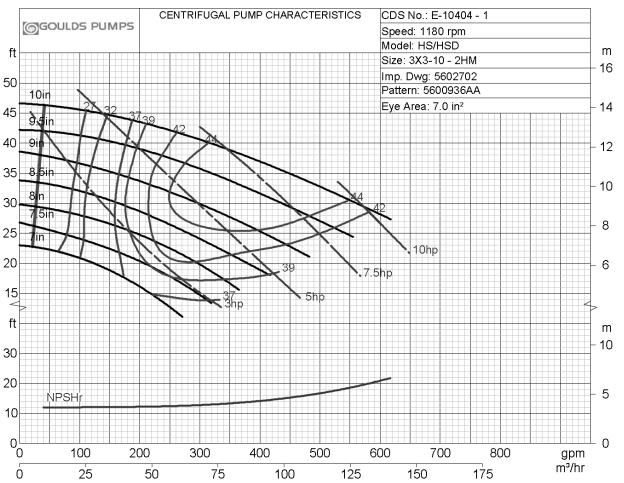
2X2-8 **1180rpm**



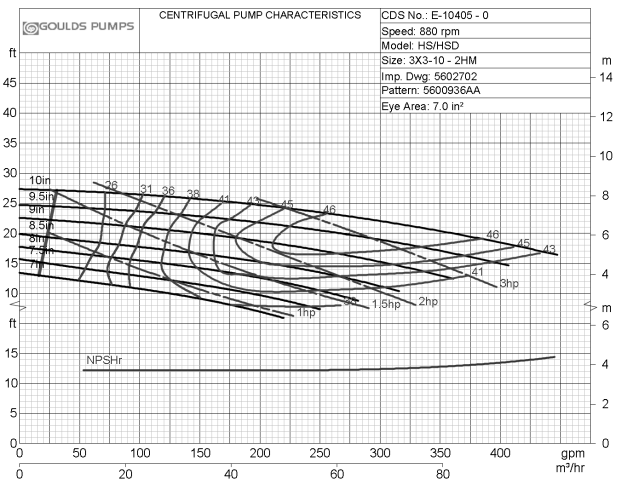
2X2-8 **880rpm**



3X3-10 **1750rpm**

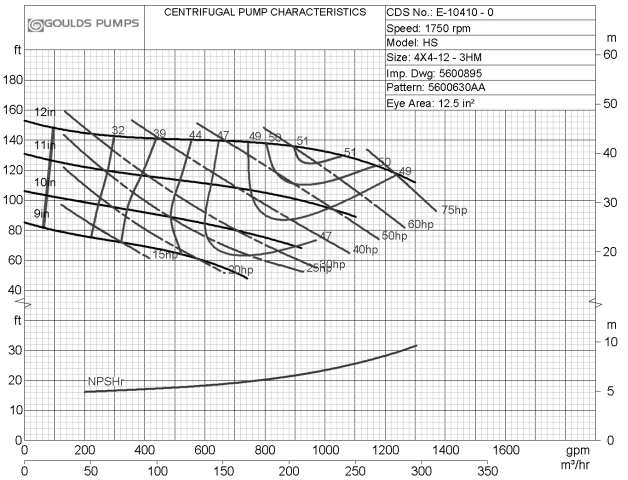


3X3-10 **1180rpm**

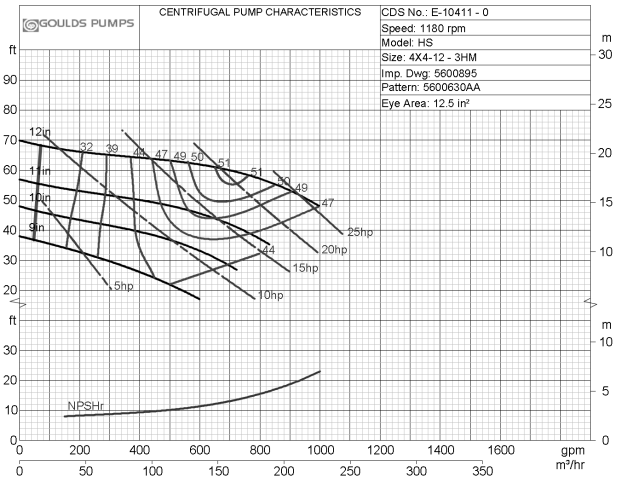


3X3-10 **880rpm**

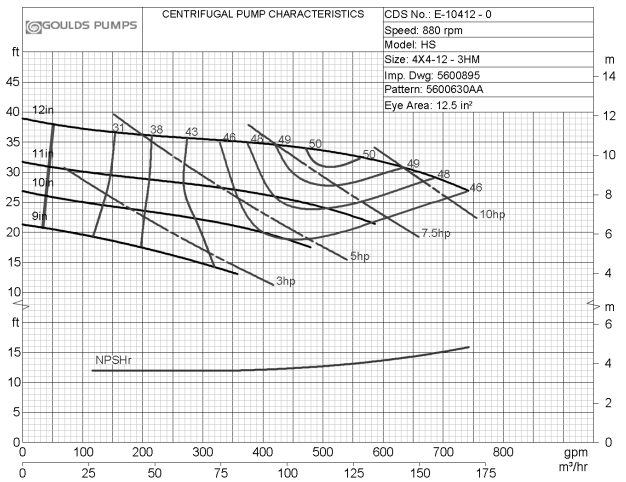
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



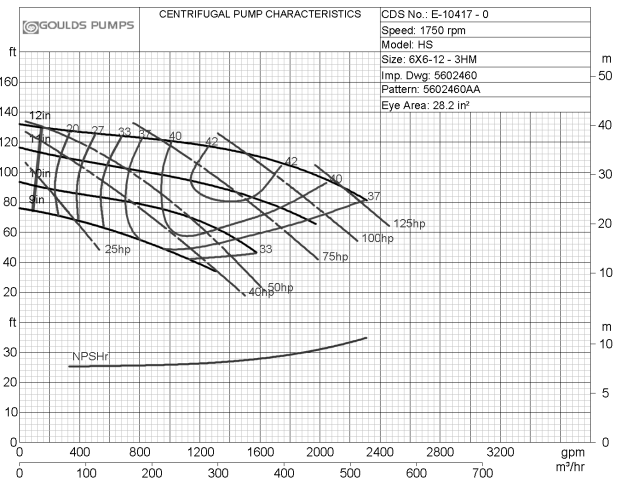
4X4-12 **1750rpm**



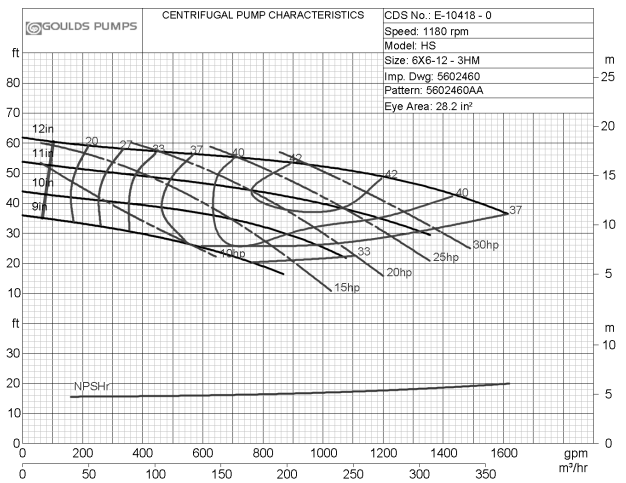
4X4-12 **1180rpm**



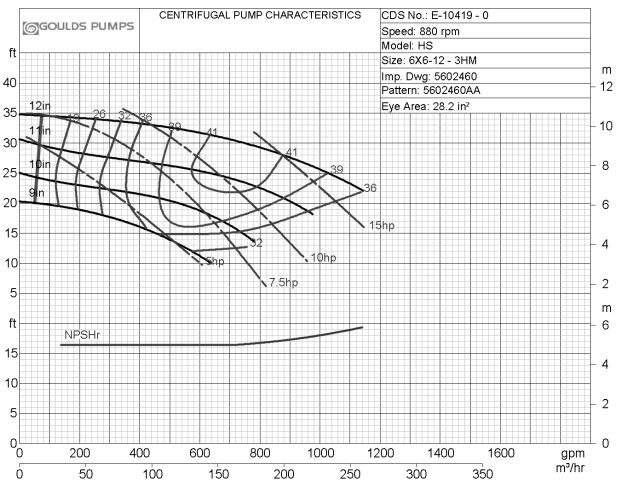
4X4-12 **880rpm**



6X6-12 **1750rpm**



6X6-12 **1180rpm**



6X6-12 **880rpm**

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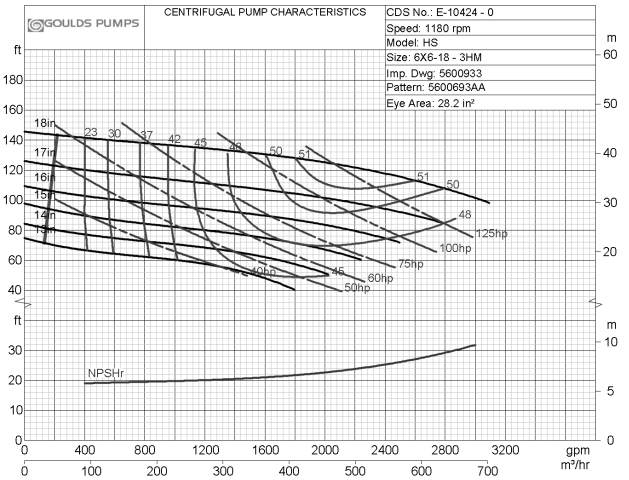
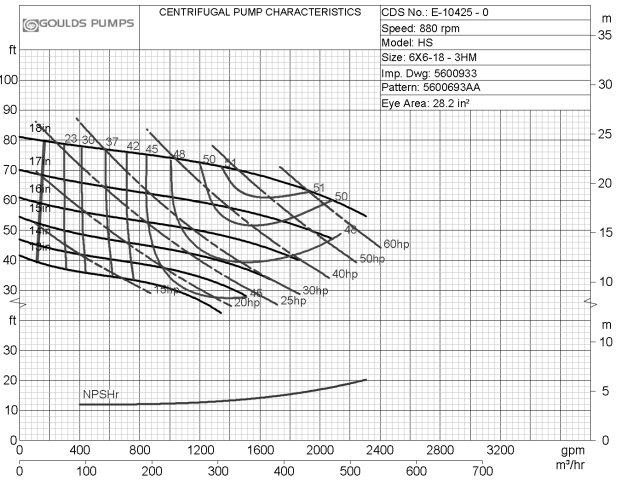
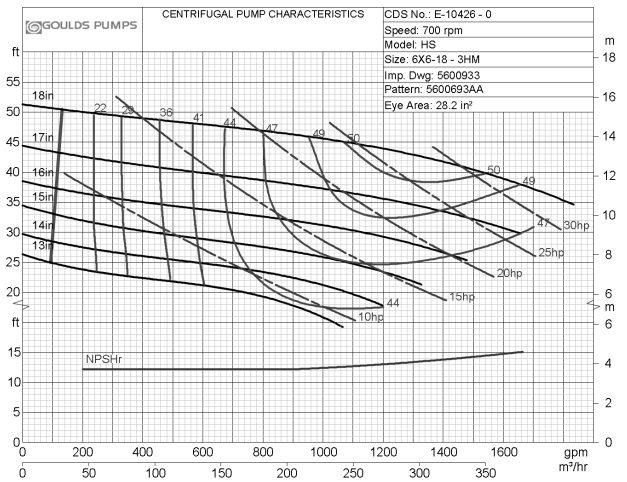


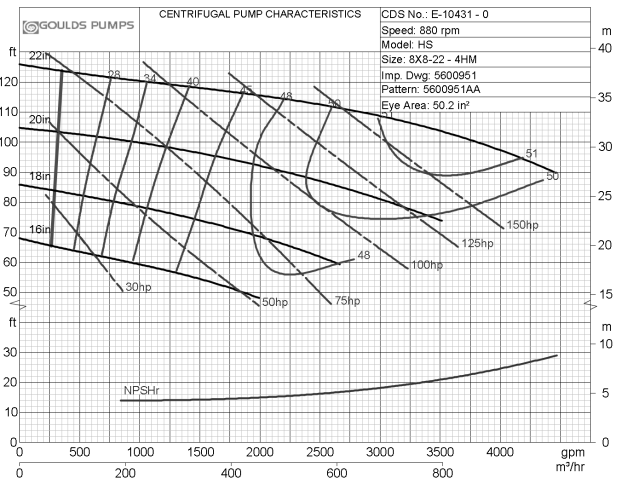
6X6-18 **1180rpm**



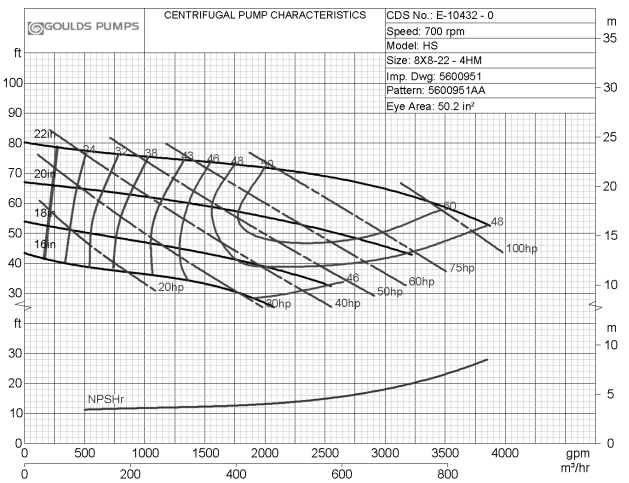
6X6-18 **880rpm**



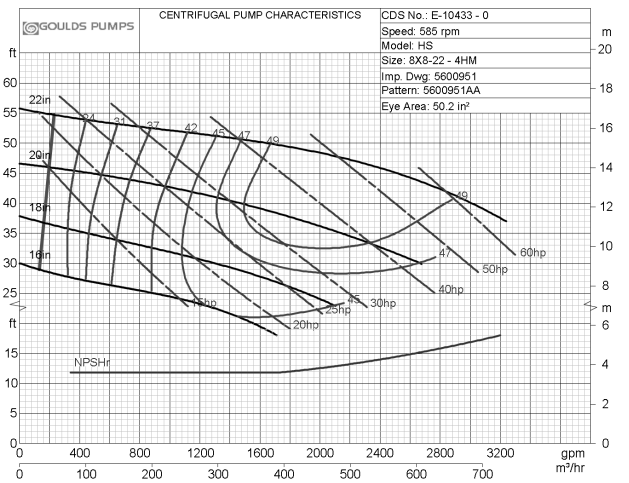
6X6-18 **700rpm**



8X8-22 **880rpm**

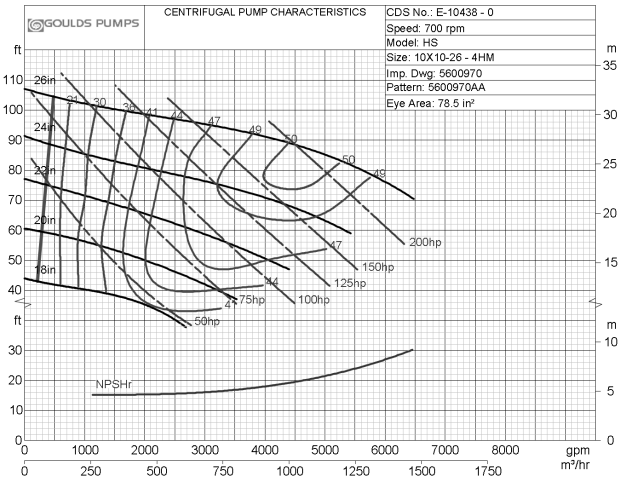


8X8-22 **700rpm**

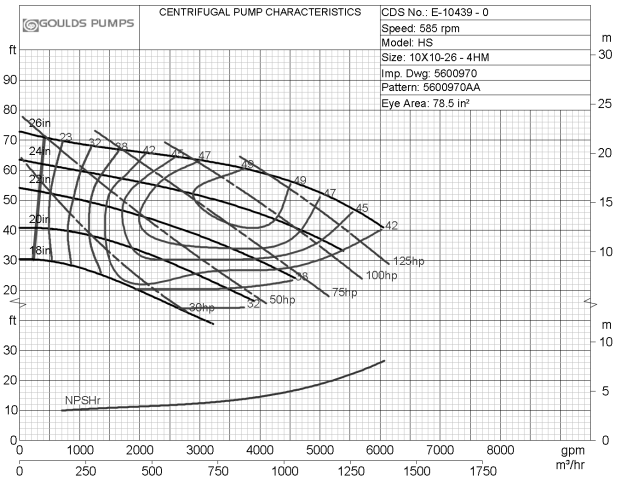


8X8-22 **585rpm**

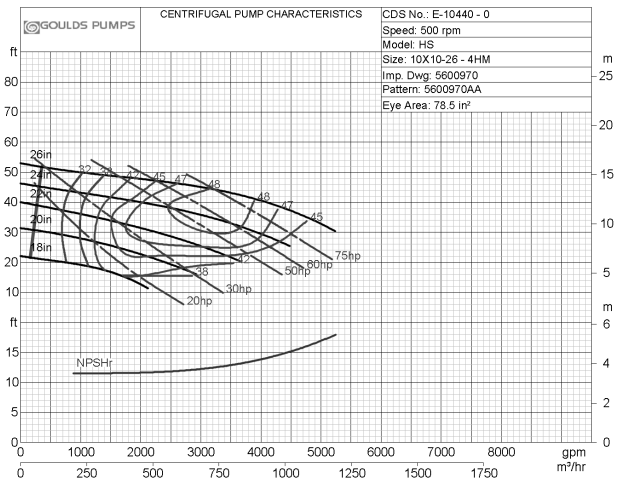
The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.



10X10-26 **700rpm**



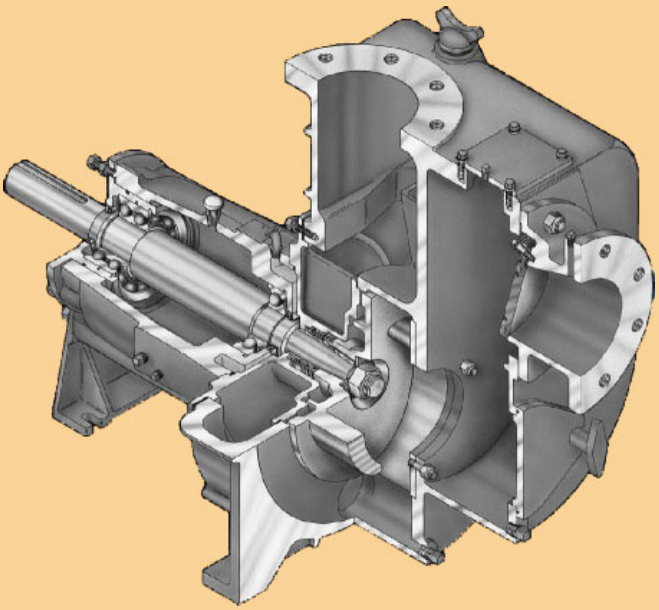
10X10-26 **585rpm**



10X10-26 **500rpm**

NOTES

NOTES



Goulds Trash Hog ®

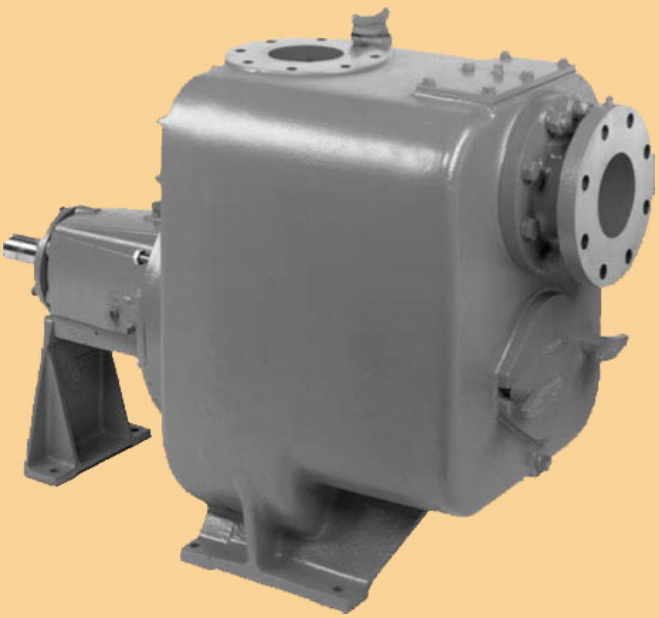
Self-Priming Pumps Designed for Toughest Solids Handling Services

- Capacities to 6,000 GPM (1,363 m^3/h)
- Heads to 140 feet (43 m)
- Temperatures to 225°F (107° C)
- Pressures to 85 PSIG (586 kPa)
- Suction Lifts to 25 feet (7.6 m)
- Spherical Solids to 3 inches (76 mm)

Goulds Trash Hog is designed for superior solids handling capability, optimum pump performance and ease of maintenance for a wide range of industrial, pulp and paper, mining and municpal wastewater services. Whether handling raw sewage, sludge, debris or plant wastes, there's no other pump that compares to the Trash Hog.

Performance Features for Self-Priming, Solids Handling Services

- **Large Capacity Priming Chamber**
  For reliable priming and repriming
- **Heavy Duty Power End**
  For extended life in toughest services
- **Non-Clog Impeller**
  Capable of passing spherical solids to 3 inches (76 mm)
- **External Impeller Adjustment**
  Easily renews optimum hydraulic performance
- **Trimmable Impeller**
  Permits most efficient use of motor horsepower



Services

Pulp and Paper Industry

- Black Liquor Sump
- Paper Machine Floor Sump
- Knotters Discharge Pump
- White Water Service

General Industry

- Wash Down Sump
- Food Wastes
- Fish Farming
- Rendering Wastes
- Machine Coolant Sump

Mining and Metal Fabrication

- Mine Dewatering
- Mill Scale Runoff
- Cutting Oil Transfer
- Construction Site Dewatering

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Trash Hog ® Self-Priming, Solids Handling Pumps

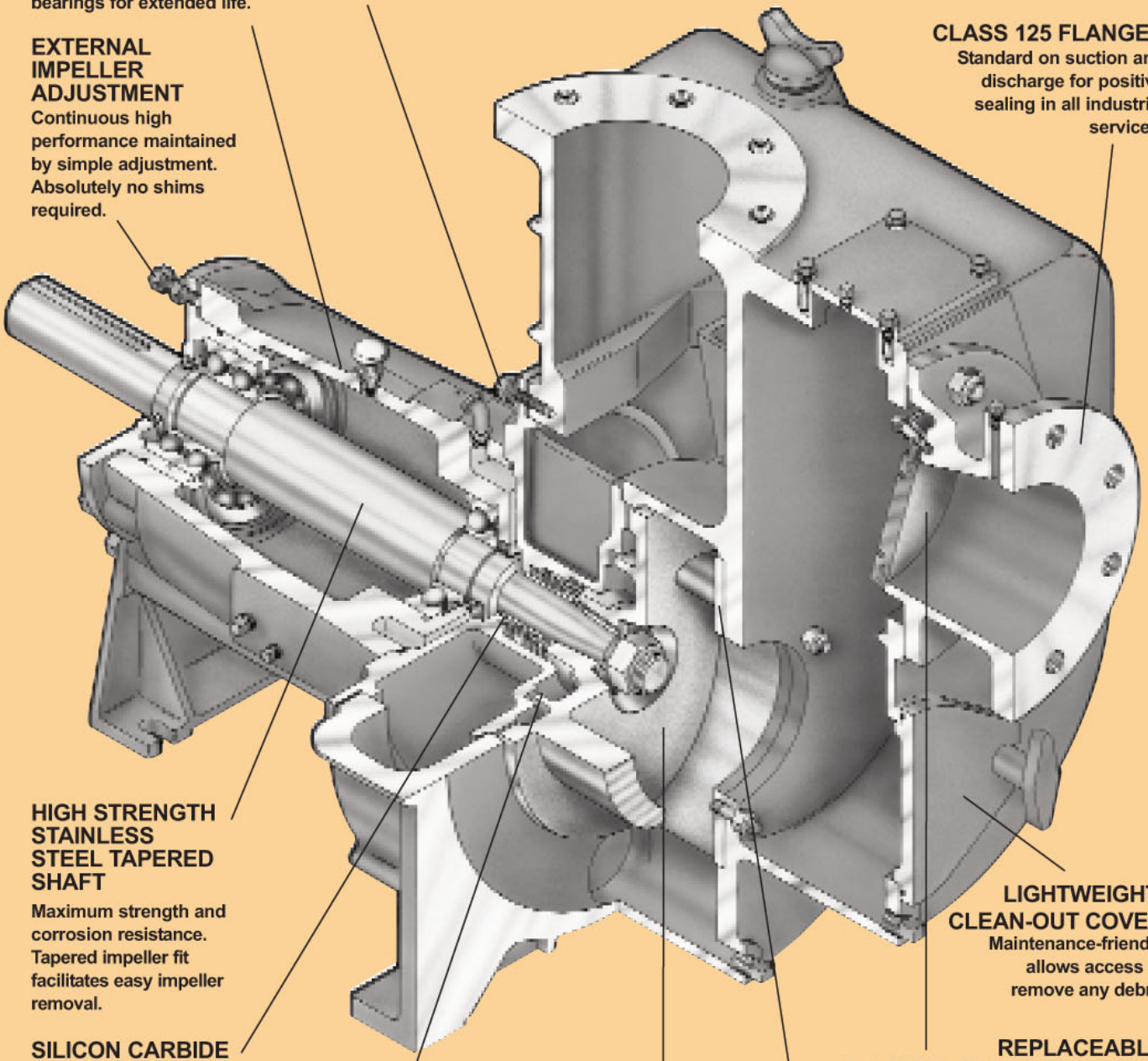
Heavy Duty Design Features for Wide Range Solids Handling Services

INDUSTRIAL-DUTY POWER END
Provides rigid shaft support. Ample oil volume results in cooler running bearings for extended life.

BACK PULL-OUT DESIGN
Complete power end with seal chamber can be easily removed from casing without disturbing suction and discharge piping. No need for special tools.

EXTERNAL IMPELLER ADJUSTMENT
Continuous high performance maintained by simple adjustment. Absolutely no shims required.

CLASS 125 FLANGES
Standard on suction and discharge for positive sealing in all industrial services.



HIGH STRENGTH STAINLESS STEEL TAPERED SHAFT
Maximum strength and corrosion resistance. Tapered impeller fit facilitates easy impeller removal.

LIGHTWEIGHT CLEAN-OUT COVER
Maintenance-friendly allows access to remove any debris.

SILICON CARBIDE MECHANICAL SEAL
Hard faces provide substantially higher resistance to wear. Carbon/ceramic seal is optional.

REPLACEABLE ELASTOMERIC CHECK VALVE
With integral blow-out disc — provides for instant repriming while preventing over-pressurization of casing.

BACK PUMP-OUT VANES AND REAR IMPELLER RING
Reduces seal chamber pressure and axial thrust for extended bearing and seal life. Prevents solids from entering seal chamber. Close radial clearance eliminates need to shim behind impeller.

HEAVY VANED OPEN IMPELLER
Designed for superior performance in toughest solids handling services.

RENEWABLE WEARPLATE
Reduces maintenance costs; allows running clearances to be maintained for maximum pumping efficiency and priming capability.

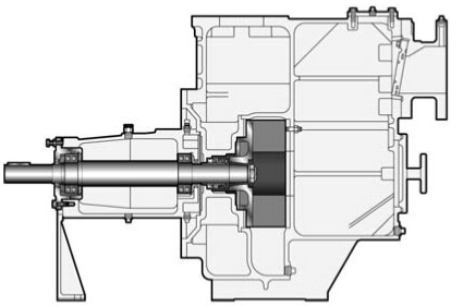
Designed for Ease of Maintenance

Easily Renewed Performance

It's common knowledge that as a pump wears, the performance decreases. The Trash Hog's open impeller can be adjusted, simply and quickly, to compensate for wear and renew performance.

Original performance can be re-set in a matter of minutes with external impeller adjustment.

Adjustable cartridge style bearing housing allows adjustment of impeller to wearplate clearance. No shims are required. No need to disassemble or drain pump.



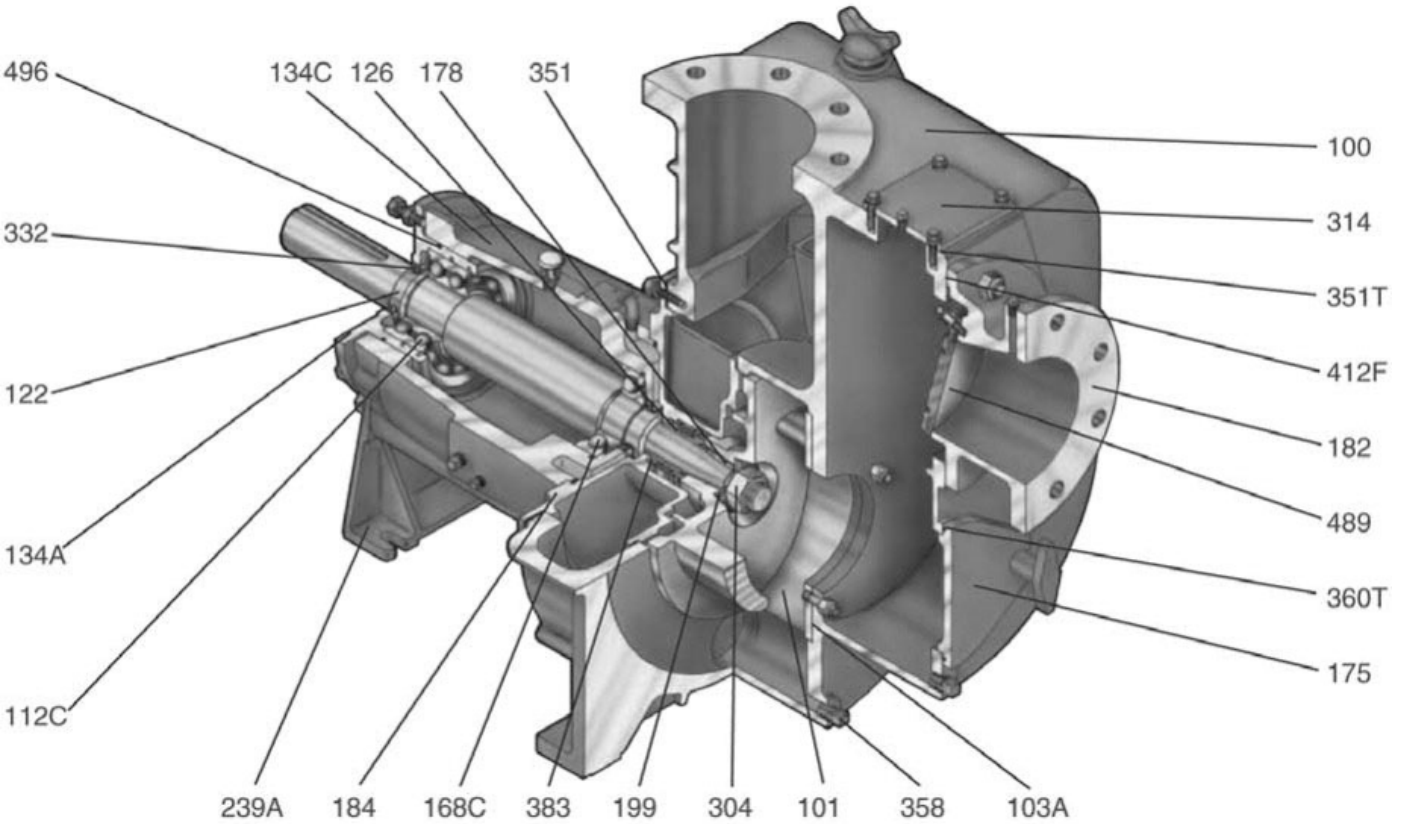
Back Pull-Out

The power end is entirely outside the pump casing allowing a safe and easy "sling point" for removal. Jacking bolt holes are provided to ease the separation of the power end from the casing.

- No special tools or "T" handles are required to remove the power end.
- No shims are used on the casing bolt circle for clearance adjustments.
- No risk of injury from "wrestling" with an awkward back pull-out design.

The tapered shaft and woodruff key design allow easy removal of the impeller from the rotating assembly.

Sectional View Trash Hog®



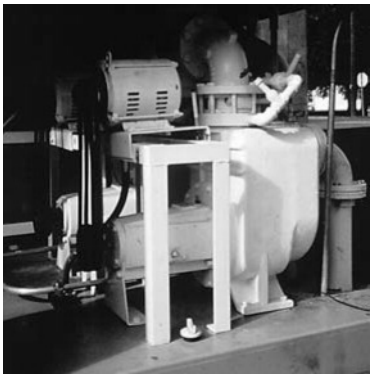
Parts List and Materials of Construction

Item Number	Part Name	Material						
		All Cast Iron	CI\316	CI\316 w\316 SB Cover	CI/HC600	CI/CD4	All 316SS	All CD4MCu
100	Casing	Cast Iron					316SS	CD4MCu
101	Impeller	Ductile Iron	316SS		HC600	CD4	316SS	CD4MCu
103A	Wear Plate	Ductile Iron	316SS		HC600	CD4	316SS	CD4MCu
112C	Thrust Bearing	Double Row Angular Contact (3)						
122	Shaft	17-4PH (2)						
126	Shaft Sleeve (Optional)	416 SS						
134A	Bearing Carrier	Cast Iron						
134C	Bearing Frame	Cast Iron						
168C	Radial Bearing	Double Row Angular Contact (1)						
175	Clean Out Cover	Cast Iron					316SS	CD4MCu
178	Impeller Key	Steel	316 SS					
182	Suction Piece	Cast Iron					316SS	CD4MCu
184	Stuffing Box Cover	Cast Iron		316SS	Cast Iron		316SS	CD4MCu
199	Impeller Washer	Carbon Steel					316SS	Alloy 20
239A	Frame Foot	Cast Iron						
304	Impeller Nut	Carbon Steel					316SS	Alloy 20
314	Inspection Cover	Cast Iron					316SS	CD4MCu
332	Oil Seal	Lip Seal (Buna\Steel)						
351	Casing Gasket	Lexide						
351T	Gasket, Inspection Cover	Lexide						
358	Casing Drain Plug	Carbon Steel					316SS	Alloy 20
360T	O-ring	Buna N						Viton
383	Mechanical Seal	Single (Silicon Carbide vs. Silicon Carbide/Viton)						
412F	Gasket, Suction Piece	Lexide						
489	Check Valve	Buna N						Viton
496	O-ring	Buna N						

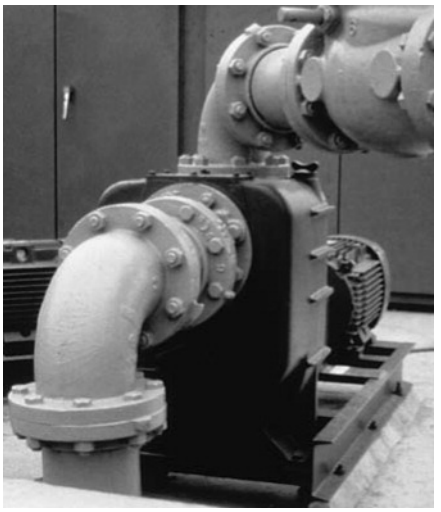
(1) Single row bearings standard on 3×3-8, 6×6-11 and 8×8-14 pumps.
(2) Carbon steel shaft standard on 3×3-8 and 4×4-10 pumps for all iron construction.
(3) Single row bearings standard on 3×3-8 pump.

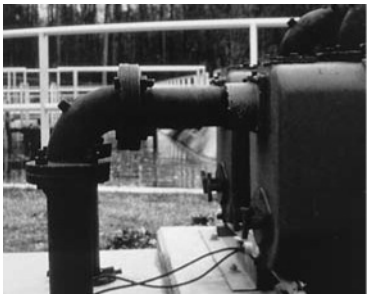
Proven Performance

Goulds Trash Hog has been designed to meet the waste handling needs of our industrial customers. Whether it be a remote lift station, an on-site treatment facility or transfer of your process wastes, Goulds has the experience to provide the engineered solution you need.



Trash Hogs are utilized in remote sewage lift stations to pump municipal waste from outlying residential areas to the local treatment plant. Here, Trash Hogs are being driven by overhead belt drives to conserve lift station space. Service will be performed by removing the rotating element to the rear as typical suction piping restricts access to the front of the pumps.





In this installation, two 3" Trash Hogs are being used to control the level of the liquid in these settling ponds. Liquid level controls in the sump determine whether either or both pumps are needed to maintain proper pond level. Trash Hogs were chosen due to their reliable priming capabilities.

Here, one of several 6" self-priming Trash Hogs is being used to pump process waste at an industrial treatment plant. Trash Hog was specified and installed due to its ability to pass a 3" diameter solid and prime and reprime a 15 feet static suction lift.

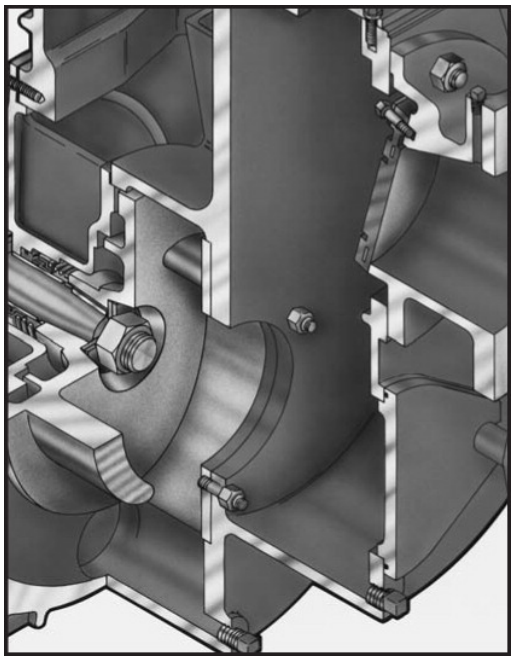
Construction Details All dimensions in inches and (mm).

		3×3-8	4×4-9	6×6-11	8×8-14	10×10-14	10×12-18
Casing	Suction/Discharge Flange	3, Class 125	4, Class 125	6, Class 125	8, Class 125	10, Class 125	Class 125
	Maximum Pressure	85 PSIG (586 kPa)			65 PSIG (448 kPa)		80 PSIG (552 Kpa)
	Minimum Thickness	0.38 (10)			0.44 (11)	0.50 (13)	0.50 (13)
	Volume	10 Gal. (38L)	14 Gal. (53L)	21 Gal. (80L)	31 Gal. (117L)	95 Gal. (360L)	70 Gal. (265L)
Shaft	Diameter at Impeller	1.38 (35)	1.75 (45)			2.0 (51)	2.75 (70)
	Diameter in Stuffing Box	1.38 (35)	1.75 (45)			2.0 (51)	2.75 (70)
	Diameter Between Bearings	2.0 (51)	2.25 (57)	3.0 (76)			4.0 (102)
	Diameter at Coupling	1.38 (35)	1.63 (41)	2.0 (51)			2.375 (60)
Bearings	Radial Bearing	308	5210	313		5313	317
	Thrust Bearing	308	5210	5313			7317
	Bearing Span	9.66 (245)	9.75 (248)	10.94 (278)		10.75 (273)	11.68 (297)
	Avg L'_{10} Bearing Life	120,000 Hrs					
	Oil Sump Capacity	1.75 Qts. (1.7L)		2.12 Qts. (2.0L)			
Max Speed		2200 RPM	2000 RPM	1750 RPM	1450 RPM		
Max Temp		225°F (107°C)					
Solids	Maximum Diameter Solids	2.5 (64)	3.0 (76)				

Reliable Self-Priming Operation

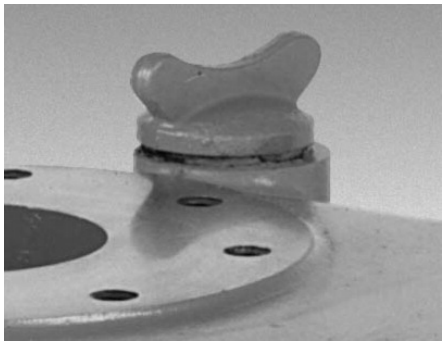
Consistent Priming and Repriming

Self-priming pumps require liquid in the priming chamber in order to prime properly. Too small a volume of liquid can adversely affect priming performance or possibly create a dangerous situation by raising the liquid temperature.



The large capacity priming chamber retains plenty of liquid for consistent priming and repriming.

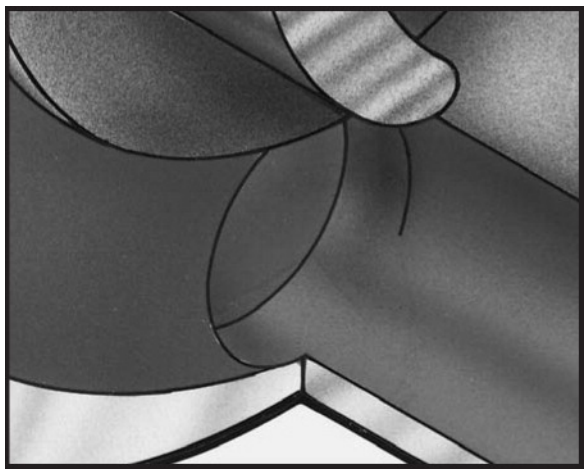
The Trash Hog is designed with an elevated suction inlet to keep liquid in the priming chamber even if the check valve fails. All Trash Hog sizes will prime up to 25 feet in under 5 minutes.



The casing fill plug provides convenient access for filling the priming chamber and provides a connection for an air release system.

Industrial Duty Solids Handling

Goulds Trash Hog is designed to handle up to 3-inch spherical solids in some of the toughest solids handling services. Other manufacturers' light duty pumps cannot match the solids handling or self-priming capability of the Trash Hog.



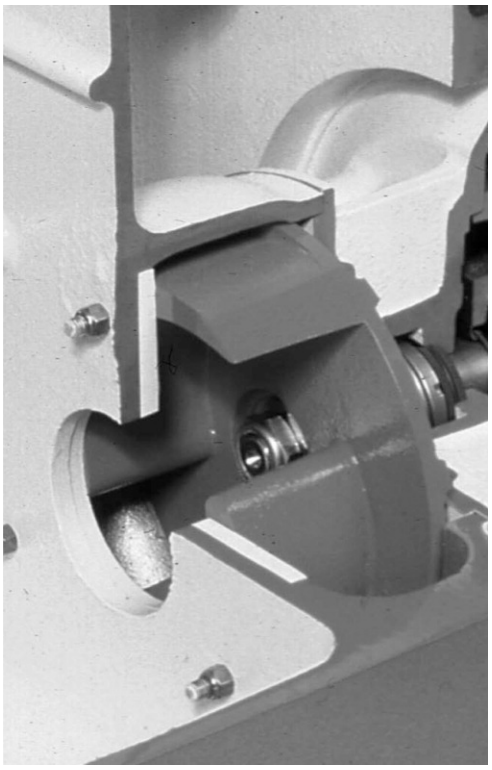
The Trash Hog uses two-vane or three-vane impellers for non-clog solids handling. Trash Hog is engineered for optimum efficiency and priming performance.

Designed for Extended Pump Life

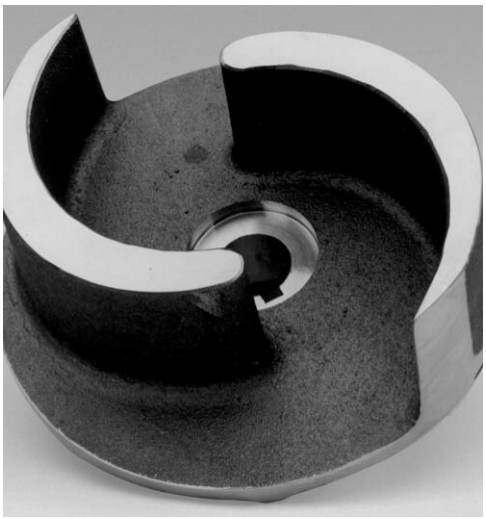
Goulds Trash Hog is a true heavy duty solids handling pump. No other self-priming solids handling pump is designed with the "beef" of a Trash Hog. All parts are engineered for maximum performance and service life.

The Trash Hog features the heaviest shaft and bearing assembly in the industry. Long bearing span minimizes bearing loads for extended bearing life. Large shaft diameter for minimal deflection, maximum mechanical seal life.

The power end is supported by a rigid cast iron foot that provides excellent support for the shaft and thrust bearing. Bearing life is extended.



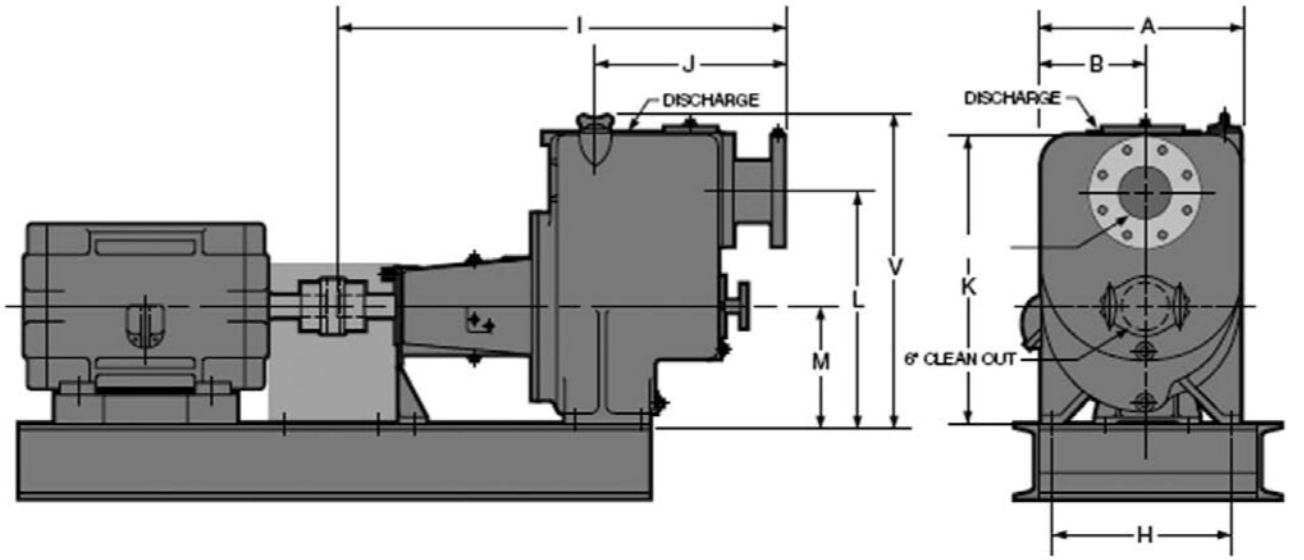
Removable wearplate provides added protection to pump casing from abrasive wear. Easily replaced.



The Trash Hog uses two-vane or three-vane impellers for non-clog solids handling. Trash Hog is engineered for optimum efficiency and priming performance.

DimensionsTrash Hog®

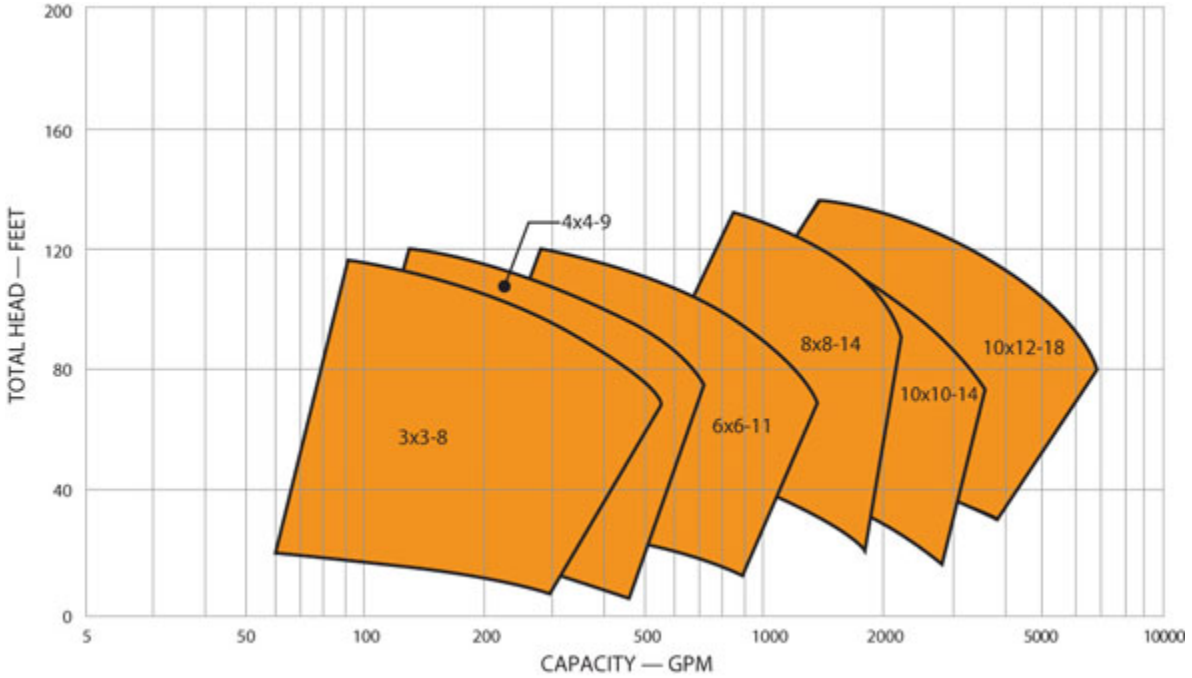
All dimensions in inches and (mm). Not to be used for construction.



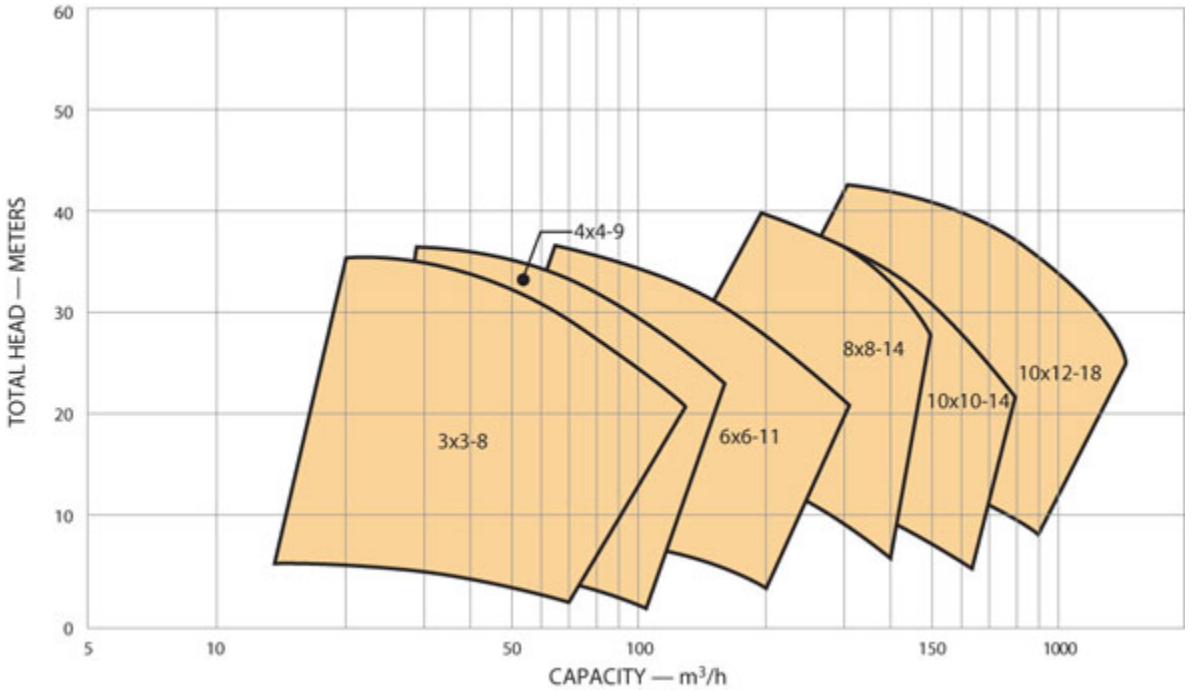
DIMENSIONS

Pump Size	Discharge	Suction	A	B	H	I	J	K	L	M	V	Weight Bare Pump	
												Lbs.	Kgs
3×3-8	3	3	14.25 (368)	7.56 (192)	13.38 (340)	38.75 (984)	17.19 (437)	25.31 (643)	21.5 (546)	11.5 (292)	26.63 (676)	480	(218)
4×4-9	4	4	16.44 (418)	8.63 (219)	15.63 (397)	40.13 (1019)	18.56 (472)	25.75 (654)	21 (533)	11.5 (292)	27.06 (687)	600	(273)
6×6-11	6	6	19.81 (503)	10.25 (260)	18.56 (472)	42.69 (1084)	16.5 (419)	27 (686)	21 (533)	10 (254)	28.56 (726)	705	(320)
8×8-14	8	8	23.25 (591)	10.56 (268)	20.25 (514)	45.56 (1157)	19.75 (502)	34 (864)	26.63 (676)	12 (305)	35.56 (903)	1150	(523)
10×10-14	10	10	28.94 (735)	13 (330)	24.5 (622)	54.13 (1375)	25.63 (651)	44 (1118)	33.5 (851)	14.75 (375)	45.31 (1151)	1800	(818)
10×12-18	10	12	36.38 (924)	16.5 (419)	31.5 (800)	64.25 (1632)	39.0 (991)	71.94 (1827)	38.88 (987)	16.38 (416)	71.94 (1827)	2470	(1123)

Hydraulic Coverage Trash Hog ® 60 Hz



Hydraulic Coverage Trash Hog ® 50 Hz



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

Coverage is based on the maximum allowable pump speed using engine drive or other type variable speed.

NOTES

Model VHS - Direct Drive Arrangement

Goulds Models VHS and VJC

Bottom Suction Vertical Cantilever Pumps for Pumping Abrasive Slurries

Model VHS Vertical Cantilever Recessed Impeller Pumps

- **Capacities to 7,000 GPM (1,590 m ^{3} /h)**
- **Heads to 140 feet (42.6 m)**
- **Solids to 10 inches (254 mm)**
- **Temperatures to 200° (93°C)**
- **Pit Depths to 11 feet (3.4 m)**

Model VJC Vertical Cantilever Bottom Suction Pump

- **Capacities to 7000 GPM (1590 m ^{3} /h)**
- **Heads to 240 feet (73 m)**
- **Solids to 2¼ inches (57 mm)**
- **Temperatures to 200°F (93°C)**
- **Pit Depths to 11 feet (3.4 m)**

Design Features

- Cantilever Design:
  No submerged bearings.
  No packing or mechanical seals.
- External Impeller Adjustment: Maintains pump efficiency and performance
- Heavy duty bearings and frame.
- Heavy Duty shaft: Operates minimum of 20% below first critical speed for reliability
- Materials of Construction: Available in a wide range of corrosion/abrasion resistant alloys

Services

Model VHS (Large or Fibrous Solids)

- Mill Scale
- Coal Slurry
- Coal Pile Runoff
- Sludge
- Clay Slurry
- Food Pulp
- Washdown Water
- Waste Paper Stock
- Black Liquor
- Plant Waste
- Sewage Treatment
- Ash Slurry

Model VJC (Extremely Abrasive Slurries)

- Coal Prep Plant
- Iron Ore Slurry
- Steel Mills
- Power Plants
- Phosphoric Acid Plants
- Cement Mills
- Mine Slurry
- Foundries
- Alumina Refineries
- Phosphate Mines

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Model VHS Vertical Recessed Impeller Pump

Design Features for Handling Large or Fibrous Solids

DIRECT OR BELT DRIVE
Direct drive offers simplicity, ease of installation and low maintenance costs. V-belt drive allows use of readily available standard speed motors along with full diameter impellers to meet desired operating conditions with greater pump efficiency. Belt drive also provides flexibility to meet changes in head/capacity requirements.

BEARING FRAME
Sealed to prevent contamination.

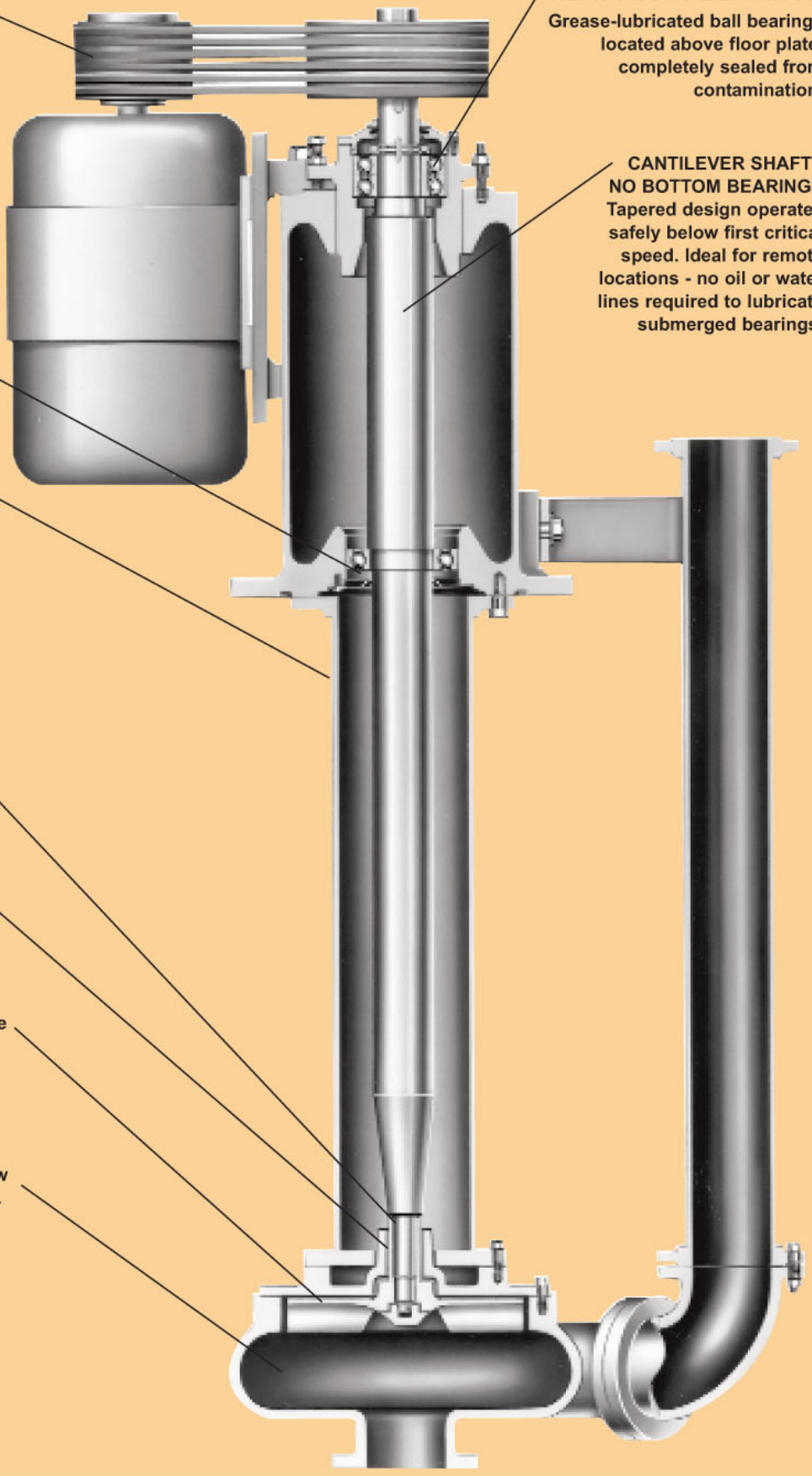
HIGH STRENGTH COLUMN PIPE
Rigidly maintains alignment between bearing frame and casing. Protects pump shaft.

RENEWABLE SHAFT SLEEVE
Full length hook-type sleeve protects shaft.

HUB DISC
Minimizes blow-back of pumpage around shaft sleeve without actual sealing contact.

FULLY RECESSED IMPELLER
Allows passage of solids equal in size to pump suction. Keyed on shaft.

RUGGED ONE-PIECE CASING
Circular design enhances vortex pumping action; dimensioned to allow large solids to pass without clogging.

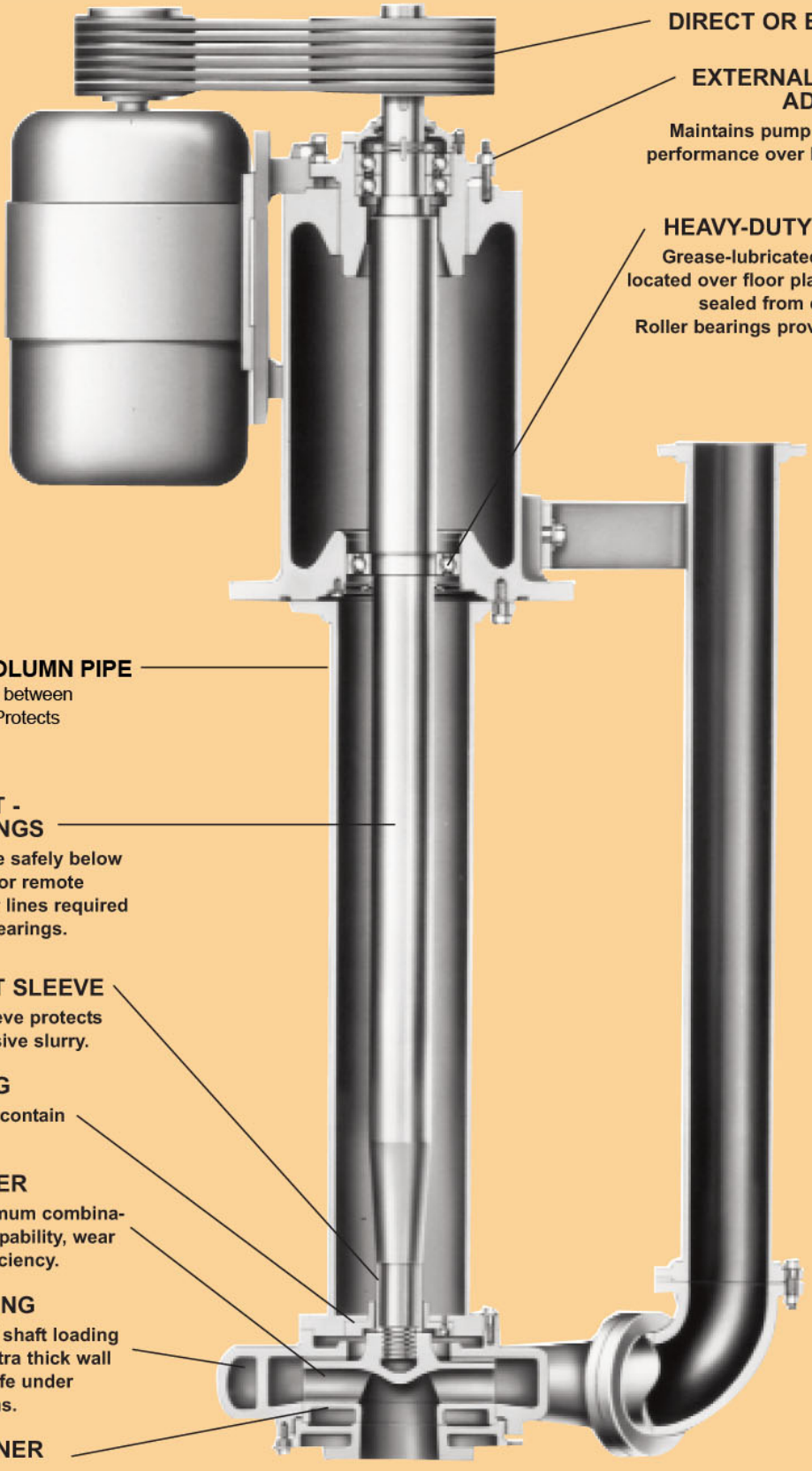


HEAVY-DUTY BEARINGS
Grease-lubricated ball bearings located above floor plate, completely sealed from contamination.

CANTILEVER SHAFT - NO BOTTOM BEARINGS
Tapered design operates safely below first critical speed. Ideal for remote locations - no oil or water lines required to lubricate submerged bearings.

Model VJC Cantilever Vertical Bottom Suction Pump

Heavy Duty Design Features for Wide Range of Severe Corrosive/Abrasive Slurry Services



DIRECT OR BELT DRIVE

EXTERNAL IMPELLER ADJUSTMENT
Maintains pump efficiency and performance over life of impeller.

HEAVY-DUTY BEARINGS
Grease-lubricated ball bearings located over floor plate, completely sealed from contamination. Roller bearings provided on larger frame sizes.

HIGH STRENGTH COLUMN PIPE
Rigidly maintains alignment between bearing frame and casing. Protects pump shaft, reduces wear.

CANTILEVER SHAFT - NO BOTTOM BEARINGS
Tapered design to operate safely below first critical speed. Ideal for remote locations - no oil or water lines required to lubricate submerged bearings.

RENEWABLE SHAFT SLEEVE
Full length hook-type sleeve protects shaft from traces of abrasive slurry.

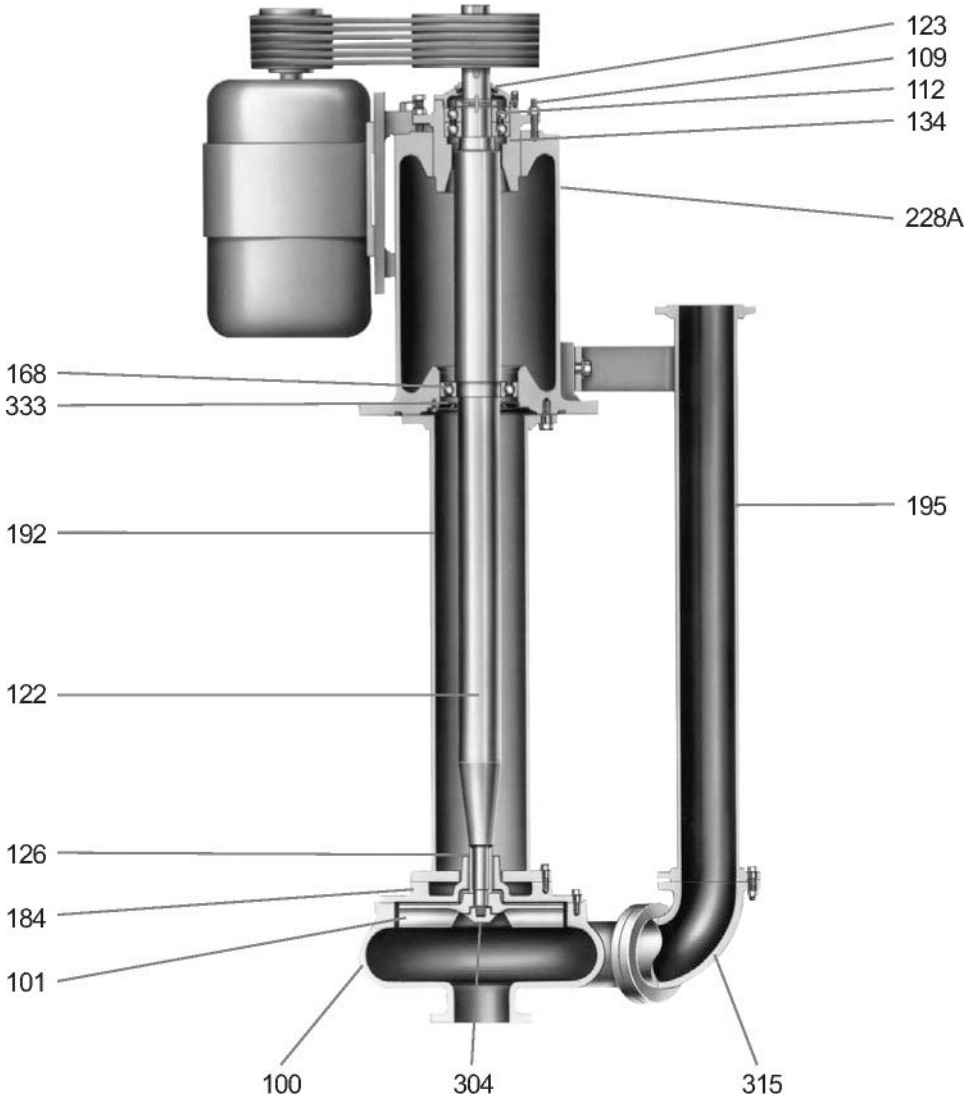
THROTTLE BUSHING
Minimizes leakage, helps contain pressure in casing.

SEMI-OPEN IMPELLER
Designed to provide optimum combination of solids handling capability, wear resistance, and pump efficiency.

DUAL VOLUTE CASING
Virtually eliminates radial shaft loading – extends bearing life. Extra thick wall sections provide longer life under severe abrasive conditions.

SUCTION COVER LINER
Renewable liner protects casing from abrasive wear.

Sectional View Model VHS



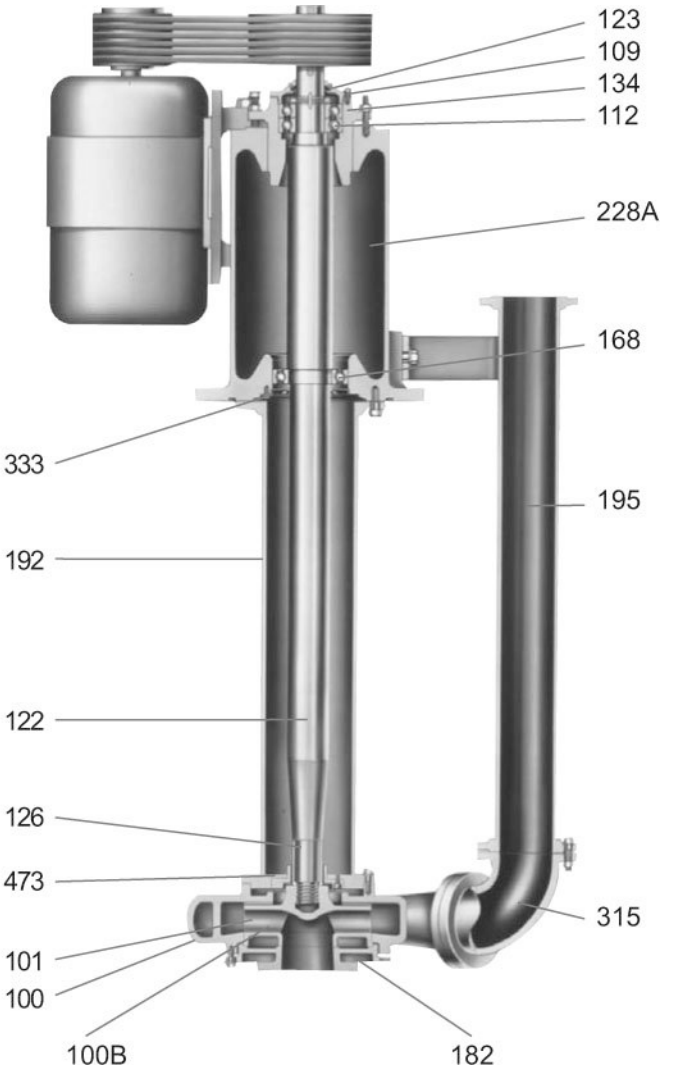
Parts List and Materials of Construction

Item No.	Part Name	Material		
		Standard		Optional *
		Cast Iron	HC600	316
100	Casing	Cast Iron	HC600	316
101	Impeller	Cast Iron	HC600	316
109	Bearing End Cover	Cast Iron		
112	Thrust Bearing	Steel		
122	Shaft	1141 Steel		316
123	Deflector	Rubber		
126	Shaft Sleeve	416		316
134	Thrust Bearing Housing	Cast Iron		
168	Radial Bearing	Steel		
184	Stuffing Box Cover	Cast Iron	HC600	316
192	Pipe Column	Steel		316
195	Discharge Pipe	Steel		316
228A	Bearing Housing	Cast Iron		
304	Impeller Nut	316	316	316
315	Discharge Elbow	Cast Iron		316
333	Labyrinth Seal	Carbon Filled Teflon ®		

* For other materials contact factory.

Sectional View Model VJC

OPTIONAL TAILPIPE
WITH STRAINER



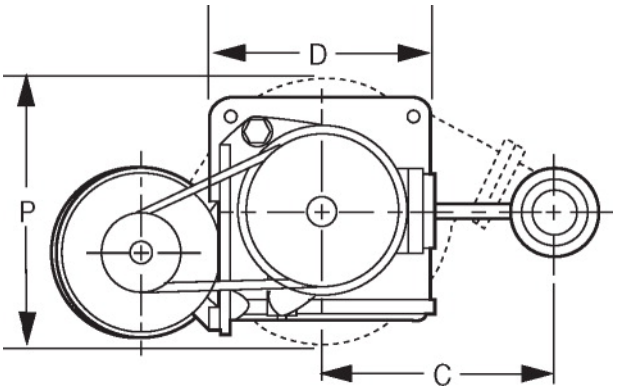
Parts List and Materials of Construction

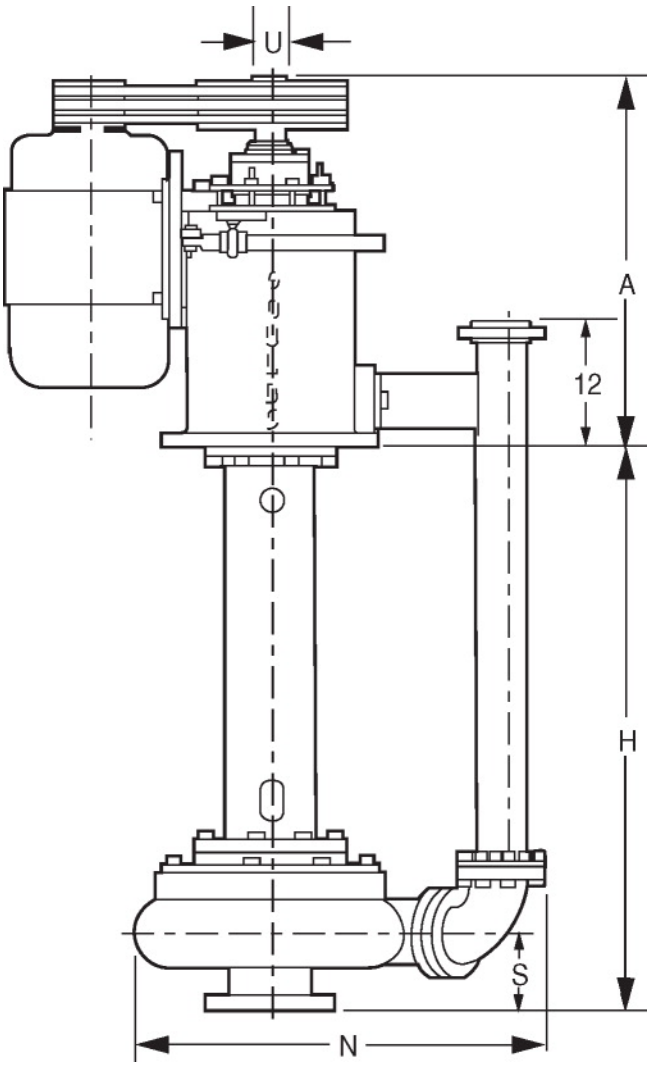
Item No.	Part Name	Material		
		Standard		Optional*
		Cast Iron	HC600	316
100	Casing	Cast Iron	HC600	316
100B	Suction Liner	Cast Iron	HC600	316
101	Impeller	Cast Iron	HC600	316
109	Bearing End Cover	Cast Iron		
112	Thrust Bearing	Steel		
122	Shaft	1141 Steel		316
123	Deflector	Rubber		
126	Shaft Sleeve	416		316
134	Thrust Bearing Housing	Cast Iron		
168	Radial Bearing	Steel		
182	Suction Cover	Steel	Steel	316
192	Pipe Column	Steel		316
195	Discharge Pipe	Steel		316
228A	Bearing Frame	Cast Iron		
315	Discharge Elbow	Steel	Steel	316
333	Labyrinth Seal	Carbon Filled Teflon ®		
473	Throttle Bushing	Cast Iron	HC600	316

*For other materials contact factory.

Dimensions Model VHS

All dimensions in inches and (mm). Not to be used for construction.





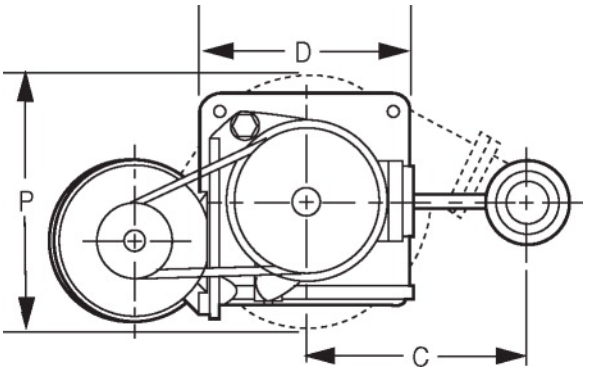
PUMP DIMENSIONS					
Pump Size	**C**	**H**	**N**	**P**	**S**
2×2-8	15 (381)	48" (1219) Standard. 42" (1067) thru 132" (3353) available in 6" (152) increments.	26 (660)	13 (330)	3 (76)
3×3-10	18.3 (465)		31 (787)	17 (432)	4.5 (114)
4×4-12	19.2 (485)		33 (838)	20 (508)	5.5 (140)
6×6-12	22.1 (561)		41 (1041)	24 (610)	7.5 (191)
6×6-18	25.9 (658)		45 (1143)	29 (734)	7.5 (191)
8×8-22	31.9 (810)		58 (1473)	35 (889)	9 (229)
10×10-26	37.8 (960)		68 (1727)	42 (1069)	10.5 (267)

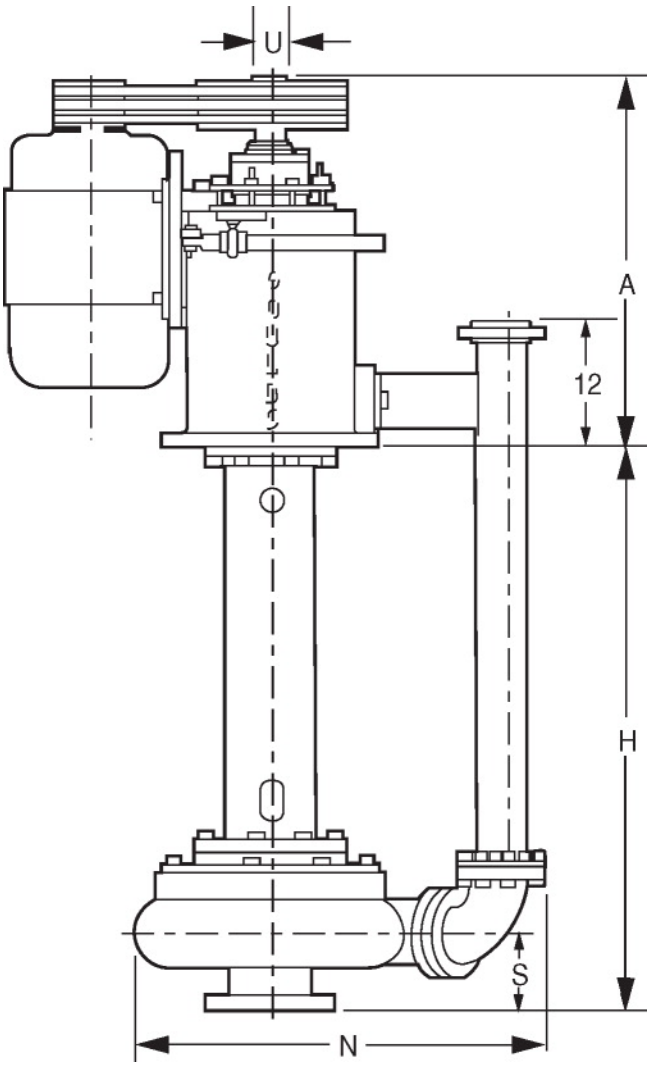
BEARING FRAME DIMENSIONS						
Frame	**C-1**	**C-2**	**C-3/C-5A**	**C-4/C-6A**	**C-5**	**C-6**
A	23 (584)	38.9 (988)	45.5 (1153)	50.8 (1290)	50.8 (1290)	53.4 (1356)
D	17 (432)	22 (559)	26 (660)	29 (737)	29 (737)	30 (762)
U	1.38 (35)	2.38 (60.4)	2.88 (73.1)	2.88 (73.1)	3.38 (85.8)	3.38 (85.8)

FLANGE DIMENSIONS				
Pump Size	**I.D.**	**O.D.**	**B.C.**	**Holes**
2x2-8	2	6	4.75	Four—5/8"
3x3-10	3	7.5	6	Four—5/8"
4x4-12	4	9	7.5	Eight—5/8"
6x6-12	6	11	9.5	Eight—3/4"
6x6-18	6	11	9.5	Eight—3/4"
8x8-22	8	13.5	11.75	Eight—3/4"
10x10-26	10	16	14.25	Twelve—7/8"

Dimensions Model VJC

All dimensions in inches and (mm). Not to be used for construction.





DIMENSIONS

Model	Pump Size	C	H	N	P	S
VJC	1½×2-11	13.25 (337)	48 (1219) Standard. 42 (1067) thru 132 (3353) avail. in 6" (152) increments.	24 (610)	16 (406)	3.5 (89)
	1½×2-14	14.63 (372)		27 (686)	19 (483)	3.5 (89)
	2×3-11	16 (406)		29 (737)	17 (432)	4 (102)
	2×3-14	17.5 (444)		31 (787)	19 (483)	4 (102)\
	3×4-11	17.8 (452)		31 (787)	19 (483)	4.8 (122)
	3×4-14	19 (483)		35 (889)	23 (584)	4.8 (122)
	4×6-14	19.4 (493)		35 (889)	23 (584)	5.3 (135)
	6×6-14	22.6 (574)		41 (1041)	26 (660)	5.6 (142)
	8×10-18	28.7 (730)		53 (1346)	37 (940)	9.6 (244)
	10×12-22	35.4 (899)		65 (1651)	41 (1041)	9.6 (244)

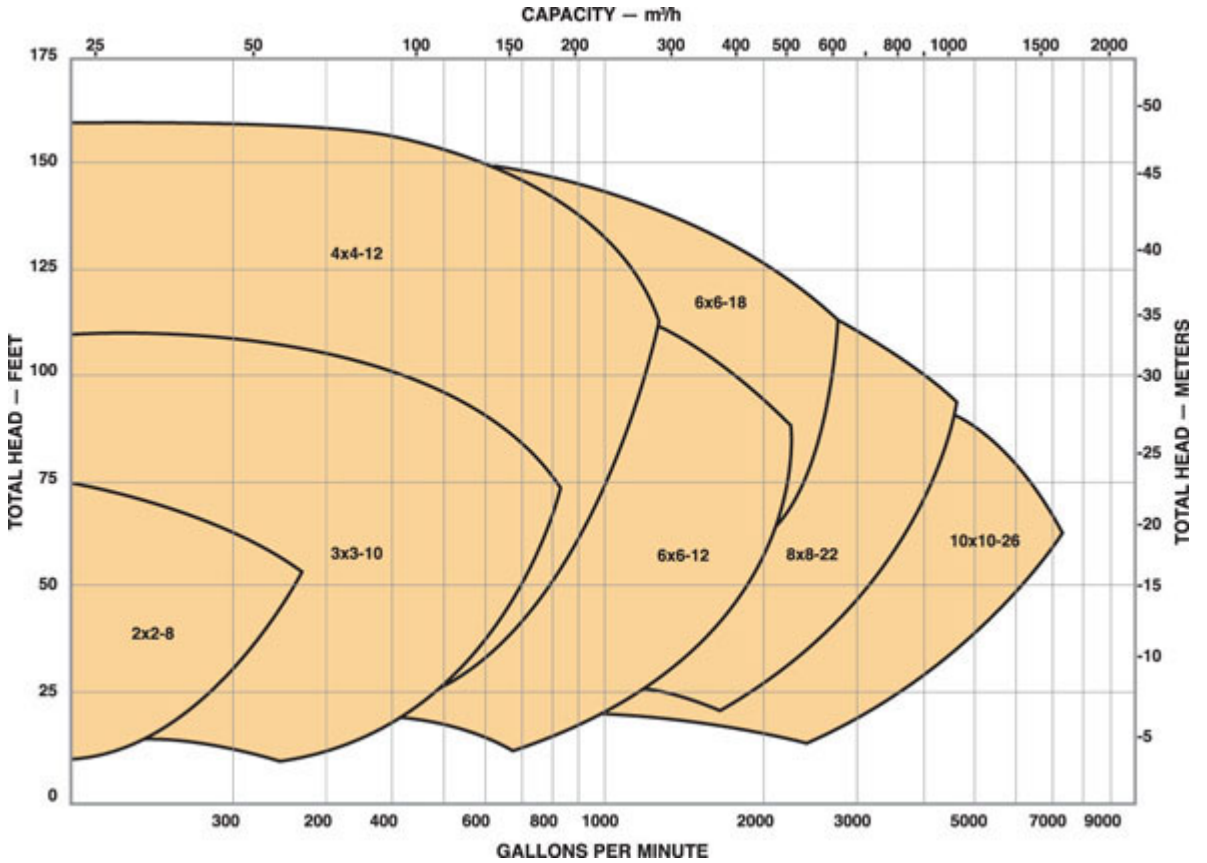
BEARING FRAME

Frame	A	D	U
C-2	38.9 (988)	22 (559)	2.38 (60.4)
C-3	45.5 (1156)	26 (660)	2.88 (73.1)
C-4	50.8 (1290)	29 (737)	2.88 (73.1)
C-5	50.8 (1290)	29 (737)	3.38 (85.8)
C-6	53.4 (1356)	30 (762)	3.38 (85.8)

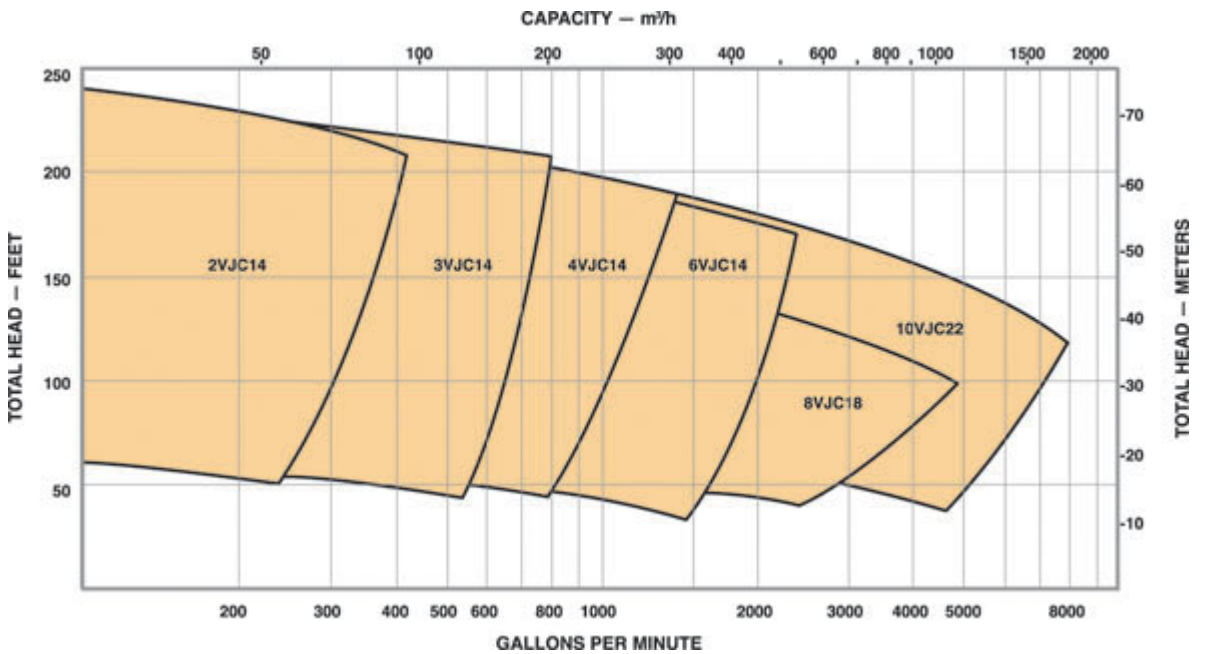
Construction Details

Model VJC	1½× 2-11	1½× 2-14	2× 3-11	2× 3-14	3× 4-11	3× 4-14	4× 6-14	6× 6-14	8× 10-18	10× 12-22
Minimum Casing Thickness–in. (mm)	3/8 (9.5)	3/8 (9.5)	9/16 (14.2)	9/16 (14.2)	5/8 (14.2)	5/8 (15.8)	5/8 (15.8)	5/8 (16)	3/4 (19)	3/4 (19)
Maximum Solid Size–in. (mm)	.75 (19)	.75 (19)	.87 (22)	.87 (22)	1.1 (28)	1.1 (28)	1.1 (28)	1.5 (38)	2 (50)	2.2 (57)
Maximum Working Pressure– PSIG (kPa)										
Cast Iron	110 (759)									
HC600 & 316 SS	127 (875)									
Maximum Liquid Temperature–°F (°C)	200 (93)									

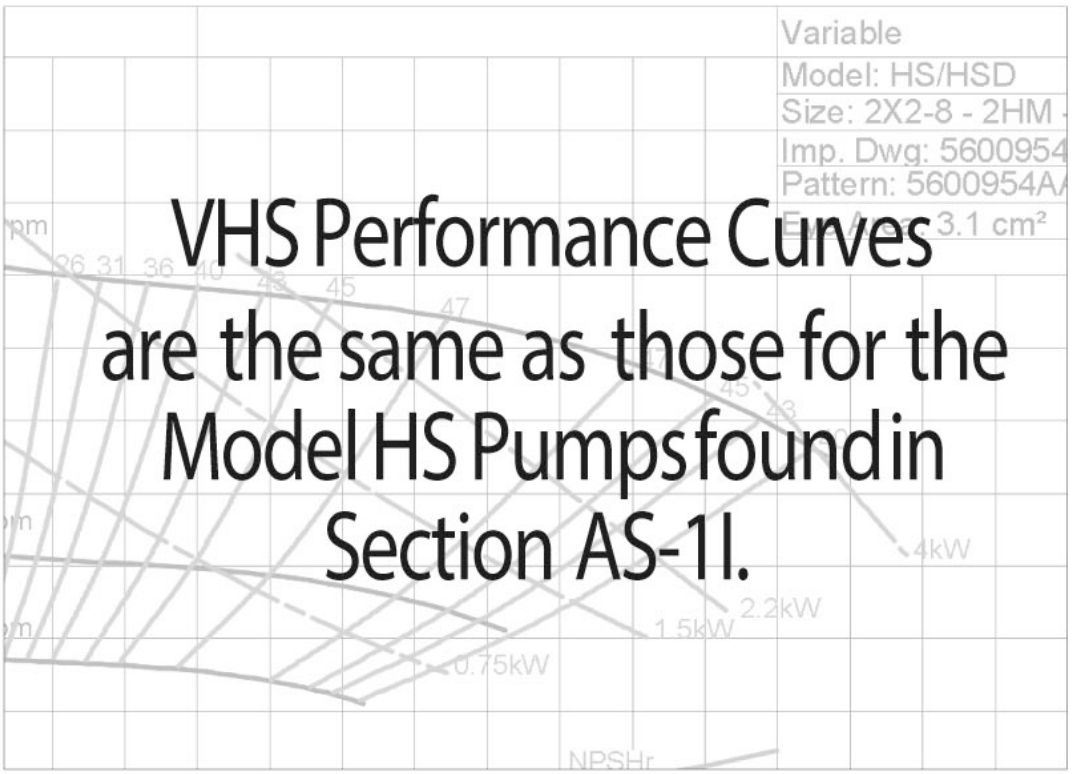
Hydraulic Coverage **Model VHS**



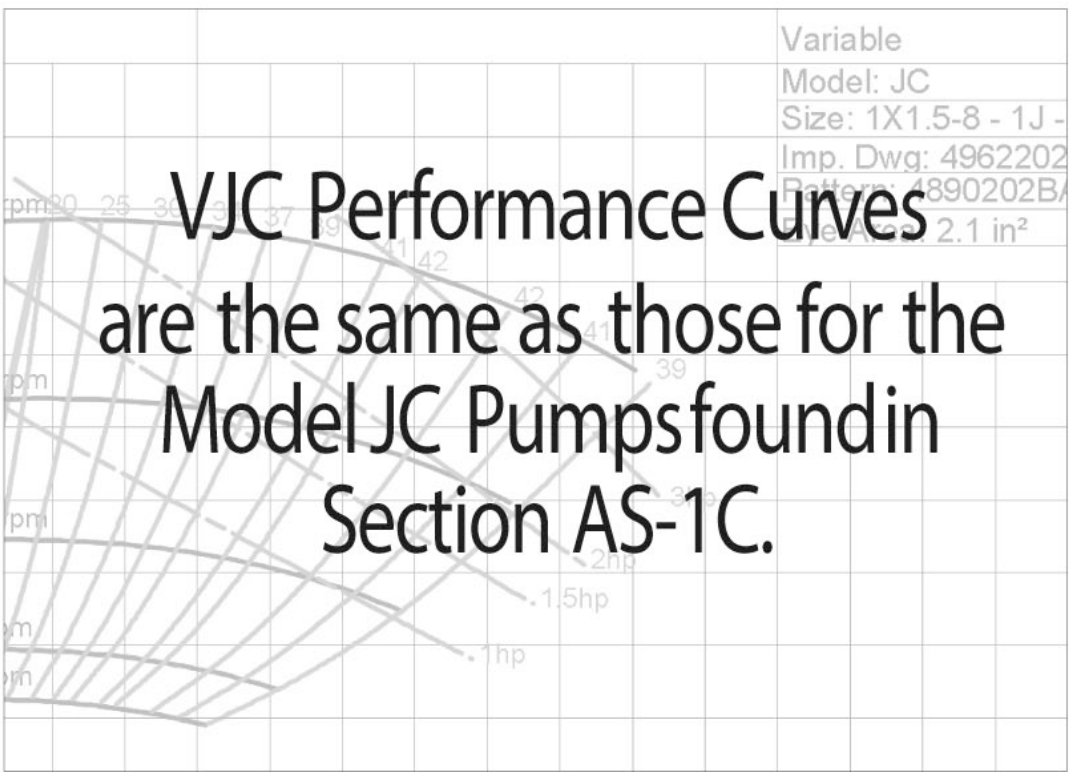
Hydraulic Coverage **Model VJC**



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.



VHS Performance Curves are the same as those for the Model HS Pumps found in Section AS-1I.



VJC Performance Curves are the same as those for the Model JC Pumps found in Section AS-1C.

NOTES

The Goulds Model VRS builds on almost a century of cantilever and rubber-lined pump design experience. The VRS is designed using the proven reliability of the SRL and Goulds cantilever pumps. By using the existing SRL wet end components along with a rugged power end and shaft design, the VRS offers higher efficiencies, with maximum reliability and interchangeability. Offered in standard lengths and a wide variety of elatometers, the VRS provides you with the right pump for your application along with years of dependable service even under the worst operating conditions.

Goulds Model VRS

Vertical Cantilever Pump Designed for Abrasive and Slurry Services

- Sizes 2, 3, 5, and 6 inch (50, 75, 125, and 150 mm)
- Flows to 1,500 GPM (341 m^3/h)
- Heads to 120 feet (37 m)
- Solids to 1/4 inch (6 mm)
- Pressures to 75 PSI (517 kPa)
- Available in 4 ft. (1.2 m) and 6 ft. (1.8 m) lengths

Design Features

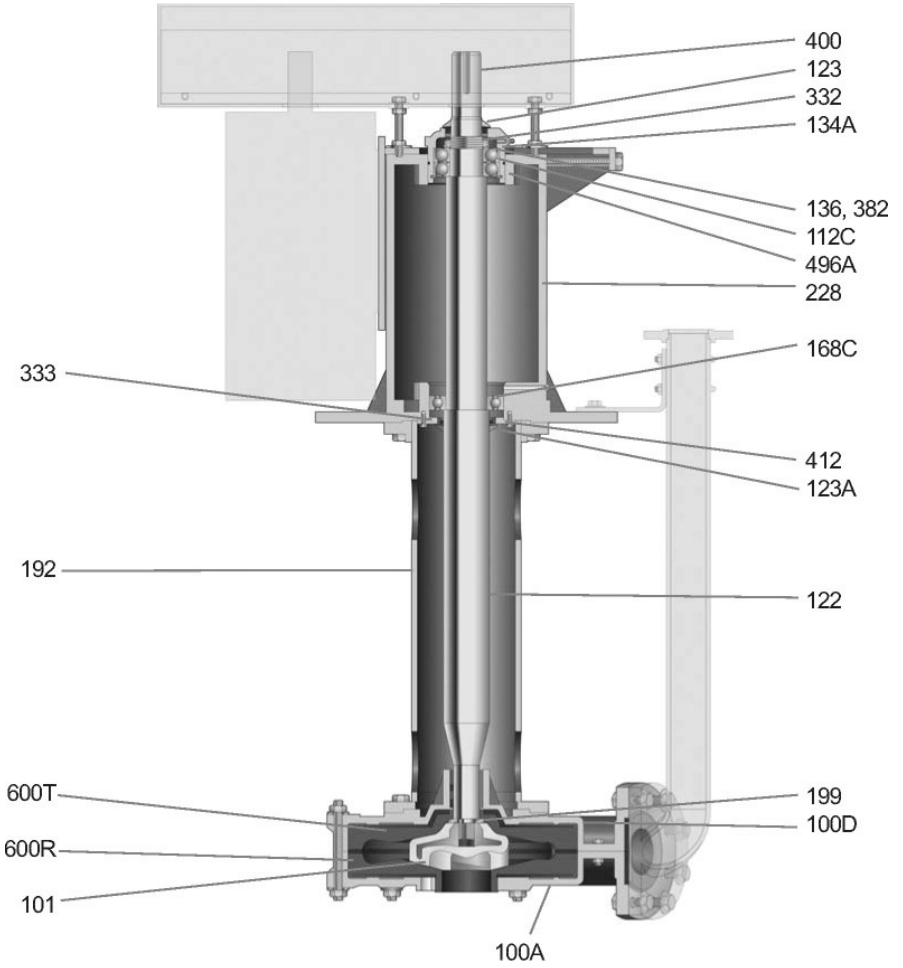
- **Maximum Interchangeability**
  - Wet ends are completely interchangeable with horizontal Model SRL to ease maintenance and reduce inventory.
- **Large Diameter Impellers**
  - Develop higher heads at lower RPMs for improved wear.
  - Open design ideal for sump service.
  - Available in a variety of elastomers to suit your application.
- **Field Replaceable Elastomer Liners**
- **Design for Lower Operating Costs**
- **Heavy-duty Bearing Frame for Reliable Performance**
- **Large Diameter Shaft for Low Deflection**

Services

- Mineral Processing
- Non-metallic Mining
  Sand and Gravel
- Power Utility
- Pulp and Paper
- General Industry

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Sectional View Model VRS



Standard Features

- Motor mount and V-belt guard provided as standard
- Integral mounting plate
- 4 ft. & 6 ft. (1.2 & 1.8 m) setting
- Field replaceable liners

Optional Features

- Discharge pipe
- Tailpipes for non-standard lengths
- Strainer
- High Motor Mount Arrangement
- Metal impellers
- Range of elastomers

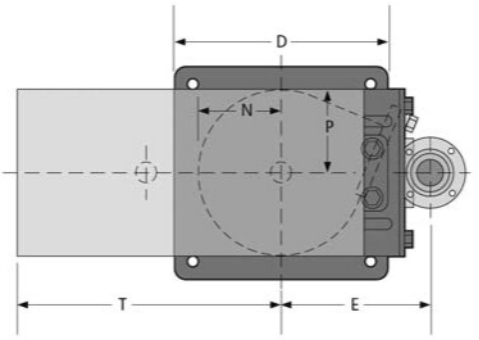
Parts List and Materials of Construction	
Item No.	**Part Name**
100A	Suction Half Casing
100D	Gland Half Casing
101	Impeller (Elastomer)
112C	Thrust Bearing
122	Shaft
123	Outboard Deflector
123A	Inboard Deflector
134A	Thrust Housing
136	Bearing Locknut
168C	Radial Bearing
192	Column Pipe
199	Shaft Washer
228	Frame
332	Outboard Seal
333	Inboard Seal
382	Bearing Lockwasher
400	Shaft Key
412	O-Ring
469A	O-Ring
600R	Suction Liner (Elastomer)
600T	Gland Liner (Elastomer)

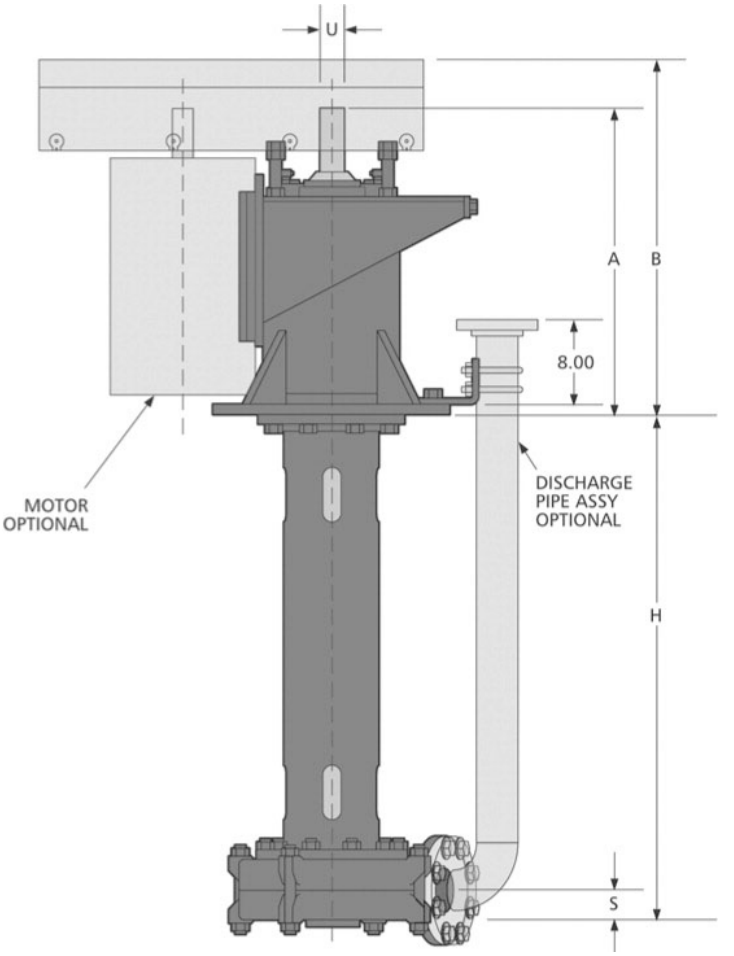
*For other materials contact factory.

Available Elastomer for VRS Pumps	
Elastomer Type	**Durometer Shore A Hardness**
Natural Rubber	40
Natural Rubber	50
Neoprene	60
Nitrile	60
Hypalon	55
Urethane	81

Dimensions Model VRS

All dimensions in inches and (mm). Not to be used for construction.

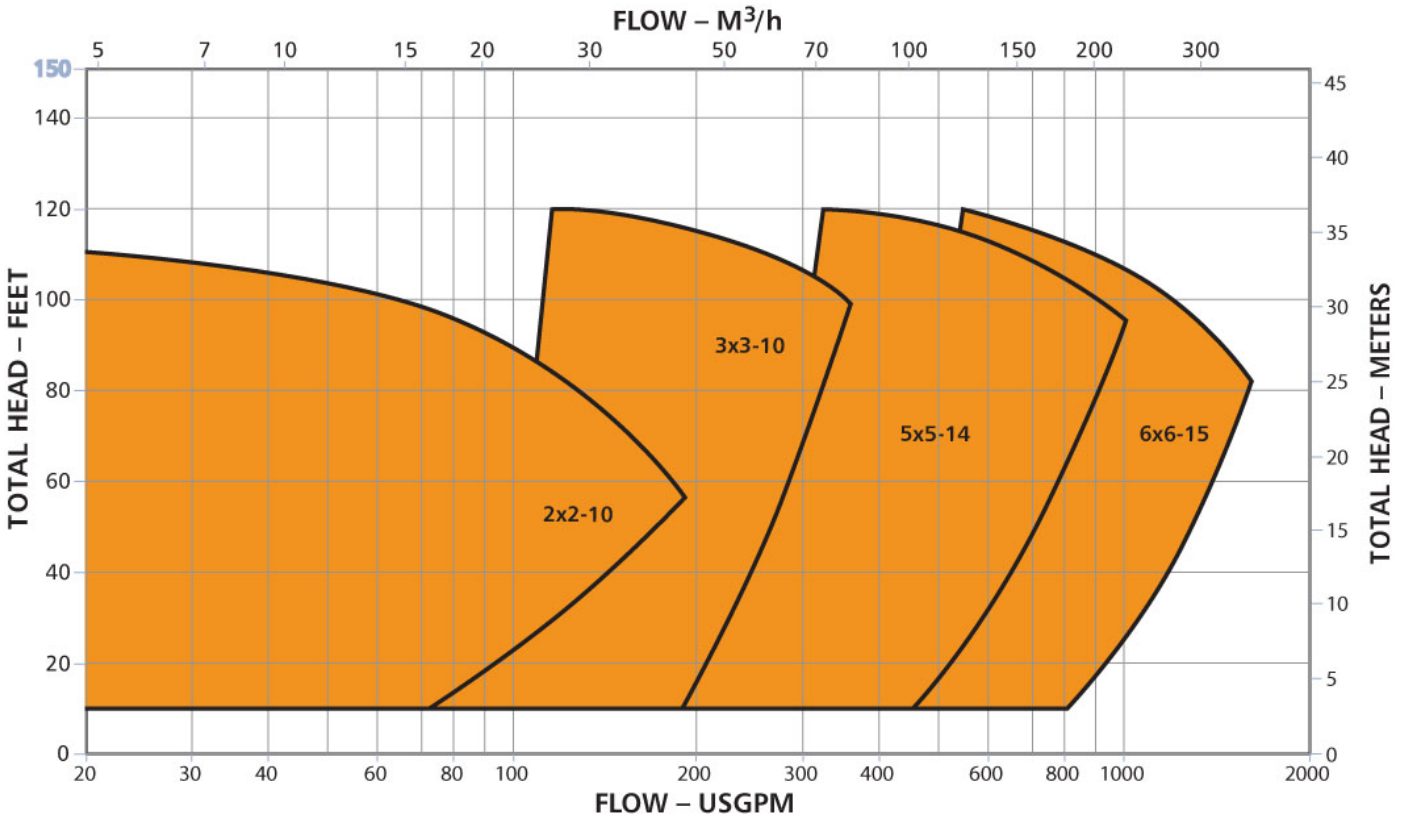




PUMP DIMENSIONS														
Pump Model	Suct. x Disch x Impeller	Setting	Frame	A	B	D	E	H	N	P	S	T	U	Weight* lbs. (kg)
2VRS4V2	2x2-10	4 ft.	V2	21.81	26.63	19.00	13.20	48.00	8.36	8.58	2.31	23.82	1.625	575 (259)
2VRS6V3	2x2-10	6 ft.	V3	28.74	33.50	22.00	15.02	72.00	8.21	8.40	2.31	27.57	2.250	925 (420)
3VRS4V3	3x3-10	4 ft.	V3	28.74	33.50	22.00	15.56	48.00	9.64	9.85	3.06	27.57	2.250	825 (374)
3VRS6V4	3x3-10	6 ft.	V4	36.68	41.50	30.00	17.88	72.00	9.81	9.98	3.06	33.76	2.875	1525 (692)
5VRS4V4	5x5-14	4 ft.	V4	36.68	41.50	30.00	21.80	46.90	13.87	13.42	3.88	33.76	2.875	1600 (726)
5VRS6V5	5x5-14	6 ft.	V5	46.82	51.67	32.00	21.80	70.90	13.87	13.42	3.88	37.76	3.875	2750 (1247)
6VRS4V4	6x6-15	4 ft.	V4	36.68	41.50	30.00	25.09	49.10	15.36	14.97	5.13	33.76	2.875	1950 (884)
6VRS6V5	6x6-15	6 ft.	V5	46.82	51.67	32.00	25.09	73.10	15.36	14.97	5.13	37.76	3.875	3125 (1417)

* Weight = weight of bare pump.

Hydraulic Coverage **Model VRS**



Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

The following curves are for reference only. Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current revision.

NOTES

Model HSU

Submersible Hydro-Solids Pumps

Model JCU

Submersible Abrasive Slurry Pumps

Model HSUL

Submersible Recessed Impeller Pumps

Models HSU, HSUL, JCU

Submersible Pumps for Pumping Large, Fibrous/Stringy and Abrasive Solids

- Capacities to 4000 GPM (910 m^3/h)
- Heads to 220 feet (67 m)
- Temperatures to 194°F (90°C)
- Solids to 6 inches (152 mm)

Reliable Submersible Performance for Solids Handling Services

- Three different pump models allow selection of pump best suited for the service conditions.
- Wide range of materials.
- Submersible motors designed and built specially for tough services. 5-year pro-rated warranty.
- Slide rail system and other options available for application flexibility.

Services

- Waste Treatment Plants
- Sewage Wet Wells
- Reclaim Sumps
- Industrial Waste Sumps
- Sludge Pits
- Drainage Sumps
- Power Plants
- Collection Basins
- General Service Sumps

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Pump Selection Guide

The Best Pump For Your Service Conditions

Model HSU

Hydro-solids pumps. Recessed impeller easily accommodates large, stringy and fibrous solids without clogging. Because it is completely submersible, the HSU can be used in virtually any sump application.

- Capacities to 1300 GPM (295 m^3/h)
- Heads to 90 Feet (27 m)
- Temperatures to 194° F (90° C)
- Pressures to 100 PSIG (690 kPa)
- Solids to 6 inches (152 mm)

SOLIDS TYPE

Will handle large, stringy, fibrous and abrasive solids.

MATERIALS

Cast Iron

28% Chrome Iron (HC600)

CD4MCu

316 Stainless Steel

Other Materials Available

Model HSUL

Submersible recessed impeller pumps easily handle any solid up to its suction/discharge size. Versatile mounting allows pump to stand or to be mounted on an optional slide rail arrangement.

- Capacities to 2800 GPM (636 m^3/h)
- Heads to 140 Feet (43 m)
- Temperatures to 194° F (90° C)
- Pressures to 100 PSIG (690 kPa)
- Solids to 6 inches (152 mm

SOLIDS TYPE

Will handle large, stringy, fibrous, and abrasive solids.

MATERIALS

Cast Iron

28% Chrome Iron (HC600)

CD4MCu

316 Stainless Steel

Other Materials Available

Model JCU

Submersible pumps for handling tough abrasive slurries. Impeller design offers optimum combination of solids handling ability, wear resistance, and efficiency. Optional slide rail assembly available for ease of maintenance.

- Capacities to 4000 GPM (910 m^3/h)
- Heads to 220 Feet (67 m)
- Temperatures to 194° F (90° C)
- Pressures to 200 PSIG (1380 kPa)
- Solids to 2 inches (50 mm)

SOLIDS TYPE

Will handle all types of abrasive solids.

MATERIALS

Cast Iron

28% Chrome Iron (HC600)

CD4MCu

316 Stainless Steel

Other Materials Available

Model HSU

Submersible Hydro-Solids Pumps

Designed to Handle Large, Fibrous/Stringy and Abrasive Solids

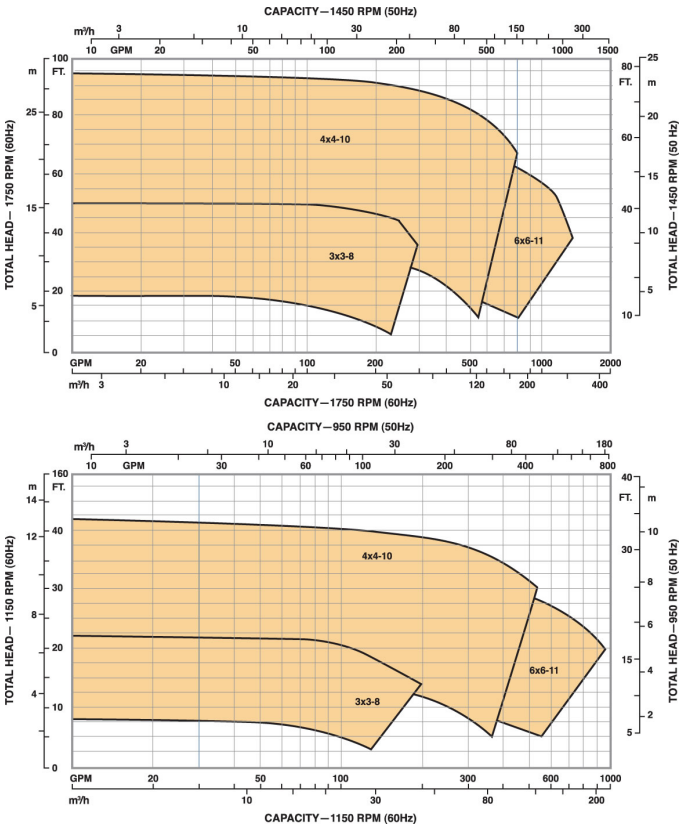
- Capacities to 1300 GPM (295 m^3/h)
- Heads to 90 Feet (27 m)
- Temperatures to 194° F (90° C)
- Pressures to 100 PSIG (690 kPa)
- Solids to 6 inches (152 mm)

Services

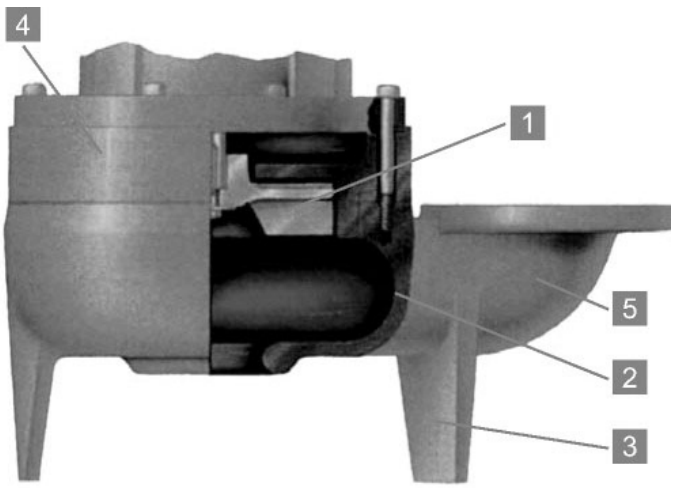
Waste Treatment Plants	Reclaim Sumps	Sludge Pits
General Service Sumps	Power Plants	Drainage Sumps
Sewage Wet Wells	Industrial Waste Sumps	Collection Basins
		Wood Yard Sumps

Hydraulic Coverage

50/60 Hz



Design Features



1 **Fully Recessed Impeller** Allows large stringy or fibrous material to pass through the pumps without binding or clogging.

2 **Concentric Casing** Concentric design facilitates flow of pumpage and solids through the pump while minimizing loads.

3 **Integral Support** Three cast-in legs provide simple, stable support without additional parts.

4 **Heavy Duty Motor Adapter** Extra thick in critical areas. Extended shroud encircles impeller and protects casing from wear.

5 **Integral Discharge Elbow** Cast-in elbow reduces parts and allows easy installation.

What Goes In—Goes Out!

Unlike self-priming trash pumps or some other submersibles or vertical pumps, the HSU will pump any solid that enters its suction without clogging. This includes such hard to pump items as rags and string. Avoid costly downtime unplugging your pump with Goulds HSU.

Model HSUL

Submersible Hydro-Solids Pumps

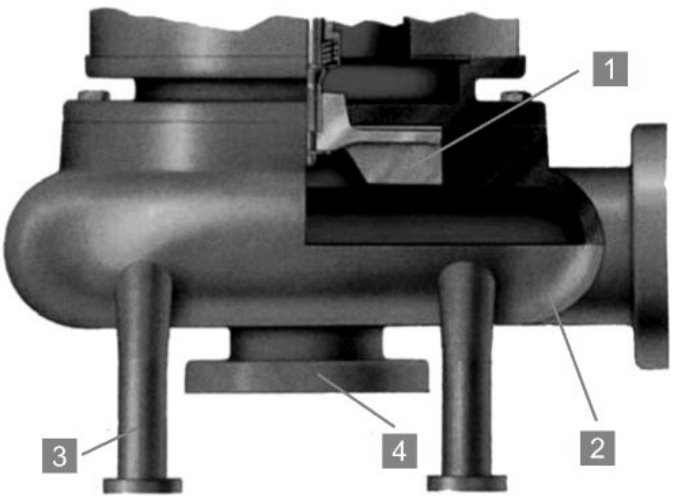
Designed toHandle Large/Stringy and Abrasive Solids

- Capacities to 2800 GPM (636 m ^{3} /h)
- Heads to 140 Feet (43 m)
- Temperatures to 194° F (90° C)
- Pressures to 100 PSIG (690 kPa)
- Solids to 6 inches (152 mm)

Services

Waste Treatment Plants	Reclaim Sumps	Sludge Pits
General Service Sumps	Power Plants	Drainage Sumps
Sewage Wet Wells	Industrial Waste Sumps	Collection Basins
		Wood Yard Sumps

Design Features



1 **Fully Recessed Impeller** Allows large stringy or fibrous material to pass through the pump without binding or clogging.

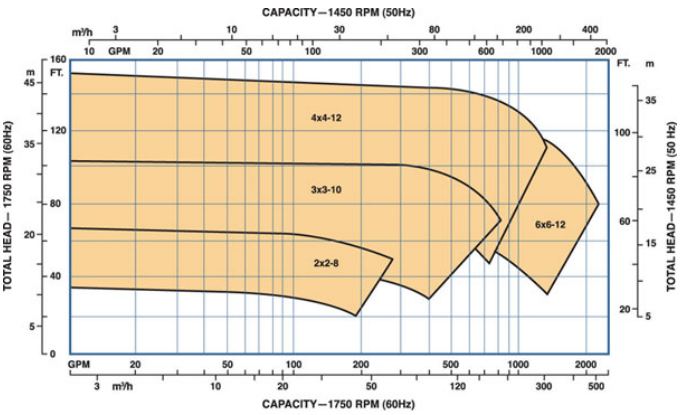
2 **Concentric Casing** Concentric design facilitates flow of pumpage and solids through the pump while minimizing `radial loads.

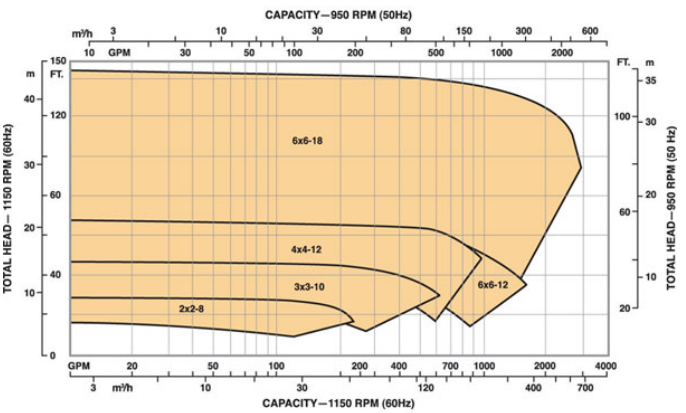
3 **Leg** Bolt-on legs provide stability on sump floor.

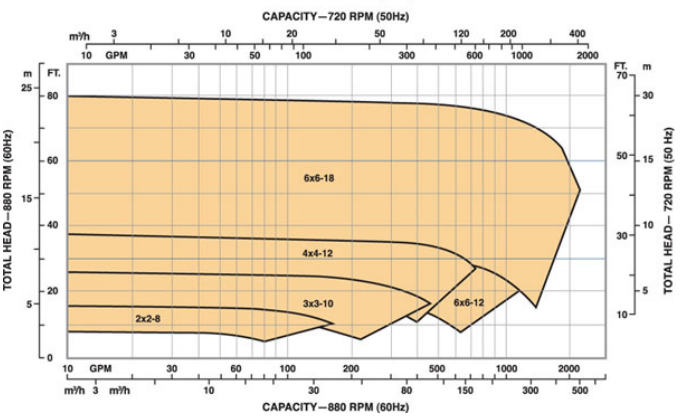
4 **Mounting Flexibility** Flanged suction and horizontal discharge allow pump to stand or be mounted on optional slide rail.

5 **Integral Discharge Elbow** Cast-in elbow reduces parts and allows easy installation.

Hydraulic Coverage 50/60 Hz







Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

Model JCU

Heavy Duty Submersible Slurry Pumps

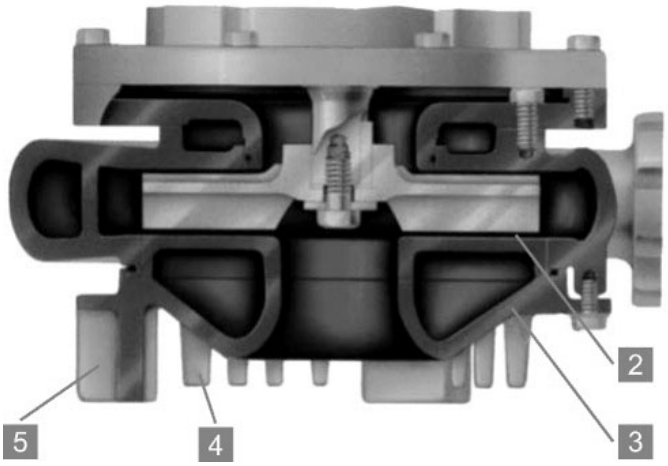
Designed For Abrasive Sump Applications

- Capacities to 4000 GPM (910 m ^{3} /h)
- Heads to 220 Feet (67 m)
- Temperatures to 194° F (90° C)
- Pressures to 200 PSIG (1380 kPa)
- Solids to 2 inches (50 mm)

Services

Fly Ash	Chemical Waste	Bauxite	Mill Scale
Sand and Gravel	Sumps	Lime Sumps	Sludge Pits
	Dirty Water Sumps	Kaolin Clay	
	Foundry Sand		

Design Features



1 **Heavy Duty Design** Extra thick wall sections in high wear areas.

2 **Replaceable Suction Liner** Easy to replace—protects casing from wear.

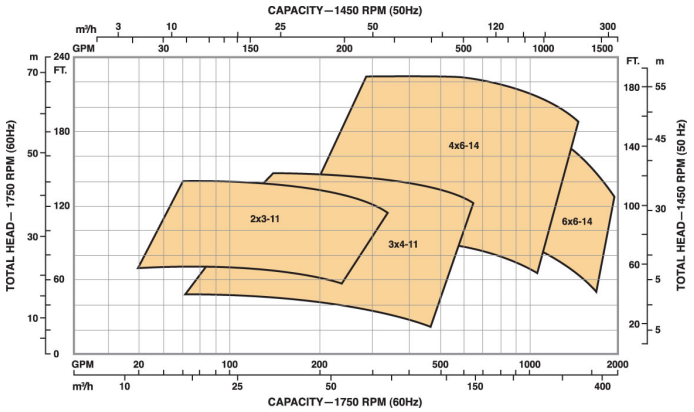
3 **Suction Cover** Bell shaped intake reduces entrance losses and improves suction characteristics.

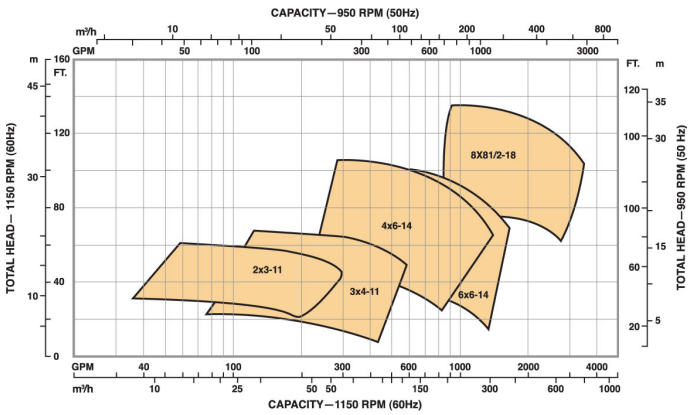
4 **Integral Strainer** Suction cover has cast-on vertical tines to prohibit oversized solids from clogging pump.

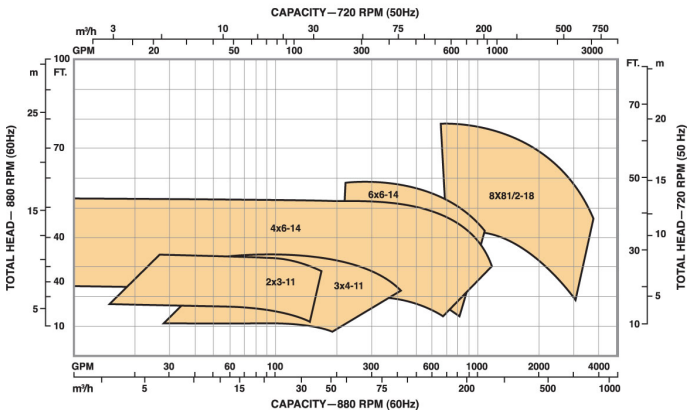
5 **Pump Mounting** Three cast-on legs give excellent support and stability. Optional slide rail also available to permit easy removal from sump.

6 **Maximum Interchangeability** Suction Cover Liner and Casing are interchangeable with Goulds Models JC (horizontal) and VJC (vertical cantilever) pumps.

Hydraulic Coverage 50/60 Hz



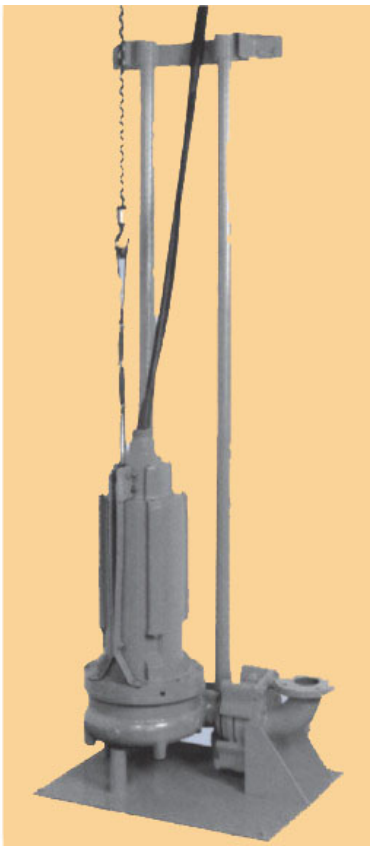




Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

Options

For Application Flexibility



Slide Rail System

Available on Models HSUL and JCU, Goulds slide rail system provides easy removal of pump unit without disturbing discharge piping. Unique *slurry* design utilizes a locking cam action with locator lugs and a large O-ring for positive sealing (no leakage) while allowing a tangential discharge for high efficiency. This is an important feature when pumping slurries; if a tight seal is not achieved, leakage can cause rapid and excessive wear of the mating flanges resulting in reduction of performance as well as increased maintenance costs. Goulds slide rail system meets all requirements for toughest slurry services.

Moisture Detector

Required on all submersibles for warranty validation. Provides one *normally open* and one *normally closed* connection for activating a warning and/or de-energizing the motor.

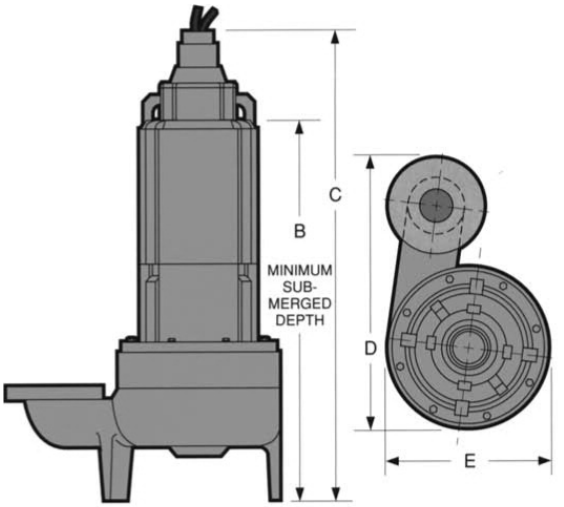
Submersible Motors

Goulds submersible series motors are designed and built specifically for tough slurry pumping. Heavy-duty design features for reliability include:

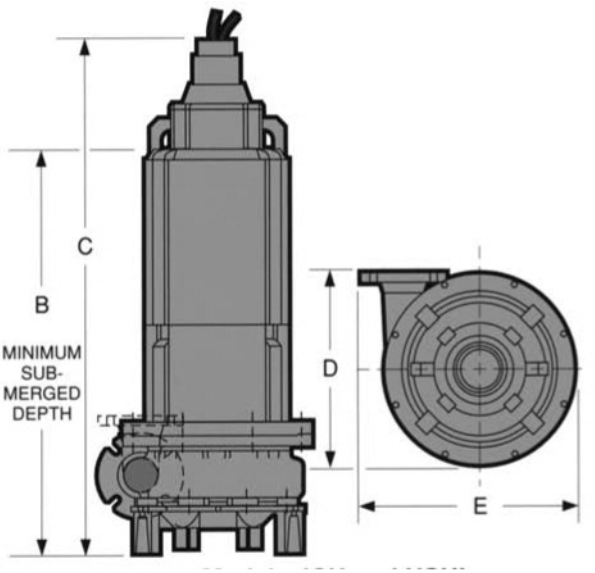
- UL and CSA Approved Explosion Proof
- Epoxy encapsulated and butt-spliced cable entry system prevents liquid from entering top of motor and provides non-wicking design.
- Permanently lubricated and sealed ball bearings.
- F Class insulation and 1.15 service factor standard.
- Tandem mechanical seals provide complete protection for motor internals.
- Thermal protection standard.
- Dual moisture probes provide early warning of seal failure.
- Conforms to NEMA, IEEE, ANSI and NEC standards.
- High temperature option allows operation to 194° F (90° C).
- **5-year Pro-Rated Warranty**

Dimensions

All dimensions in inches and (mm). Not to be used for construction.



Model HSU



Models JCU and HSUL

DIMENSIONS						
Model	**Pump Size**	**B***	**C***	**D**	**E**	**Weight Lbs. (kg)**
HSU	3×3-8	32.3 (821)	39.8 (1010)	22.6 (575)	15.4(391)	470 (213)
	4×4-10	38.3	48.6 (1235)	28.6 (727)	18.3 (464)	1060 (481)
	6×6-11	45.6 (1159)	53.0 (1346)	32.0 (813)	20.3 (514)	1170 (531)
HSUL	2×2-8	32.0 (813)	40.0 (1016)	14.0 (356)	14.0 (356)	500 (227)
	3×3-10	42.0 (1067)	54.0 (1372)	19.0 (483)	19.0 (483)	1450 (658)
	4×4-12	44.0 (1118)	57.0 (1448)	21.0 (533)	21.0 (533)	1410 (640)
	6×6-12	57.0 (1448)	68.0 (1727)	24.0 (610)	23.0 (584)	1950 (885)
	6×6-18	57.0 (1448)	68.0 (1727)	30.0 (762)	29.0 (737)	2025 (918)
JCU	1×1.5-11	31.1 (790)	39.4 (1000)	19.5 (495)	15.4 (391)	500 (227)
	2×3-11	31.1 (790)	39.4 (1000)	23.1 (587)	17.2 (437)	500 (227)
	2×3-14	36.0 (914)	46.4 (1178)	25.8 (655)	20.3 (514)	900 (408)
	3×4-11	36.0 (914)	46.4 (1178)	26.5 (673)	19.3 (490)	990 (449)
	4×6-14	47.1 (1197)	58.0 (1473)	32.9 (836)	24.2 (614)	1880 (853)
	6×6-14	47.3 (1202)	58.2 (1478)	39.3 (998)	27.3 (692)	2030 (921)
	8×10-18	51.3 (1301)	62.9 (1597)	50.1 (1273)	34.8 (885)	2460 (1116)
	10×12-22	53.6 (1362)	64.5 (1638)	59.0 (1499)	43.1 (1095)	3280 (1488)

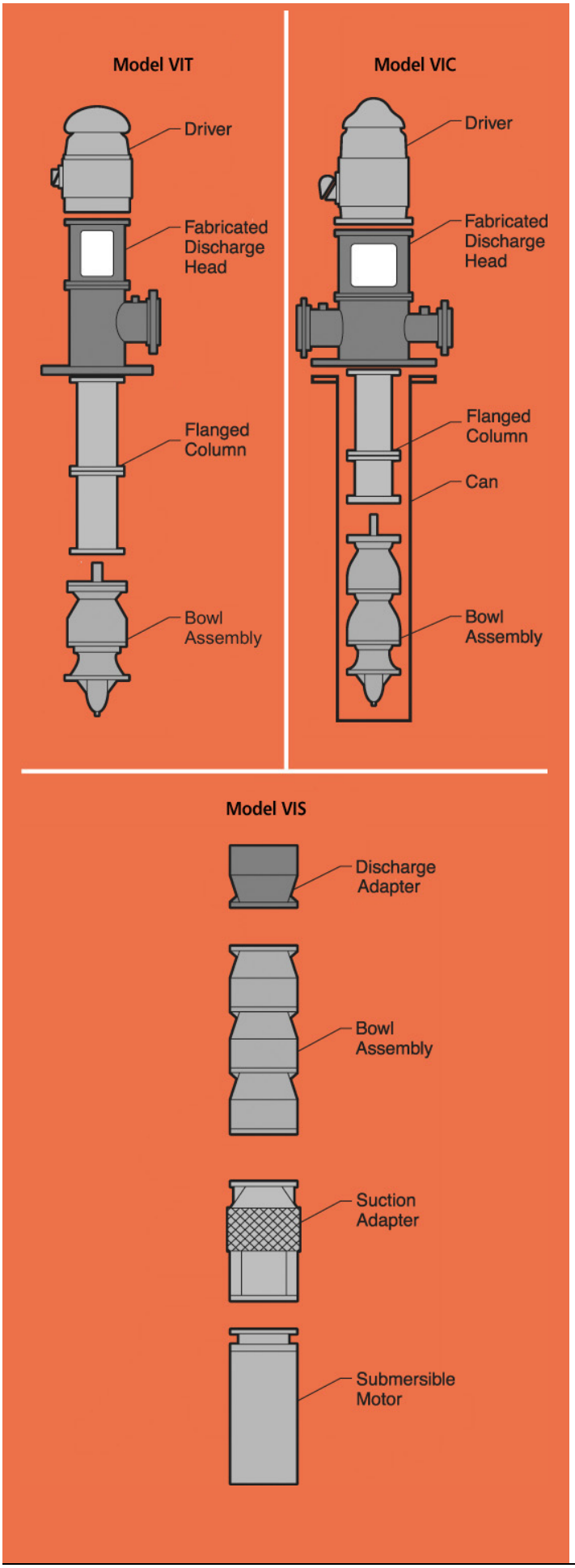
* Dimensions based on largest motor available for the given pump size.
All dimensions in inches and (mm). Not to be used for construction.

Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

NOTES

7

Vertical Turbine, Dry Pit and High Capacity



Goulds Vertical Turbine Pumps

Flexibility by Design: Three Pump Models, One Common Bowl Assembly

The three different pump models in the vertical turbine line have one thing in common – the hydraulic design of the pump bowl assembly. Using state-of-the-art techniques in turbine pump design, Goulds vertical turbine line covers a wide range of hydraulic conditions to meet virtually every pumping service in the industry with optimum efficiency.

Goulds flexibility of design allows the use of a wide range of materials and design features to meet the custom requirements of the user. No matter what the requirements, Goulds can design and manufacture the pump to best satisfy them, specifically and thoroughly.

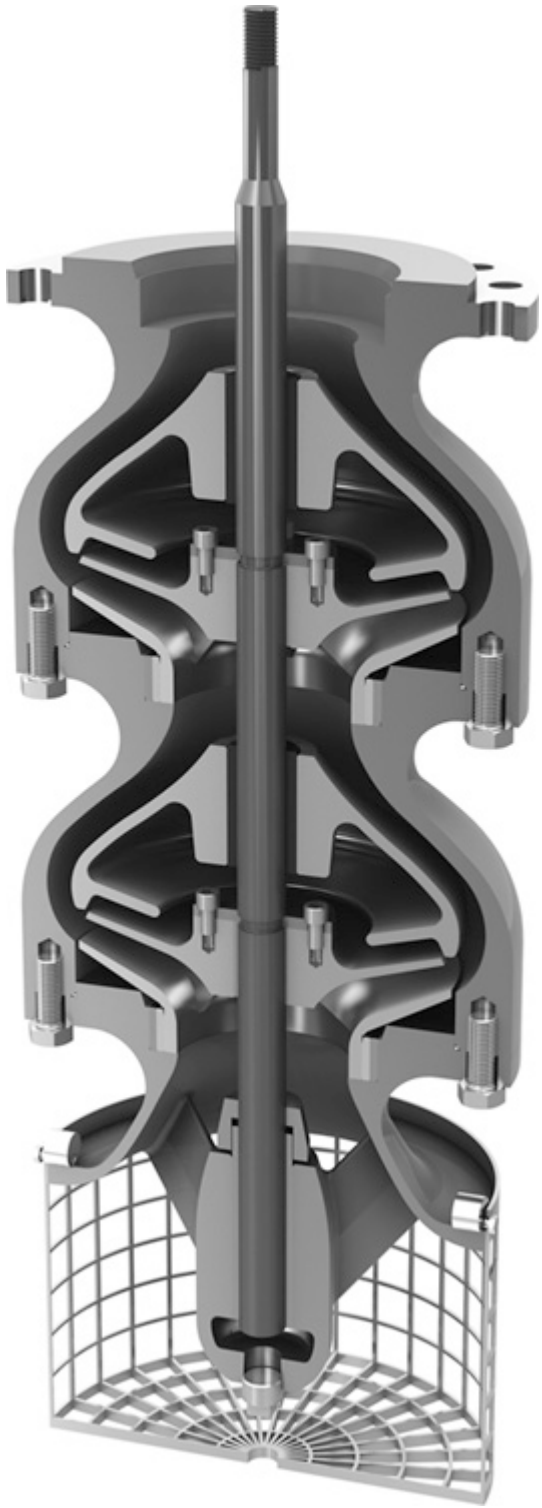
The GPM is designed to assist the user in selecting the best pump for the conditions required, however, any questions will be answered promptly by calling the Goulds sales office or representative in your area.

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Pump Bowl Assembly

The bowl assembly is the heart of the vertical turbine pump. The impeller and diffuser type casing are designed to deliver the head and capacity that your system requires in the most efficient way possible. The fact that the vertical turbine pump can be multi-staged allows maximum flexibility both in the initial pump selection and in the event that future system modifications require a change in the pump rating.

A variety of material options allows the selection of a pump best suited for even the most severe services. The many bowl assembly options available ensure that the vertical turbine pump satisfies the users' needs for safe, efficient, reliable and maintenance-free operation.



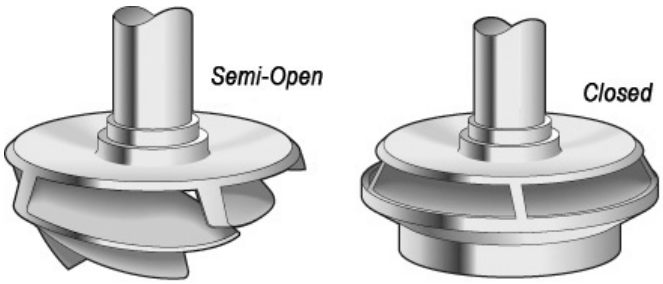
Standard Design Features

- **SUCTION BELL** - Allows smooth entry of liquid into first stage impeller eye, minimizes foundation opening.
- **SUCTION BELL BEARING** - Provided for shaft stability.
- **SAND COLLAR** - Prevents solids from entering suction bearing.
- **IMPELLER** - Semi-open or enclosed for appropriate service.
- **PUMP SHAFT** - Heavy duty 416SS standard, other alloys available for strength and corrosion resistance.
- **FLANGED BOWLS** - Registered fits assure positive alignment, ease of maintenance.
- **DIFFUSER BOWL** - Available in variety of cast materials.
- **SLEEVE TYPE BEARING** - Provided at each stage to assure stable operation.
- **KEYED IMPELLERS** - Standard for API applications, 18" and larger sizes; furnished on all pumps for temperatures above 180° F (82° C) and on cryogenic services. Regardless of size, keyed impellers provide ease of maintenance and positive locking under fluctuating load and temperature conditions.

Pump Bowl Assembly Options

CHOICE OF SEMI-OPEN OR ENCLOSED IMPELLERS

Available in alloy construction for a wide range of corrosive/abrasive services.

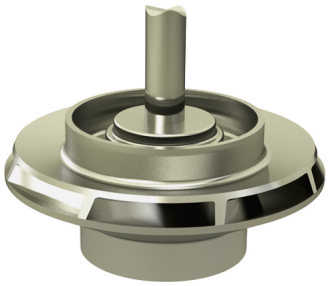


STRAINERS/VORTEX SUPPRESSOR

Basket strainers are available to provide protection from large solids.

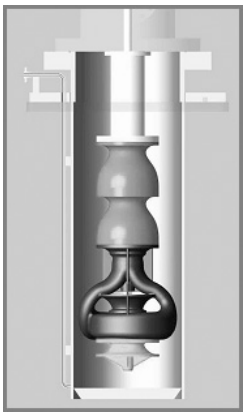
HYDRAULIC BALANCED IMPLELLER

Optional dynamic balance to ISO Grade 1.0 (4 w/n)



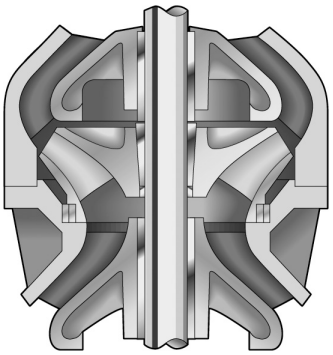
FIRST STAGE-LOW NPSH X IMPELLER OR DOUBLE SUCTION

For low NPSHA applications, either large eye or double suction first stage available to minimize pump length.



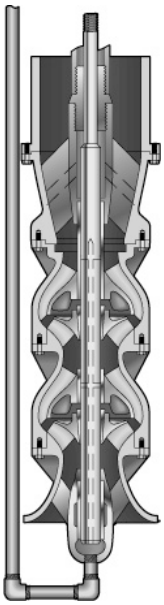
DUAL WEAR RINGS

Available for enclosed impellers and bowls; permits re-establishing initial running clearances and efficiency at lower cost. Hard facing of wear rings can be flushed when solids are present in pumpage.



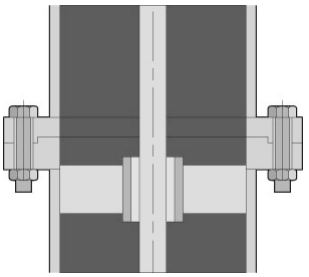
HARDFACING & RIFLE DRILLED SHAFT

Hardfacing the surface of bearing and/or shaft to protect against wear from abrasives in the bearing area. Rifle drilling of bowl shafts available for bearing protection on abrasive services. Discharge bowl included with enclosed lineshaft construction.



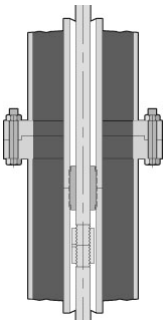
Flanged Column

Column sections are provided with flanged ends incorporating registered fits for ease of alignment during assembly to ensure concentricity. Our standard bearing retainers are welded into the column section.



OPEN LINESHAFT BEARING

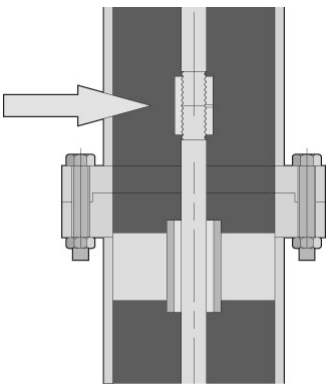
Flanged column / product lubricated lineshaft is recommended for ease of maintenance. Renewable shaft sleeve or hard facing of shaft available for longer life.



ENCLOSED LINESHAFT

The lineshaft is protected by water flushing the enclosing tube bearing on corrosive / abrasive services. Oil lubricated lineshaft available on long settings.

Alignment is attained by register fit between the flange faces.



THREADED LINESHAFT COUPLING

Threaded lineshaft coupling is commonly used for lower horsepower pumps. It is more economical.

KEYED LINESHAFT

Keyed lineshaft coupling is recommended for motors larger than 700 HP. It provides ease of maintenance.

Discharge Heads

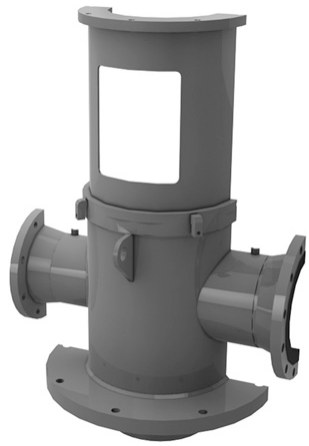
The discharge head functions to change the direction of flow from vertical to horizontal and to couple the pump to the system piping in addition to supporting and aligning the driver. Discharge head accommodates all types of driver configurations. Optional sub-base can be supplied. Goulds offers three basic types for maximum flexibility.

VIT DISCHARGE HEAD

Suitable for all service conditions such as high or low temperature or corrosive services. Various materials available. Segmented elbow available for efficiency improvement. Access ports for easy access to seals and couplings. Base flange can be machined to match ANSI tank flange.

VIC DISCHARGE HEAD

VIC can also be supplied with the pump suction in the can.



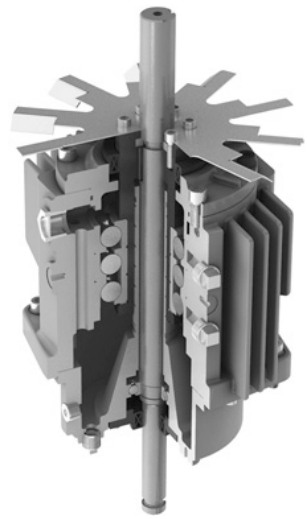
BELOW GROUND DISCHARGE HEAD

Use whenever VIT pump is required to adapt to an underground discharge system.

- Finite Element Analysis is typically recommended on this configuration to evaluate the pump's dynamic behavior and capability to withstand the loads
- Robust design as a result of the cantilever load distribution applied to the foundation and anchor bolts
- Customized design to minimize the foundation opening

FAN AIR COOLED THRUST POT

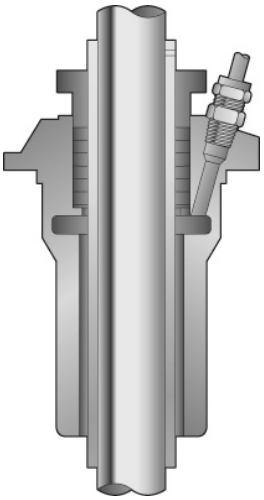
- Cast steel body meeting API standard
- 25,000-hour L10 bearing life
- Two or three bearing configurations
- Momentary up-thrust capability
- Inpro seals - prevent oil contamination
- Vibration and temperature monitoring are standard provisions
- Oil lubricated thrust bearings & permanently-lubricated



Seals & Couplings

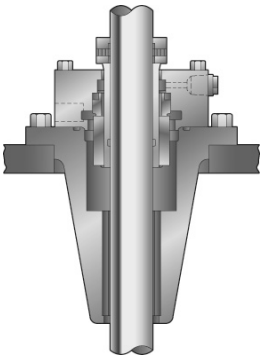
PACKED BOX WITH OR WITHOUT SLEEVE OPEN LINESHAFT

Whenever packing lubrication leakage can be tolerated and the discharge pressure does not exceed 150 psi, a packed box may be used. Optional headshaft sleeve or shaft hardfacing available to protect shaft.



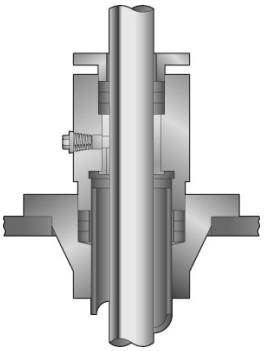
SINGLE SEAL

Most popular method — used for low to medium pressures. Cartridge style for ease of installation and maintenance.



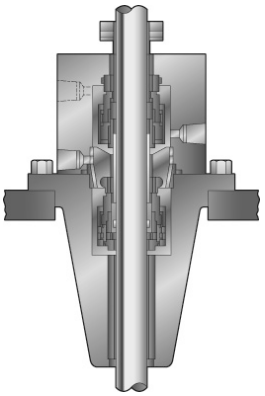
WATER FLUSH OR OIL LUBRICATED ENCLOSED LINESHAFT

Water flush tube connection is supplied when pressurized water is introduced into the enclosing tube for bearing protection on abrasive services.



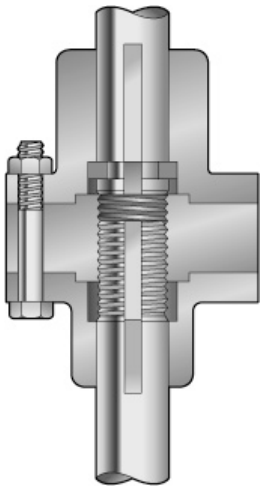
DUAL SEALS

Two seals mounted in-line. Chamber between seals can be filled with a buffer liquid and may be fitted with a pressure sensitive annunciating device for safety.



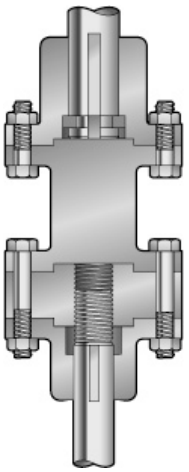
ADJUSTABLE COUPLING (TYPE A)

For vertical solid shaft driver, impeller adjustment made by using adjustable plate in the coupling.



ADJUSTABLE SPACER COUPLING (TYPE AS)

Same function as Type A coupling with addition of spacer. Spacer may be removed for mechanical seal maintenance without removing the driver.



Model VIT

Vertical Industrial Turbine Pump (For higher flows refer to high capacity section.)

- Flows to 70,000 GPM (15,900 m^3/Hr)
- Heads to 3,500 feet (1,067 m)
- Pressures to 2,500 psi (176 kg/cm^2)
- Bowl sizes from 6" to 55" (152.4 mm to 1,400 mm)
- Temperatures to 500° F (260°C)
- Horsepower to 5,000 HP (3,730 KW)

Design Advantages

- Fabricated discharge head and flanged column
- Flanged bowl construction
- 416SS shafting
- Alloy construction with external flush of critical wear areas available for corrosive / abrasive services
- Built-in alignment and simple piping for less costly installation and ease of maintenance/ reduced downtime

Typical Services

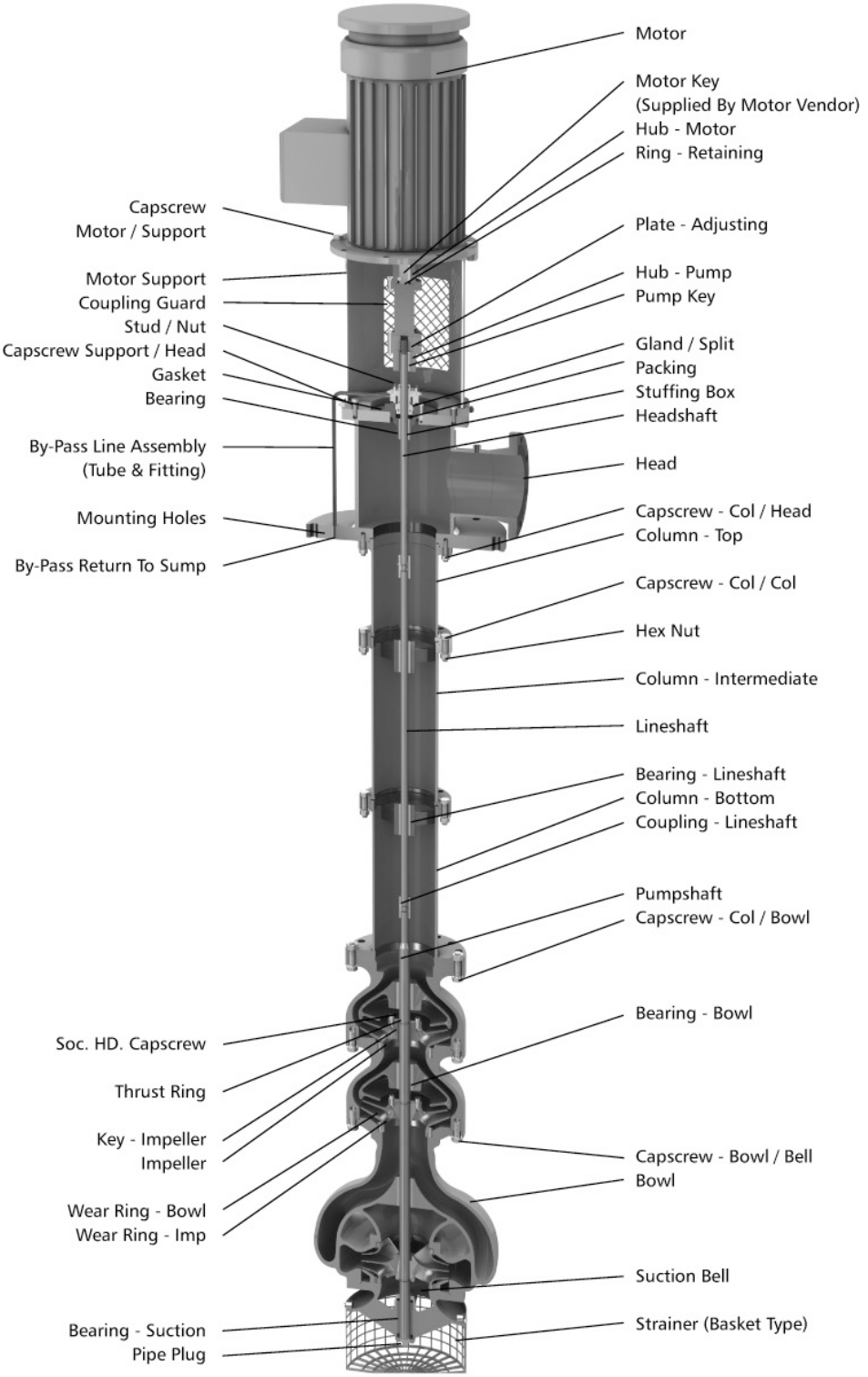
- Cooling Water
- Seawater and River Water Intake
- Industrial Process Pumps
- Utility Circulating Water
- Condenser Circulating Water Pumps
- Fire Service
- Reclaimed Water

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

Cross Sectional VIT *(Product Lube)*

Typical Markets Served

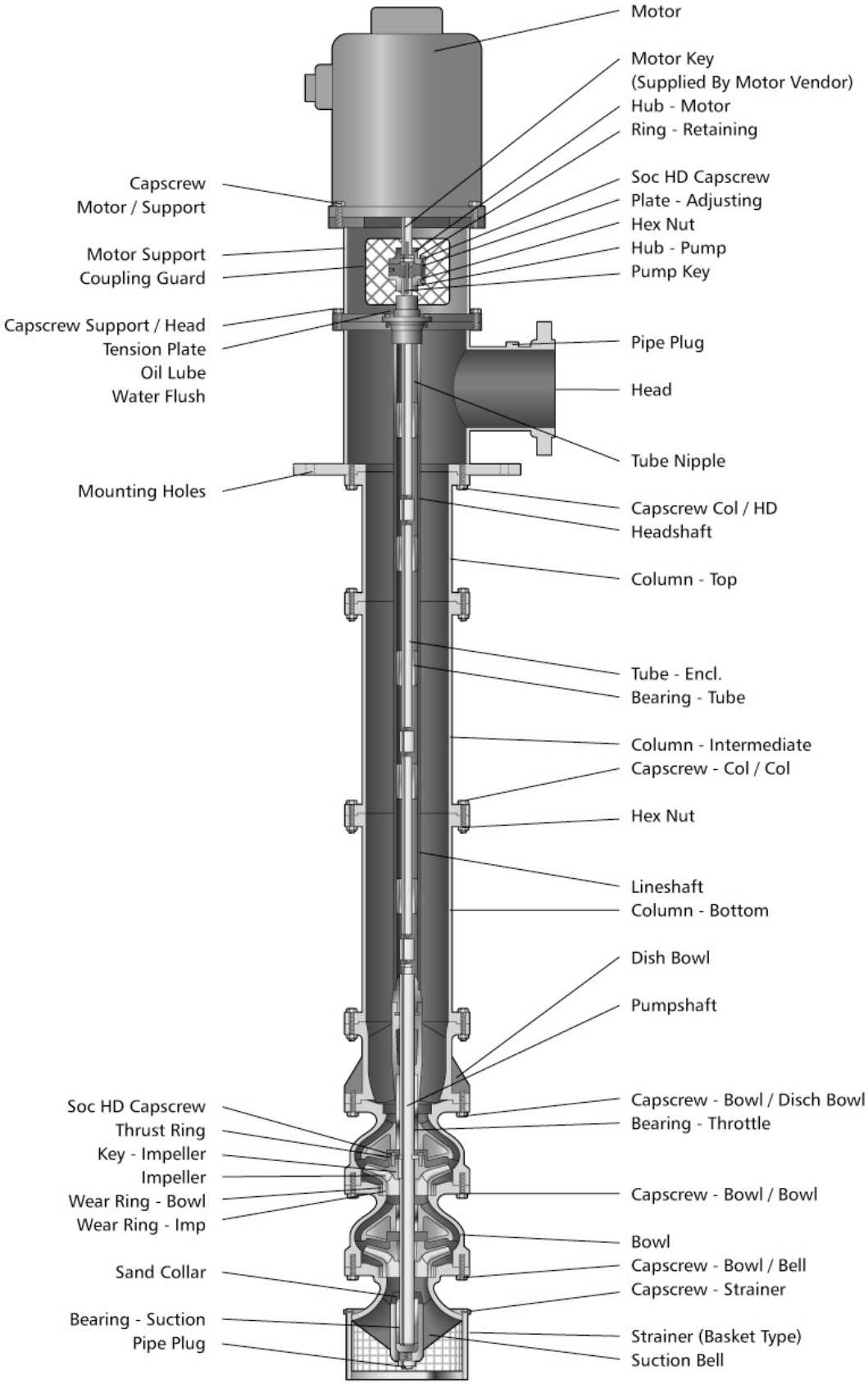
- Power Generation
- Oil & Gas
- Mining
- Municipal
- General Industry
- Chemical



Cross Sectional VIT *(Enclosed Lineshaft)*

Typical Markets Served

- Mining
- Oil & Gas
- Municipal
- Power Generation
- General Industry
- Chemical



NOTES

Model VIC

Vertical Industrial Can-Type Pump

- Flows to 70,000 GPM (15,900 m^3/Hr)
- Heads to 3,500 feet (1,067 m)
- Pressures to 2500 psi (176 kg/cm^2)
- Bowl sizes from 6" to 55" (152.4 mm to 1,400 mm)
- Temperatures to 500° F (260°C)
- Horsepower to 5000 HP (3730 KW)

Design Advantages

- Fabricated discharge head and flanged column
- Flanged bowl construction
- 416SS shafting
- In-line suction and discharge simplifies installation
- Optional suction in can for site piping flexibility
- Inherent design features on Model VIC allow efficient operation at any NPSH available
- Alloy construction for corrosive / abrasive services

Typical Services

- Pipeline Booster
- Product Transfer, Refinery Blending
- Injection-Secondary Recovery
- Chemical Transfer
- Boiler Feed
- Condensate
- Cryogenics
- LNG Transfer
- Light Hydrocarbons
- Water Services

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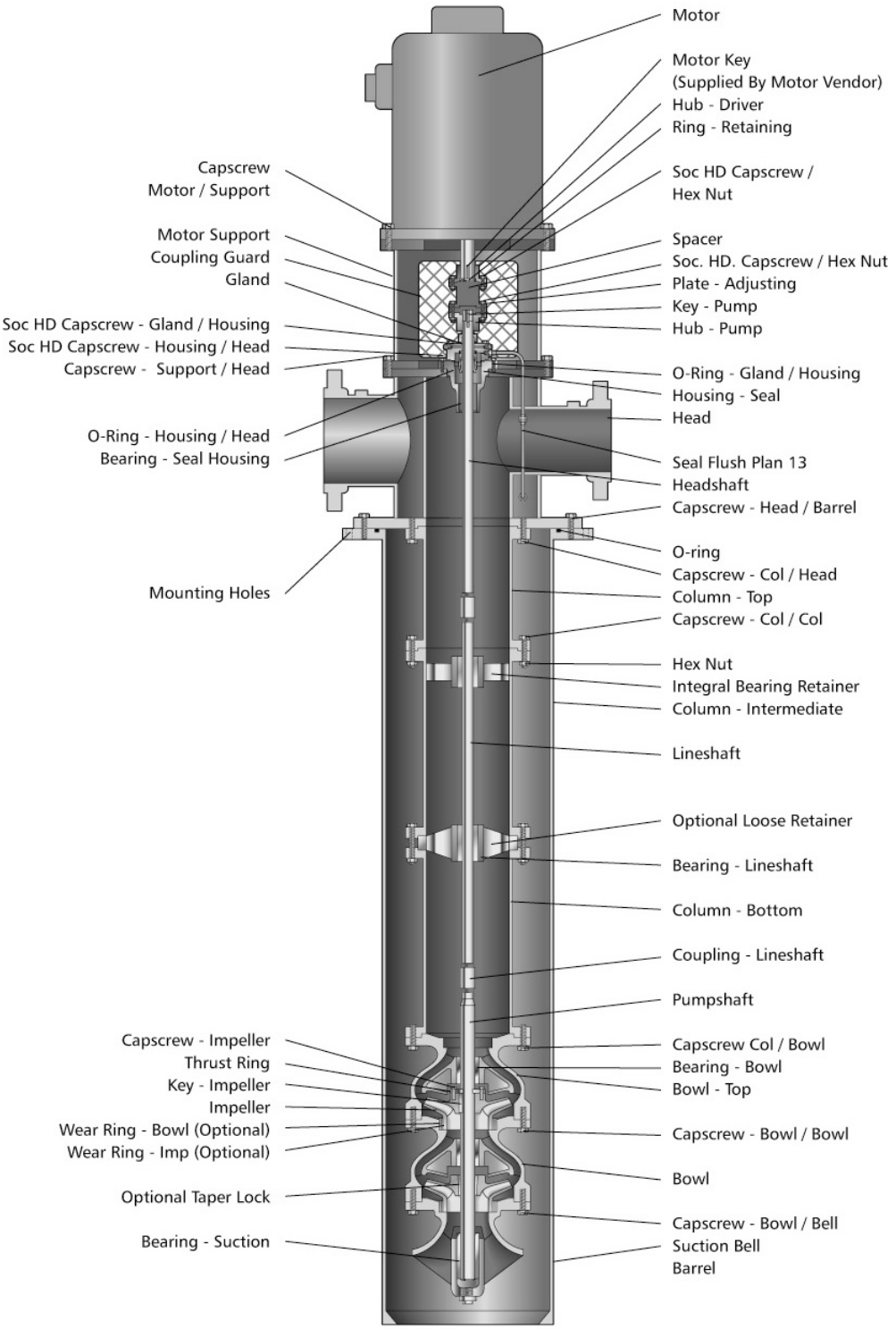
Cross Sectional VIC

Typical Markets Served

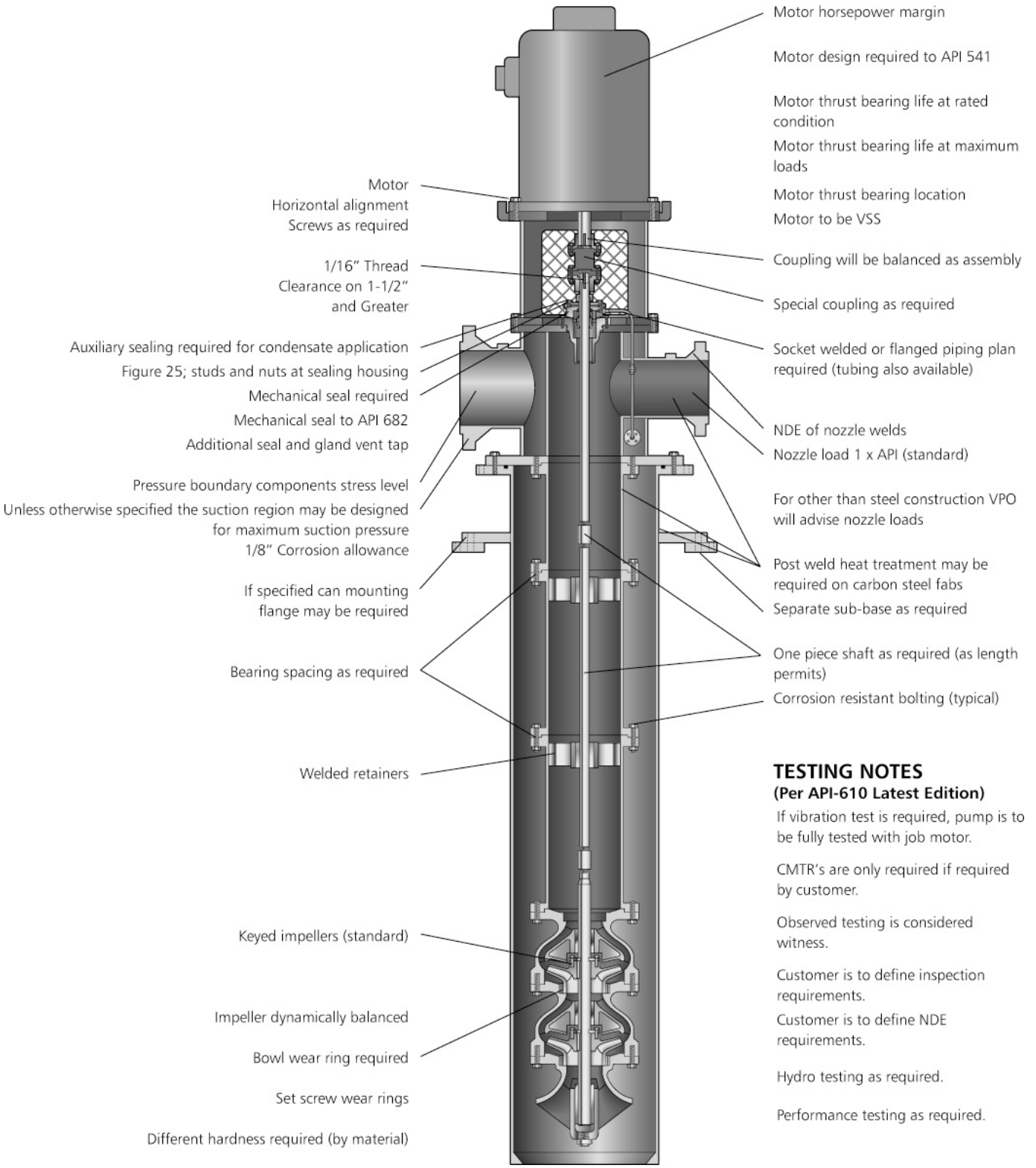
- Power Generation
- Chemical
- Mining
- General Industry



Cross Sectional VIC *(Per API-610)*

Typical Markets Served

- Oil & Gas
- Chemicals
- Pipeline Transfer
- Mining



TESTING NOTES
(Per API-610 Latest Edition)

If vibration test is required, pump is to be fully tested with job motor.

CMTR's are only required if required by customer.

Observed testing is considered witness.

Customer is to define inspection requirements.

Customer is to define NDE requirements.

Hydro testing as required.

Performance testing as required.

NOTES

Model VIS

Vertical Industrial Pump

- Capacities to 70,000 GPM (15,900 m^3/hr)
- Heads to 3,500 feet (1,067m)
- Pressures to 2,500 psi (176kg/cm^2)
- Bowl sizes from 6" to 55" (152.4 mm to 1,400 mm)

Design Advantages

- Ideal for deep set applications where use of lineshaft pumps is impractical.
- Complete unit is installed underground, resulting in quiet operation and space saving.
- Long life / low maintenance — no lubrication, alignment.

Services

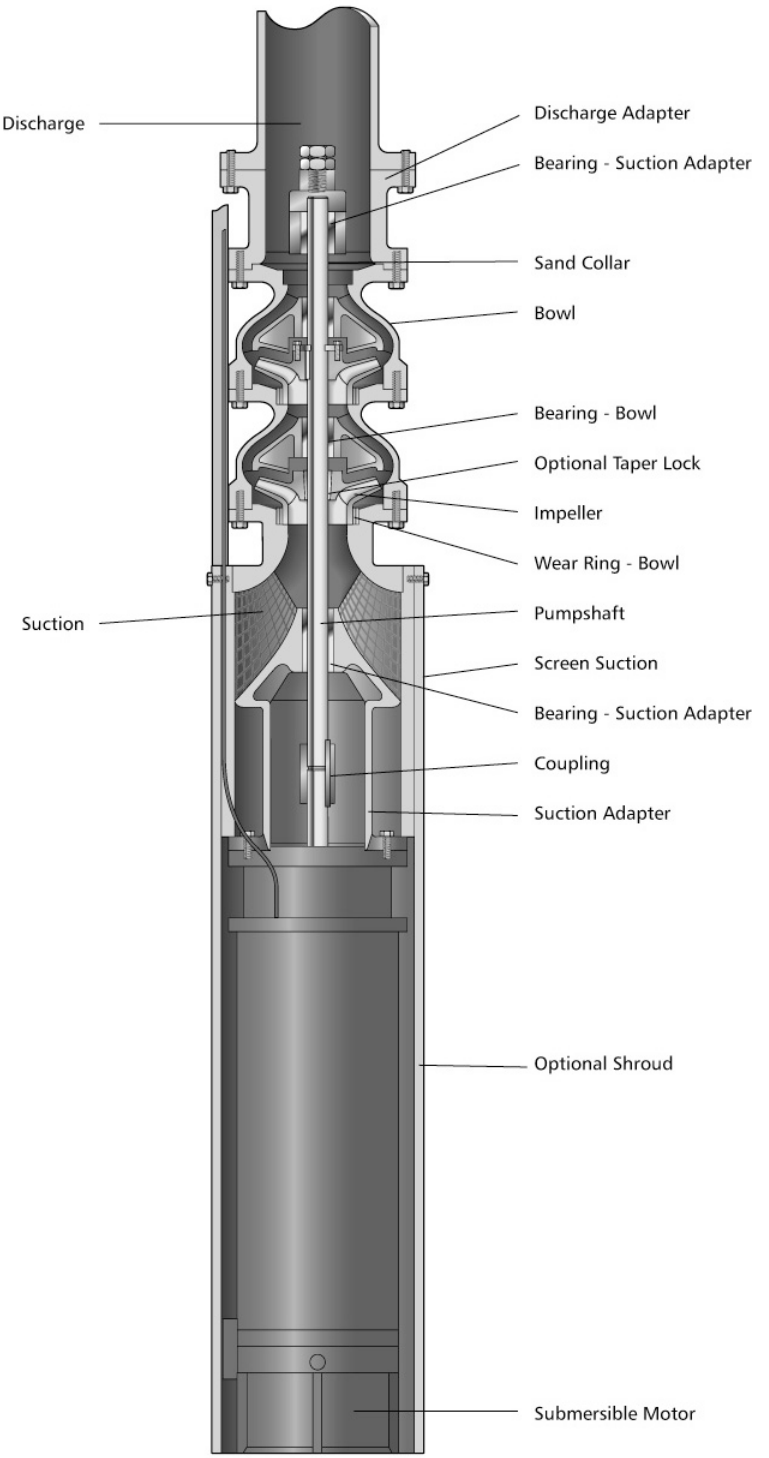
- Irrigation
- Service Water
- Deep Well
- Sea Water Lift

Please note that, for global consistency throughout this manual, numerical units of thousands will be separated by commas, while fractional values will be denoted by decimal points. For example, "one hundred thousand and one half" of a given unit would be represented as 100,000.5.

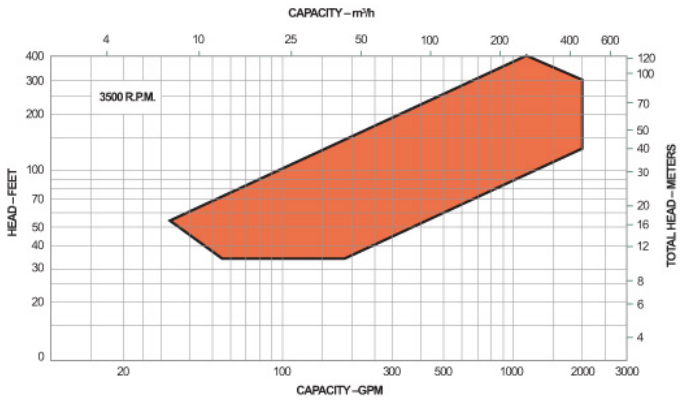
Cross Sectional VIS

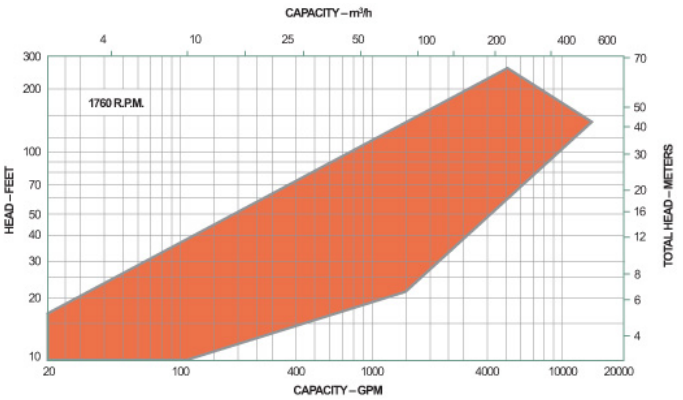
Typical Markets Served

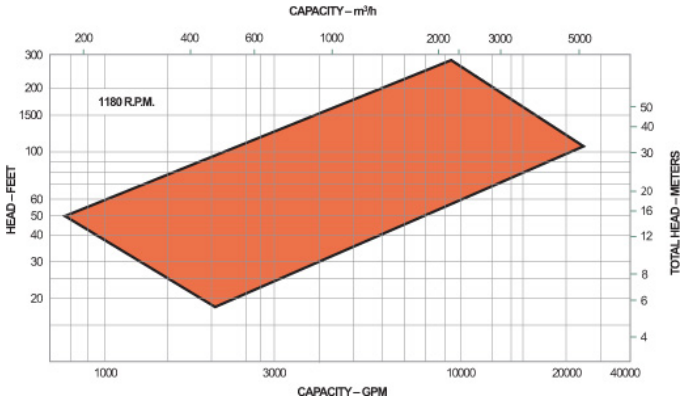
- General Industry
- Oil & Gas

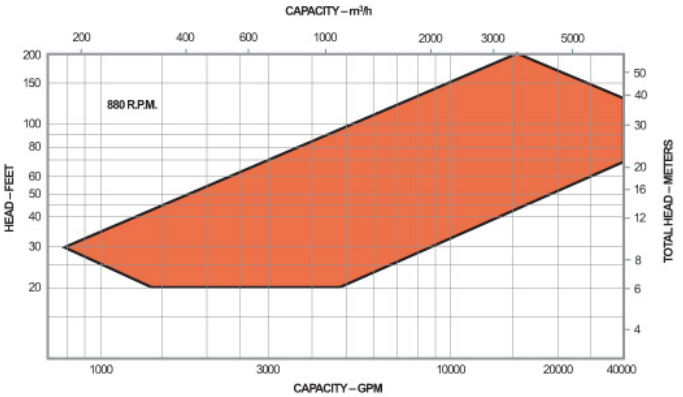


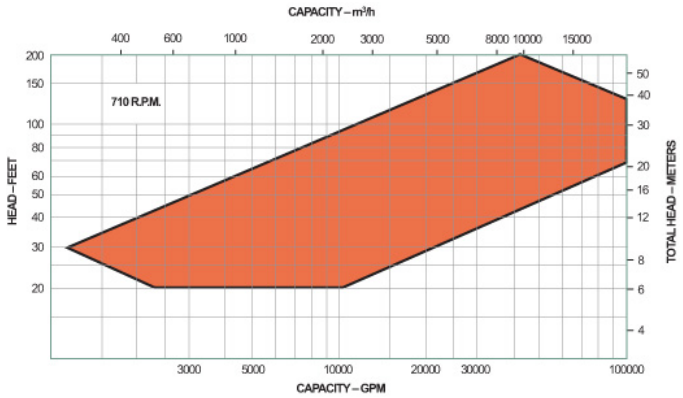
Hydraulic Coverage for models VIT, VIC and VIS

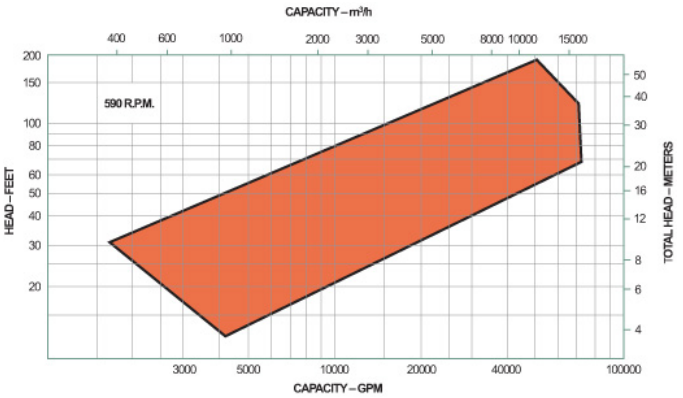


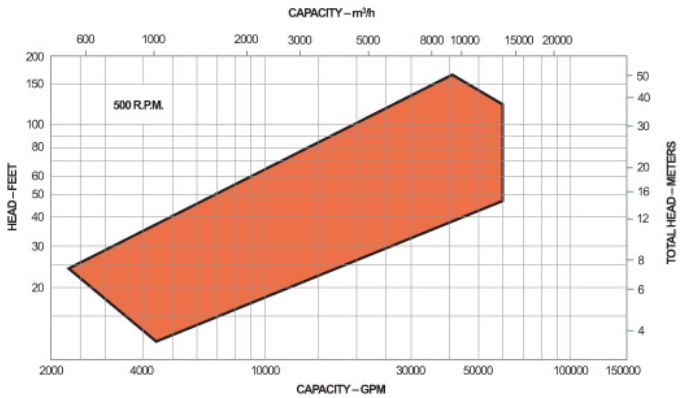


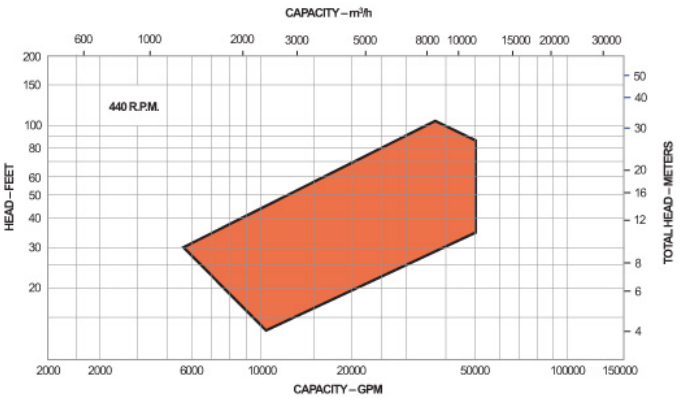












* Head is per stage.

Please refer to the Pump Selection System (PSS) at www.gouldspumps.com for the most current curves.

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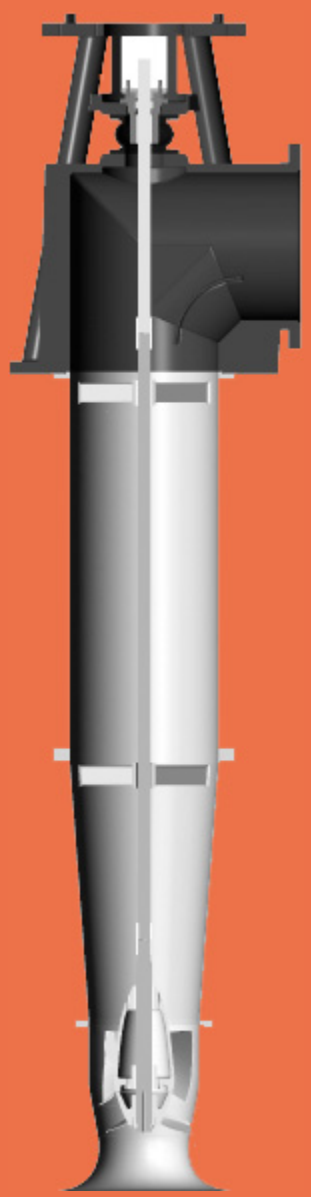
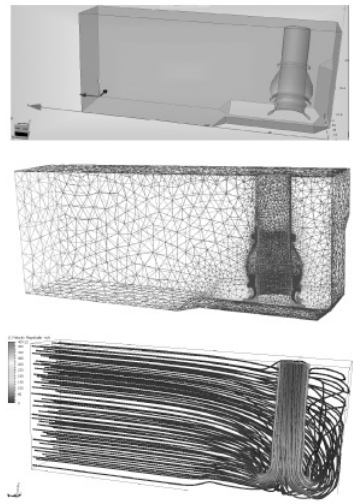


Model WC-GP

Design Features for Optimum Efficiency, Reliability and Cost Savings

- Hydraulic selection at best efficiency point using advanced 3-D tools with parametric design. Each pump is designed for optimum hydraulic and mechanical conditions for the required application. The suction bell provides flared inlet controls to accelerate the fluid to the desired inlet velocity. Outer wall on the bowls provides structural integrity and the flanges with precise rabbet fits are located at each end for positive alignment. The contour of the diffuser/bowl provides accurate fit to the impeller for optimum operating efficiency.
- Cantilever rotor design with no tail bearings. Extra long length bearing or double bearing for added stability in the upper bearing above the first stage impeller. No auxiliary lubrication system needed. The process fluid ensures proper lubrication at all times for increased life expectancy. Elimination of the tail bearing provides lower NPSHR values and improved fluid inlet conditions for hydraulic performance.
- Computational fluid dynamic analysis is available to determine the sump flow conditions at the pump inlet for superior performance.



- Using a thermal casting solidification simulation program, Goulds Pumps is able to design optimum castings to meet specific customer conditions, providing better design standards in the market.
- Shaft sleeves optional. Provides renewable bushings. Prevents wear of shaft itself. Materials can be provided to resist abrasion which are not available in shafting in some cases. Recommended on large shafts due to the shaft replacement cost and lead times.
- Pull-out design is optional. This option provides an effective way to maintain the equipment and replace wear components without the need to remove the complete pump and disconnect the flanges from the main pipe. The removable component is only the rotor for optimum reliability and to reduce costs during maintenance.

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High Capacity Pumps

Model WC-GP

Design Features for Optimum Efficiency, Reliability and Cost Savings

- Innovative O-Head design using finite element analysis provides maximum equipment reliability throughout its operating hydraulic range without high vibrations from structural resonance frequency. In addition, lateral and torsional rotor analysis addresses unstable rotor dynamics.
- Thrust pot design is optional. It is designed to carry the pump down thrust generated by the rotor weight and the hydraulic action of the pump during operation. Thrust pots are ideally on units equipped with IEC motors where their thrust capacity is basically zero beyond the motor weight. Thrust pots are designed for easy dismantling without the need to remove the unit driver. Additional advantages include capacity of the thrust pot to withstand a large range of thrust forces, meeting international standards for bearing temperature and extended life, in addition to being air cooled for most of the applications.
- The hydraulic balance achieved on the rotor does not have balance holes in the impeller like other brands on the market. Reducing the down thrust of the pump will reduce the cost of the driver by reducing the size of the thrust bearing in the motor, which makes the Goulds Pumps design more competitive.
- Below-grade discharge elbow is optional, and the structural analysis design considers the overturning forces with respect to the anchor bolt location and pump centerline. This results in robust components to prevent equipment deformation. Discharge heads are designed to withhold certain discharge hydraulic and mechanical forces. It is always recommended to minimize these external forces by supporting the system independently. Do not use the rotating equipment as a piping anchor.

High Capacity & Higher Head Pumps

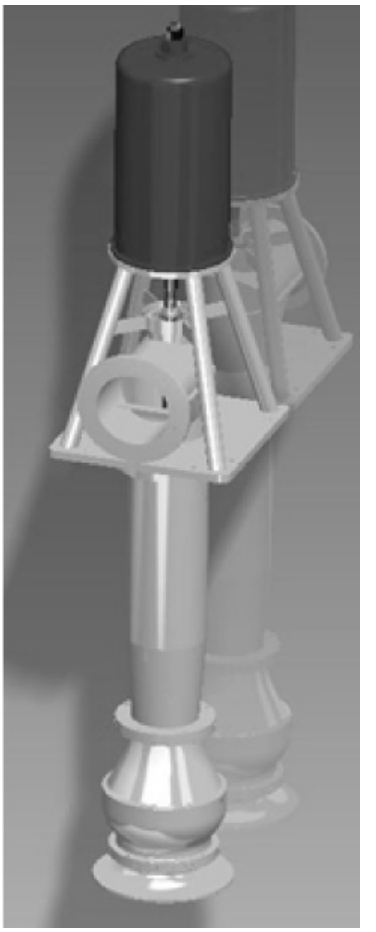
Model WC-GP

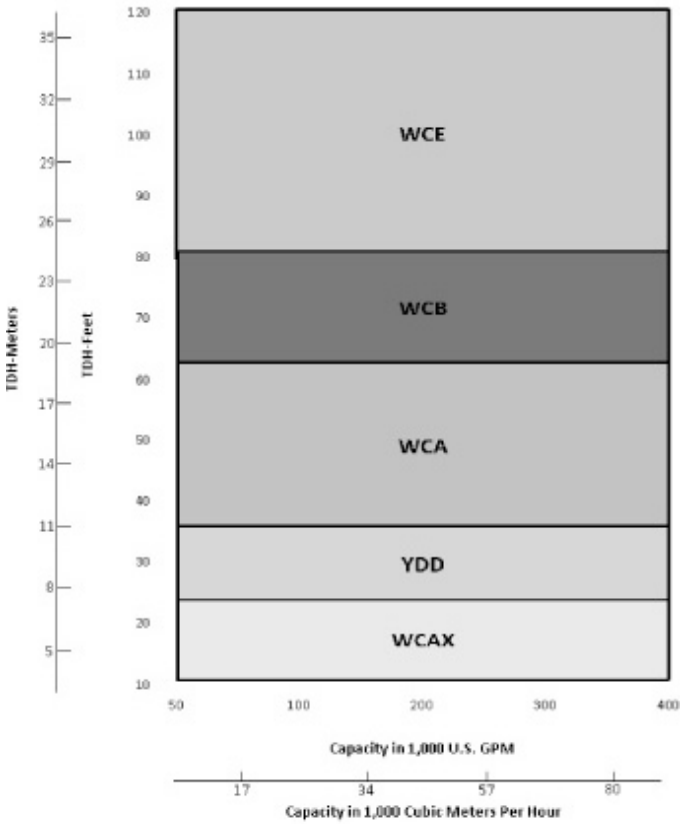
Vertical circulating water pumps or wet pit column pumps are classified as VS1 pumps for power generation condenser cooling, recirculation and desalination sea water intake, and as VS3 pumps for flood protection, storm water disposal, waste treatment plants, industrial services, and sump drainage.

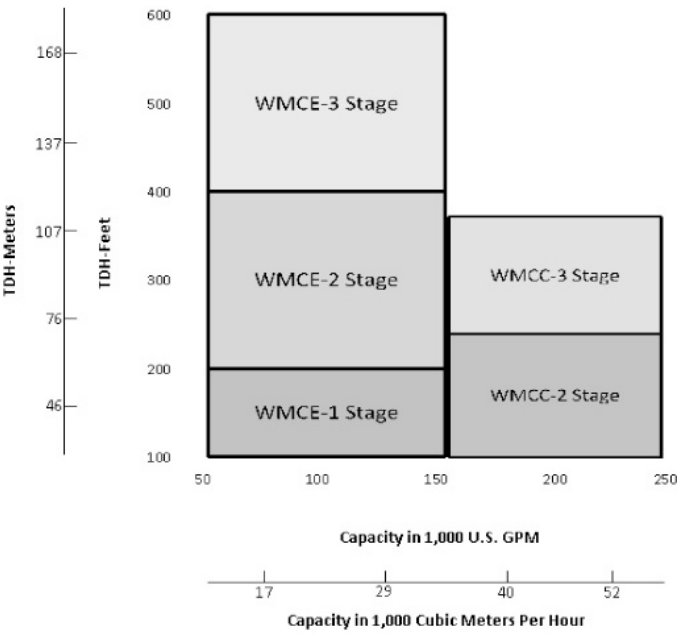
High capacity pumps having a CCW (counter clockwise) rotation when viewing the equipment from the top meet Hydraulic Industry Standards and are in full compliance.

These high capacity pumps can be designed in multistage with a HEAVY DUTY configuration for a wide range of heads and extended service life, and are ideal when the installation requires minimum floor space.

Pumps ship completely assembled to the job site as long as they fit within freight dimension limitations. Pumps are shipped in sub-assemblies when the complete assembly exceeds the capacity of the transportation.







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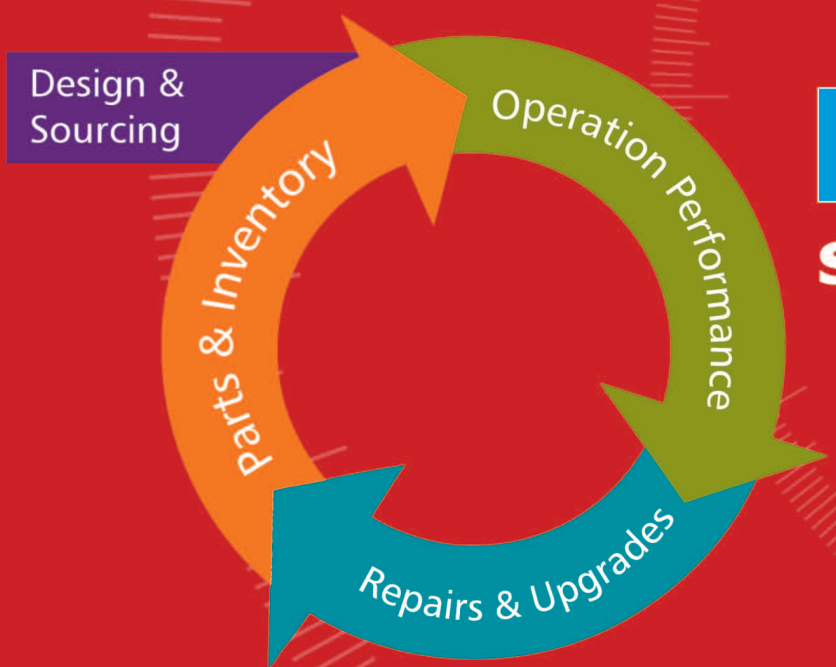
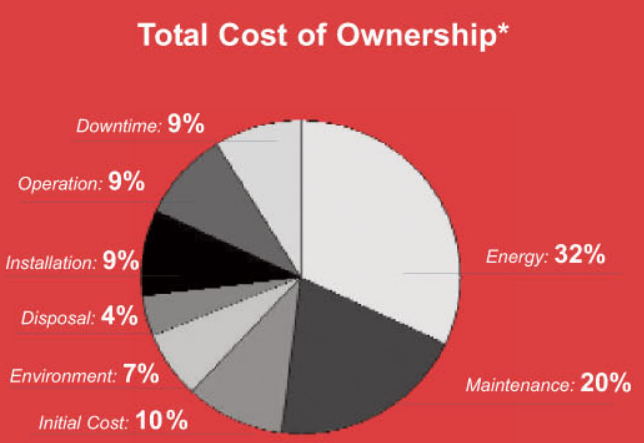
Aftermarket



PRO services



* Source: Top 10 Global Chemical Manufacturer 2006

ITT PRO Services®

Reduce total cost of pump ownership with ITT PRO Services

The initial purchase price of a pump is only a fraction of the total cost of ownership. Maintenance, energy, operational and downtime costs are your real concerns - year after year - over the life of the equipment.

Together, they represent over 60 percent of your real costs and these are items you can address and aggressively bring under control.

Addressing Needs

ITT PRO Services® can be deployed as stand-alone or integrated solutions. It all depends on the needs of your company.

Depending on the issues and level of service needed, ITT PRO Services will tailor solutions that will:

- **Level 1:** Maintain like New - keep your equipment in like new condition
- **Level 2:** Analysis for Improvement - provide data and information that empower customers to improve equipment reliability and reduce cost
- **Level 3:** Implementation Solutions - deliver plant & equipment optimization

Improving Operations, Maximizing Savings

ITT PRO Services can typically return savings of up to 25 percent annually. Depending upon your situation, significant savings accrue by realizing some or all of the following:

- Longer equipment life
- Lower maintenance costs
- Lower energy costs
- Improved technical support
- Increased equipment efficiency

ITT PRO Services has the experts to get the job done right. Each delivering the same passion and expertise we've put into manufacturing Goulds pumps for more than 160 years. And we service every brand of pump and rotating equipment. Whether you need parts, upgrades, repairs, inventory services, condition monitoring or any other life cycle service, all you need to do is call your ITT PRO Services representative. Because reliability has no quitting time.

ITT PRO Services ®

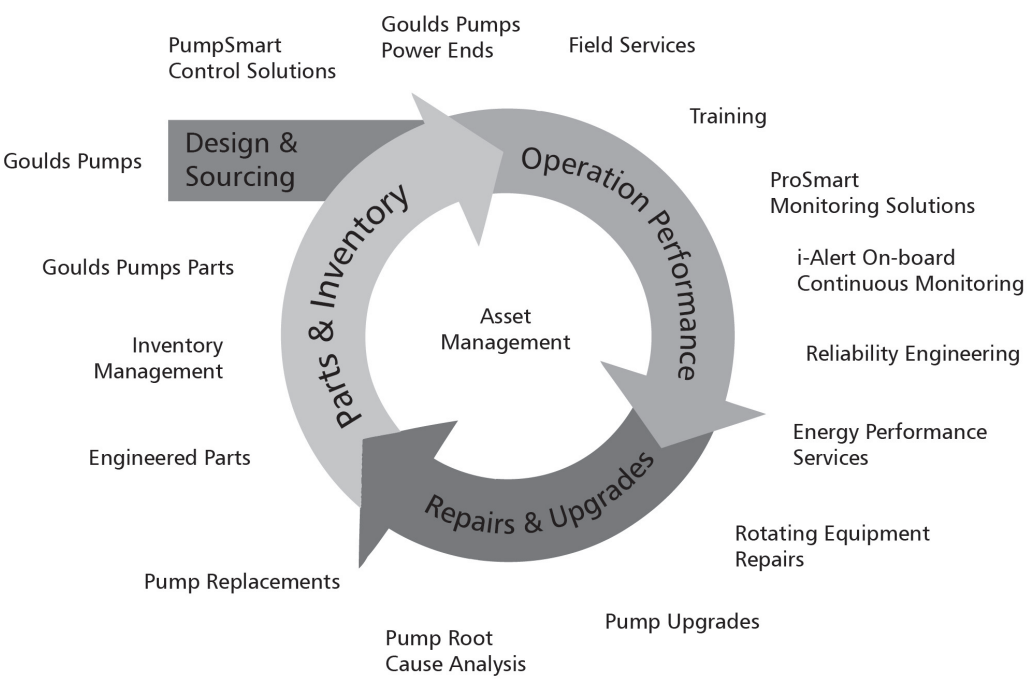
Reliability has no quitting time.

Building on over 160 years of Goulds Pumps experience, **PRO Services** provides an array of products and services focused on reducing equipment total cost of ownership (TCO) and increasing plant output, including predictive monitoring, maintenance contracts, field service, engineered upgrades, inventory management, and overhauls for pumps and other rotating equipment.

Depending on the issues and level of service needed, ITT PRO Services will tailor solutions that will:

- Level 1: Maintain like New - keep your equipment in like new condition
- Level 2: Analysis for Improvement - provide data and information that empower customers to improve equipment reliability and reduce cost
- Level 3: Implementation Solutions - deliver plant & equipment optimization

Your Total Solution for Equipment Life Cycle Optimization



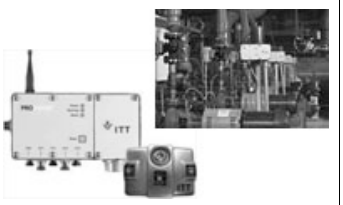
		Level 1: Maintain like New	Level 2: Analysis for Improvement	Level 3: Implementation Solutions
		Keep Your Equipment in Like-New Condition	*Information that Empowers Customers to Improve Equipment Reliability & Reduce Cost*	*Deliver Plant & Equipment Optimization*
Parts & Inventory	Quality OEM Parts	OEM Parts for Goulds Pumps, AC, Morris, Goyne, CB, HVC, UXN, ROV		
	Inventory Management	Parts evaluation and storeroom optimization		
	Engineered Parts	Orphaned and obsolete equipment		Orphaned and obsolete equipment
	Pump Replacements	Power-end replacement/ exchange programs		
	Asset Data	Information on equipment throughout lifecycle		
Operation Performance	Reliability Engineering		"MTBF, Bad Actors/ high cost failures, pareto/ failure mode reports, investigation & recommendation"	Actiion plan development and project management
	Training	Operator Training, Maintenance Training	"Management Training; Asset Management; Six Sigma; Engineer Training"	All training skills to improve capabilities
	Energy Performance Services		Efficiency & Hydraulic System Assessments	
	Control Solutions			Variable speed controls (PumpSmart) for pump protection & control
	Monitoring Solutions	Condition Monitoring Instrumentation (ProSmart, iAlert)	Condition Monitoring Service (ProAnalysis)	
	Field Services	Installation & Commissioning. Variable labor source for push/pull equipment;		
Repairs & Upgrades	Root Cause Analysis		Equipment health analysis. Identify source of poor reliability and recommend corrective action plans.	
	Pump Upgrades			Pump modifications to meet current standards & process management
	Rotating Equipment Repairs	Repair to OEM standard		

Program Elements

Provide parts in a timely manner to meet end user requirements for the following brands and products.

Quality OEM Parts	• Goulds Pumps products • AC Pump products CB (multistage BB5), which has been upgraded to latest API edition Goulds model 7200CB • HVC (multistage BB2), which has been upgraded to Goulds model 3600 • UXN (multistage BB3), which has been upgraded to Goulds model 3620 • ROV (multistage BB2), which has been upgraded to Goulds model 3640 • Morris models: CKX, RX, JC, HS, VJC, VHS, JCU, HSU, HSUC • Goyne models: 5000, 5050, 5100 and 5150	
Inventory Management	Optimize quantity and quality of stored inventory. Live visibility to on-hand and vendor stocked inventory	
Engineered Parts	For orphaned pumps & obsolete rotating equipment	
Pump Replacements	Pump and subassemblies • **Power End Program** – Factory assembled sub components to eliminate the need to stock individual parts, reducing Mean Time To Repair and maximizing reliability.	
Asset Data	The data you need, when and where you need it: barcode enabled, smartphone/ tablet access to plant asset database: location, condition & specifications (including pump curve, parts lists, manual , maintenance history, repair reports)	
Reliability Engineering	MTBF, Bad Actors/ high cost failures, pareto/ failure mode reports, investigation & recommendation. Project management to drive change	
Training	Increase the skills of your work force: eliminate induced failures . Training programs include: Operator Training, Maintenance Training, Management Training, Asset Management, Six Sigma, Engineer Training	

Program Elements

Energy Performance Services	Reduce energy use: Energy audits, analysis and services to reduce energy consumption, hydraulic analysis and recommendations.	
Control Solutions	Variable speed controls (PumpSmart) for pump protection & control	
Monitoring Solutions	Online monitoring & analysis of critical rotating equipments with ProSmart and continuous monitoring of balance-of-plant equipment with iAlert. Monitoring services.	
Field Services	Installation & Commissioning, Labor when you need it: Push/ Pull equipment.	
Root Cause Analysis	– Equipment health analysis. Identify source of poor reliability and recommend corrective action plans.	
Pump Upgrades	Pump modifications to meet current standards and process requirements.	
Rotating Equipment Repairs	Leverage the available capacity of local and regional certified repair shops. Repair and Remanufacturing to OEM specifications with as-new warranty.	

Case Studies

A large paper manufacturer with over 1,000 centrifugal pumps

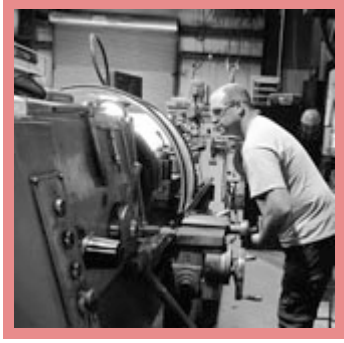
An Energy Performance Services assessment yielded recommendations for 23 pumps, with a projected savings of $1.1 million in energy and maintenance costs on a capital investment of $591,000.

An oil refinery with a capacity of 120,000 barrels of oil per day ITT conducted a root cause analysis (REsolve) on 30 "bad-actor" pumps.

Over two years, repair costs have been cut by 75 percent and emissions by 95 percent.

A multibillion-dollar supplier of basic and specialty chemicals.

In the first four years after implementing ITT's comprehensive plant optimization service, mean time between failure (MBTF) for pumps has improved 71 percent, netting $1.5 million in operations and maintenance savings.



A company producing atmospheric gases through cryogenic distillation

ITT design engineers refitted a Goulds 3196 pump to function as a hydro-turbine, capturing depressurized water. This modification allows 70 kW of previously lost power to be captured and used, resulting in an energy savings of $24,000 per year.

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ProSmart®

Predictive Condition Monitoring

Simplicity

Wireless architecture and remote world-wide access reduce installation, operation, and maintenance cost.

Continuous Monitoring

Automated data collection and notification save time and resources to focus only on machines in need.

Increase Uptime

Early warning and advanced diagnotics enable to increase total process uptime, by preventing unplanned downtime.

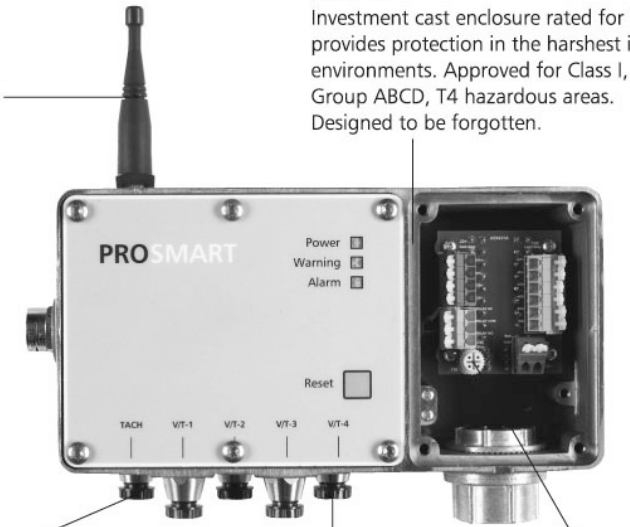
Reduce Maintenance Cost

Predictive monitoring reduces unplanned failures and unnecessary preventive maintenance costs.

DATA ACQUISITION AND ANALYSIS

WIRELESS
2.4 GHz 100mW power in FCC unlicensed band provides up to 3 kM of point-to-multipoint communication range, in harsh industrial environments.

304 SS
Investment cast enclosure rated for NEMA 4X provides protection in the harshest industrial environments. Approved for Class I, Division 2, Group ABCD, T4 hazardous areas. Designed to be forgotten.



TACHOMETER
Plug & Play connection for tachometer input simplifies and speeds field installation.

VIBRATION / TEMPERATURE
Plug & Play connections simplify and speed field installation of the ProSmart Vibration/Temperature sensors. Each sensor is capable of monitoring 3 axes of vibration and temperature.

SIMPLIFIED CONNECTIONS
Easy-to-access terminal blocks for power and process signals ease installation. Required input power 12-24VDC readily available from flexible sources.

Qty 3	4-20 mA Inputs
Qty 2	Digital Inputs
Qty 1	Form C Relay

Processing Power

A powerful digital signal processor, capable of analyzing 155 channels of data every 5 seconds, including 4,000 lines spectrums on 12 channels of vibration data, the ProSmart® DM22x brings intelligence to your machines.

ITT Smart Battery Module

- 304SS Investment case enclosure
- Rated for CID2 Group ABCD T4
- Plug-n-Play power connections
- Rechargeable Lithium-ion Batteries

ITT VT-03

- 3-Axis Vibration & Temperature
- MeMs based accelerometer
- Dynamic range +/- 6G
- 6-3500 Hz

IMI VS-03/VS-01

- 3-Axis Vibration or Single Axis vibration with Temperature
- Piezoelectric based accelerometer
- Dynamic range +/- 15G
- 6-3500 Hz

ITT ST-02

- Inductive Speed Sensor
- 5 mm sensing range

Process Transmitters

Ability to integrate any standard process signal adds diagnostic capability

APPLICATIONS

Primary Services

A machine does not have to be a critical asset to have a massive impact on plant production when it goes down. Unfortunately, it is a costly proposition to continuously monitor anything but your most critical machines. ProSmart solves this problem by providing near continuous monitoring on machines at an installed cost that is fractions of traditional systems.

Remote Locations

Monitoring hundreds of small cogeneration plants, each with 20-30 pieces of rotating equipment, created a significant challenge for this customer. How do you ensure equipment availability and uptime without adding dedicated resources to each plant? ProSmart solved this by providing data collection and advanced analysis capabilities to each machine, all tied into the Internet and providing access worldwide and to the best vibration analysts available..

Problem Solving

Periodic bearing failures on your compressor are more than just aggravating; the repair costs and lost production is costly. The challenge of diagnosing problematic equipment is that they typically fail when you're not there. ProSmart has solved this problem by providing the ability to process conditions and motor load conditions in addition to machinery vibration and temperature. Sampling every 5 seconds for 24 hours-a-day means that ProSmart is there when you're not..

Resource Optimization

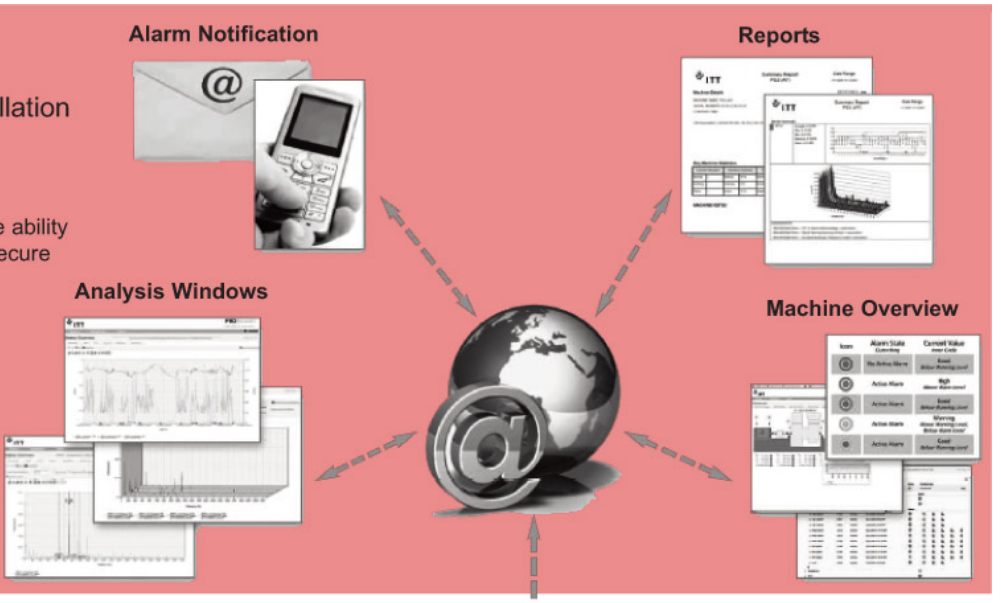
Walking around and collecting data takes valuable time away from the real capabilities of your vibration analysts — solving problems. In addition, the walk-around misses critical transients and changes in the operating conditions of your equipment which can lead to faulty conclusions. ProSmart solved this problem by automating the data collection of one customer's system. This enabled their monitoring program to be expanded without having to add hard-to-find resources..

HOW IT WORKS

Web Application...
client eliminates software installation and management costs.

HOSTED INTERFACE
The ProNet user interface provides the ability to view, analyze, and store data in a secure environment anywhere in the world.

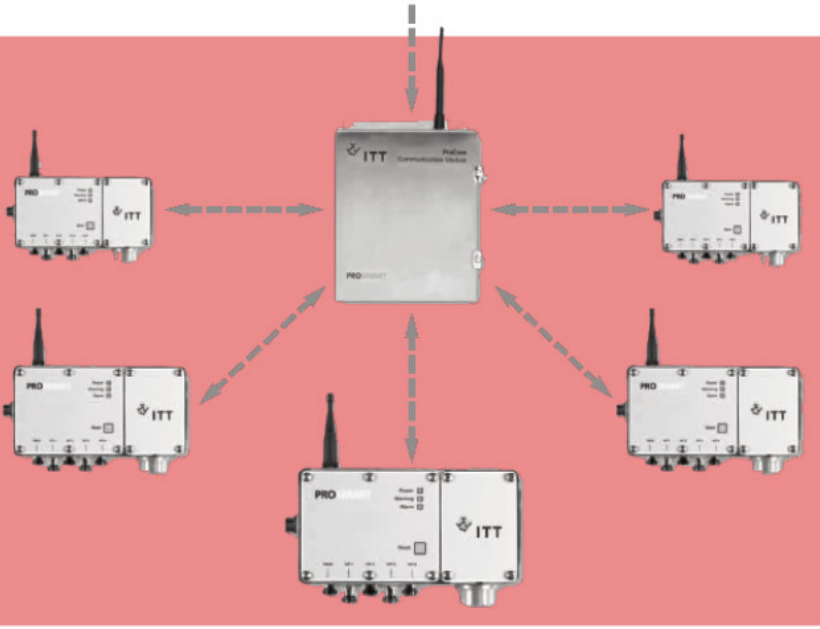
With online reports that range from supervisory overviews to detailed analysis windows, ProSmart provides benefits to each level of your organization.



Wireless architecture...
reduces installation costs and complexity.

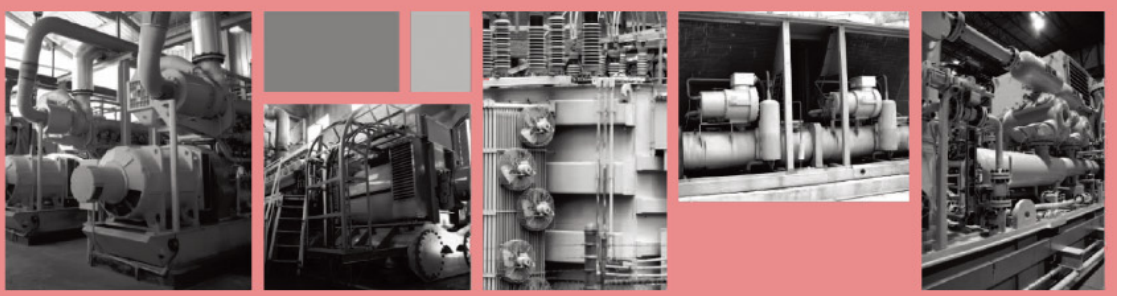
COMMUNICATION MODULE
As the gateway to the Internet, the ProSmart CM provides a secure connection to the ProNet platform via LAN, DSL, cellular, or 802.11 wireless routers.

DATA MONITOR
Integrated processing capabilities allow 22 channels of information to be collected every 5 seconds, 24/7/365..



ProSmart delivers...
key machinery health data directly to you.

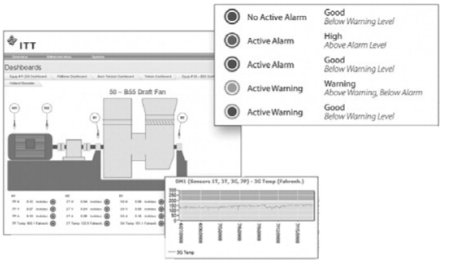
MACHINE LEVEL
ProSmart can be used to provide continuous machinery monitoring of all your rotating equipment. Standard process signals can be integrated for greater diagnostic capabilities.



ProNet

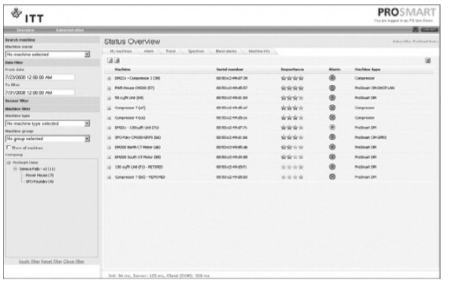
DASHBOARDS

Dashboards take the abstract nature of your machine data and ties it into a visual representation of your machine. ProNet uses easy-to-understand status circles to quickly identify the condition of each machine. A rollover 'quick-view' plot of critical data can be views from the Dashboard.



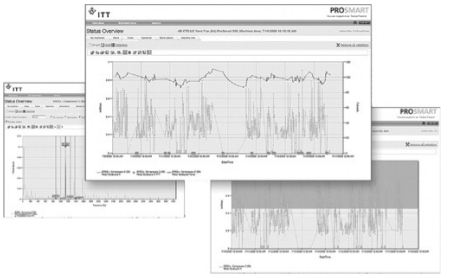
MY MACHINES

ProNet provides the ability to easilt manage the machine you are monitoring by automatically sorting machines based upon user-defined machine importance, then by alarm state. Status circles on each page quickly and easily identify machine condition.



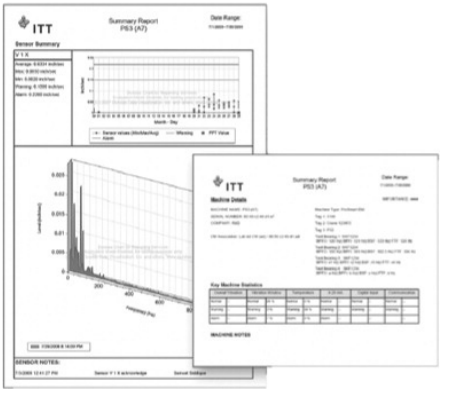
TRENDS

ProNet provides the ability to overlay data to easily visualize the interaction between different signals and perform root cause diagnosis. Advanced analysis tools, such as waveform and spectral data with harmonic and side band cursors are available.



REPORTS

Reports can be easily created and published on a periodic bases. Report options include statistical averages of key sensor data, overall trends with high-low-averages, and notes and actions taken on different alarm conditions.



TECHNICAL SPECIFICATIONS

INPUT VOLTAGE	External 12-24 VDC or Smart Battery Module
VIB/TEMP SENSOR	12 channels vibration 4 channels temp
TACHOMETER INPUT	1 channel
4-20Ma ANALOG INPUT	3 channels 12 Ω resistance
DIGITAL INPUT	2 channels
FORM-C RELAY OUTPUT	1 channel resistive load
SAMPLING CYCLE	5 seconds
ANALYSIS DATA	FFT Spectrum and Time Waveform
FREQUENCY RANGE	5-3500 Hz
SPECTRAL BANDWIDTH	1 Hz and 0.25 Hz
DATA BLOCK LENGTHS	1024 AND 4096
WINDOWING	Hanning

RADIO FREQUENCY	2.4 GHz FHSS [1]
RADIO OUTPUT POWER	100 mW
WIRELESS PROTOCOL	Proprietary FHSS
WIRELESS ARCHITECTURE	Point-to-Multipoint
TRANSMITTING RANGE	1.6 miles LOS [2] typical 650-130 ft
NETWORK PROTOCOL	Standard Ethernet
NETWORK ADDRESSING	DHCP or Static IP
GUI ENCRYPTION	128 Bit SSL
GUI BROWSER	Internet Explorer
NETWORK CONNECTIONS	LAN/DSL, GPRS/GSM/CDMA Modem ModBus/TCPIP Slave
OPERATING TEMPERATURE	-40°C to 70°C (-40°F to 158°F)
CERTIFICATION	CSA, FCC, Class 1 Division 2 Group ABCD T4, C-Tick

[1] Frequency Hopping Spread Spectrum
[2] Line of Sight

Improving Plant Profitability

Our products leverage over 160 years of process machinery knowledge and provide enhanced control and continuous monitoring yielding increased UPTIME and decreased MAINTENANCE and ENERGY cost. The ProSmart predictive monitoring system identifies and solves problems before they impact production. Our PumpSmart control products provide advanced process control, valuable process knowledge without the need for additional sensors, enhanced reliability through failure prevention, and significantly lower energy costs – up to 65%. The 3196 *i* - FRAME™ provides early warning of improper operation before catastrophic failure through daily monitoring of thrust bearing vibration and temperature. LED's provide operators a visual indicator of equipment health.

NOTES

NOTES

PumpSmart is the latest advancement in pump control and protection to reduce energy consumption, increase uptime and decrease maintenance cost. It allows the pump to be right-sized to the application by dialing in the speed and torque which increases flow economy, reduces heat and vibration, and improves overall system reliability.

PUMPSMART®

Simplicity

PumpSmart was designed specifically to optimize pumping applications and can be used to control a single pump or coordinate between multiple pumps without the need for an external controller.

Drive for Pumps

While most VFD's can only provide basic information, PumpsSmart offers unparalleled insight to the pump operation which allows for smoother process control and efficiency.

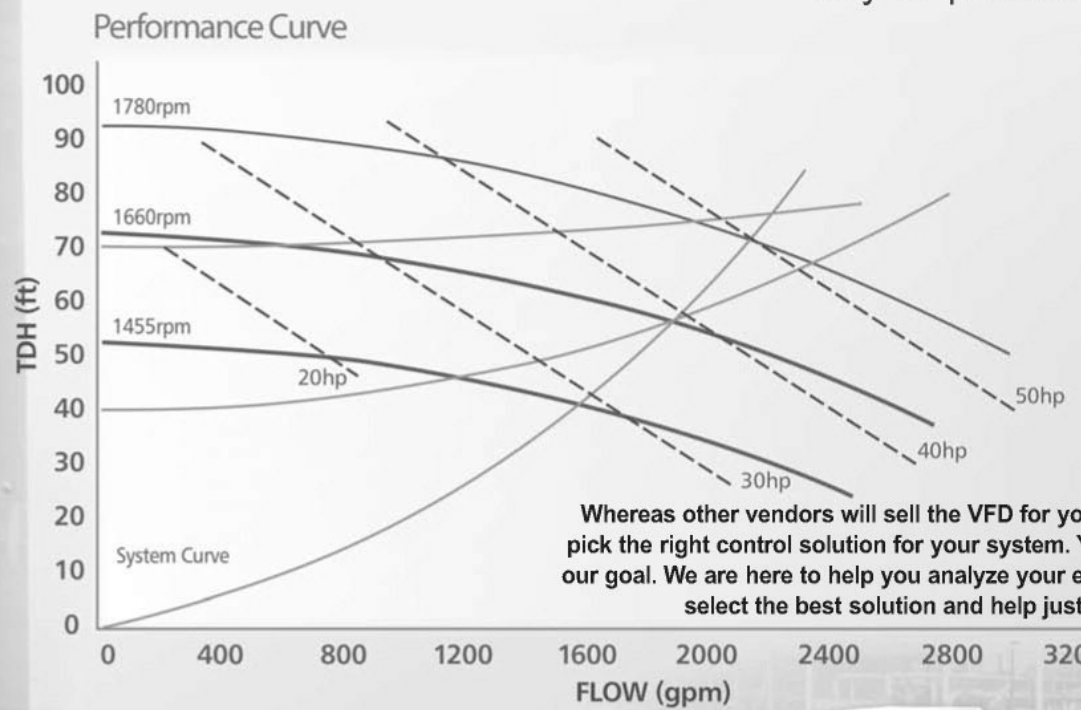
SmartFlow

PumpSmart features a sensorless flow function for centrifugal pumps that can calculate the flow of the pump with in ± 5% of the pump rated flow.

Pump Protection

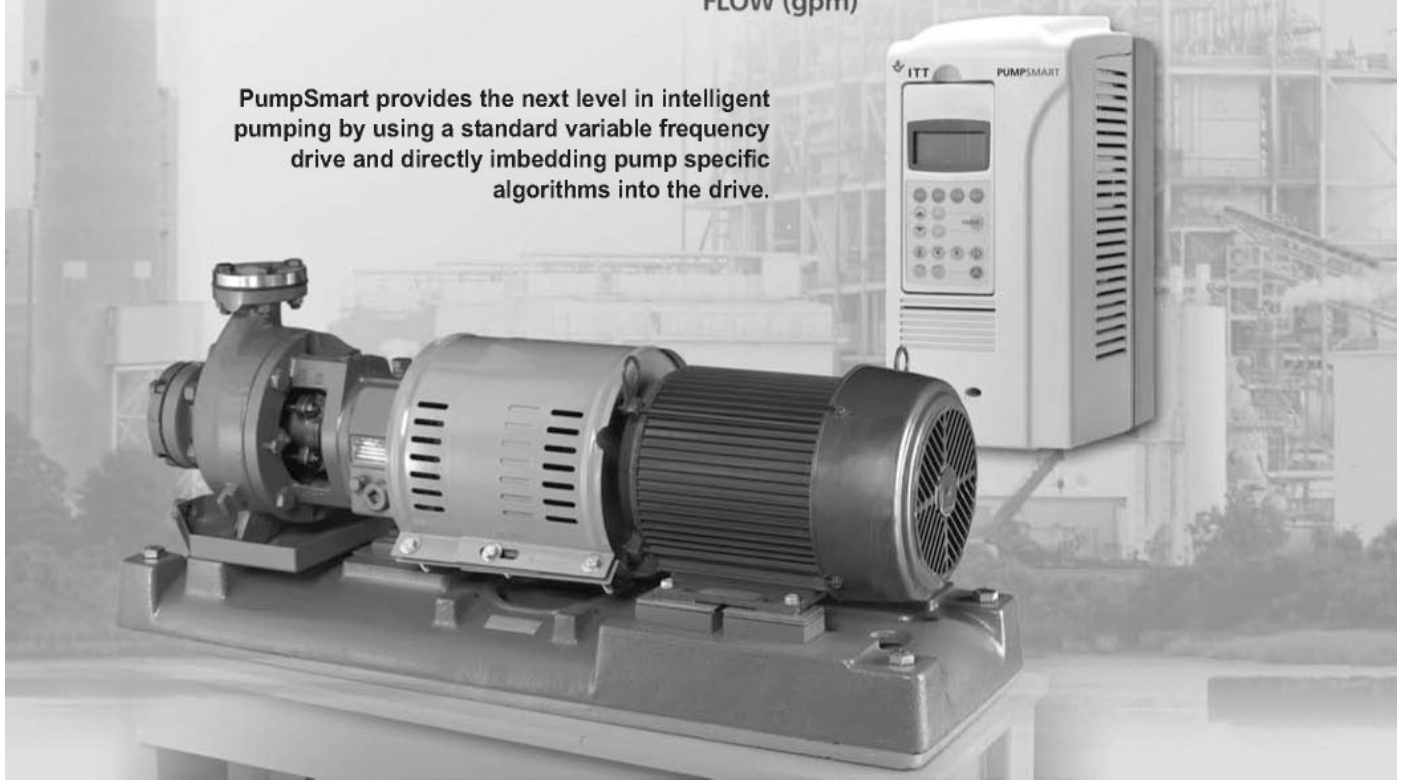
PumpSmart guarantees to protect the pump from upset conditions with patented sensorless pump protection algorithms.

Advanced pump **Control**, **Protection**, and **Optimization** logic designed to prevent failures, improve pump reliability and maximize the **Flow Economy** of your process systems.



Whereas other vendors will sell the VFD for your pump; let us pick the right control solution for your system. Your success is our goal. We are here to help you analyze your existing system, select the best solution and help justify the benefits.

PumpSmart provides the next level in intelligent pumping by using a standard variable frequency drive and directly imbedding pump specific algorithms into the drive.



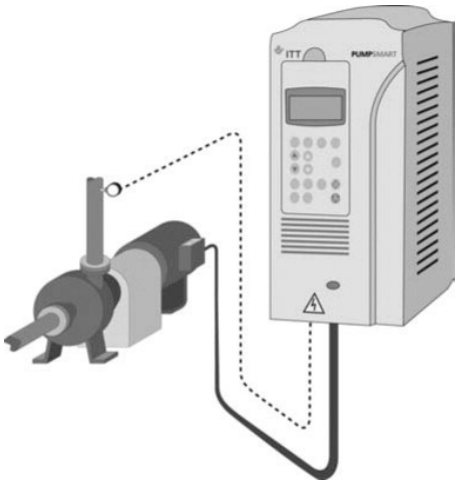
2 Ways to Benefit

Integrated Process Control

PumpSmart offers automatic pump control by integrating the pump controller in the drive. No external controller is required, making PumpSmart a simple and cost-effective solution for your basic pumping needs.

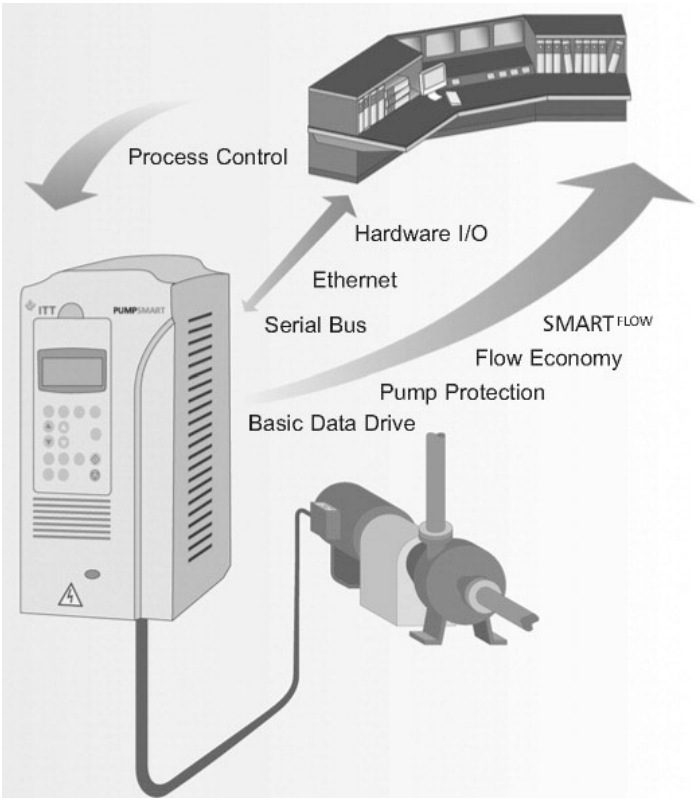
Process Control Features

- Single Pump
- Multipump
- Advanced Pressure Control
- Cavitation Control
- PID Smart Flow



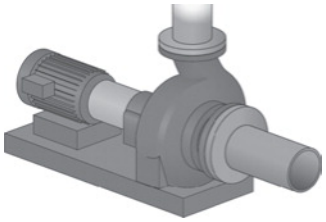
Drive for the DCS

While most VFD's can provide basic information to your control system, PumpSmart systems have been designed to provide the important data you need to help run your process smoothly and efficiently.



Use PumpSmart® as a standard VFD, but gain unprecedented insight into the performance of the pump with sensorless functions such as Smart Flow, Flow Economy and Advanced Pump Protection.

As standard, PumpSmart® systems come equipped with advanced process control features that help optimize your pumping system for maximum uptime, reliability and energy savings. PumpSmart® is pump-specific and was developed to protect the pump and optimize pump control. PumpSmart® can be applied to any manufacturer's centrifugal or positive displacement pump.



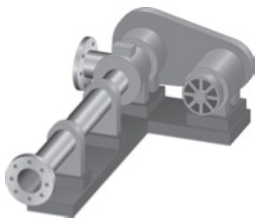
Horizontal Centrifugal Pump

Vertical Centrifugal Pump

Double Suction Centrifugal Pump

Submersible Pump

Positive Displacement Pump



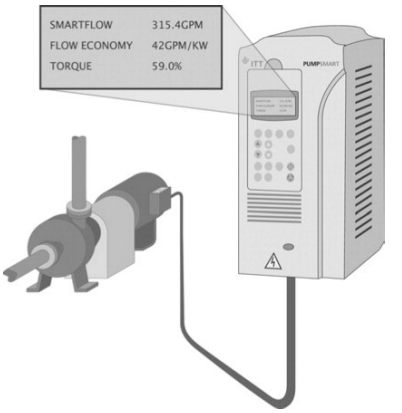
Progressive Cavity Pump

Enhanced Data

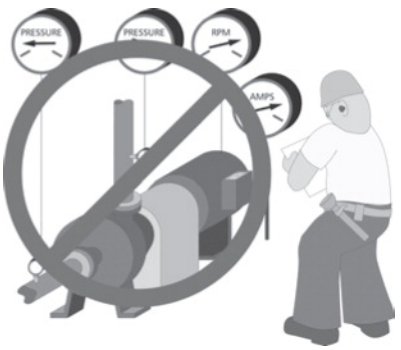
Smart Flow

Sensorless flow measurement within ± 5% of the pump's rated flow.

Determining the flow of a centrifugal pump can be a challenging exercise without a flow meter. PumpSmart® is able to capture real-time data such as speed, torque and power and use this information to calculate the flow of the pump.



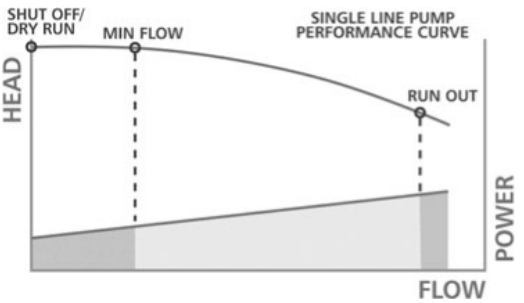
Smart Flow requires only four pieces of standard price book performance curve data. A self-calibration function takes into account changes in mechanical losses and volumetric efficiency, and separates the true hydraulic load to calculate the actual pump flow.

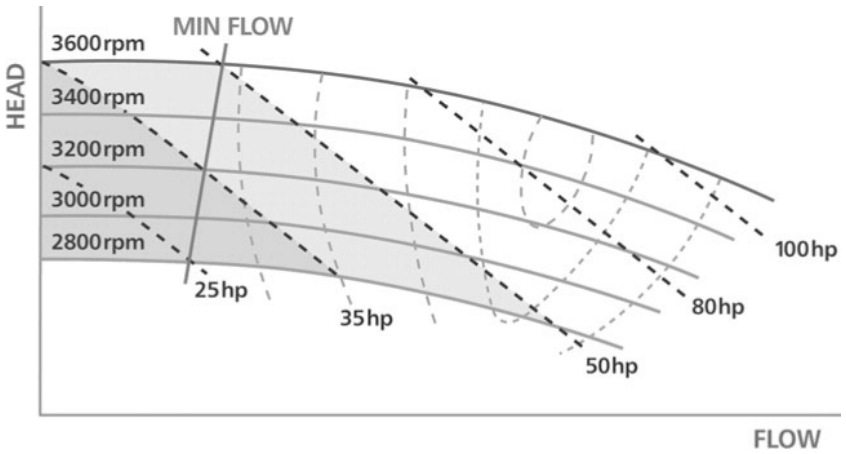


Pump Protection

Delete the crossed out text and graphic and replace with the following:
PumpSmart® can protect your pump from process upset conditions, such as dry-run, dead-head, shut-off, minimum flow and run-out. With patented sensorless pump protection algorithms, PumpSmart is able to determine the operating state of your pump at any operating speed. Using a simple load monitor function on a variable speed pump application can lead to false indications of pump distress. Be confident your pump is protected by the pump experts. Factors you must include in your pump protection logic:

- Variable Torque Load
- Mechanical Losses
- Volumetric Efficiency
- Eddy Current Losses
- Pump Wear



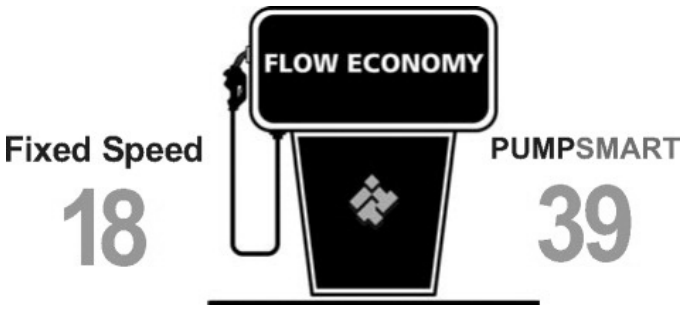


Optimized Control

Flow Economy

Flow Economy is a simple metric that defines how much fluid can be moved per unit of energy. Similar to fuel economy of your car, Flow Economy defines how much flow (gpm or m3/hr) can be moved with 1 kilowatt (kW) of power.

Combined with Smart Flow, PumpSmart is able to calculate the Flow Economy of your pump allowing you to know what the true pump system efficiency is.



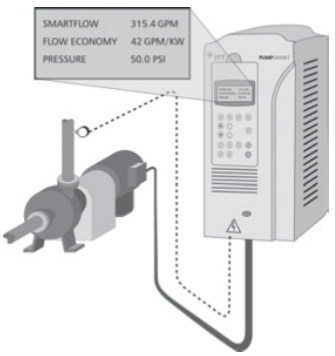
Integrated PID Control

PumpSmart® includes an integrated pump controller that can automatically control the pump based on feedback from a process transmitter. Pump-specific algorithms make field setup quick and simple.

PumpSmart® is ideal for all pumps that can benefit from simple and automatic control.

Typical Services:

- Pressure
- Flow
- Level
- Temperature



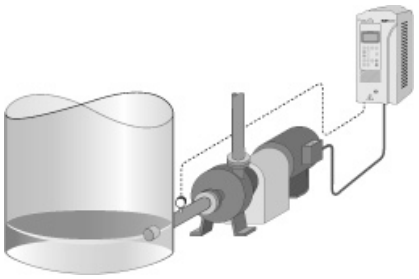
Cavitation Control & Protection

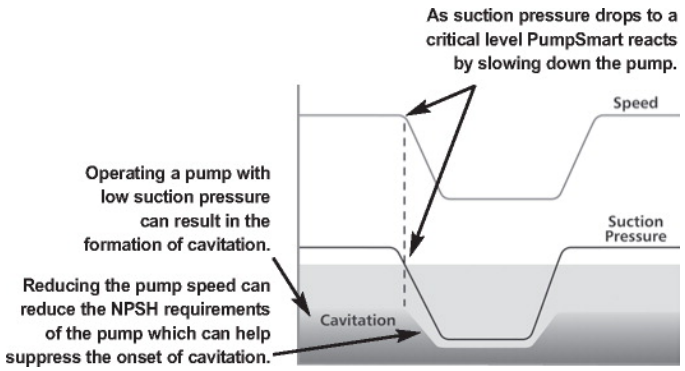
Low suction pressure can lead to the onset of cavitation, resulting in reduced flow and lower pump efficiencies. Prolonged exposure can even result in eventual pump failure.

PumpSmart® can monitor the suction conditions of your pump to protect against cavitation. Cavitation Control improves overall pump reliability in low NPSH services that routinely cause pump failure.

Typical Services:

- Evaporator
- Condensate
- Batch Transfer
- Unloading

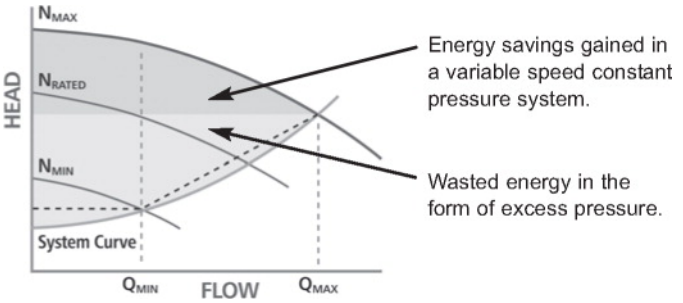


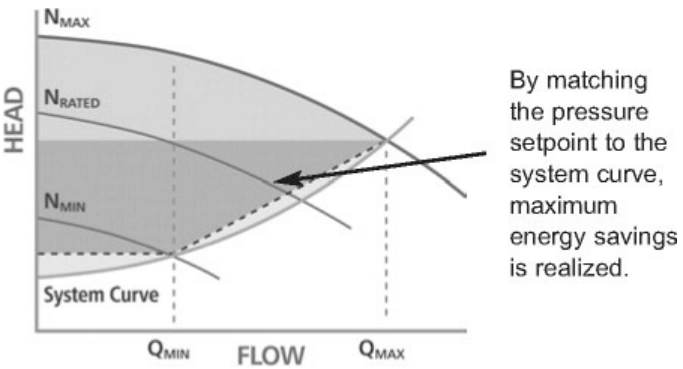


Advanced Pressure Control

The practice of setting the pump to maintain the highest pressure requirement is a wasted opportunity to maximize the energy savings in a constant pressure system.

Advanced Pressure Control recognizes an increase in demand and automatically increases the pressure setpoint to match the system resistance curve, maximizing flow economy.



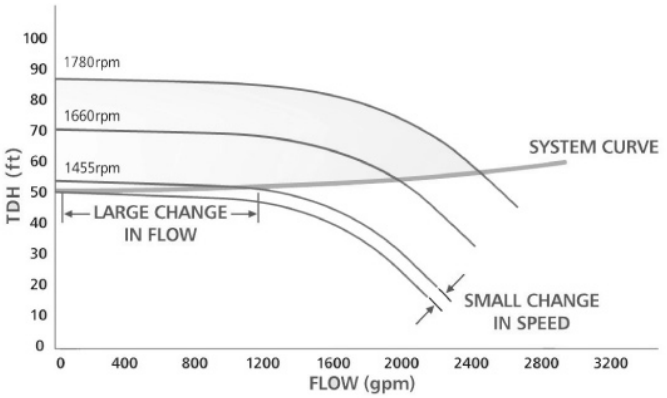


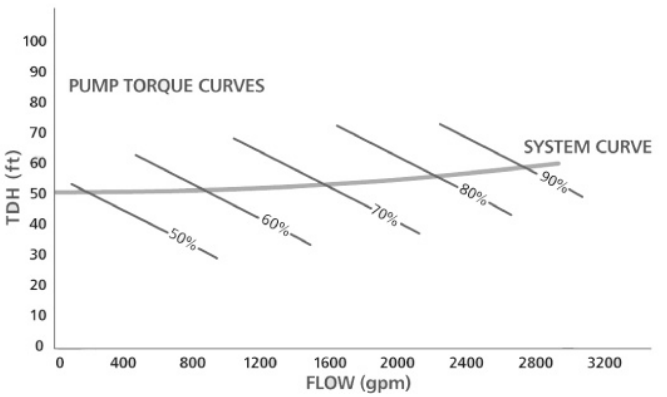
Smart Control

When changing the speed of the pump with a relatively flat head-capacity curve, a small speed change can result in a large swing in flow.

This type of system can result in unstable flow, making control very difficult.

SMART CONTROL is able to increase and decrease pump flow by changing the pump torque rather than the pump speed. Controlling to pump torque can change a relatively flat pump performance curve into a steep, easy-to-control pump performance curve.



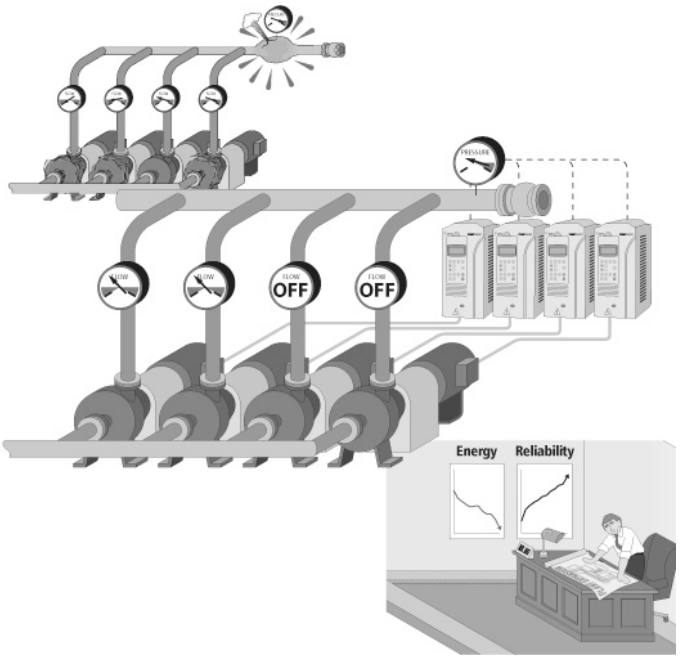


MultiPump Control

Control coordination between 2 to 4 pumps

All too often, multi-pump systems end up running with all the pumps on, all the time. This situation leads to high vibrations, pressure buildup and excess energy consumption… to name a few.

PumpSmart runs only the pumps necessary to meet the current system demand. In addition, it ensures that flow is balanced between the operating pumps using our SmartControl functionality. In total, energy consumption is greatly reduced, and mean time between failure of the pumps and the surrounding system is vastly improved.



Product Portfolio

PS200

POWER ..... 1-2250hp / 300-10,000hp
VOLTAGE ..... 208-690Vac / 4-6.9kVac
INPUT FREQUENCY 48-63HZ
EFFICIENCY ..... 98% at nominal load

OUTPUT ..... Pulse Width Modulated (PWM)
MOTOR CONTROL ..... Direct Torque Control
OUTPUT FREQUENCY ..... 0-300Hz (0-75Hz @ 4-6.9kV)
ENCLOSURE NEMA1, NEMA12 (IP21, IP54)
TEMPERATURE ..... 5-104F (-5-40C) standard
122F (50C) with de-rate
ALTITUDE ..... 0-3300ft (0-1000M) standard
13123 ft (4000m) with de-rate
HUMIDITY ..... 5-95% non-condensing
APPLICABLE STANDARDS UL 508C, CSA C22 No. 14-95, EN 50178, EN60204-1, IEC 60529, IEC 60664-1, EN61800-3 + Amendment A11, CE Compliant

OPTIONS
Low Harmonic (AFE)
Field Bus Communication
Fused Disconnects
NEMA3R (IP55)
NEMA4 (IP65)
NEMA4x (IP66)
VFD Bypass
Multi-pump Panels

PS75

POWER 1-150hp (1-90kW)
VOLTAGE ..... 208-600Vac 3Ph +/– 10%
208-240Vac 1Ph +/– 10%
(50% de-rate)
INPUT FREQUENCY 48-63HZ
EFFICIENCY ..... 98% at nominal load
Rectifier
OUTPUT ..... Pulse Width Modulated (PWM)
MOTOR CONTROL .....Sensorless Vector
OUTPUT FREQUENCY 0-300Hz
ENCLOSURE NEMA1, NEMA12 (IP21, IP54)
TEMPERATURE ..... 5-104F (-5-40C) standard
122F (50C) with de-rate
ALTITUDE ..... 0-3300ft (0-1000M) standard
13123 ft (4000m) with de-rate
HUMIDITY ..... 5-95% non-condensing
APPLICABLE STANDARDS UL 508C, CSA C22 No. 14-95, EN 50178, EN60204-1, IEC 60529, IEC 60664-1, EN61800-3 + Amendment A11, CE Compliant

OPTIONS
Field Bus Communication
Fused Disconnects
NEMA3R (IP55)
NEMA4 (IP65)
NEMA4x (IP66)
MCC Bucket Mount
VFD Electronic Bypass

SMART FLOW	Flow Economy	Sensorless Pump Protection	Protection Limit	SMART CONTROL	Torque Balance	PID Process Control	PID Sleep Function	Cavitation Control	Advanced Pressure Control	Multipump Synchronous	Multipump Constant Slave	Condition Monitoring	Secondary Protection	Energy Savings Calculator
●	●	●	●	●	●	●	●	●	●	●	●		●	●
		●	●				●	●				●	●	

PUMPSMART FEATURES TABLE

For technical details, visit www.ittmc.com

NOTES

9

Technical Data

Table of Contents Technical Data Section

The information in this section is, to the best of our knowledge, reliable. However, the data presented are not to be construed as a warranty or representation.

TECH-A **Centrifugal Pump Fundamentals**

TECH-A-1 Head 862
TECH-A-2 Capacity 864
TECH-A-3 Power and Efficiency 864
TECH-A-4 Specific Speed and Pump Type 865
TECH-A-5 Net Positive Suction Head (NPSH) and Cavitation 865
TECH-A-6 NPSH Suction Specific Speed and Suction Energy 867
TECH-A-7 Centrifugal Pump Operation without NPSH Problems 868
TECH-A-8 Pump Characteristic Curves 871
TECH-A-9 Affinity Laws 873
TECH-A-10 System Curves 875
TECH-A-11 Basic Formulas and Symbols 877

TECH-B **Pump Application Data**

TECH-B-1 Corrosion & Materials of Construction 878
TECH-B-2 Material Selection Chart 879
TECH-B-3 Piping Design 885
TECH-B-4A Sealing 887
TECH-B-4B Magnetic Drive Pumps 900
TECH-B-5 Field Testing Methods 902
TECH-B-6 Vibration Analysis 904
TECH-B-7 Vertical Turbine Pumps 905
TECH-B-8 Self Priming Pump System Guidelines 908
TECH-B-9 Priming Time Calculations 909

TECH-C **Water Data**

TECH-C-1 Friction Loss for Water – Sched 40 Steel Pipe 910
TECH-C-2 Resistance Coefficients for Valves and Fittings 914
TECH-C-3 Resistance Coefficients for Increasers and Diffusers 916
TECH-C-4 Resistance Coefficients for Reducers 916
TECH-C-5 Properties of Water at Various Temperatures from 32° to 705.4°F 917
TECH-C-6 Atmospheric Pressure, Barometric Reading and Boiling Point of Water 918
TECH-C-7 Saturation: Temperatures 919
TECH-C-8 Saturation: Pressures 920

TECH-D **Properties of Liquids**

TECH-D-1 Viscosity 921
TECH-D-2A Viscosity Conversion Table 922
TECH-D-2B Viscosity Conversion Table 923
TECH-D-3 Determination of Pump Performance When Handling Viscous Liquids 924
TECH-D-4A Viscosity of Common Liquids 925
TECH-D-4B Physical Properties of Common Liquids 928
TECH-D-5 Friction Loss for Viscous Liquids 932
TECH-D-6 Pumping Liquids with Entrained Gas 933
TECH-D-7A Solids and Slurries - Definition of Terms 933
TECH-D-7B Solids and Slurries - Slurry Pump Applications 934
TECH-D-7C Solids and Slurries - Useful Formulas 936
TECH-D-7D Abrasive Slurries and Pump Wear 945
TECH-D-8 Vapor Pressure – Various Liquids 946

TECH-E **Paper Stock**

TECH-E-1 Paper Stock Discussion 948
TECH-E-2 Conversion Chart of Mill Output in Tons per 24 Hours 949
TECH-E-2.1 Definitions/Conversion Factors 949
TECH-E-3 Friction Loss of Pulp Suspensions in Pipe 950
TECH-E-4 Pump Types Used in the Pulp & Paper Industry 958

TECH-F **Mechanical Data**

TECH-F-1 Weights and Dimensions of Mechanical Joint Cast Iron Pipe 959
TECH-F-2 125 Lb. & 250 Lb. Cast Iron Pipe Flanges and Flanged Fittings 960
TECH-F-3 Steel Pipe, Dimensions and Weights 961
TECH-F-4 150 Lb. and 300 Lb. Steel Pipe Flanges and Fittings 962
TECH-F-5 150 Lb. ANSI/Metric Flange Comparison 963
TECH-F-6 300 Lb. ANSI/Metric Flange Comparison 964
TECH-F-7 Weights and Dimensions of Steel & Wrought Iron Pipe 965
TECH-F-8 Capacities of Tanks of Various Dimensions 966

TECH-G **Motor Data**

TECH-G-1 Motor Enclosures 968
TECH-G-2 NEMA Frame Assignments 969
TECH-G-3 NEMA Frame Dimensions 970
TECH-G-4 Synchronous and Approximate Full Load Speed of Standard A.C. Induction Motors 971
TECH-G-5 Full Load Amperes at Motor Terminals 971
TECH-G-6 Motor Terms 972
TECH-G-7 Electrical Conversion Formulae 973
TECH-G-8 Vertical Motors 974
TECH-G-9 I.E.C. Motor Frames 976
TECH-G-10 TEFC IP55 Metric IEC Motors (Conversion NEMA to Metric) 978

TECH-H **Conversion Factors**

TECH-H-1 Temperature Conversion Chart {Centigrade (Celsius)-Fahrenheit} 979
TECH-H-2 A.P.I. and Baumé Gravity Tables and Weight Factors 980
TECH-H-3 Approximate Conversion Table 981
TECH-H-4 Conversion Factors 981
TECH-H-5 Quick Convert Tables 987
TECH-H-6 Conversion Chart–Gallons Per Minute to Barrels Per Day 988
TECH-H-7 Decimal and Millimeter Equivalents of Fractions 988
TECH-H-8 Atmospheric Pressures and Barometric Readings 989

TECH-I **Basic Troubleshooting**

TECH-I-1 Symptoms and Causes of Hydraulic and Mechanical Pump Failure 990
TECH-I-2 Troubleshooting Centrifugal Pumps 991

TECH-J **Miscellaneous Pump Information**

TECH-J-3 Raised Face and Flat Face Flanges (Mating Combinations) 994
TECH-J-4 Predictive and Preventive Maintenance Program 995

TECH-A-1 Head

The pressure at any point in a liquid can be thought of as being caused by a vertical column of the liquid which, due to its weight, exerts a pressure equal to the pressure at the point in question. The height of this column is called the static head and is expressed in terms of feet of liquid.

The static head corresponding to any specific pressure is dependent upon the weight of the liquid according to the following formula.

$$\text{Head in Feet} = \frac{\text{Pressure in psi x 2.31}}{\text{Specific Gravity}}$$

A centrifugal pump imparts velocity to a liquid. This velocity energy is then transformed largely into pressure energy as the liquid leaves the pump. Therefore, the head developed is approximately equal to the velocity energy at the periphery of the impeller This relationship is expressed by the following well-known formula:

$$H = \frac{v^2}{2g}$$

where H = Total head developed in feet.

v = Velocity at periphery of impeller in feet per sec.

g = 32.2 Feet/Sec.^{2}

We can predict the approximate head of any centrifugal pump by calculating the peripheral velocity of the impeller and substituting into the above formula. A handy formula for peripheral velocity is:

$$v = \frac{\text{RPM x D}}{229}$$ Where D = Impeller diameter in inches

The above demonstrates why we must always think in terms of feet of liquid rather than pressure when working with centrifugal pumps. A given pump with a given impeller diameter and speed will raise a liquid to a certain height regardless of the weight of the liquid, as shown in Fig. 1.

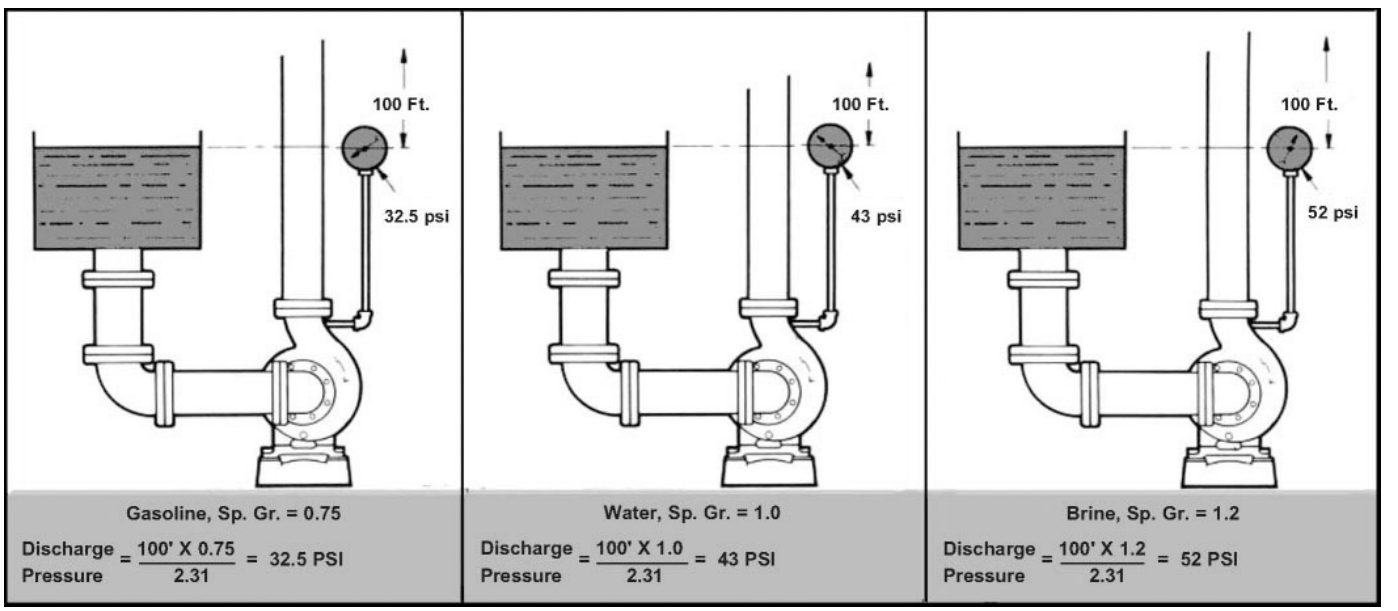


Fig. 1 Identical Pumps Handling Liquids of Different Specific Gravities.

All of the forms of energy involved in a liquid flow system can be expressed in terms of feet of liquid. The total of these various heads determines the total system head or the work which a pump must perform in the system. The various forms of head are defined as follows.

SUCTION LIFT exists when the source of supply is below the centerline of the pump. Thus the STATIC SUCTION LIFT is the vertical distance in feet from the centerline of the pump to the free level of the liquid to be pumped.

SUCTION HEAD exists when the source of supply is above the centerline of the pump. Thus the STATIC SUCTION HEAD is the vertical distance in feet from the centerline of the pump to the free level of the liquid to be pumped.

STATIC DISCHARGE HEAD is the vertical distance in feet between the pump centerline and the point of free discharge or the surface of the liquid in the discharge tank.

TOTAL STATIC HEAD is the vertical distance in feet between the free level of the source of supply and the point of free discharge or the free surface of the discharge liquid.

The above forms of static head are shown graphically in Fig. 2-a & 2-b

FRICTION HEAD (h_f) is the head required to overcome the resistance to flow in the pipe and fittings. It is dependent upon the size and type of pipe, flow rate, and nature of the liquid. Frictional tables are included in section TECH-C.

VELOCITY HEAD (h_v) is the energy of a liquid as a result of its motion at some velocity V. It is the equivalent head in feet through which the water would have to fall to acquire the same velocity, or in other words, the head necessary to accelerate the water. Velocity head can be calculated from the following formula:

$$h_v = \frac{V^2}{2g}$$

where g = 32.2 ft/sec.^{2}

V = liquid velocity in feet per second

The velocity head is usually insignificant and can be ignored in most high head systems. However, it can be a large factor and must be considered in low head systems.

PRESSURE HEAD must be considered when a pumping system either begins or terminates in a tank which is under some pressure other than atmospheric. The pressure in such a tank must first be converted to feet of liquid. A vacuum in the suction tank or a positive pressure in the discharge tank must be added to the system head, whereas a positive pressure in the suction tank or vacuum in the discharge tank would be subtracted. The following is a handy formula for converting inches of mercury vacuum into feet of liquid.

$$\text{Vacuum, ft. of liquid} = \frac{\text{Vacuum, in. of Hg x 1.134}}{\text{Sp. Gr.}}$$

The above forms of head, namely static, friction, velocity, and pressure, are combined to make up the total system head at any particular flow rate. Following are definitions of these combined or "Dynamic" head terms as they apply to the pump.

TOTAL DYNAMIC SUCTION LIFT (h_s) is the static suction lift minus the velocity head at the pump suction flange plus the total friction head in the suction line. The total dynamic suction lift, as determined on pump test, is the reading of a gauge on the suction flange, converted to feet of liquid and corrected to the pump centerline, minus the velocity head at the point of gauge attachment.

TOTAL DYNAMIC SUCTION HEAD (h_s) is the static suction head plus the velocity head at the pump suction flange minus the total friction head in the suction line. The total dynamic suction head, as determined on pump test, is the reading of the gauge on the suction flange, converted to feet of liquid and corrected to the pump centerline, plus the velocity head at the point of gauge attachment.

TOTAL DYNAMIC DISCHARGE HEAD (h_d) is the static discharge head plus the velocity head at the pump discharge flange plus the total friction head in the discharge line. The total dynamic discharge head, as determined on pump test, is the reading of a gauge at the discharge flange, converted to feet of liquid and corrected to the pump centerline, plus the velocity head at the point of gauge attachment.

TOTAL HEAD (H) or TOTAL DYNAMIC HEAD (TDH) is the total dynamic discharge head minus the total dynamic suction head or plus the total dynamic suction lift.

$$TDH = h_d + h_s \text{ (with a suction lift)}$$
$$TDH = h_d - h_s \text{ (with a suction head)}$$

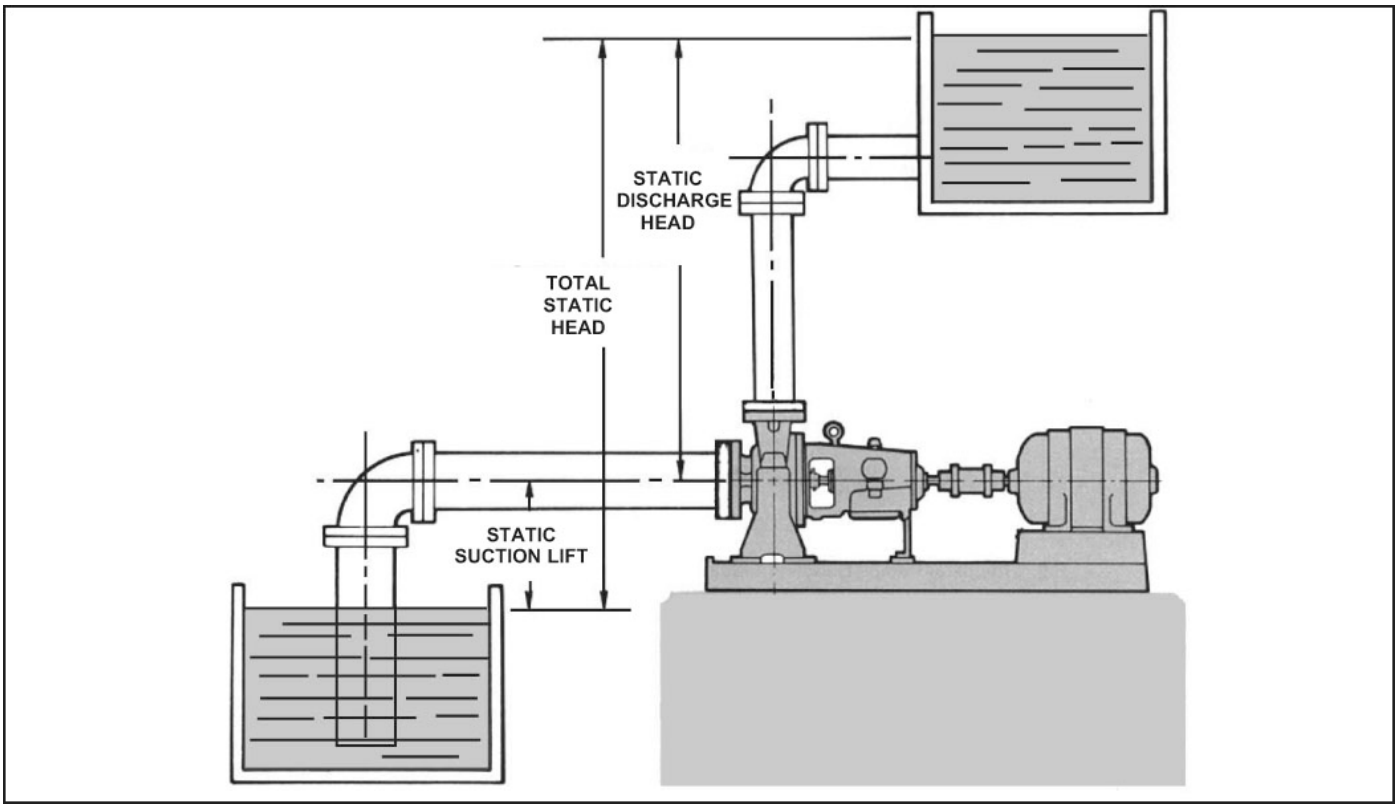


Fig. 2-a Suction Lift – Showing Static Heads in a Pumping System Where the Pump is Located Above the Suction Tank. (Static Suction Lift)

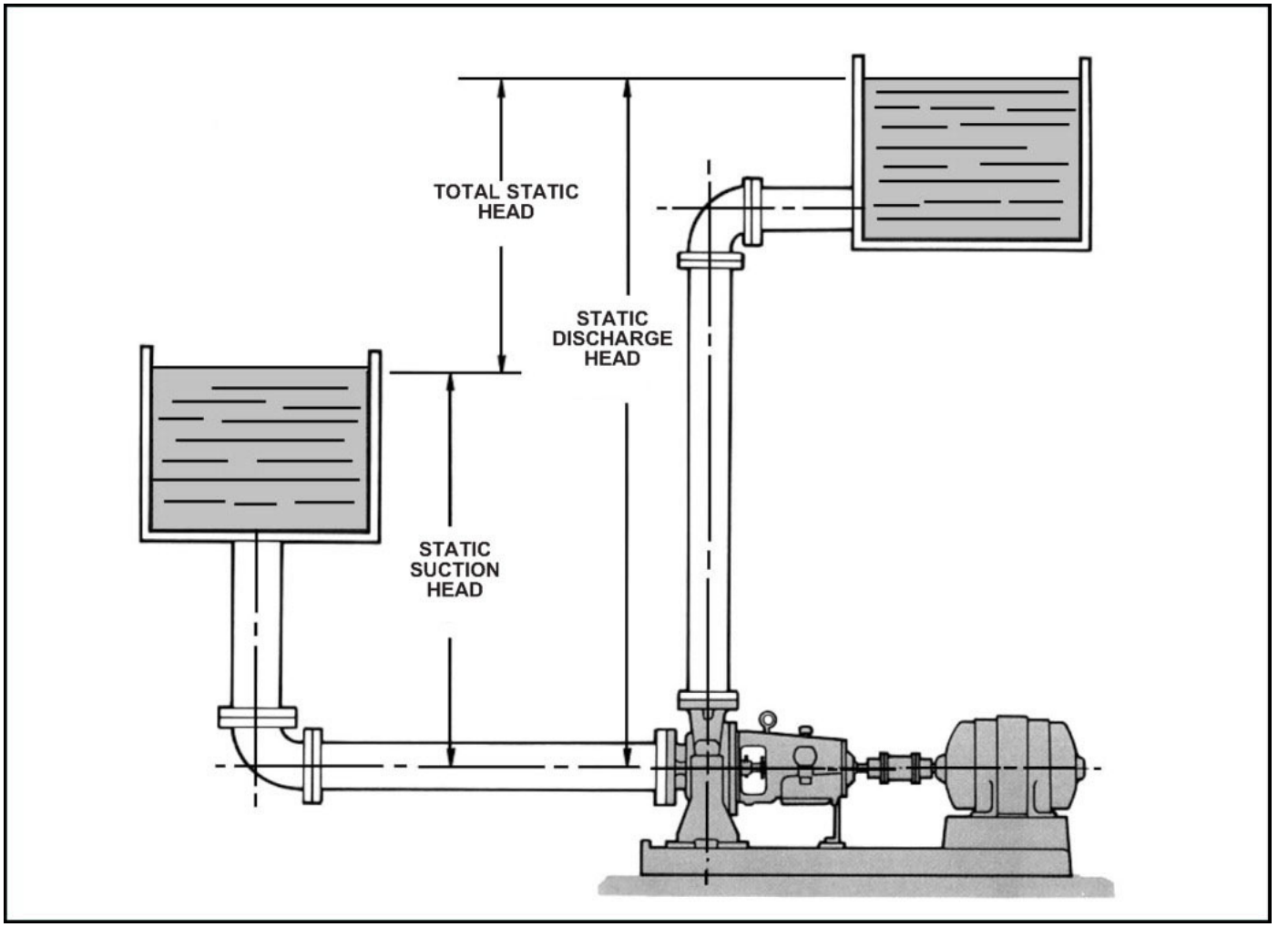


Fig. 2-b Suction Head – Showing Static Heads in a Pumping System Where the Pump is Located Below the Suction Tank. (Static Suction Head)

TECH-A-2 Capacity

Capacity (Q) is normally expressed in gallons per minute (gpm). Since liquids are essentially incompressible, there is a direct relationship between the capacity, or flow rate, and the pipe sze and fluid velocity. This relationship is as follows:

$$Q = V \times (ID^2) \times 2.445$$

where
ID = inside diameter of the pipe, inches
V = Velocity of the liquid, feet per second
Q = capacity, gallons per minute

TECH-A-3 Power and Efficiency

The work performed by a pump is a function of the total head and the weight of the liquid pumped in a given time period. The pump capacity in gpm and the liquid specific gravity are normally used in the formulas rather than the actual weight of the liquid pumped.

Pump input or brake horsepower (bhp) is the actual horsepower delivered to the pump shaft. Pump output or hydraulic horsepower (whp) is the liquid horsepower delivered by the pump. These two terms are defined by the following formulas.

$$whp = \frac{Q \times TDH \times Sp.\ Gr.}{3960}$$

$$bhp = \frac{Q \times TDH \times Sp.\ Gr.}{3960 \times Pump\ Efficiency}$$

The constant 3960 is obtained by dividing the number or foot pounds for one horsepower (33,000) by the weight of one gallon of water (8.33 pounds.)

The brake horsepower or input to a pump is greater than the hydraulic horsepower or output due to the mechanical and hydraulic losses incurred in the pump. Therefore the pump efficiency is the ratio of these two values.

$$Pump\ Eff = \frac{whp}{bhp} = \frac{Q \times TDH \times Sp.\ Gr.}{3960 \times bhp}$$

TECH-A-4 Specific Speed and Pump Type

Specific speed (N_s) is a non-dimensional design index used to classify pump impellers as to their type and proportions. It is defined as the speed in revolutions per minute at which a geometrically similar impeller would operate if it were of such a size as to deliver one gallon per minute against one foot head.

The understanding of this definition is of design engineering significance only, however, and specific speed should be thought of only as an index used to predict certain pump characteristics. The following formula is used to determine specific speed:

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}}$$

where N = Pump speed in RPM

Q = Capacity in USGPM (m^3/hr) at the best efficiency point

H = Total head per stage (feet/meters) at the best efficiency point

The specific speed determines the general shape or class of the impeller as depicted in Fig. 3. As the specific speed increases, the ratio of the impeller outlet diameter, D_2, to the inlet or eye diameter, D_1, decreases. This ratio becomes 1.0 for a true axial flow impeller.

Radial flow impellers develop head principally through centrifugal force. Pumps of higher specific speeds develop head partly by centrifugal force and partly by axial force. A higher specific speed indicates a pump design with head generation more by axial forces and less by centrifugal forces. An axial flow or propeller pump with a specific speed of 10,000 or greater generates its head exclusively through axial forces.

Radial impellers are generally low flow high head designs whereas axial flow impellers are high flow low head designs.

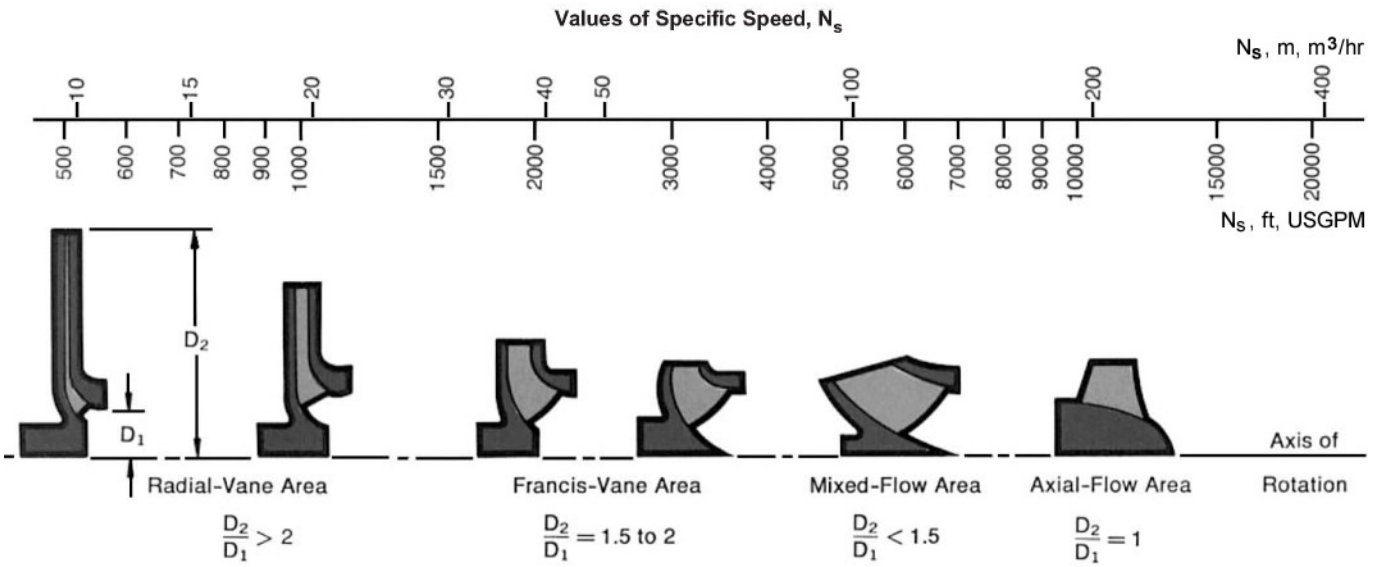


Fig. 3 Impeller Design vs Specific Speed

TECH-A-5 Net Positive Suction Head (NPSH) and Cavitation

The Hydraulic Institute defines NPSH as the total suction head in feet absolute, determined at the suction nozzle and corrected to datum, less the vapor pressure of the liquid in feet absolute. Simply stated, it is an analysis of energy conditions on the suction side of a pump to determine if the liquid will vaporize at the lowest pressure point in the pump.

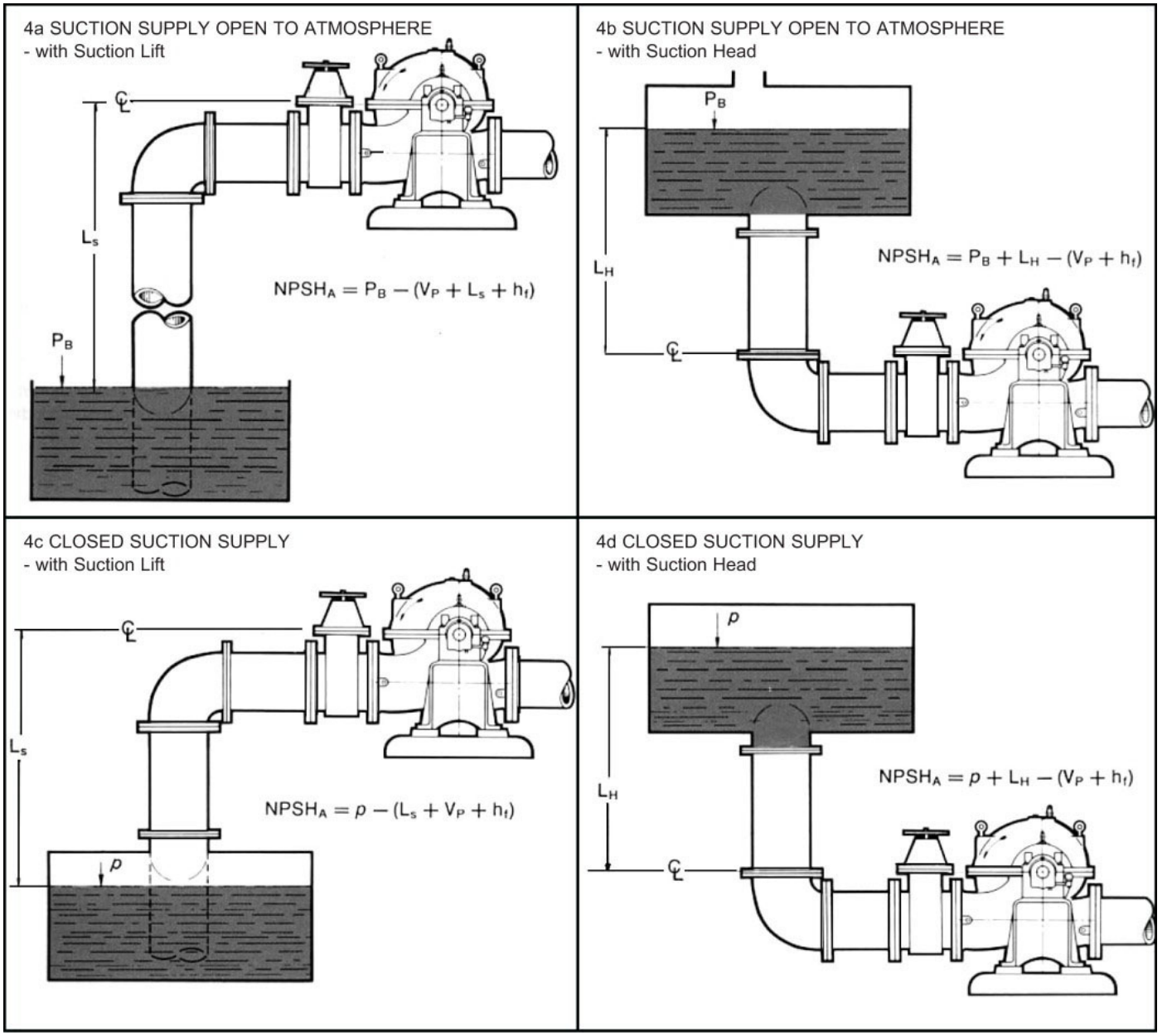
The pressure which a liquid exerts on its surroundings is dependent upon its temperature. This pressure, called vapor pressure, is a unique characteristic of every fluid and increases with increasing temperature. When the vapor pressure within the fluid reaches the pressure of the surrounding medium, the fluid begins to vaporize or boil. The temperature at which this vaporization occurs will decrease as the pressure of the surrounding medium decreases.

A liquid increases greatly in volume when it vaporizes. One cu. ft. (0.03 m^3) of water at room temperature becomes 1700 cu. ft. (48 m^3) of vapor at the same temperature.

It is obvious from the above that if we are to pump a fluid effectively, we must keep it in liquid form. NPSH is simply a measure of the amount of suction head present to prevent this excess vaporization at the lowest pressure point in the pump.

NPSH Required is a function of the pump design. As the liquid passes from the pump suction to the eye of the impeller, the velocity increases and the pressure decreases. There are also pressure losses due to shock and turbulence as the liquid strikes the impeller. The centrifugal force of the impeller vanes further increases the velocity and decreases the pressure of the liquid. The NPSH Required is the positive head in feet absolute required at the pump suction to overcome these pressure drops in the pump and maintain enough of the liquid above its vapor pressure to limit the head loss, due to the blockage of the cavitation vapor bubble, to 3 percent. The 3% head drop criteria for NPSH Required is used worldwide and is based on the ease of determining the exact head drop off point. Most standard low suction energy pumps can operate with little or no margin above the NPSH Required, without seriously affecting the service life of the pump. The NPSH Required varies with speed and capacity within any particular pump. Pump manufacturer's curves normally provide this information.

NPSH Available is a function of the system in which the pump operates. It is the excess pressure of the liquid in feet absolute over its vapor pressure as it arrives at the pump suction. Fig. 4 shows four typical suction systems with the NPSH Available formulas applicable to each. It is important to correct for the specific gravity of the liquid and to convert all terms to units of "feet absolute" in using the formulas.



P_B = Barometric pressure, in feet (meters) absolute.

V_P = Vapor pressure of the liquid at maximum pumping temperature, in feet (meters) absolute.

p = Pressure on surface of liquid in closed suction tank, in feet (meters) absolute.

L_S = Maximum static suction lift in feet (meters).

L_H = Minimum static suction head in feet (meters).

h_f = Friction loss in feet (meters) in suction pipe at required capacity.

In an existing system, the NPSH Available can be determined by a gauge on the pump suction. The following formula applies:

$$NPSH_A = P_B - V_p \pm Gr + h_v$$

Where Gr = Gauge reading at the pump suction expressed in feet (meters) (plus if above atmospheric, minus if below atmospheric) corrected to the pump centerline.

h_v = Velocity head in the suction pipe at the gauge connection, expressed in feet (meters).

Cavitation is a term used to describe the phenomenon, which occurs in a pump when there is insufficient NPSH Available. The pressure of the liquid is reduced to a value equal to or below its vapor pressure and small vapor bubbles or pockets begin to form. As these vapor bubbles move along the impeller vanes to a higher pressure area, they rapidly collapse.

The collapse, or "implosion," is so rapid that it may be heard as a rumbling noise, as if you were pumping gravel. In high suction energy pumps, the collapses are generally high enough to cause minute pockets of fatigue failure on the impeller vane surfaces. This action may be progressive, and under severe (very high suction energy) conditions can cause serious pitting damage to the impeller.

The accompanying noise is the easiest way to recognize cavitation. Besides possible impeller damage, excessive cavitation results in reduced capacity due to the vapor present in the pump. Also, the head may be reduced and/or be unstable and the power consumption may be erratic. Vibration and mechanical damage such as bearing failure can also occur as a result of operating in excessive cavitation, with high and very high suction energy pumps.

The way to prevent the undesirable effects of cavitation in small to medium size pumps is to ensure NPSH Available in the system exceeds the pump NPSH Required by ratio of at least 1.2 or 3ft (1m) whichever is greater. Larger or high speed pumps require additional NPSH margin. Refer to ANSI/H1 STANDARD 9.6.2 2012 for how to determine the recommended margin.

TECH-A-6 NPSH Suction Specific Speed and Suction Energy

In designing a pumping system, it is essential to provide adequate NPSH Available for proper pump operation. Insufficient NPSH Available may seriously restrict pump selection, or even force expensive system redesign. On the other hand, providing excessive NPSH Available may needlessly increase system cost.

Suction specific speed may provide help in this situation in understanding what pump performance is possible.

Suction specific speed (N_{ss}) is defined as:

$$N_{ss} = \frac{N\sqrt{Q}}{NPSH_R^{0.75}}$$

Where **N** = Pump speed RPM

Q = Pump flow at best efficiency point and maximum impeller diameter. (For double entry impellers divide the total pup flow by two)

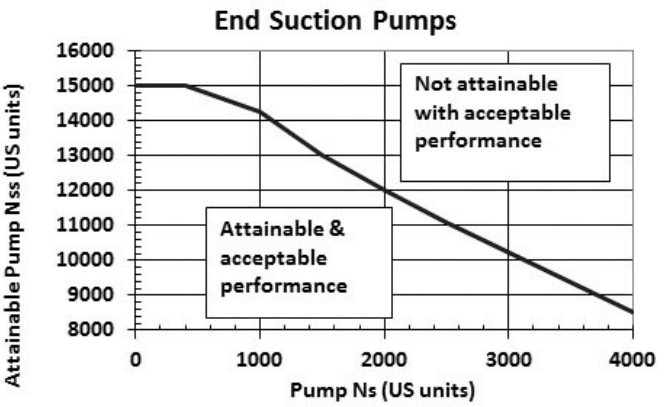
$NPSH_R$ = Pump NPSH required at beast efficiency point and maximum impeller diameter

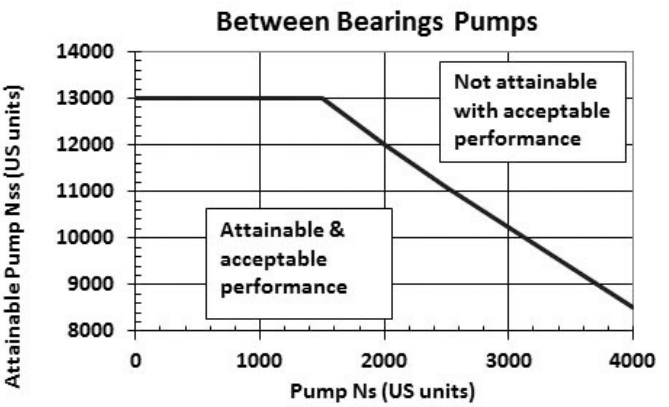
For a given pump, the suction specific speed (N_{ss}) is generally a constant - it does not change when the pump speed is changed. The maximum practical suction specific speed depends on the pump specific speed (N_s). As the pump specific speed increases, the maximum practical suction specific speed decreases.

This is because when the pump specific speed or suction specific speed increase, the ratio of D1/D2 (impeller eye diameter/impeller outlet diameter), tends to increase as well. The ratio D1/D2 also determines when suction side recirculation starts, the larger the ratio, the closer to BEP suction recirculation and the vibration that accompanies it occurs.

In order to prevent excessive suction side recirculation, the suction specific speed must be limited to miantain a suitable D1/D2 ratio. (Clearly the pump specific speed can't be changed since this is the primary design goal).

The charts show the range of achievable suction specific speeds as a function of pump specific speed. While exceptions to these recommendations exist, the charts are a good general guide to what can be achieved.





TECH-A-7 Centrifugal Pump Operation without NPSH Problems

Centrifugal Value with Centrifugal Pumps

General

There are many detailed publications on the subject of the NPSH value. In practice, however, mistakes are made repeatedly, with pump damage or even complete system failure as a result.

This guideline is therefore intended to indicate where and how the system NPSH value can be rendered more favorable using various parameters, and the criteria which are important for pump selection.

NPSH means "Net Positive Suction Head." A system from which, for instance, cold water flows to a pump from a height of 3 ft (1 m) without a pressure drop has an NPSH value of aprox 36 ft. (11 m), (not 3 ft. (1m)).

NPSH A = 36 ft. (11 m)

A = available

Here, only one pump with an NPSHR value of 33 ft. (10 m) or less can normally be used, in order that a safety margin of at least 3 ft. (1 m) is available. Note that some pumps require more than 3 ft (1 m). Refer to ANSI/H1 9.6.1 2012 for more guidance.

NPSHR = 33 ft. (10 m)

R = required

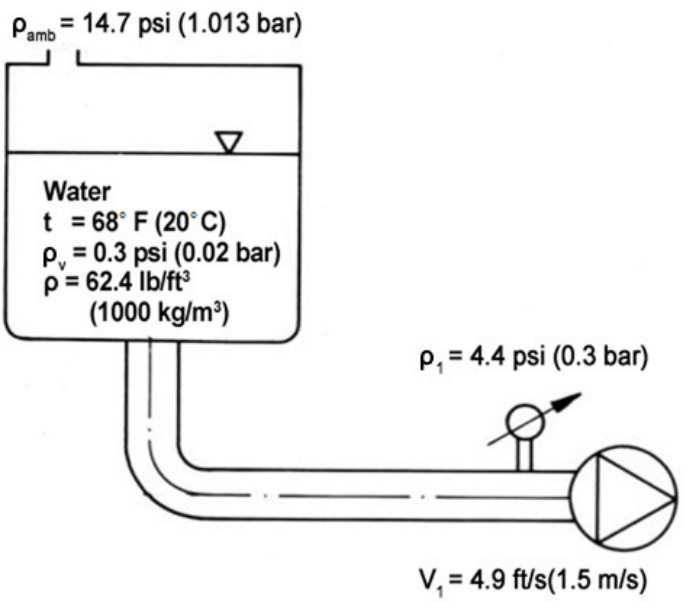
NPSHA Value of the System

$$NPSHA = \frac{4622\,(\rho_1 + \rho_{amb} - \rho_v)}{\varrho} + \frac{v_1^2}{2g}$$

NPSHA in ft (m)	Net positive suction head $_{avail.}$
ρ_1	in psi (bar)
	Gauge pressure in suction nozzle directly upstream the pump (in case of underpressure, this value is used with a negative "=" sign).
	in psi (bar)
ρ_{amb}	in psi (bar) absolute
	Air pressure, normally 14.69 psi (1.013 bar) absolute
ρ_v	in psi (bar) absolute
	Vapor pressure of the fluid at working temperature.
ϱ	in lb/ft^3 (kg/m^3)
	Density of the fluid at working temperature.
V_1	in ft/s (m/s)
	Velocity of fluid conveyed in the suction nozzle.

This data is referred directly to the center point of the suction nozzle. .

Example 1



Calculation:

$$NPSHA = \frac{10^5 (p_1 + p_{amb} - p_v)}{\rho g} + \frac{V_1^2}{2g} \text{ (SI units)}$$

$$NPSHA = \frac{10^5 (0.3 + 1.013 - 0.02)}{1000 * 9.81} + \frac{1.5^2}{2 * 9.81} = 13.3m \text{ (SI units)}$$

$$NPSHA = \frac{4622 (p_1 + p_{amb} - p_v)}{\rho g} + \frac{V_1^2}{2g} \text{ (US units)}$$

$$NPSHA = \frac{4622 (4.4 + 14.7 - 0.3)}{62.4 * 32.2} + \frac{4.9^2}{2 * 32.2} = 43.6\ ft \text{ (US units)}$$

Suggestions for Remedies to NPSH Problems

NPSHR Value of the Pump

This value can be roughly calculated, but is generally determined on a test rig, at a specified speed, a defined impeller diameter and a defined delivery rate. The NPSHR value is determined by ascertaining the total delivery head of the pump at various suction heads. In order to obtain various suction heads, the pressure in the suction reservoir is lowered by means of a throttling device. Combinations of these methods are frequently used in order to achieve the required vacuum.

The greater the vacuum on the impeller inlet becomes, the more cavitation occurs. This impairs the pump's delivery head. The value at which the pump's total delivery head drops by 3% as a result of such cavitation is now stated as the NPSHR value.

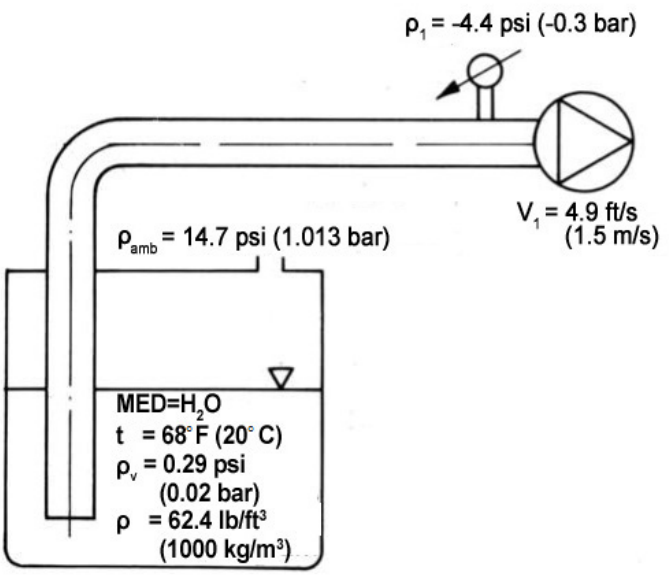
Several tests at the same delivery rate and differing pressure in the suction nozzle are necessary, until by means of repeated measurement/calculation, etc., a total delivery head drip of 3% has been ascertained.

For determination of an NPSHR curve, these measurements are performed at various flows and at various impeller diameters. The compilation of such a series of curves consequently requires a lot of tests.

NPSHA<NPSHR - What can be done?
Referring to the system, the individual formula values can be adhered to.

ρ_1	Increase pressure at the suction nozzle, i.e. feed more fluid, which is to say, raise the fluid level in the feed reservoir, raise the intake reservoir to a higher level or lower the pump, e.g., one floor down. On the other hand, the nominal diameter of the suction line should be adequately dimensioned, and it should be ensured that the valves/fittings in the suction line have the minimum possible friction loss coefficient in order that ρ_1 is as high as possible at the pump. Ball valves with a fully open cross-section, for instance, are particularly suitable.
ρ_{amb}	No opportunities for change unless the tank is closed and pressurized.
ρ_v	In few cases, the fluid can be cooled before its entry to the pump, in order to reduce vapor pressure.
ϱ	No opportunities for change of the fluid density.
V_1	Since this value accords with that of the pump's suction nozzle, it is of no significance for this discussion. V_1 should, naturally, be as small as possible, as already mentioned with respect to ρ_v.

Example 2



Calculation:

$$NPSHA=\frac{10^5(p_1+p_{amb}-p_v)}{\rho g}+\frac{V_1^2}{2g}\ \text{(SI units)}$$

$$NPSHA=\frac{10^5(-0.3+1.013-0.02)}{1000*9.81}+\frac{1.5^2}{2*9.81}=7.2m\ \text{(SI units)}$$

$$NPSHA=\frac{4622(p_1+p_{amb}-p_v)}{\rho g}+\frac{V_1^2}{2g}\ \text{(US units)}$$

$$NPSHA=\frac{4622(-4.4+14.7-0.3)}{62.4*32.2}+\frac{4.9^2}{2*32.2}=23.6\ ft\ \text{(US units)}$$

The following remedies can be applied to the pump:

Reduce delivery rate	The NPSHR value will generally become smaller, and the NPSHA value greater. If necessary, split delivery to several pumps, e.g., operate standby pump as well.
Install larger impeller	The NPSHR may show improvement, but power consumption is, of course, also greater.
Reduce speed	Pumps running at lower speeds have better NPSHR values. In many cases, however, a larger pump also becomes necessary.
Install larger impeller and reduce speed	If a relatively small impeller is installed in the pump, this solution is ideal from a hydraulic view-point (smoother running, less wear).
Operate pump with cavitation	In individual cases, the pump supplier and the operator of the system can agree, that total delivery head drop should be not 3%, but more. This must be determined carefully, however, in order that delivery does not collapse completely.
Select pump with better NPSH value	Larger pumps in many cases have better NPSH values at the same delivery rate. If necessary, special impellers designed specifically for good suction can be installed.

Miscellaneous

Plastic pumps are, generally, relatively insensitive to cavitation. It is also difficult to hear this phenomenon, since plastic is a good sound insulator.

Magnetic pumps can be treated like pumps with single mechanical seals. The temperature of the fluid should be at least 68°F (20°C) below its boiling point.

The Influence of Vapor Pressure

In this context, the significance of vapor pressure on the reliable operation of the pump should again be emphasized:

Vapor pressure is a function of temperature. Fluids which are pumped close to vapor pressure are a particular hazard, since even slight increases in temperature can cause evaporation. Not only the temperature fluctuations in general, but also obstructed cooling or an uncontrolled input of heat can trip this off. Inadequate heat dissipation can, for instance, be due to an excessively low delivery rate. Heat input may occur due to increased friction in a mechanical seal, increased bearing friction in magnetic pumps, and also particularly due to heat losses (eddy currents) in metal cans on sealless pumps.

Pumps with double mechanical seals are the least susceptible, since the contact surfaces are lubricated by a separate circuit.

TECH-A-8 Pump Characteristic Curves

The performance of a centrifugal pump can be shown graphically on a characteristic curve. A typical characteristic curve shows the total dynamic head, power, efficiency, and net positive suction head all plotted over the capacity range of the pump.

Figures 5, 6, & 7 are non-dimensional curves which indicate the general shape of the characteristic curves for the various types of pumps. They show the head, power, and efficiency plotted as a percent of their values at the design or best efficiency point of the pump.

Fig. 5 shows that the head curve for a radial flow pump is relatively flat and that the head decreases gradually as the flow increases. Note that the power increases gradually over the flow range with the maximum normally at the point of maximum flow.

Mixed flow centrifugal pumps and axial flow or propeller pumps have considerably different characteristics as shown in Figs. 6 and 7. The head curve for a mixed flow pump is steeper than for a radial flow pump. The shut-off head is usually 150% to 200% of the design head. The power remains fairly constant over the flow range. For a typical axial flow pump, the head and power both increase drastically near shutoff as shown in Fig. 7.

The distinction between the above three classes is not absolute, and there are many pumps with characteristics falling somewhere between the three. For instance, the Francis vane impeller would have a characteristic between the radial and mixed flow classes. Most turbine pumps are also in this same range depending upon their specific speeds.

Fig. 8 shows a typical pump curve as furnished by a manufacturer. It is a composite curve which tells at a glance what the pump will do at a given speed with various impeller diameters from maximum to minimum. Constant power, efficiency, and NPSH $_R$ lines are superimposed over the various head curves. It is made up from individual test curves at various diameters.

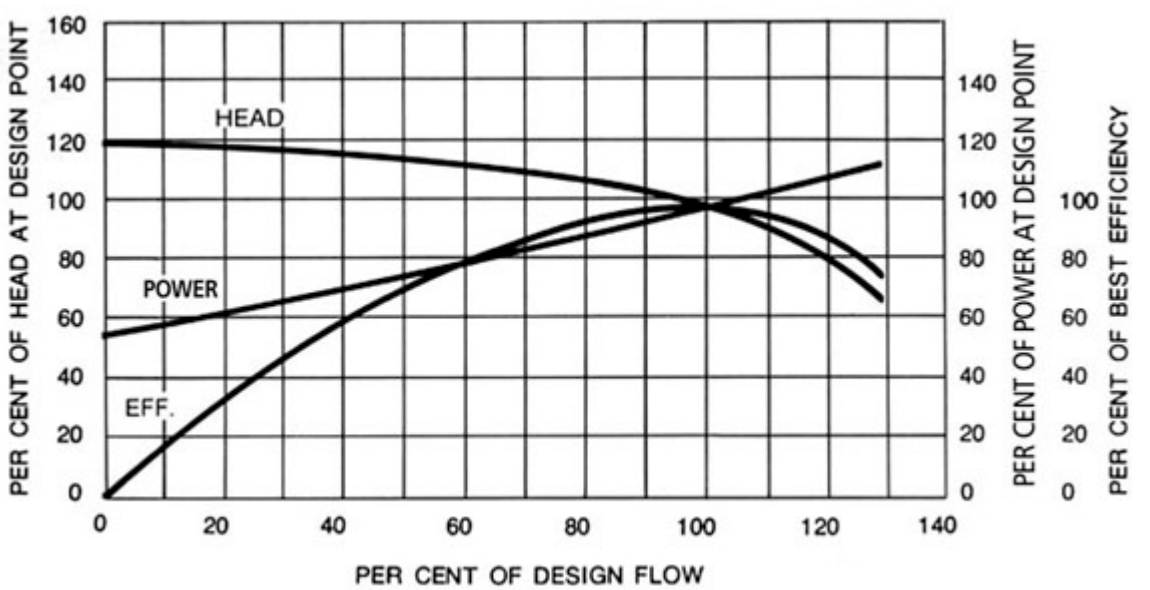


Fig. 5 Radial Flow Pump

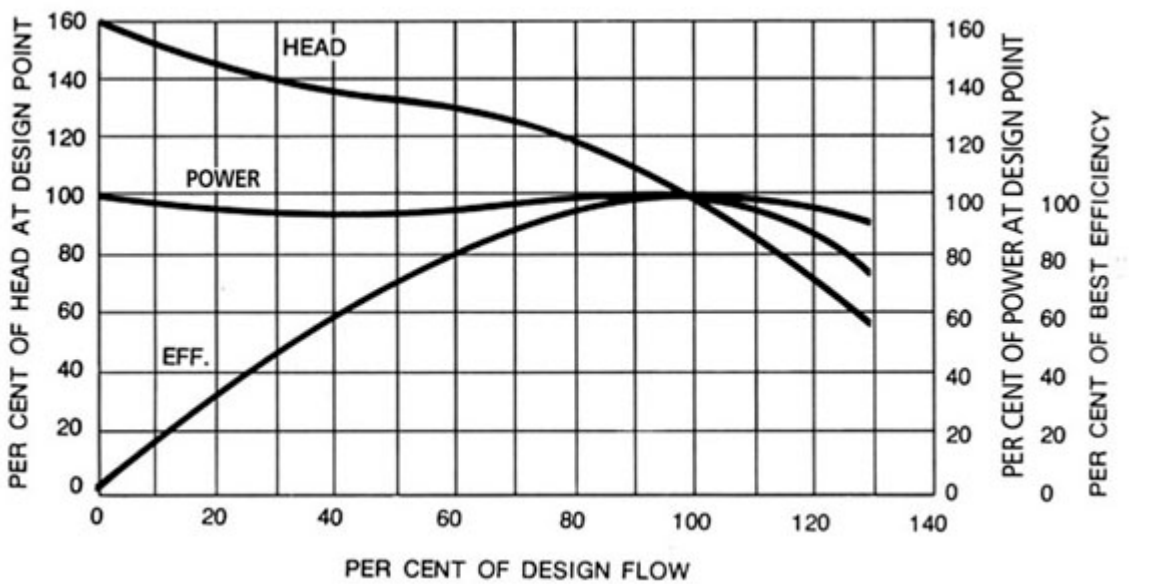


Fig. 6 Mixed Flow Pump

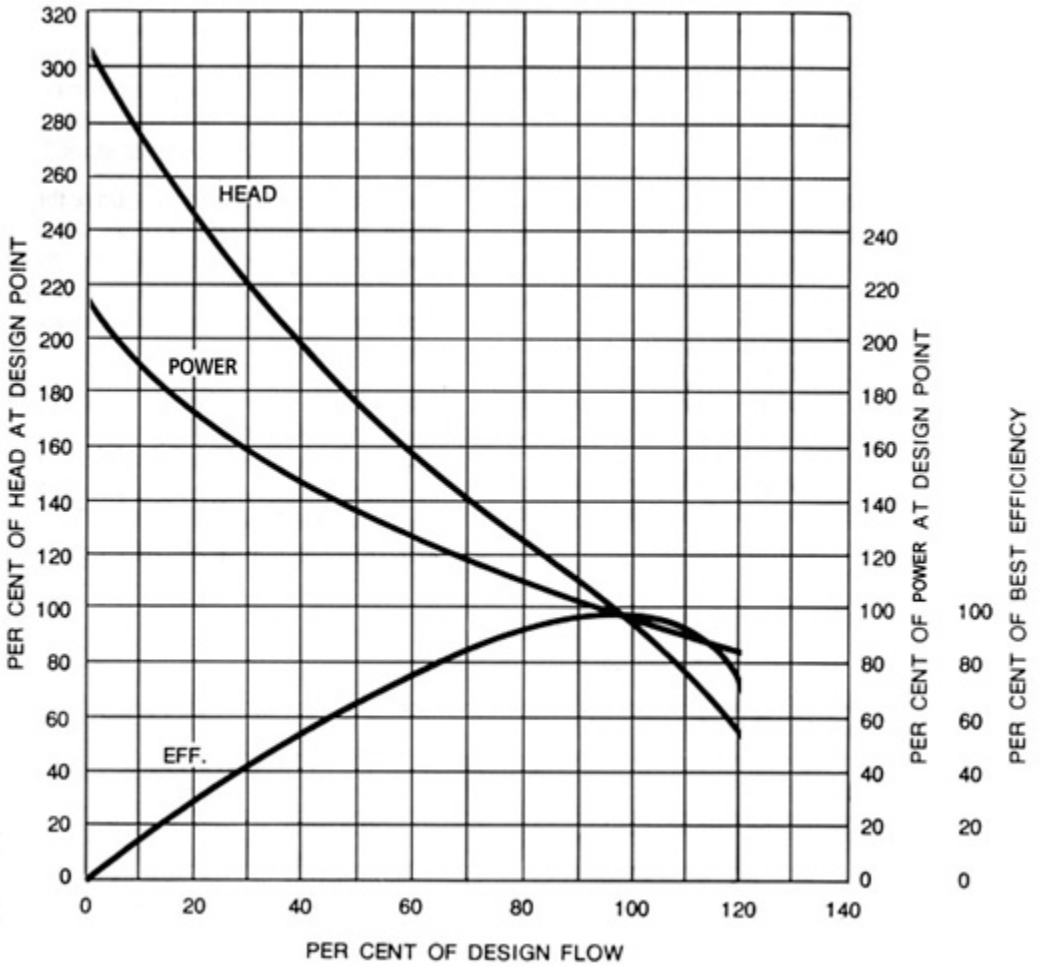


Fig. 7 Axial Flow Pump

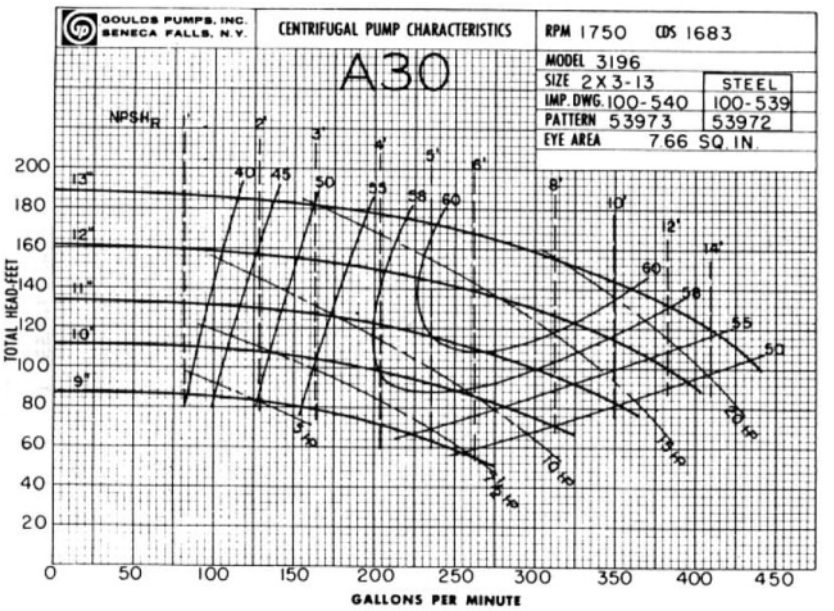


Fig. 8 Composite Performance Curve

TECH-A-9 Affinity Laws

The affinity laws express the mathematical relationship between the several variables involved in pump performance. They apply to all types of centrifugal and axial flow pumps. They are as follows:

1 With impeller diameter, D, held constant:

A. $\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$

B. $\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2$

C. $\frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3$

Where: Q = Capacity, USGPM (m^3/hr)

H = Total Head, Feet (meters)

P = Power HP (DW)

N = Pump Speed, RPM

2 With speed, N, held constant:

A. $\frac{Q_1}{Q_2} = \frac{D_1}{D_2}$

B. $\frac{H_1}{H_2} = \left(\frac{D_1}{D_2}\right)^2$

C. $\frac{P_1}{P_2} = \left(\frac{D_1}{D_2}\right)^3$

When the performance (Q_1, H_1, & P_1) is known at some particular speed (N_1) or diameter (D_1), the formulas can be used to estimate the performance (Q_2, H_2, & P_2) at some other speed (N_2) or diameter (D_2). The efficiency remains nearly constant for speed changes and for small changes in impeller diameter.

EXAMPLE:

To illustrate the use of these laws, refer to Fig. 8. It shows the performance of a particular pump at 1750 RPM with various impeller diameters. This performance data has been determined by actual tests by the manufacturer. Now assume that you have a 13″ (330 mm) maximum diameter impeller, but you want to belt drive the pump at 2000 RPM.

The affinity laws listed under 1 above will be used to determine the new performance, with N_1 = 1750 RPM and N_2 = 2000 RPM. The first step is to read the capacity, head, and horsepower at several points on the 13″ (330 mm) diameter curve in Fig. 9. For example, one point may be near the best efficiency point where the capacity is 300 USGPM (681 m^3/hr), the head is 160 ft (649 m), and the power is approx. 20 hp (14.7 kw).

US Version	Metric Version
$\frac{300}{Q_2} = \frac{1750}{2000}$ Q_2 =343 *USGPM*	$\frac{68.1}{Q_2} = \frac{1750}{2000}$ Q_2=77.8 m^3/hr
$\frac{160}{H_2} = \left(\frac{1750}{2000}\right)^2$ H_2 = 209 *ft.*	$\frac{49}{H_2} = \left(\frac{1750}{2000}\right)^2$ H_2 = 64 *m*
$\frac{14.7}{P_2} = \left(\frac{1750}{2000}\right)^3$ P_2 = 30 *hp*	$\frac{20}{P_2} = \left(\frac{1750}{2000}\right)^3$ P_2 = 21.9 *KW*

This will then be the best efficiency point on the new 2000 RPM curve. By performing the same calculations for several other points on the 1750 RPM curve, a new curve can be drawn which will approximate the pump's performance at 2000 RPM, Fig. 9.

Trial and error would be required to solve this problem in reverse. In other words, assume you want to determine the speed required to make a rating of 343 USGPM (77.3 m^3/hr) at a head of 209 ft (64 m). You would begin by selecting a trial speed and applying the affinity laws to convert the desired rating to the corresponding rating at 1750 RPM. When you arrive at the correct speed, 2000 RPM in this case, the corresponding 1750 RPM rating will fall on the 13″ (330 mm) diameter curve.

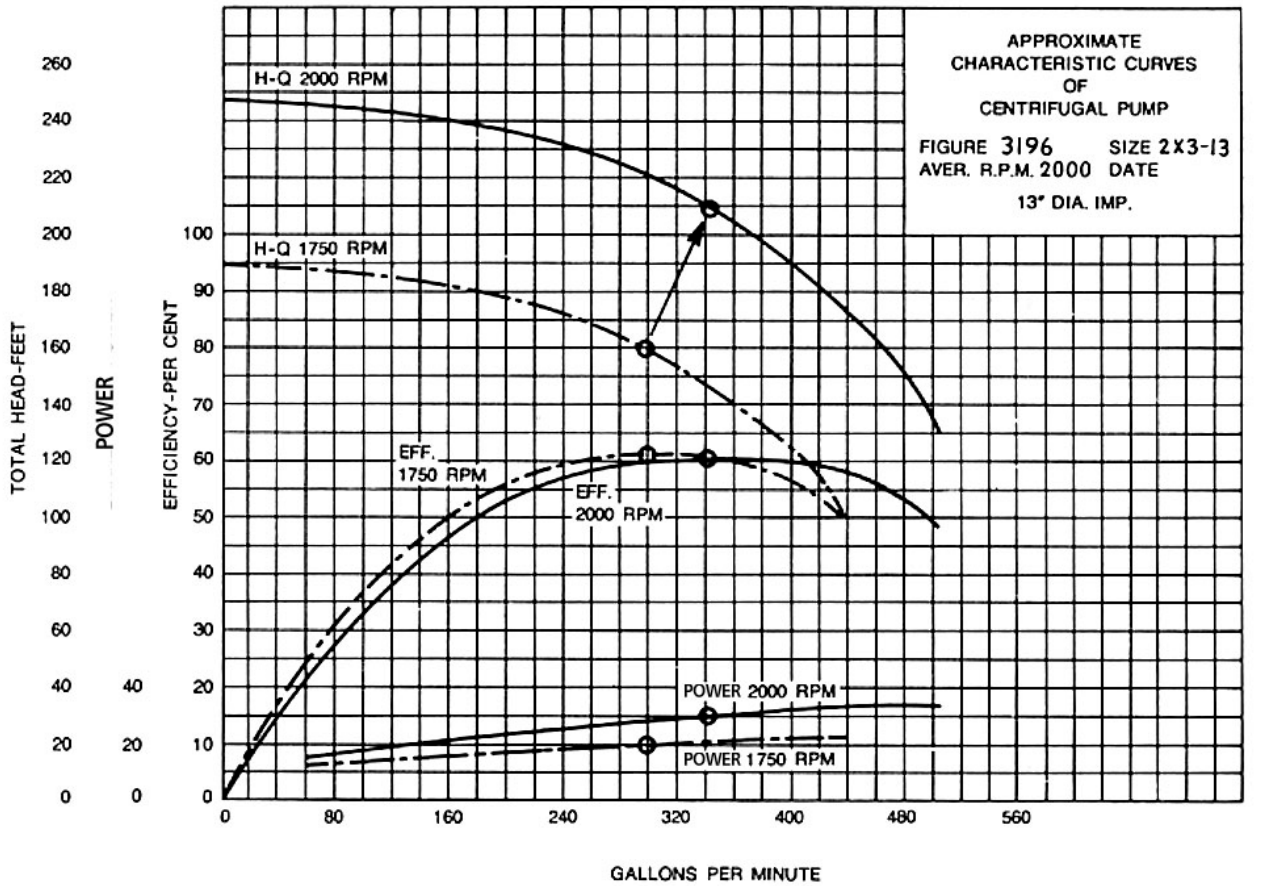
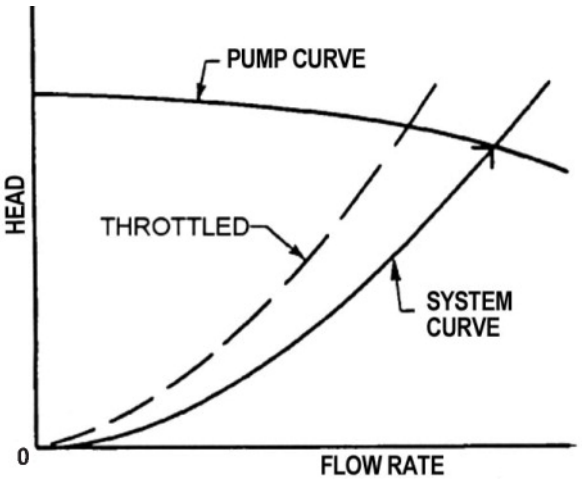

APPROXIMATE
CHARACTERISTIC CURVES
OF
CENTRIFUGAL PUMP
FIGURE 3196 SIZE 2X3-13
AVER. R.P.M. 2000 DATE
13" DIA. IMP.
H-Q 2000 RPM
H-Q 1750 RPM
EFF. 1750 RPM
EFF. 2000 RPM
POWER 2000 RPM
POWER 1750 RPM
TOTAL HEAD-FEET
POWER
EFFICIENCY-PER CENT
GALLONS PER MINUTE
260
240
220
200
180
160
140
120
100
80
60
40
20
0
40
20
0
100
90
80
70
60
50
40
30
20
10
0
0
80
160
240
320
400
480
560

Fig. 9

TECH-A-10 System Curves

For a specified impeller diameter and speed, a centrifugal pump has a fixed and predictable performance curve. The point where the pump operates on its curve is dependent upon the characteristics of the system in which it is operating, commonly called the *System Head Curve* …or, the relationship between flow and hydraulic losses * in a system. This representation is in a graphic form and, since friction losses vary as a square of the flow rate, the system curve is parabolic in shape.



By plotting the system head curve and pump curve together, it can be determined:

1 Where the pump will operate on its curve.

2 What changes will occur if the system head curve or the pump performance curve changes.

NO STATIC HEAD – ALL FRICTION

As the levels in the suction and discharge are the same (Fig. 1), there is no static head and, therefore, the system curve starts at zero flow and zero head and its shape is determined solely from pipeline losses. The point of operation is at the intersection of the system head curve and the pump curve. The flow rate may be reduced by throttling valve.

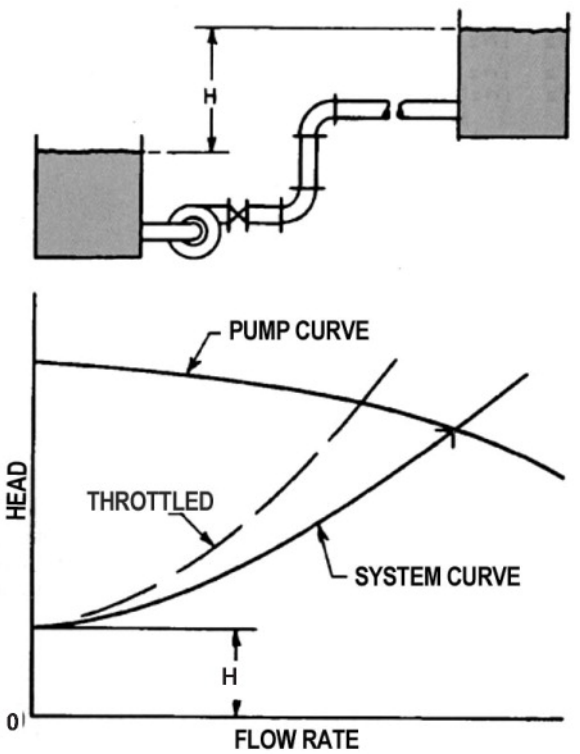


Fig. 1 No Static Head - All Friction

POSITIVE STATIC HEAD

The parabolic shape of the system curve is again determined by the friction losses through the system including all bends and valves. But in this case there is a *positive* static head involved. This static head does not affect the shape of the system curve or its "steepness," but it does dictate the head of the system curve at zero flow rate.

The operating point is at the intersection of the system curve and pump curve. Again, the flow rate can be reduced by throttling the discharge valve.

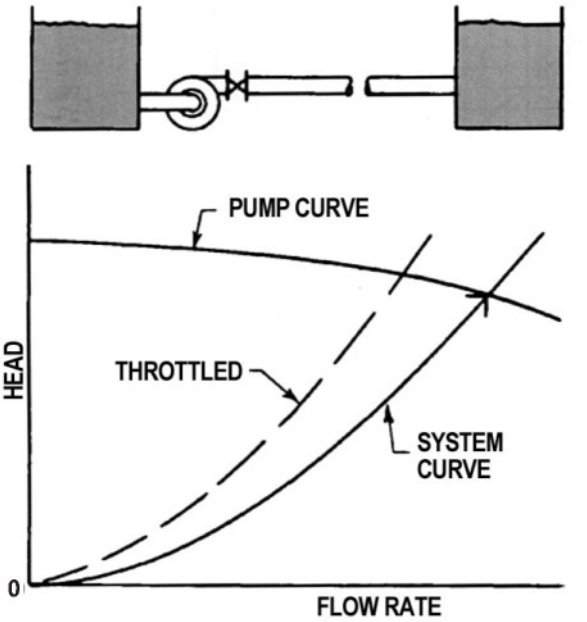


Fig. 2 Positive Suction Head

* Hydraulic losses in piping systems are composed of pipe friction losses, valves, elbows and other fittings, entrance and exit losses (these to the entrance and exit to and from the pipeline normally at the beginning and end – not the pump) and losses from changes in pipe size by enlargement or reduction in diameter.

NEGATIVE (GRAVITY) HEAD

In this illustration, a certain flow rate will occur by *gravity head* alone. But to obtain higher flows, a pump is required to overcome the pipe friction losses in excess of "H" – the head of the suction above the level of the discharge. In other words, the system curve is plotted exactly as for any other case involving a static head and friction head, except the static head is now *negative* . The system curve begins at a negative value and shows the limited flow rate obtained by gravity alone. More capacity requires extra work.

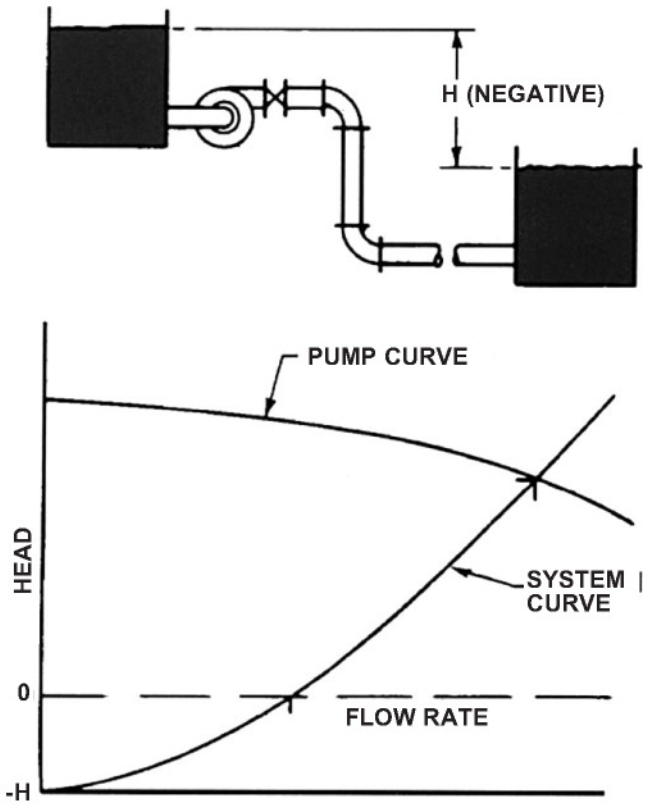


Fig. 3 Negative (Gravity) Head

MOSTLY LIFT- LITTLE FRICTION HEAD

The system head curve in this illustration starts at the static head "H" and zero flow. Since the friction losses are relatively small (possibly due to the large diameter pipe), the system curve is "flat." In this case, the pump is required to overcome the comparatively large static head before it will deliver any flow at all.

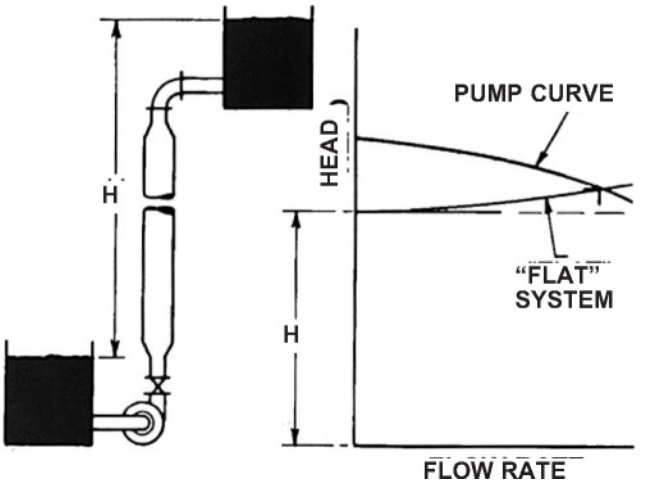


Fig. 4 Mostly Lift - Little Friction Head

TECH-A-11 Basic Formulas and Symbols

Formulas

$$GPM = \frac{0.002 \times Lb./Hr.}{Sp.\ Gr.}$$

$$GPM = \frac{Lbs./Hr.}{500 \times Sp.\ Gr.}$$

$$GPM = 449 \times CFS$$

$$GPM = 0.7 \times BBL/Hr.$$

$$H = \frac{2.31 \times psi}{Sp.\ Gr.}$$

$$H = \frac{1.134 \times In.\ Hg.}{Sp.\ Gr.}$$

$$h_v = \frac{V^2}{2g} = .0155\ V^2$$

$$V = \frac{GPM \times 0.321}{A} = \frac{GPM \times 0.409}{(I.D.)^2}$$

$$BHP = \frac{GPM \times H \times Sp.\ Gr.}{3960 \times Eff.} = \frac{GPM \times psi}{1715 \times Eff.}$$

$$Eff. = \frac{GPM \times H \times Sp.\ Gr.}{3960 \times BHP}$$

$$Sp.\ Gr. = \frac{141.5}{131.5 + degrees\ A.P.I.}$$

$$N_C = \frac{187.7}{\sqrt{f}}$$

$$f = \frac{PL^3}{mEI}$$

$$N_s = \frac{N\sqrt{GPM}}{H^{3/4}}$$

$$H = \frac{v^2}{2g}$$

$$v = \frac{N \times D}{229}$$

$$DEG.\ C = (DEG.\ F - 32) \times 5/9$$

$$DEG.\ F = (DEG.\ C \times 9/5) + 32$$

*** SEE SECTION TECH-D-7C FOR SLURRY FORMULAS**

Symbols

GPM = gallons per minute

CFS = cubic feet per second

Lb. = pounds

Hr. = hour

BBL = barrel (42 gallons)

Sp. Gr. = specific gravity

H = head in feet

psi = pounds per square inch

In. Hg. = inches of mercury

h_v = velocity head in feet

V = velocity in feet per second

g = 32.16 ft/sec^2 (acceleration of gravity)

A = area in square inches

I.D. = inside diameter in inches

BHP = brake horsepower

Eff. = pump efficiency expressed as a decimal

N_s = specific speed

N = speed in revolutions per minute

v = peripheral velocity of an impeller in feet per second

D = impeller diameter in inches

N_c = critical speed

f = shaft deflection in inches for impellers mounted between bearings

P = total force in lbs.

L = bearing span in inches

m = constant usually between 48 and 75 for pump shafts

E = modulus of elasticity, psi – 27 to 30 million for steel

TECH-B-1 Corrosion & Materials of Construction

Selecting the right pump type and sizing it correctly are critical to the success of any pump application. Equally important is the selection of *materials of construction.* Choices must be made between metals and/or non-metals for pump components that come into contact with the pumpage. In addition, gaskets and O-ring material selections must be made to assure long leak-free operation of the pump's dynamic and static sealing joints. To assist in proper selection, included in this section is a brief discussion of specific types of corrosion and a general material selection guide.

Corrosion

Corrosion is the destructive attack of a metal by chemical or electrachemical reaction with its environment. It is important to understand the various types of corrosion and factors affecting corrosion rate to properly select materials.

TYPES OF CORROSION

(1) Galvanic corrosion is the electro-chemical action produced when one metal is in electrical contact with another more noble metal, with both being immersed in the same corroding medium called the electrolyte. A galvanic cell is formed and current flows between the two materials. The least noble material called the anode will corrode while the more noble cathode will be protected. It is important that the smaller wearing parts in a pump be of a more noble material than the larger more massive parts, as in an iron pump with bronze or stainless steel trim.

Following is a galvanic series listing the more common metals and alloys.

Corroded End
(Anodic, or least noble)
Magnesium
Magnesium Alloys
Zinc
Aluminum 2S
Cadmium
Aluminum 175T
Steel or Iron
Cast Iron
Stainless Steel, 400 Series (Active)
Stainless Steel, Type 304 (Active)
Stainless Steel, Type 316 (Active)
Lead-tin Solders
Lead
Tin
Nickel (Active)
Nickel base alloy (active)
Brasses
Copper
Bronzes
Copper-Nickel Alloy
Monel
Silver Solder
(Passive)
Nickel Base Alloy (Passive)
Stainless Steel, 400 Series (Passive)
Stainless Steel, Type 304 (Passive)
Stainless Steel, Type 316 (Passive)
Silver
Graphite
Gold
Platinum Protected End
(Cathodic, or most noble)

(2) Uniform Corrosion is the overall attack on a metal by a corroding liquid resulting in a relatively uniform metal loss over the exposed surface. This is the most common type of corrosion and it can be minimized by the selection of a material which offers resistance to the corroding liquid.

(3) Intergranular corrosion is the precipitation of chromium carbides at the grain boundaries of stainless steels. It results in the complete destruction of the mechanical properties of the steel for the depth of the attack. Solution annealing or the use of extra low carbon stainless steels will eliminate intergranular corrosion.

(4) Pitting Corrosion is a localized rather than uniform type of attack. It is caused by a breakdown of the protective film and results in rapid pit formation at random locations on the surface.

(5) Crevice or Concentration Cell Corrosion occurs in joints or small surface imperfections. Portions of the liquid become trapped and a difference in potential is established due to the oxygen concentration difference in these cells. The resulting corrosion may progress rapidly leaving the surrounding area unaffected.

(6) Stress Corrosion is the failure of a material due to a combination of stress and corrosive environment, whereas the material would not be affected by the environment alone.

(7) Erosion-Corrosion is the corrosion resulting when a metal's protective film is destroyed by high velocity fluids. It is distinguished from abrasion which is destruction by fluids containing abrasive solid particles.

pH VALUES

The pH of a liquid is an indication of its corrosive qualities, either acidic or alkaline. It is a measure of the hydrogen or hydroxide ion concentration in gram equivalents per liter. pH value is expressed as the logarithm to the base 10 of the reciprocal of the hydrogen ion concentration. The scale of pH values is from zero to 14, with 7 as a neutral point. From 6 to zero denotes increasing hydrogen ion concentration and thus increasing acidity, and from 8 to 14 denotes increasing hydroxide ion concentration and thus increasing alkalinity.

The table below outlines materials of construction usually recommended for pumps handling liquids of known pH value

pH Value	Material of Construction
10 to 14	Corrosion Resistant Alloys
8 to 10 6 to 8 4 to 6	Iron, Stainless Steel, Bronze, Carbon Steel
0 to 4	Corrosion Resistant Alloys

The pH value should only be used as a guide with weak aqueous solutions. For more corrosive solutions, temperature and chemical composition should be carefully evaluated in the selection of materials of construction.

TECH-B-2 Material Selection Chart

The material selection chart (Table 1) is intended to be a guide in the preliminary selection of economic materials. Corrosion rates may vary widely with temperature, concentration and the presence of trace elements or abrasive solids. Blank spaces in the chart indicate a lack of accurate corrosion data for those specific conditions. Maximum temperature limits are shown where data are available.

Compatibility data for fluoropolymers EPDM, FKM, FFKM, PVDF and ECTFE (see code chart) were supplied by manufacturers.

By Richard Blong, former Global Chemical Market Manager, Goulds Pumps Inc., Seneca Falls, NY; and Brayton O. Paul, P.E., Senior Technical Editor, Chemical Processing Magazine.

Code for Table 1.	
A	Recommended
B	Useful resistance
X	Unsuitable
Steel	Carbon steel, cast iron and ductile iron
Brz	Bronze
316	Stainless steel
A-20	Carpenter stainless
CD4MCu	CD4MCu stainless steel
Alloy 2205	Alloy 2205 stainless steel
C-276	Wrought Hastelloy ® C-276 alloy
Ti	Titanium unalloyed
Zi	Zirconium
ETFE	Ethylenetetrafluoroethylene (Tefzel ®)
FP	Fluoropolymers (e.g., Teflon ®) including perfluoroalkoxy (PFA), Hyflon (MFA),polytetrafluoroethylene (PTFE) and fluorinated ethylene propylene (FEP)
FRP	Fiber-reinforced plastic (vinylester resin)
EPDM	Ethylenepropylene rubber (Nordel ®)
FKM1	Standard grades; dipolymers of hexafluoropropylene (HFP) and vinylidene fluoride (VF_2 ; Viton ® , Tecnoflon ®)
FKM2	Specialty grades; terpolymers comprising at least three of the following: HFP, VF_2 , tetrafluorethylene (TFE), perfluoromethylvinyl ether (PMVE) or ethylene (E). Specialty grades may have significantly improved chemical compatibility compared to standard grades in many harsh chemical environments (Viton ® , Tecnoflon ®).
FFKM	Copolymer of TFE and PMVE (Kalrez ® , Tecnoflon ®)
PVDF	Polyvinylidene fluoride (Kynar ® , Hylar, Solef ®)
ECTFE	Ethylene chlorotrifluoroethylene (Halar ®)

Compatibility is dependent on specific form and/or grade. Contact elastomer manufacturer.

Guidelines for information purposes and not design guidelines *

TABLE 1. MATERIAL SELECTION CHART.

Corrosive	Steel	Brz	316	A-20	CD4MCuN	Alloy 2205	C-276	Ti	Zi	ETFE	FP	FRP	EPDM	FKM1	FKM2	FFKM	PVDF	ECTFE
Acetaldehyde, 70°F	B	A	A	A	A	A	A	A	A	A	A	X	A	X	X	A	X	B
Acetic acid, 70°F	X	A	A	A	A	A	A	A	A	A	A	X	A	X	B	A	A	A
Acetic acid, <50%, to boiling	X	B	A	A	B	B	A	A	A				A	X	B	A	B	A
Acetic acid, >50%, to boiling	X	X	B	A	X	X	A	A	A	104°C	A	X	B	X	B	A	X	B
Acetone, to boiling	A	A	A	A	A	A	A	A	A	104°C	A	X	A	X	X	A	X	X
Aluminum chloride, <10%, 70°F	X	B	X	B	X	X	A	B	A	A	A	A	A	A	A	A		A
Aluminum chloride, >10%, 70°F	X	X	X	B	X	X	A	B	A	A	A	A	A	A	A	A	A (to 40°C)	A
Aluminum chloride, <10%, to boiling	X	X	X	X	X	X	B	X	A	104°C	A	X	A	A	A	A	A	A
Aluminum chloride, >10%, to boiling	X	X	X	X	X	X	B	X	A	104°C	A	X	A	A	A	A	A (to 40°C)	A
Aluminum sulphate, 70°F	X	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Aluminum sulphate, <10%, to boiling	X	B	B	A	B	B	A	A	A	104°C	A		A	A	A	A	A	A
Aluminum sulphate, >10%, to boiling	X	X	X	B	X	X	A	X	B	104°C	A		A	A	A	A	A	A
Ammonium chloride, 70°F	X	X	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Ammonium chloride, <10%, to boiling	X	X	B	B	X	X	A	A	A	104°C	A		A	A	A	A	A	A
Ammonium chloride, >10%, to boiling	X	X	X	X	X	X	B	X	X	104°C	A		A	A	A	A	A	A
Ammonium fluosilicate, 70°F	X	X	X	B	X	X		X	X							A		
Ammonium sulphate, <40%, to boiling	X	X	B	B	X	X	B	A	A	104°C	A		A	X	B	A	A	A
Arsenic acid, to 225°F	X	X	X	B	X	X				A	A		A	A	A	A	A	A
Barium chloride, 70°F <30%	X	B	X	B	X	X	A	B	B	A	A	A	A	A	A	A	A	A
Barium chloride, <5%, to boiling	X	B	X	B	X	X	B	A	A	104°C	A		A	A	A	A	A	A
Barium chloride, >5%, to boiling	X	X	X	X	X	X	B	X	X	104°C	A		A	A	A	A	A	A
Barium hydroxide, 70°F	B	X	A	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A
Barium nitrate, to boiling	X	X	B	B	B	B		B	B	104°C	A					A	A	A
Barium sulphide, 70°F	X	X	B	B	B	B		A	A	A	A	A	A	B	A	A	A	A
Benzoic acid	X	X	B	B	B	B	A	A	A	A	A		X	A	A	A	110°C	A
Boric acid, to boiling	X	X	B	B	B	B	A	B	B	104°C	A		A	A	A	A	A	A
Boron trichloride, 70°F dry	B	B	B	B	B	B	B									A	A	A
Boron trifluoride, 70°F 10%, dry	B	B	B	A	B	B	A						X	X	X	B	A	A
Brine (acid), 70°F	X	X	X	X	X	X	B	B		A	A	A	A	A	A	A	A	A
Bromine (dry), 70°F	X	X	X	X	X	X	B	X	X	A	A	X	X	A	A	A	A	A
Bromine (wet), 70°F	X	X	X	X	X	X	B	X	X	A	A	X	X	B	A	A	A	A
Calcium bisulphite, 70°F	X	X	B	B	B	B	B	A	A	A	A		X	A	A	A	A	A
Calcium bisulphite	X	X	X	B	X	X	B	A	A	A	A		X	A	A	A	95°C	A
Calcium chloride, 70°F	B	X	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Calcium chloride <5%, to boiling	X	X	B	B	B	B	A	A	A	104°C	A		A	A	A	A	A	A
Calcium chloride >5%, to boiling	X	X	X	B	X	X	A	B	B	104°C	A		A	B	A	A	A	A
Calcium hydroxide, 70°F	B	B	B	B	B	B	A	A		A	A	A	A	A	A	A	A	A
Calcium hydroxide, <30%, to boiling	X	B	B	B	B	B	A	A		104°C	A		A	B	A	A	A	A
Calcium hydroxide, >30%, to boiling	X	X	X	X	X	X	B	A		104°C	A		A	B	A	A	A	A
Calcium hypochlorite, <2%, 70°F	X	X	X	X	X	X	A	A	A	A	A	X	B	A	A	A	A	A
Calcium hypochlorite, >2%, 70°F	X	X	X	X	X	X	B	A	B	A	A	X	B	A	A	A	A	A
Carbolic acid, 70°F (phenol)	X	B	A	A	A	A	A	A	A	A	A		B	B	A	A	50°C	A
Carbon bisulphide, 70°F	B	B	A	A	A	A		A		A	A		X	A	A	A		A
Carbonic acid, 70°F	B	X	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A

Corrosive	Steel	Brz	316	A-20	CD4MCuN	Alloy 2205	C-276	Ti	Zi	ETFE	FP	FRP	EPDM	FKM1	FKM2	FFKM	PVDF	ECTFE
Carbon tetrachloride, dry to boiling	B	B	A	A	A	A	B	A	A	104°C	149° C		X	B	A	A	A	
Chloric acid, 70°F	X	X	X	B	X	X	B			A	A					A	A	A
Chlorinated water, 70°F	X	X	B	B	B	B	A	A	A	A	A		A	A	A	A		A
Chloroacetic acid, 70°F	X		X	X			A	A	B	A	A	A	A	X	B	A	X	A
Chlorosulphonic acid, 70°F	X	X	X	X	X	X	A	B	X	A	A	A	X	X	X	A	X	A
Chromic acid, <30%	X	X	X	B	X	X	B	A	A	65°C	A	X	X	A	A	A	80°C	A
Citric acid	X	X	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Copper nitrate, to 175°F	X	X	B	B	B	B	B	B		A	A	A				A	A	A
Copper sulphate, to boiling	X	X	X	B	X	X	A	A	A	104°C	A		A	A	A	A	A	A
Cresylic acid	X	X	B	B	B	B	B			A	A		X	A	A	A	65°C	A
Cupric chloride	X	X	X	X	X	X	B	B	X	A	A			A	A	A	A	A
Cyanohydrin, 70°F	X		B	B	B	B				A	A	A		X	X	A		
Dichloroethane	X	B	B	B	B	B	B	A	B	65°C	A			B	A	A	A	23°C
Diethylene glycol, 70°F	A	B	A	A	A	A	B	A	A	A	A		A	B	A	A	A	A
Dinitrochlorobenzene, 70°F (dry)	X	B	A	A	A	A	A	A	A	A	A			X	B	A	A	
Ethanolamine, 70°F	B	X	B	B	B	B		A	A	A	A		B	X	X	A	X	X
Ethers, 70°F	B	B	B	A	A	A	A	A	A	A	A		X	X	X	A	B	B
Ethyl alcohol, to boiling	A	A	A	A	A	A	A	A	A	104°C	A		A	B	A	A	A	A
Ethyl cellulose, 70°F	A	B	B	B	B	B	B	A	A	A	A		B	X	X	A		A
Ethyl chloride, 70°F	X	B	B	A	B	B	B	A	A	A	A	X	X	B	A	A	A	A
Ethyl mercaptan, 70°F	X	X	B	A	B	B				A	A	X	X	B	B	A	A	A
Ethyl sulphate, 70°F	X	B	B	A	B	B	A			A	A	X		X	X	A		A
Ethylene chlorohydrin, 70°F	X	B	B	B	B	B	B	A	A	A	A	X	B	A	A	A	A	A
Ethylene dichloride, 70°F	X	B	B	B	B	B	A	A	A	A	A	X	X	A	A	A	A	A
Ethylene glycol, 70°F	B	B	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Ethylene oxide, 70°F	X	X	B	B	B	B	A	A	A	A	A		X	X	X	A	A	A
Ferric chloride, <5%, 70°F	X	X	X	X	X	X	A	A	B	A	A	A	A	A	A	A	A	A
Ferric chloride, >5%, 70°F	X	X	X	X	X	X	B	B	X	A	A	X	A	A	A	A	A	A
Ferric nitrate, 70°F	X	X	B	A	B	B	B			A	A	A	A	A	A	A	A	A
Ferric sulphate, 70°F	X	X	X	B	X	X	B	B	B	A	A	A	A	A	A	A	A	A
Ferrous sulphate, 70°F	X	X	X	B	X	X	A	A	A	A	A	A		A	A	A	A	A
Formaldehyde, to boiling	B	B	A	A	A	A	B	A	A	104°C	A		A	X	B	A	X	B
Formic acid, to 212°F	X	X	X	A	B	B	A	X	A	A	A		A	X	X	A	A	A
Freon, 70°F	A	A	A	A	A	A	A	A	A	A	A		A/X [1]	A/X [1]	A/X [1]	A/B [1]	A	A
Hydrochloride acid, <1%, 70°F	X	X	X	B	X	X	A	B	A	A	A	A	A	A	A	A	A	A
Hydrochloric acid, 1% to 20%, 70°F	X	X	X	X	X	X	A	X	A	A	A	A	A	A	A	A	A	A
Hydrochloric acid, >20%, 70°F	X	X	X	X			A	X	B	A	A	X	A	B	A	A	A	A
Hydrochloric acid, < $^{1}/_{2}$ %, 175°F	X	X	X	X	X	X	A	X	A	A	A	X	X	B	A	A	A	A
Hydrochloric acid, $^{1}/_{2}$ % to 2%, 175°F	X	X	X		X	X	A	X	A	A	A	X	X	B	A	A	A	A
Hydrocyanic acid, 70°F	X	X	X	B	X	X				A	A	A	A	A	A	A	A	A
Hydrogen peroxide, <30%, <150°F	X	X	B	B	B	B	B	A	A	A	A		B	B	A	A	B	A
Hydrofluoric acid, <20%, 70°F	X	B	X	B	X	X	A	X	X	A	A		X	B	A	A	A	A
Hydrofluoric acid, >20%, 50°F	X	X	X	X	X	X	B	X	X	A	A		X	B	A	A	A	A
Hydrofluoric acid, to boiling	X	X	X	X	X	X	B	X	X				X	X	B	A	B	A
Hydrofluorsilicic acid, 70°F	X		X	B	X	X	B			A	A		B	A	A	A	A	A
Lactic acid, <50%, 70°F	X	B	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A
Lactic acid, >50%, 70°F	X	B	B	B	B	B	A	A	A	A	A		A	A	A	A	A	A
Lactic acid, <5%, to boiling	X	X	X	B	X	X	B	A	A	104°C	A		X	B	A	A	50°C	A
Lime slurries, 70°F	B	B	B	B	A	B	A	B	B				A	A	A	A		A
Magnesium chloride, 70°F	X	X	B	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Magnesium chloride, <5%, to boiling	X	X	X	B	X	X	A	A	A	104°C	A		A	A	A	A	140°C	A

Corrosive	Steel	Brz	316	A-20	CD4MCuN	Alloy 2205	C-276	Ti	Zi	ETFE	FP	FRP	EPDM	FKM1	FKM2	FFKM	PVDF	ECTFE
Magnesium chloride, >5%, to boiling	X	X	X	X	X	X	B	B	B	104°C	A		A	A	A	A	140°C	A
Magnesium hydroxide, 70°F	B	A	B	B	A	A	B	A		A	A	A	A	A	A	A	A	A
Magnesium sulphate	X	X	B	A	B	B	A	B	B	A	A		A	A	A	A	135°C	A
Maleic acid	X	X	B	B	B	B	A	A		A	A		B	A	A	A	120°C	A
Mercaptans	A	X	A	A	A	A				A	A			X	B	A	A	A
Mercuric chloride, <2%, 70°F	X	X	X	X	X	X	B	A	A	A	A		A	A	A	A	A	A
Mercurous nitrate, 70°F	X	X	B	B	B	B	X			A	A			A	A	A	A	A
Methyl alcohol, 70°F	A	A	A	A	A	A	A	A	A	A	A		A	X	A	A	A	A
Naphthalene sulphonic acid, 70°F	X	X	B	B	B	B	B			A	A					A	A	A
Napthalenic acid	X	X	B	B	B	B	B			A	A		X	A	A	A	A	A
Nickel chloride, 70°F	X	X	X	B	X	X	A	B	B	A	A	A	A	A	A	A	A	A
Nickel sulphate	X	X	B	B	B	B	B		A	A	A		A	A	A	A	A	A
Nitric acid	X	X	B	B	B	B	X	B	B				X	X	B	A	70%, 50°C	90%, 70°C
Nitrobenzene, 70°F	A	X	A	A	A	A	A	A		A	A	X	A	B	A	A	A	A
Nitroethane, 70°F	A	A	A	A	A	A	A	A	A	A	A	X	B	X	X	A	A	A
Nitropropane, 70°F	A	A	A	A	A	A	A	A	A	A	A	X	X	X	X	A	B	A
Nitrous acid, 70°F	X	X	X	X	X	X	A			A	A	A		X	X	A		A
Nitrous oxide, 70°F	X	X	X	X	X	X				A	A			B	B	A	X	A
Oleic acid	X	X	B	B	B	B	B	X	X	A	A	X	B	B	B	A	120°C	A
Oleum acid, 70°F	B	X	B	B	B	B	B	B		A	A	X	X	B	A	A	X	B
Oxalic acid	X	X	X	B	X	X	B	X	A	A	A	X	A	A	A	A	50°C	A
Palmitic acid	B	B	B	A	B	B	B			A	A		B	A	A	A	120°C	A
Phenol (see carbolic acid)										A	A		B	B	A	A	50°C	A
Phosgene, 70°F	X	X	B	B	B	B	B			A	A			X	X	A	A	X
Phosphoric acid, <10%, 70°F	X	X	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Phosphoric acid, >10% to 70%, 70°F	X	X	A	A	A	A	A	B	B	A	A	X	A	A	A	A	A	A
Phosphoric acid, <20%, 175°F	X	X	B	B	B	B	A	X	B	A	A	X	A	A	A	A	A	A
Phosphoric acid, >20%, 175°F, <85%	X	X	X	B	X	X	A	X	X	A	A	X	A	A	A	A	A	A
Phosphoric acid, >10%, boil, <85%	X	X	X	X	X	X	B	X	X				A	A	A	A	A	A
Phthalic acid, 70°F	X	B	B	A	B	B	A	A	A	A	A			B	B	A	A	A
Phthalic anhydride, 70°F	B	X	A	A	A	A	A			A	A			B	B	A		A
Picric acid, 70°F	X	X	X	B	X	X	B			A	A		B	A	A	A	A	A
Potassium carbonate	B	B	A	A	A	A	B	A	A	A	A	A		A	A	A	140°C	A
Potassium chlorate	B	X	A	A	A	A	B	A	A	A	A	A		A	A	A	95°C	A
Potassium chloride, 70°F	X	X	B	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Potassium cyanide, 70°F	B	X	B	B	B	B	A			A	A	A	A	A	A	A	A	A
Potassium dichromate	B	B	A	A	A	A	B	A	A	A	A		A	A	A	A	140°C	A
Potassium ferricyanide	X	B	B	B	B	B	B	A	A	A	A			B	B	A	140°C	A
Potassium ferrocyanide, 70°F	X	B	B	B	B	B	B		B	A	A	A		B	B	A	A	A
Potassium hydroxide, 70°F	X	X	B	A	B	B	A	B	A	A	A	A	A	X	B	A	X	A
Potassium hypochlorite	X	X	X	B	X	X	B	A		A	A			X	X	A	95°C	A
Potassium iodide, 70°F	X	B	B	B	B	B	A	A	A	A	A			A	A	A	A	A
Potassium permanganate	B	B	B	B	B	B	B			A	A	A		B	B	A	120°C	A
Potassium phosphate	X	X	B	B	B	B		B	B	A	A	A		A	A	A		A
Seawater, 70°F	X	B	B	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Sodium bisulphate, 70°F	X	X	X	B	X	X	B	B	A	A	A	A		A	A	A	A	A
Sodium bromide, 70°F	B	X	B	B	B	B	B			A	A	A		A	A	A	A	A
Sodium carbonate	B	B	B	A	B	B	A	A	A	A	A	A		A	A	A	140°C	A
Sodium chloride, 70°F	X	B	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Sodium cyanide	B	X	B	B	B	B	A	B		A	A		A	A	A	A	135°C	A

Corrosive	Steel	Brz	316	A-20	CD4MCuN	Alloy 2205	C-276	Ti	Zi	ETFE	FP	FRP	EPDM	FKM1	FKM2	FFKM	PVDF	ECTFE
Sodium dichromate	B	X	B	B	B	B	B	B		100°C	A			A	A	A	95°C	A
Sodium ethylate	B	A	A	A	A	A	A			A	A					A	A	A
Sodium fluoride	X	X	B	B	B	B	A	B	B	A	A			A	A	A	140°C	A
Sodium hydroxide, 70°F	B	B	B	A	B	B	A	A	A	A	A	A	A	B	A	A	X	A
Sodium hypochlorite	X	X	X	X	X	X	B	A	B	A	A	X	B	B	A	A	40%, 95°C	A
Sodium lactate, 70°F	B	X	X	X	X	X	A			A	A	A				A	A	A
Stannic chloride, <5%, 70°F	X	X	X	X	X	X	B	A	A	A	A	A	A	A	A	A	A	A
Stannic chloride, >5%, 70°F	X	X	X	X	X	X	B	B	B	A	A		A	A	A	A	A	A
Sulphite liquors, to 175°F	X	X	B	B	B	B	B	A					B	A	A	A	A	A
Sulphur (molten)	B	X	A	A	A	A	A	A					A	A	A	A	120°C	
Sulphur dioxide (spray), 70°F	X	X	B	B	B	B	B	X		A	A		A	A	A	A	A	A
Sulphuric acid, <2%, 70°F	X	X	B	A	B	B	A	B	A	A	A	A	A	A	A	A	A	A
Sulphuric acid, 2%t o 40%, 70°F	X	X	X	B	X	X	A	X	A	A	A	A	B	A	A	A	A	A
Sulphuric acid, 40%, <90%, 70°F	X	X	X	B	X	X	A	X	X	A	A	X	B	B	A	A	A	A
Sulphuric acid, 93% to 98%, 70°F	B	X	B	B	B	B	A	X	X	A	A	X	X	B	A	A	A	A
Sulphuric acid, <10%, 175°F	X	X	X	B	X	X	A	X	B	A	A	A	X	A	A	A	A	A
Sulphuric acid, 10% to 60% & >80%, 175°F	X	X	X	B	X	X	B	X	X	A	A	X	B	A	A	A	A	
Sulphuric acid, 60% to 80%, 175°F	X	X	X	X	X	X	B	X	X	A	A	X	X	B	A	A	A	A
Sulphuric acid, < $^{3}/_{4}$ %, boiling	X	X	X	B	X	X	A	X	B				X	B	A	A	120°C	120° C
Sulphuric acid, $^{3}/_{4}$ % to 40%, boiling	X	X	X	X	X	X	X	X	B				X	B	A	A	120°C	120° C
Sulphuric acid, 40% to 65% & >85%, boiling	X	X	X	X	X	X	X	X	X			X	X	B	A	B	120°C	
Sulphuric acid, 65% to 85%, boiling	X	X	X	X	X	X	X	X	X				X	X	B	A	95°C	120° C
Sulphurous acid, 70°F	X	X	X	B	X	X	B	A	B	A	A	A	X	X	B	A	A	A
Titanium tetrachloride, 70°F	X		X	B	X	X	A			A	A		X	B	B	B	A	A
Tirchlorethylene, to boiling	B	X	B	B	B	B	B	A	A				X	B	A	A	A	20°C
Urea, 70°F	X	X	B	B	B	B	A	B	B	A	A			B	A	A	A	A
Vinyl acetate	B	B	B	B	B	B	A			A	A			B	B	A	120°C	20°C
Vinyl chloride	B	X	B	B	B	B	A	A		A	A		X	A	A	A	95°C	B
Water, to boiling	B	A	A	A	A	A	A	A	A				A	A	A	A	A	A
Zinc chloride	X	X	B	A	B	A	A	A	A	A	A	A	A	A	A	A	140°C	A
Zinc cyanide, 70°F	X	B	B	B	B	B	B	B	B	A	A					A	A	A
Zinc sulphate	X	X	A	A	A	A	A	A		A	A	A	A	A	A	A	140°C	A

*** NOTE:**
The use of tables, graphs and charts, and text suggestions contained in these guidelines is provided for information purposes only. The performance of materials in services can be affected by minor variations in the operating environment and pumping operating conditions that may affect corrosion performance.
It is the responsibility of the user to determine the operating conditions and suitability of selected materials. It is the user's responsibility to ensure that a material will be satisfactory in the intended service and environment. Before using any material, the end user should satisfy himself as to the suitability of any material for the proposed end use.

Rubber Lined Slurry Pump Elastomer Selection Guide

Please use the following chart as a general guide only. Refer to detailed selection tables or the factory for specific elastomer recommendations.

Elastomer	Shore (A) Hardness	Max Temp Limit	pH Range	Abrasion	Resistance to Moderate Chemicals	Oils Hydrocarbons
Natural Rubber	40	154 F	5 - 12	E	G (1)	P
Polyurethane	81	149 F	3 - 11	E (2)	G (1)	E
Neoprene	60	212 F	3 - 12	G	G (1)	G
Nitrile	60	220 F	4 - 12	G	G (1)	E
Hypalon	55	230 F	1 - 14	G	E	G
Chlorobutyl	50	300 F	3 - 12	G	E	P

(1) Poor for oxidizing chemicals and strong acids.
(2) Fine particles only (200 mesh or less).
E = Excellent
G = Good
P = Poor

TECH-B-3 Piping Design

The design of a piping system can have an important effect on the successful operation of a centrifugal pump. Such items as sump design, suction piping design, suction and discharge pipe size, and pipe supports must all be carefully considered.

Selection of the discharge pipe size is primarily a matter of economics. The cost of the various pipe sizes must be compared to the pump size and power cost required to overcome the resulting friction head.

The suction piping size and design is far more important. Many centrifugal pump troubles are caused by poor suction conditions.

The suction pipe should never be smaller than the suction connection of the pump and, in most cases, should be at least one size larger. Suction pipes should be as short and as straight as possible. Suction pipe velocities should be in the 5 to 8 feet per second range unless suction conditions are unusually good.

Higher velocities will increase the friction loss and can result in troublesome air or vapor separation. This is further complicated when elbows or tees are located adjacent to the pump suction nozzle, in that uneven flow patterns or vapor separation keeps the liquid from evenly filling the impeller. This upsets hydraulic balance leading to noise vibration, possible cavitation, and excessive shaft deflection. Cavitation erosion damage, shaft breakage or premature bearing failure may result.

On pump installations involving suction lift, air pockets in the suction line can be a source of trouble. The suction pipe should be exactly horizontal, or with a uniform slope upward from the sump to the pump as shown in Fig. 1. There should be no high spots where air can collect and cause the pump to lose its prime. Eccentric rather than concentric reducers should always be used.

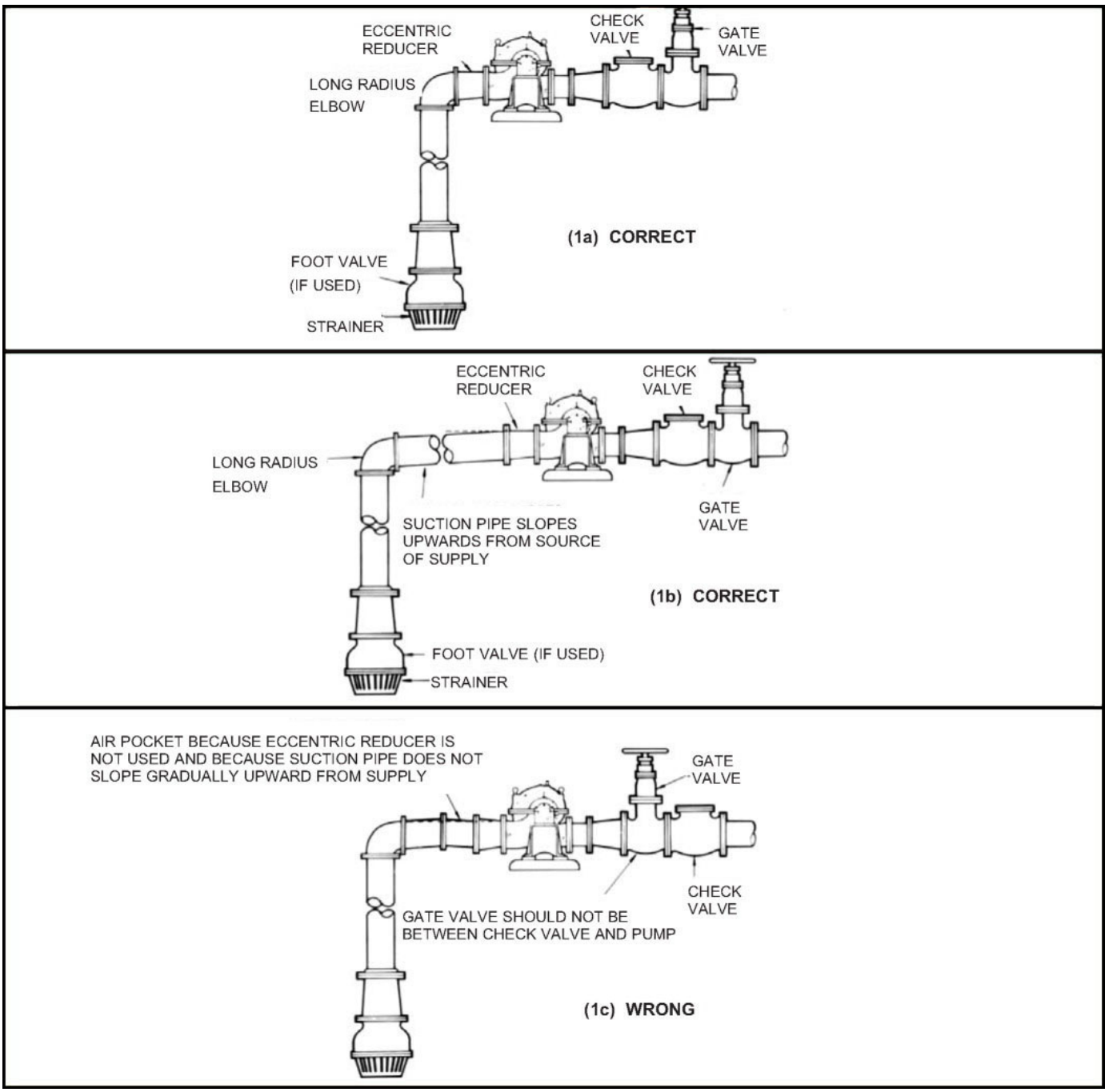


Fig. 1 Air Pockets in Suction Piping

If an elbow is required at the suction of a double suction pump, it should be in a vertical position if at all possible. Where it is necessary for some reason to use a horizontal elbow, it should be a long radius elbow and there should be a minimum of five diameters of straight pipe between the elbow and the pump as shown in Fig. 2. Fig. 3 shows the effect of an elbow directly on the suction. The liquid will flow toward the outside of the elbow and result in an uneven flow distribution into the two inlets of the double suction impeller. Noise and excessive axial thrust will result.

There are several important considerations in the design of a suction supply tank or sump. It is imperative that the amount of turbulence and entrained air be kept to a minimum. Entrained air may cause reduced capacity and efficiency as well as vibration, noise, shaft breakage, loss of prime, and/or accelerated corrosion.

The free discharge of liquid above the surface of the supply tank at or near the pump suction can cause entrained air to enter the pump. All lines should be submerged in the tank, and baffles should be used in extreme cases as shown in Fig. 4.

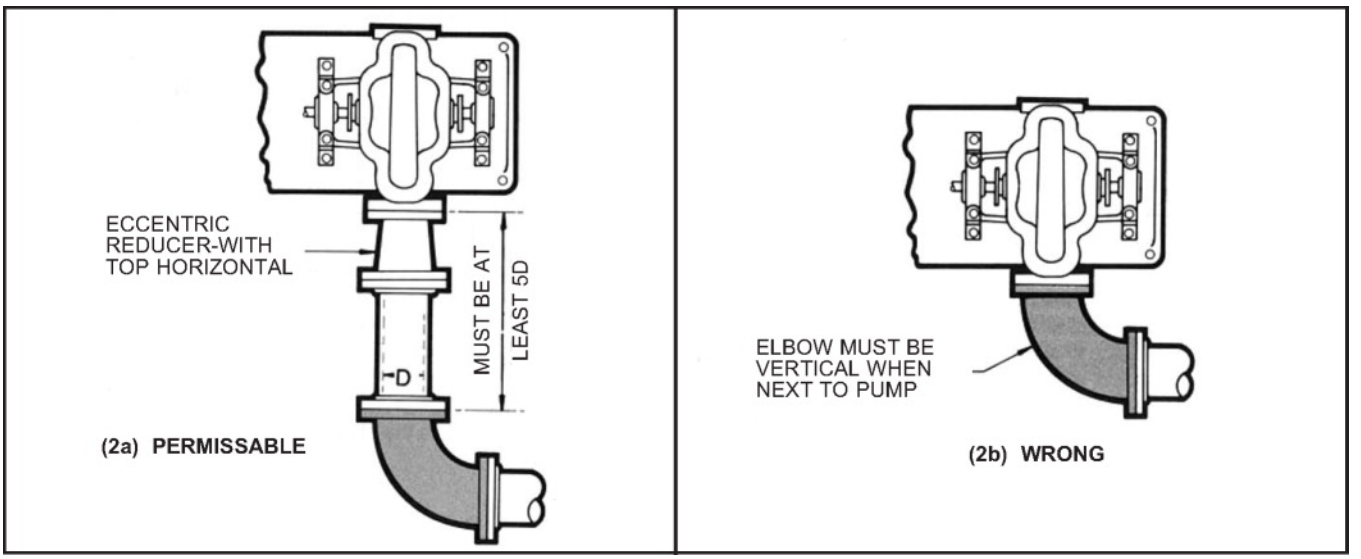


Fig. 2 Elbows At Pump Suction

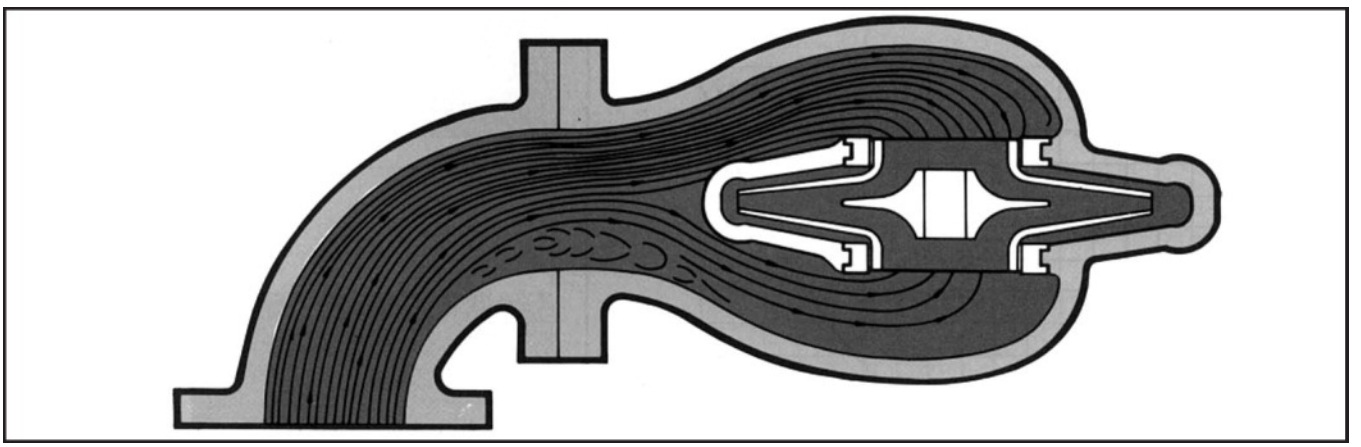


Fig. 3 Effect of Elbow Directly on Suction

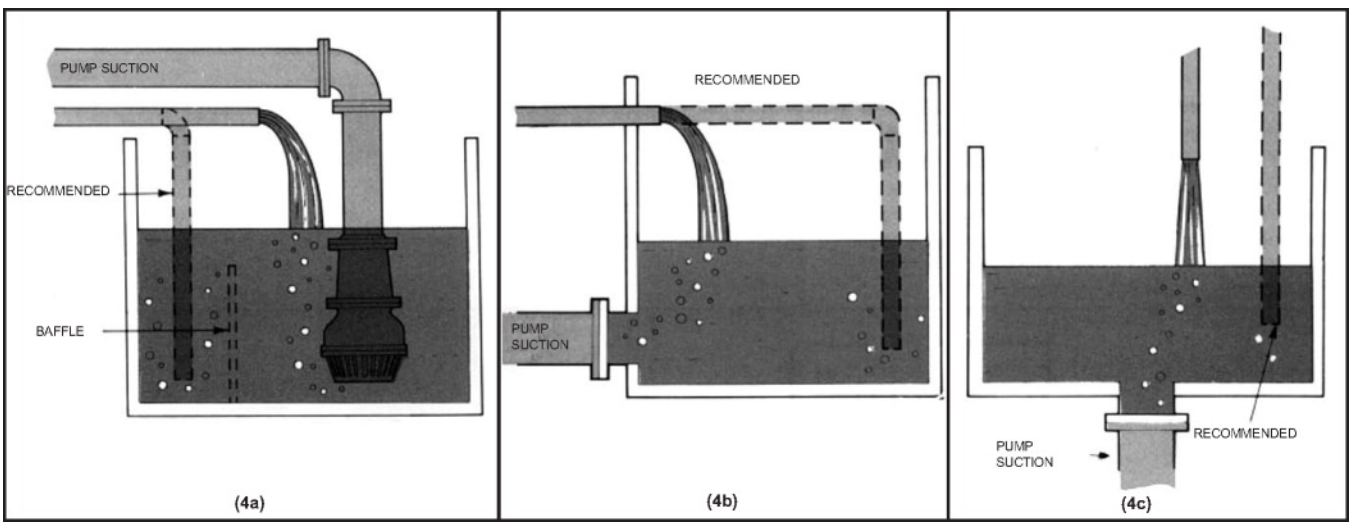


Fig. 4 Keeping Air Out of Pump

Improper submergence of the pump suction line can cause a vortex, which is a swirling funnel of air from the surface directly into the pump suction pipe. In addition to submergence, the location of the pipe in the sump and the actual dimensions of the sump are also important in preventing vortexing and/or excess turbulence.

The submergence of the suction pipe must also be carefully considered. The amount of submergence required depends upon the size and capacity of the individual pumps as well as on the sump design. Past experience is the best guide for determining the submergence. The pump manufacturer should be consulted for recommendations in the absence of other reliable data.

The American National Standard for Pump Intake Design (ANSI/HI 9.8-1998 should be used in absence of past experience. The standard provides designers, owners, and users of pumping facilities a foundation upon which to develop functional and economical pumping facility designs. The standard provides intake design recommendations for both suction pipes and all types of wet pits.

TECH-B-4A Sealing

The proper selection of a seal is critical to the success of every pump application. For maximum pump reliability, choices must be made between the type of seal and the seal environment. In addition, a sealless pump is an alternative which would eliminate the need for a dynamic type seal entirely.

Sealing Basics

There are two basic kinds of seals: *static and dynamic* . Static seals are employed where no movement occurs at the juncture to be sealed. Gaskets and O-rings are typical static seals.

Dynamic seals are used where surfaces move relative to one another. Dynamic seals are used, for example, where a rotating shaft transmits power through the wall of a tank (Fig. 1), through the casing of a pump (Fig. 2), or through the housing of other rotating equipment such as a filter or screen.

A common application of sealing devices is to seal the rotating shaft of a centrifugal pump. To best understand how such a seal functions, a quick review of pump fundamentals is in order.

In a centrifugal pump, the liquid enters the suction of the pump at the center (eye) of the rotating impeller (Figures 3 and 4).

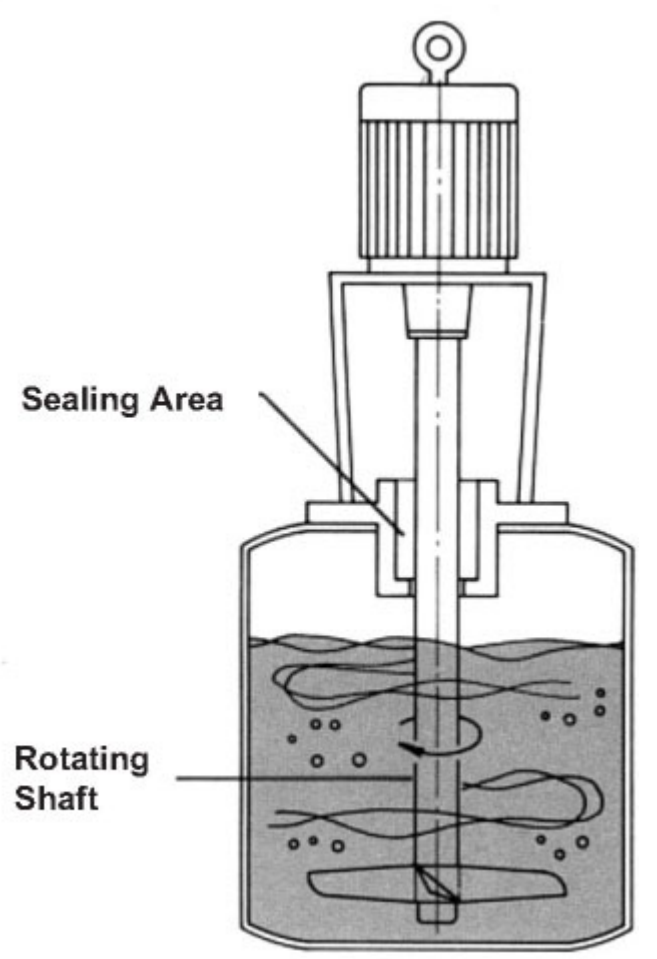


Fig. 1 Cross Section of Tank and Mixer

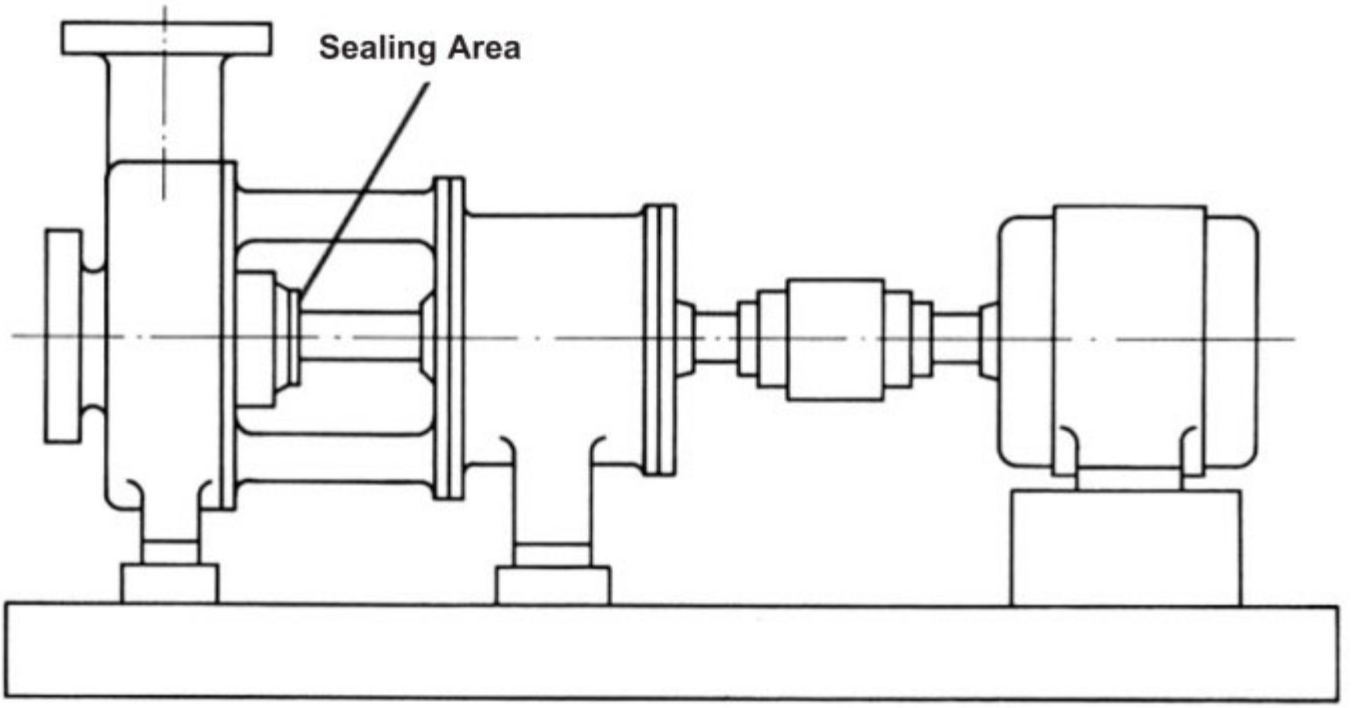


Fig. 2 Typical Centrifugal Pump

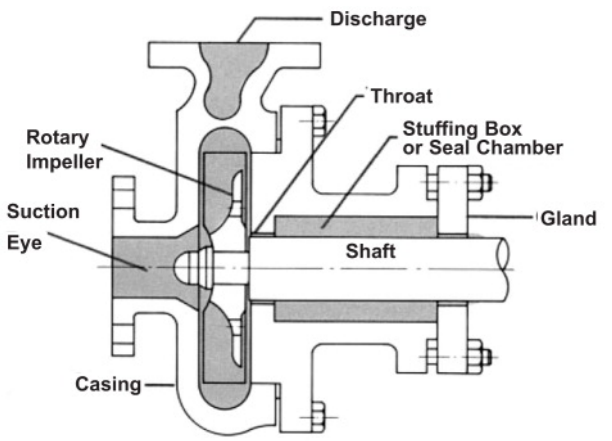


Fig. 3 Centrifugal Pump, Liquid End

As the impeller vanes rotate, they transmit motion to the incoming product, which then leaves the impeller, collects in the pump casing, and leaves the pump under pressure through the pump discharge.

Discharge pressure will force some product down behind the impeller to the drive shaft, where it attempts to escape along the rotating drive shaft. Pump manufacturers use various design techniques to reduce the pressure of the product trying to escape. Such techniques include: 1) the addition of balance holes through the impeller to permit most of the pressure to escape into the suction side of the impeller, or 2) the addition of back pump-out vanes on the back side of the impeller.

However, as there is no way to eliminate this pressure completely, sealing devices are necessary to limit the escape of the product to the atmosphere. Such sealing devices are typically either compression packing or end-face mechanical seals.

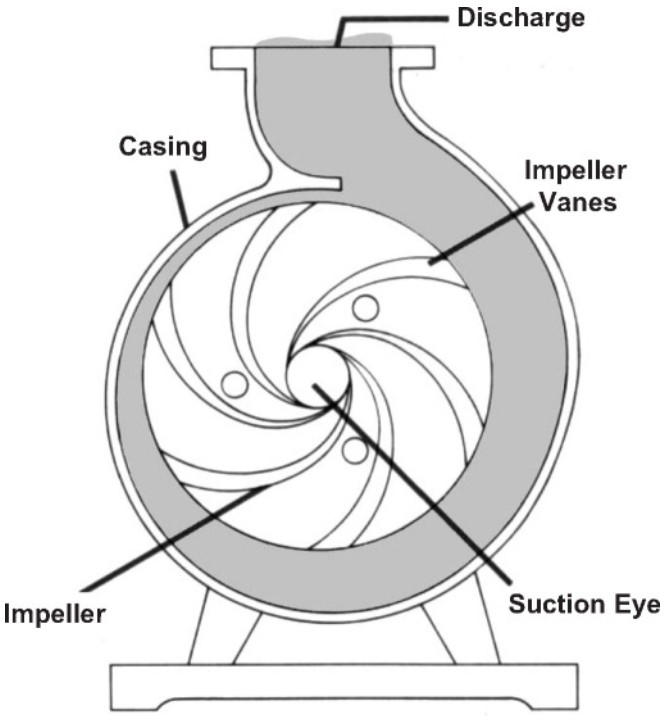


Fig. 4 Fluid Flow in a Centrifugal Pump

Stuffing Box Packing

A typical packed stuffing box arrangement is shown in Fig. 5. It consists of: A) Five rings of packing, B) A lantern ring used for the injection of a lubricating and/or flushing liquid, and C) A gland to hold the packing and maintain the desired compression for a proper seal.

The function of packing is to control leakage and not to eliminate it completely. The packing must be lubricated, and a flow from 40 to 60 drops per minute out of the stuffing box must be maintained for proper lubrication.

The method of lubricating the packing depends on the nature of the liquid being pumped as well as on the pressure in the stuffing box. When the pump stuffing box pressure is above atmospheric pressure and the liquid is clean and nonabrasive, the pumped liquid itself will lubricate the packing (Fig. 6). When the stuffing box pressure is below atmospheric pressure, a lantern ring is employed and lubrication is injected into the stuffing box (Fig. 7). A bypass line from the pump discharge to the lantern ring connection is normally used providing the pumped liquid is clean.

When pumping slurries or abrasive liquids, it is necessary to inject a clean lubricating liquid from an external source into the lantern ring (Fig. 8). A flow of from .2 to .5 gpm is desirable and a valve and flowmeter should be used for accurate control. The seal water pressure should be from 10 to 15 psi above the stuffing box pressure, and anything above this will only add to packing wear. The lantern ring is normally located in the center of the stuffing box. However, for extremely thick slurries like paper stock, it is recommended that the lantern ring be located at the stuffing box throat to prevent stock from contaminating the packing.

The gland shown in Figures 5 through 8 is a quench type gland. Water, oil, or other fluids can be injected into the gland to remove heat from the shaft, thus limiting heat transfer to the bearing frame. This permits the operating temperature of the pump to be higher than the limits of the bearing and lubricant design. The same quench gland can be used to prevent the escape of a toxic or volatile liquid into the air around the pump. This is called a smothering gland, with an external liquid simply flushing away the undesirable leakage to a sewer or waste receiver.

Today, however, stringent emission standards limit use of packing to non-hazardous water based liquids. This, plus a desire to reduce maintenance costs, has increased preference for mechanical seals.

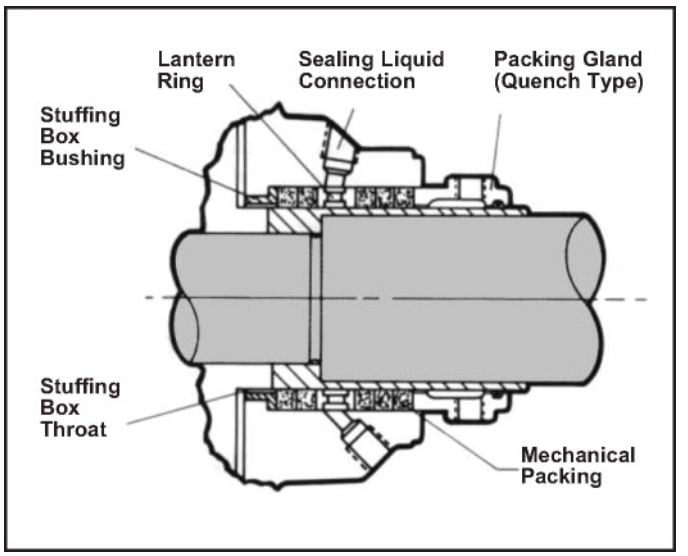


Fig. 5 Typical Stuffing Box Arrangement (Description of Parts)

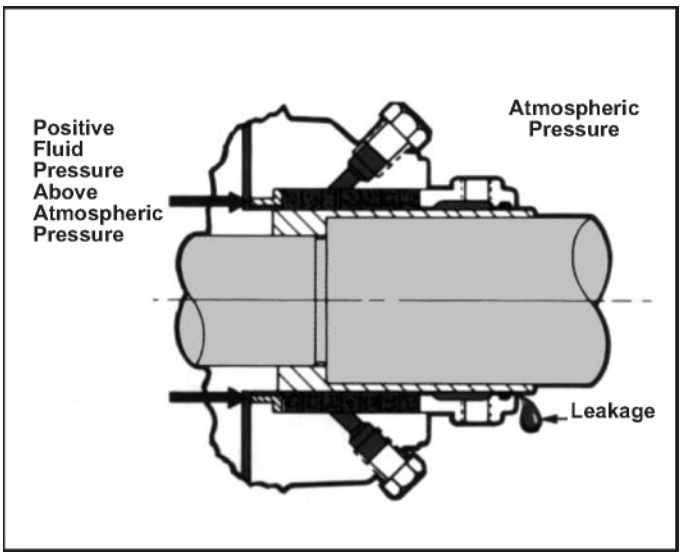


Fig. 6 Typical Stuffing Box Arrangement When Stuffing Box Pressure is Above Atmospheric Pressure

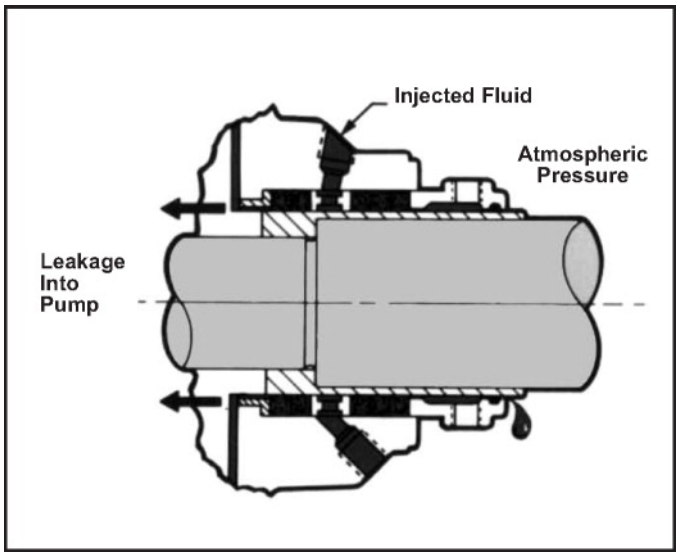


Fig. 7 Typical Stuffing Box Arrangement When Stuffing Box Pressure is Below Atmospheric Pressure

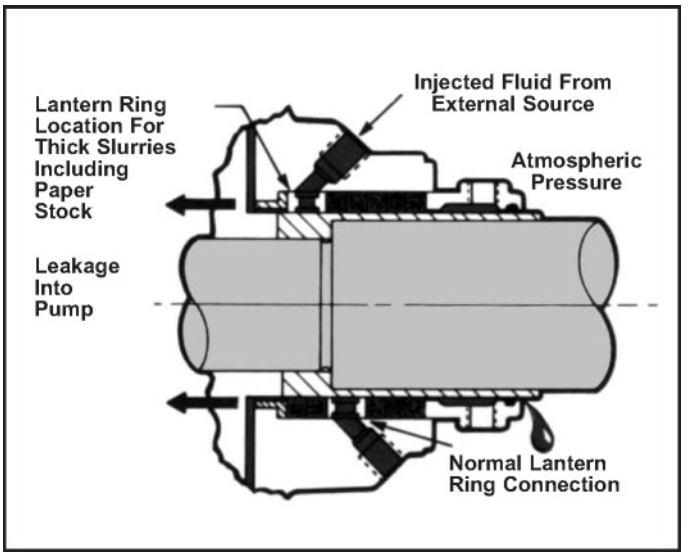


Fig. 8 Typical Stuffing Box Arrangement When Pumping Slurries

Mechanical Seals

A mechanical seal is a sealing device which forms a running seal between rotating and stationary parts. They were developed to overcome the disadvantages of compression packing. Leakage can be reduced to a level meeting environmental standards of government regulating agencies and maintenance costs can be lower. Advantages of mechanical seals over conventional packing are as follows:

1. Zero or limited leakage of product (meet emission regulations.)
2. Reduced friction and power loss.
3. Elimination of shaft or sleeve wear.
4. Reduced maintenance costs.
5. Ability to seal higher pressures and more corrosive environments.
6. The wide variety of designs allows use of mechanical seals in almost all pump applications.

The Basic Mechanical Seal

All mechanical seals are constructed of three basic sets of parts as shown in Fig. 9:

1. A set of primary seal faces: one rotary and one stationary...shown in Fig. 9 as seal ring and insert.

2. A set of secondary seals known as shaft packings and insert mountings such as O-rings, wedges and V-rings.

3. Mechanical seal hardware including gland rings, collars, compression rings, pins, springs and bellows.

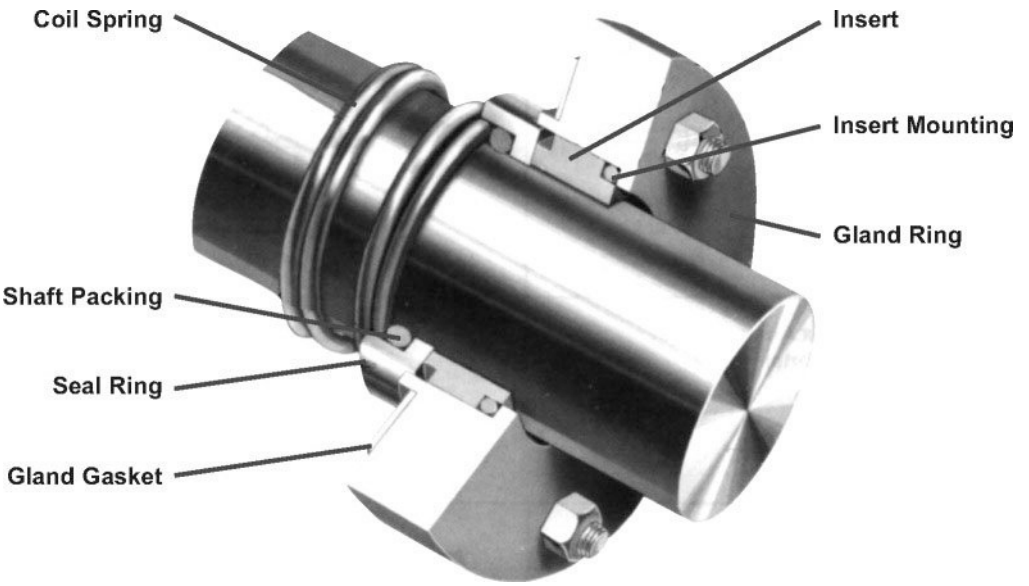


Fig. 9 A Simple Mechanical Seal

How A Mechanical Seal Works

The *primary seal* is achieved by two very flat, lapped faces which create a difficult leakage path perpendicular to the shaft. Rubbing contact between these two flat mating surfaces minimizes leakage. As in all seals, one face is held *stationary* in a housing and the other face is fixed to, and *rotates* with, the shaft. One of the faces is usually a non-galling material such as *carbon-graphite* . The other is usually a relatively hard material like *silicon-carbide* . Dissimilar materials are usually used for the stationary Insert and the rotating seal ring face in order to prevent adhesion of the two faces. The softer face usually has the smaller mating surface and is commonly called the *wear nose.*

There are four main sealing points within an end face mechanical seal (Fig. 10). The primary seal is at the seal face, Point A. The leakage path at Point B is blocked by either an O-ring, a V-ring or a wedge. Leakage paths at Points C and D are blocked by gaskets or O-rings.

The faces in a typical mechanical seal are lubricated with a boundary layer of gas or liquid between the faces. In designing seals for the desired leakage, seal life, and energy consumption, the designer must consider how the faces are to be lubricated and select from a number of modes of seal face lubrication.

To select the best seal design, it's necessary to know as much as possible about the operating conditions and the product to be sealed. Complete information about the product and environment will allow selection of the best seal for the application.

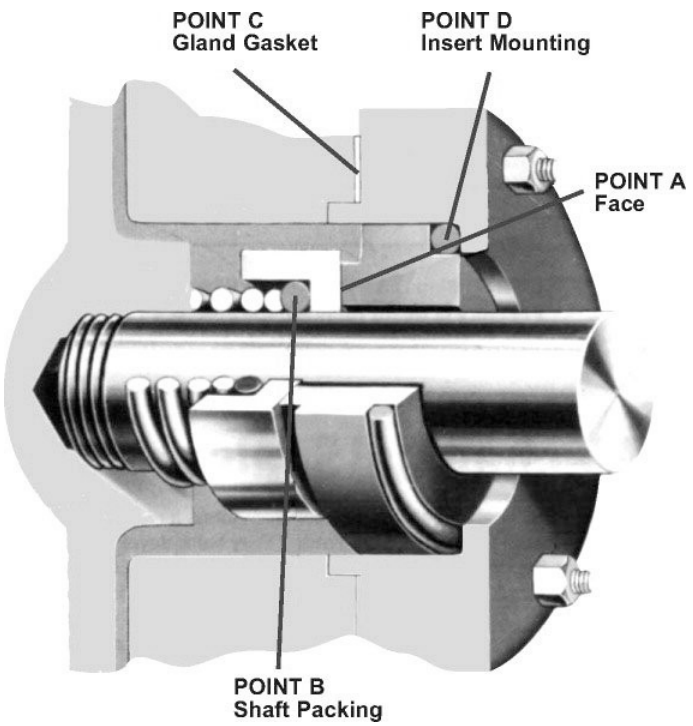
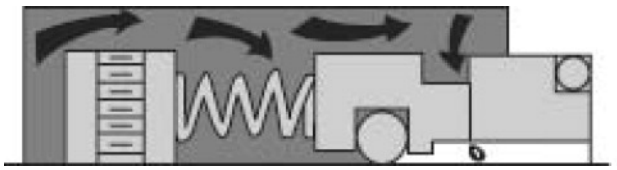
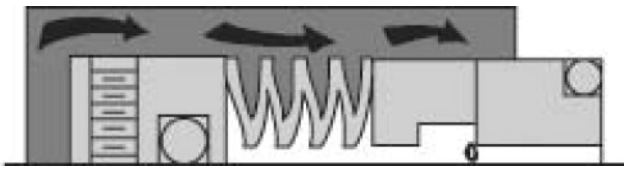


Fig. 10 Sealing Points for Mechanical Seal

Mechanical Seal Types

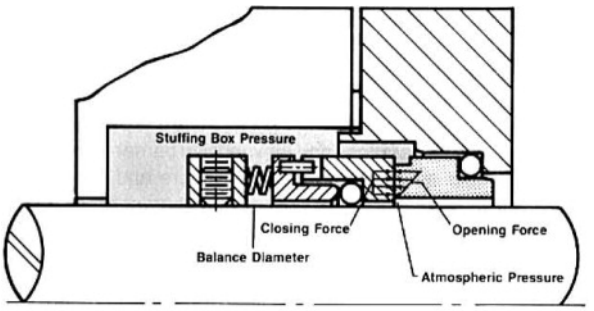
Mechanical seals can be classified into several types and arrangements:





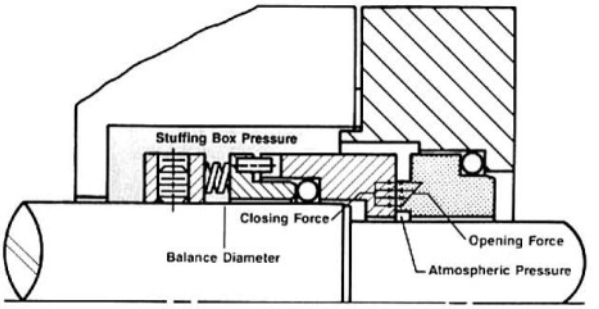
PUSHER:

Incorporate secondary seals that move axially along a shaft or sleeve to maintain contact at the seal faces. This feature compensates for seal face wear and wobble due to misalignment. The pusher seals advantage is that it's inexpensive and commercially available in a wide range of sizes and configurations. Its disadvantage is that it's prone to secondary seal hang-up and fretting of the shaft or sleeve.



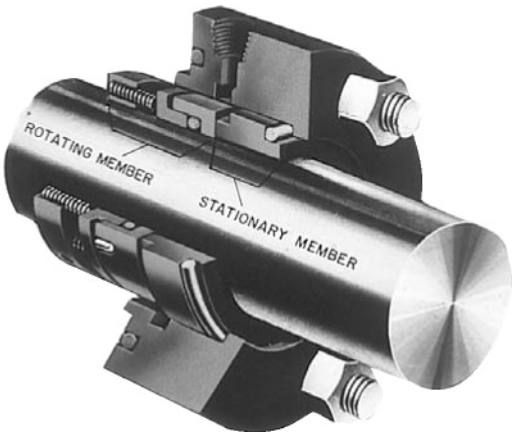
NON-PUSHER:

The non-pusher or bellows seal does not have to move along the shaft or sleeve to maintain seal face contact. The main advantages are its ability to handle high and low temperature applications, and does not require a secondary seal (not prone to secondary seal hang-up). A disadvantage of this style seal is that its thin bellows cross sections must be upgraded for use in corrosive environments.



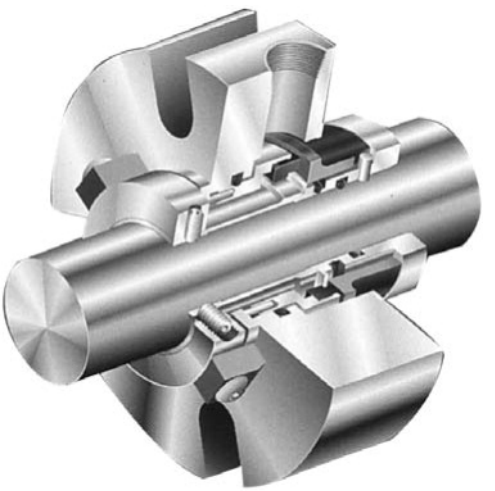
UNBALANCED:

They are inexpensive, leak less, and are more stable when subjected to vibration, misalignment, and cavitation. The disadvantage is their relative low pressure limit. If the closing force exerted on the seal faces exceeds the pressure limit, the lubricating film between the faces is squeezed out and the highly loaded dry running seal fails.



BALANCED:

Balancing a mechanical seal involves a simple design change which reduces the hydraulic forces acting to close the seal faces. Balanced seals have higher pressure limits, lower seal face loading, and generate less heat. This makes them well suited to handle liquids with poor lubricity and high vapor pressures such as light hydrocarbons.



CONVENTIONAL:

Examples are ones which require setting and alignment of the seal (single, double, tandem) on the shaft or sleeve of the pump. Although setting a mechanical seal is relatively simple, today's emphasis on reducing maintenance costs has increased preference for cartridge seals.

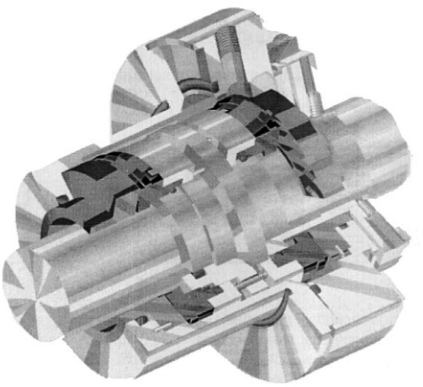
CARTRIDGE:

Examples are ones which have the mechanical seal premounted on a sleeve including the gland and fit directly over the Model 3196 shaft or shaft sleeve (available single, double, tandem). The major benefit, of course, is no requirement for the usual seal setting measurements for their installation. Cartridge seals lower maintenance costs and reduce seal setting errors.

Mechanical Seal Arrangements

SINGLE INSIDE:

This is the most common type of mechanical seal. These seals are easily modified to accommodate seal flush plans and can be balanced to withstand high seal environment pressures. Recommended for relatively clear non-corrosive and corrosive liquids with satisfactory lubricating properties where cost of operation does not exceed that of a double seal.



SINGLE OUTSIDE:

If an extremely corrosive liquid has good lubricating properties, an outside seal offers an economical alternative to the expensive metal required for an inside seal to resist corrosion. The disadvantage is that it is exposed outside of the pump which makes it vulnerable to damage from impact and hydraulic pressure works to open the seal faces so they have low pressure limits (balanced or unbalanced).

DOUBLE GAS BARRIER (PRESSURIZED DUAL GAS):

Very similar to cartridge double seals...sealing involves an inert gas, like nitrogen, to act as a surface lubricant and coolant in place of a liquid barrier system or external flush required with conventional or cartridge double seals. This concept was developed because many barrier fluids commonly used with double seals can no longer be used due to new emission regulations. The gas barrier seal uses nitrogen or air as a harmless and inexpensive barrier fluid that helps prevent product emissions to the atmosphere and fully complies with emission regulations. The double gas barrier seal should be considered for use on toxic or hazardous liquids that are regulated or in situations where increased reliability is the required on an application.

DOUBLE (DUAL PRESSURIZED):

This arrangement is recommended for liquids that are not compatible with a single mechanical seal (i.e. liquids that are toxic, hazardous [regulated by the EPA], have suspended abrasives, or corrosives which require costly materials). The advantages of the double seal are that it can have five times the life of a single seal in severe environments. Also, the metal inner seal parts are never exposed to the liquid product being pumped, so viscous, abrasive, or thermosetting liquids are easily sealed without a need for expensive metallurgy. In addition, recent testing has shown that double seal life is virtually unaffected by process upset conditions during pump operation. A significant advantage of using a double seal over a single seal.

The final decision between choosing a double or single seal comes down to the initial cost to purchase the seal, cost of operation of the seal, and environmental and user plant emission standards for leakage from seals.

TANDEM (DUAL UNPRESSURIZED):

Due to health, safety, and environmental considerations, tandem seals have been used for products such as vinyl chloride, carbon monoxide, light hydrocarbons, and a wide range of other volatile, toxic, carcinogenic, or hazardous liquids.

Tandem seals eliminate icing and freezing of light hydrocarbons and other liquids which could fall below the atmospheric freezing point of water in air (32°F or 0°C). (Typical buffer liquids in these applications are ethylene glycol, methanol, and propanol.) A tandem also increases online reliability. If the primary seal fails, the outboard seal can take over and function until maintenance of the equipment can be scheduled.

Mechanical Seal Selection

The proper selection of a mechanical seal can be made only if the full operating conditions are known:

1 **Liquid**
2 **Pressure**
3 **Temperature**
4 **Characteristics of Liquid**
5 **Reliability and Emission Concerns**

1. Liquid. Identification of the exact liquid to be handled is the first step in seal selection. The metal parts must be corrosion resistant, usually steel, bronze, stainless steel, or Hastelloy. The mating faces must also resist corrosion and wear. Carbon, ceramic, silicon carbide or tungsten carbide may be considered. Stationary sealing members of Buna, EPR, Viton and Teflon are common.

2. Pressure. The proper type of seal, balanced or unbalanced, is based on the pressure on the seal and on the seal size.

3. Temperature. In part, determines the use of the sealing members. Materials must be selected to handle liquid temperature.

4. Characteristics of Liquid. Abrasive liquids create excessive wear and short seal life. Double seals or clear liquid flushing from an external source allow the use of mechanical seals on these difficult liquids. On light hydrocarbons balanced seals are often used for longer seal life even though pressures are low.

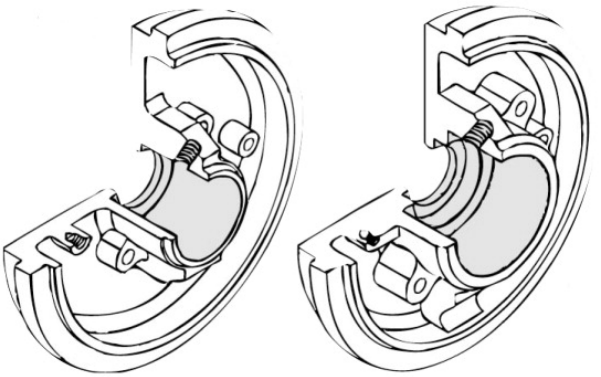
5. Reliability and Emission Concerns. The seal type and arrangement selected must meet the desired reliability and emission standards for the pump application. Double seals and double gas barrier seals are becoming the seals of choice.

Seal Environment

The number one cause of pump downtime is failure of the shaft seal. These failures are normally the result of an unfavorable seal environment such as improper heat dissipation (cooling), poor lubrication of seal faces, or seals operating in liquids containing solids, air or vapors. To achieve maximum reliability of a seal application, proper choices of seal housings (standard bore stuffing box, large bore, or large tapered bore seal chamber) and seal environmental controls (CPI and API seal flush plans) must be made.

STANDARD BORE STUFFING BOX COVER

Designed thirty years ago specifically for packing. Also accommodates mechanical seals (clamped seat outside seals and conventional double seals.)

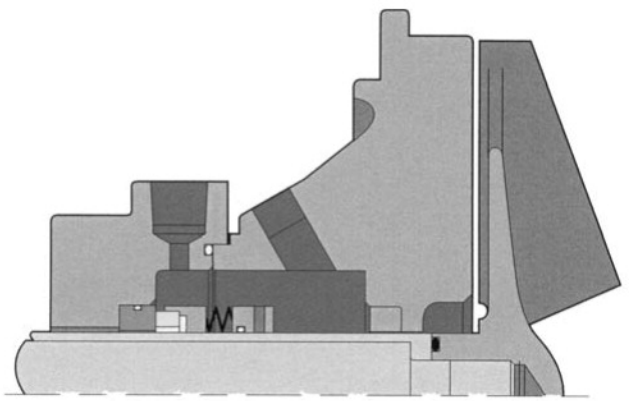


CONVENTIONAL LARGE BORE SEAL CHAMBER

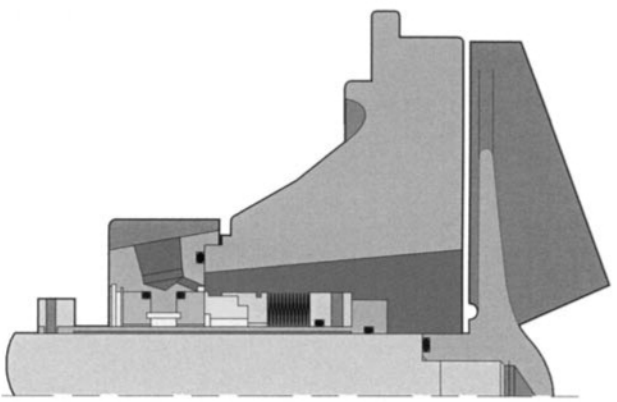
Designed specifically for mechanical seals. Large bore provides increased life of seals through improved lubrication and cooling of faces. Seal environment should be controlled through use of CPI or API flush plans. Often available with internal bypass to provide circulation of liquid to faces without using external flush. Ideal for conventional or cartridge single mechanical seals in conjunction with a flush and throat bushing in bottom of chamber. Also excellent for conventional or cartridge double or tandem seals.

LARGE BORE SEAL CHAMBERS

Introduced in the mid-80's, enlarged bore seal chambers with increased radial clearance between the mechanical seal and seal chamber wall, provide better circulation of liquid to and from seal faces. Improved lubrication and heat removal (cooling) of seal faces extend seal life and lower maintenance costs.



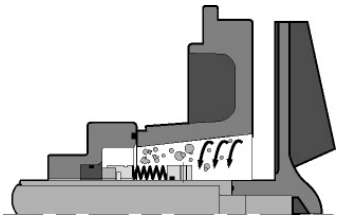
BigBore™ Seal Chamber



TaperBore™ Seal Chamber

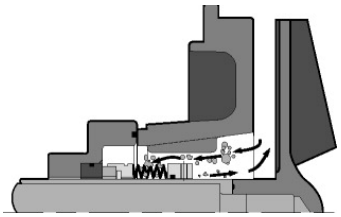
Large Tapered Bore Seal Chambers

Provide increased circulation of liquid at seal faces without use of external flush. Offers advantages of lower maintenance costs, elimination of tubing/piping, lower utility costs (associated with seal flushing) and extended seal reliability. The tapered bore seal chamber is commonly available with ANSI chemical pumps. API process pumps use conventional large bore seal chambers. Paper stock pumps use both conventional large bore and large tapered bore seal chambers. Only tapered bore seal chambers with flow modifiers provide expected reliability on services with or without solids, air or vapors.



Conventional Tapered Bore Seal Chamber: Mechanical Seals Fail When Solids or Vapors Are Present in Liquid

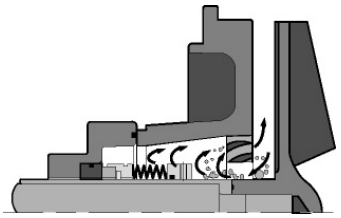
Many users have applied the conventional tapered bore seal chamber to improve seal life on services containing solids or vapors. Seals in this environment failed prematurely due to entrapped solids and vapors. Severe erosion of seal and pump parts, damaged seal faces and dry running were the result.



Modified Tapered Bore Seal Chamber with Axial Ribs: Good for Services Containing Air, Minimum Solids

This type of seal chamber will provide better seal life when air or vapors are present in the liquid. The axial ribs prevent entrapment of vapors through improved flow in the chamber. Dry running failures are eliminated. In addition, solids less than 1% are not a problem.

The new flow pattern, however, still places the seal in the path of solids/liquid flow. The consequence on services with significant solids (greater than 1%) is solids packing the seal spring or bellows, solids impingement on seal faces and ultimate seal failure.



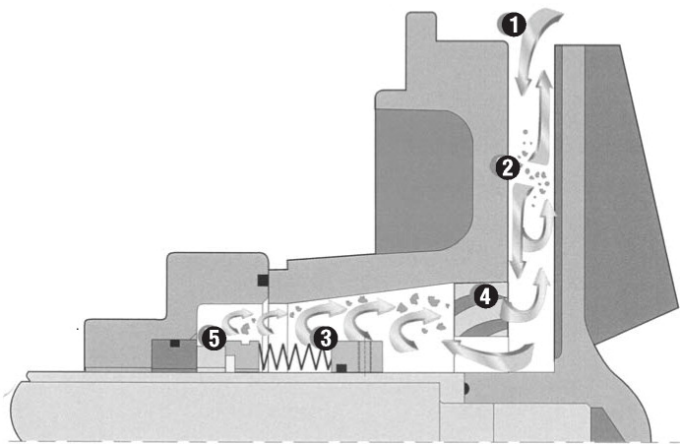
Goulds Standard TaperBore™ *PLUS* Seal Chamber: The Best Solution for Services Containing Solids and Air or Vapors

To eliminate seal failures on services containing vapors as well as solids, the flow pattern must direct solids away from the mechanical seal, and purge air and vapors. Goulds Standard TaperBore™ *PLUS* completely reconfigures the flow in the seal chamber with the result that seal failures due to solids are eliminated. Air and vapors are efficiently removed eliminating dry run failures. Extended seal and pump life with lower maintenance costs are the results.

Goulds TaperBore™ *Plus* : How It Works

The unique flow path created by the Vane Particle Ejector directs solids away from the mechanical seal, not at the seal as with other tapered bore designs. And the amount of solids entering the bore is minimized. Air and vapors are also efficiently removed. On services with or without solids, air or vapors, Goulds TaperBore™ *PLUS* is the effective solution for extended seal and pump life and lower maintenance costs.

1. Solids/liquid mixture flows toward mechanical seal/seal chamber.
2. Turbulent zone. Some solids continue to flow toward shaft. Other solids are forced back out by centrifugal force (generated by back pump-out vanes).
3. Clean liquid continues to move toward mechanical seal faces. Solids, air, vapors flow away from seal.
4. Low pressure zone create by Vane Particle Ejector. Solids, air, vapor liquid mixture exit seal chamber bore.
5. Flow in TaperBore™ *PLUS* seal chamber assures efficient heat removal (cooling) and lubrication. Seal face heat is dissipated. Seal faces are continuously flushed with clean liquid.



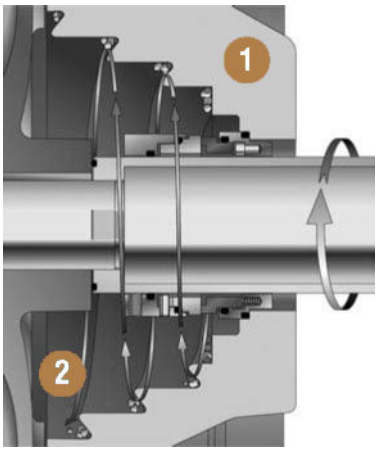
Patented Cyclone Seal Chamber Design

At the heart of our program is the patented cyclone seal chamber that not only provides the optimum seal environment in the presence of solids and vapors, but also improves maintainability and reduces installation cost by eliminating seal flush piping.

Here's How It Works :

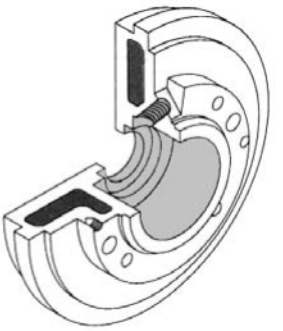
1. Cast helical ribs act as a barrier to particles traveling within the inward boundary layer flow found on the tapered walls of the seal chamber.
2. Once caught in the grooves of the helical ribs, the "cyclone-like" rotational velocity created by the impeller carries particles out of the seal chamber away from the seal.

Solids removal is key to prevent seal and seal chamber wear as well as clogging of the mechanical seal for guaranteed reliability .



JACKETED STUFFING BOX COVER

Designed to maintain proper temperature control (heating or cooling) of seal environment. (Jacketed covers do not help lower seal face temperatures to any significant degree). Good for high temperature services that require use of a conventional double seal or single seal with a flush and API or CPI plan 21.



JACKETED LARGE BORE SEAL CHAMBER

Maintains proper temperature control (heating or cooling) of seal environment with improved lubrication of seal faces. Ideal for controlling temperature for services such as molten sulfur and polymerizing liquids. Excellent for high temperature services that require use of conventional or cartridge single mechanical seals with flush and throat bushing in bottom of seal chamber. Also, great for conventional or cartridge double or tandem seals.

Stuffing Box Cover and Seal Chamber Guides

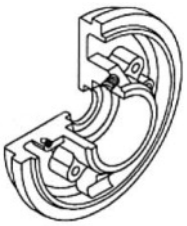
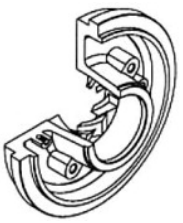
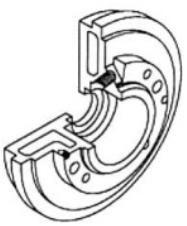
The following two selection guides are designed to assist selection of the proper seal housing for a pump application.

Stuffing Box and Seal Chamber Application Guide

Stuffing Box Cover Seal Chamber	Application
Standard Bore Stuffing Box Cover	Use for soft packing. Outside mechanical seals. Double seals. Also, accommodates other mechanical seals.
Jacketed Stuffing Box Cover	Same as above, but used in high temperature applications when the temperature of the seal area needs to be controlled.
Conventional Large Bore	Use for all mechanical seal applications where the seal environment requires use of CPI or API seal flush pans. Cannot be used with outside type mechanical seals
Jacketed Large Bore	Same as Large Bore but also need to control temperature of liquid in seal area.
Tapered Large Bore with Axial Ribs	Clean services that require use of single mechanical seals. Can also be used with cartridge double seals. Also, effective on services with light solids up to 1% by weight. Paper stock to 1% by weight.
Tapered Large Bore with Patented Vane Particle Ejector (Alloy Construction)	Services with light to moderate solids up to 10% by weight. Paper stock to 5% by weight. Ideal for single mechanical seals. No flush required. Also, accommodates cartridge double seals. Cannot be used with outside mechanical seals.

Selection Guide

Goulds engineered seal chambers provide best seal environment for selected sealing arrangements/services.

A Ideally Suited B Acceptable C Not Recommended	**TYPE 1** **Standard Bore Stuffing Box Cover** *Designed for packing. Also accommodates mechanical seals .*	**TYPE 2** **Conventional Large Bore** *Enlarged chamber for increased seal life through improved lubrication and cooling. Seal environment should be controlled through use of CPI flush plans .*	**TYPE 3** **Tapered Bore** *Lower seal face temperatures, self-venting and draining. Solids and vapors circulated away from seal faces wtih VPE and cyclone seal chamber designs. Often no flush required. Superior patented design maximizes seal life with or without solids and vapor in liquid .*	**TYPE 4** **Jacketed Stuffing Box** *Maintains proper temperature control (heating or cooling) of seal environment .*	**TYPE 5** **Jacketed Large Bore** *Maintains proper temperature control (heating or cooling) of seal environment with improved lubrication of seal faces. Ideal for controlling temperatures on services such as molten sulfur and polymerizing liquids .*
Service Acceptable Ideally Suited					
Ambient Water With Flush	A	A	A	-	-
Entrained Air or Vapor	C	B	A	C	B
Solids 0-10%, No Flush	C	C	A	C	C
Solids up to and greater than 10% With Flush	B	A	A	B	A
Paper Stock 0-5%, With No Flush	C	C	A	-	-
Paper Stock 0-5%, With Flush	B	A	A	-	-
Slurries 0-5%, No Flush	C	C	A	C	C
High Boiling Point Liquids, no flush	C	C	A	C	C
Temperature Control	C	C	C	B	A
Self-Venting and Draining	C	C	A	C	C
Seal Face Heat Removal	C	A	A	C	A
Molten or Polymerizing Liquid, No Flush	C	C	B	C	C
Molten or Polymerizing Liquid With Flush	C	B	B	C	A

Environmental Controls

Environmental controls are necessary for reliable performance of a mechanical seal on many applications. Goulds Pumps and the seal vendors offer a variety of arrangements to combat these problems:

1 Corrosion

2 Temperature Control

3 Dirty or Incompatible Environments

CORROSION

Corrosion can be controlled by selecting seal materials that are not attacked by the pumpage. When this is difficult, external fluid injection of a non-corrosive chemical to lubricate the seal is possible. Single or double seals could be used, depending on if the customer can stand delusion of his product.

TEMPERATURE CONTROL

As the seal rotates, the faces are in contact. This generates heat and if this heat is not removed, the temperature in the stuffing box or seal chamber can increase and cause sealing problems. A simple by-pass of product over the seal faces will remove the heat generated by the seal (Fig. 25). For higher temperature services, by-pass of product through a cooler may be required to cool the seal sufficiently (Fig. 26). External cooling fluid injection can also be used.

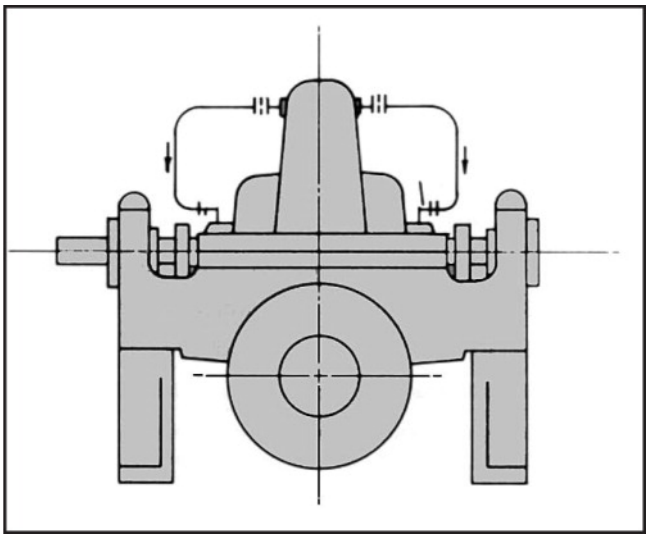


Fig. 25

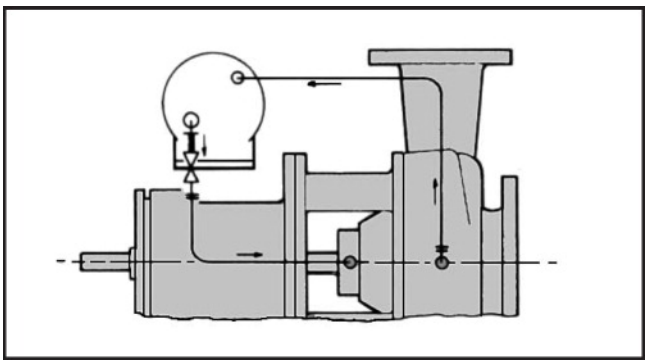


Fig. 26

DIRTY or INCOMPATIBLE ENVIRONMENTS

Mechanical seals do not normally function well on liquids which contain solids or can solidify on contact with the atmosphere. Here, by-pass flush through a filter, a cyclone separator or a strainer are methods of providing a clean fluid to lubricate seal faces.

Strainers are effective for particles larger than the openings on a 40 mesh screen.

Cyclone separators are effective on solids 10 micron or more in diameter, if they have a specific gravity of 2.7 and the pump develops a differential pressure of 30-40 psi. Filters are available to remove solids 2 microns and larger.

If external flush with clean liquid is available, this is the most fail proof system. Lip seal or restricting bushings are available to control flow of injected fluid to flows as low as ⅛ GPM.

Quench type glands are used on fluids which tend to crystallize on exposure to air. Water or steam is put through this gland to wash away any build up. Other systems are available as required by the service.

API and CPI Plans

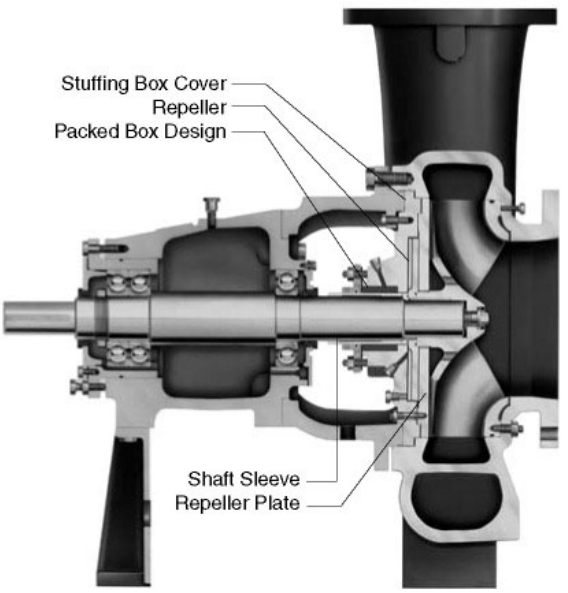
API and CPI mechanical seal flush plans are commonly used with API and CPI process pumps. The general arrangement of the plans are similar regardless of the designation whether API or CPI. The difference between the flush plans is the construction which provides applicable pressure-temperature capability for each type of pump. API plans have higher pressure and temperature capability than CPI plans. Each plan helps provide critical lubrication and cooling of seal faces to maximize seal reliability.

Plan No.	Recommended Applications
01	Single mechanical seals and TDH less then 125 feet.
02	Used with some outside seals. In most cases not recommended.
11	Single and tandem seals. Always consider a plan 11 with balanced seals. Apply when TDH is greater than 125 ft.
12	Same application as 11. Additionally, a 12 will strain particles from the flush liquid. This helps prevent solid impingement on seal faces.
13	Single and tandem seals. Use when difference in pressure between the seal chamber or stuffing box and pump suction exceed 35 psi.
21	Single and tandem seals. Required when the flush needs to be cooled before flushing at the seal faces. (ex. water above 200°F, light hydrocarbons or any other liquids with poor lubricating qualities and high vapor pressures.)
22	Same application as 21. Additionally, a plan 22 will strain particles from the flush liquid. This helps prevent solid impingement on seal faces.
23	Single and tandem seals. Use when difference in pressure between the seal chamber or stuffing box and pump suction exceed 35 psi. 3600 RPM only.
31	Single and tandem seals. Apply when strainers are inadequate to clean flushing liquid.
32	Single and tandem seals. Required when pumpage is not suitable to lubricate seal faces. Use of bushing or lip seal is also recommended.
33	Used with double seals when external system is available from user.
41	Apply with liquids that require simultaneous cyclone separation and cooling. (Single and tandem seals).
51	Single seals. Required when sealed liquid will crystallize, coke, solidify, etc. at seal faces if contact with air. Common blankets are isopropyl alcohol, glycol, and water. Normally used with FVD gland and bushing or packed auxiliary box.
52	Tandem seals. Plan provides buffer liquid for outside seal. A plan 01 or plan 11 is also recommended with tandem seals to properly flush inboard seal. Pumping rings recommended.
53	Double seals. Plan provides flushing and cooling to both sets of seal faces. Pumping ring recommended.
54	Double seals or packed auxiliary stuffing box.

Maximum Sealing Flexibility - Dynamic Seal

For Elimination of Mechanical Seal Problems and Reduced Maintenance

Goulds' Dynamic Seal pumps are designed to handle the tough applications where conventional mechanical seals or packing require outside flush and constant, costly attention. The major advantage is that external seal water is not required, thus eliminating leakage, pumpage contamination, product dilution and problems associated with piping from a remote source.



TECH-B-4B Magnetic Drive Pumps

INTRODUCTION

Environmental concerns and recurring mechanical seal problems have created a need for sealless pumps in the chemical and petrochemical industries. In some cases, more stringent regulations by the EPA, OSHA and local agencies are mandating the use of sealless pumps. One type of sealless pump is the magnetic drive pump which uses a permanent magnetic coupling to transmit torque to the impeller without the need for a mechanical seal for packing.

PRINCIPLES OF OPERATION

Magnetic drive pumps use a standard electric motor to drive a set of permanent magnets that are mounted on a carrier or drive assembly located outside of the containment shell. The drive magnet assembly is mounted on a second shaft which is driven by a standard motor. The external rotating magnetic field drives the inner rotor.

The coaxial synchronous torque coupling consists of two rings of permanent magnets as shown in Fig. 1. A magnetic force field is established between the north and south pole magnets in the drive and driven assemblies. This provides the no slip or synchronous capability of the torque coupling. The magnetic field is shown as dashed lines and shaded areas in Fig. 3.

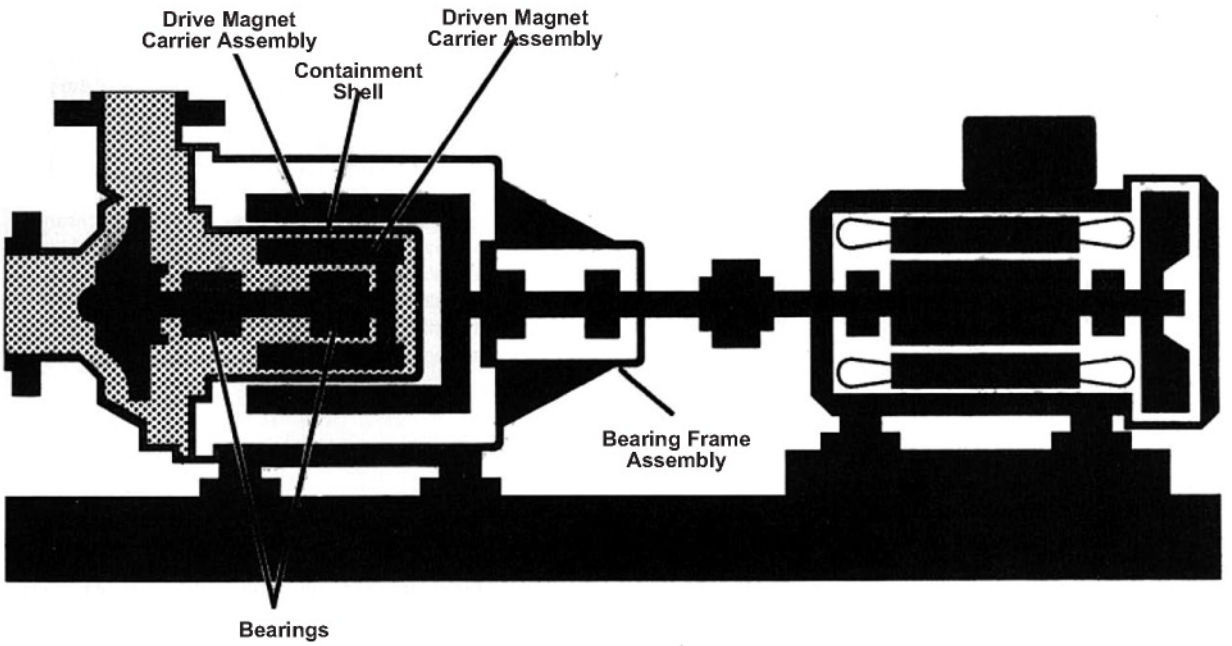


Fig. 1 Typical Magnetic Drive Pump

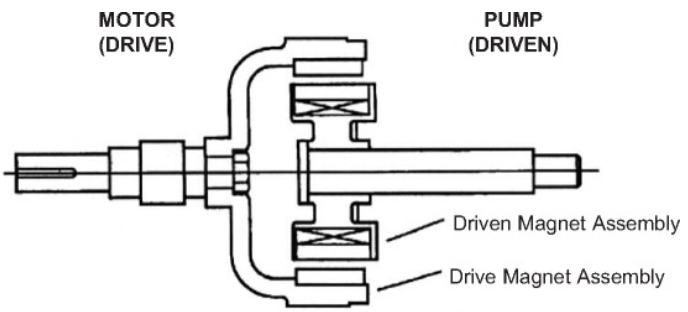


Fig. 2. Coaxial Synchronous Magnetic Torque Coupling

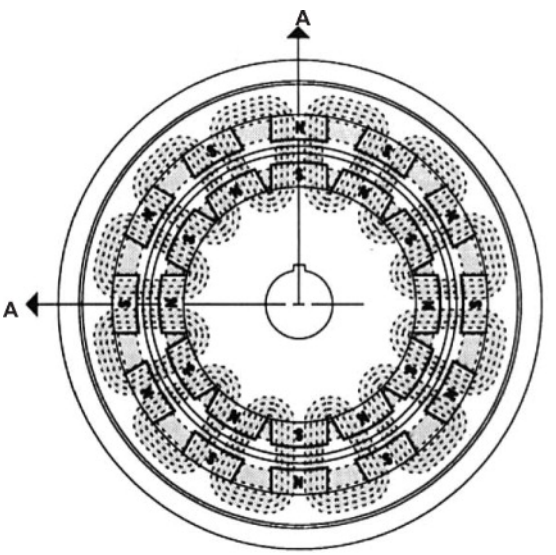


Fig. 3

Containment Shell Designs

The containment shell is the pressure containing barrier which is fitted between the drive and the driven magnet assembly. It must contain full working pressure of the pump, since it isolates the pumped liquid from the atmosphere. One-piece formed shells offer the best reliability, eliminating welds used for two-piece shells.

Since the torque coupling magnetic force field must pass through the shell, it must be made of a non-magnetic material. Non-magnetic metals such as Hastelloy and 316SS are typical choices for the containment shell. The motion of the magnets past an electrically conductive containment shell produces eddy currents, which generate heat and must be removed by a process fluid recirculation circuit.

The eddy currents also create a horsepower loss, which reduces the efficiency of the pump. Metals with low electrical conductivity have lower eddy current losses, providing superior pump efficiency. Hastelloy has a relatively low electrical conductivity and good corrosion resistance, thus is an excellent choice for metal containment shells. Electrically non-conductive materials such as plastic and ceramics are also good choices for containment shells, since the eddy current losses are totally eliminated. This results in pump efficiencies equal to conventionally sealed pumps. Plastic containment shells are generally limited to lower pressures and temperatures due to the limited strength of plastics.

Sleeve and Thrust Bearings

Magnetic drive pumps utilize process lubricated bearings to support the inner drive rotor. These bearings are subject to the corrosive nature of the liquids being pumped, thus need to be made from corrosion resistant materials. Two commonly used materials are hard carbon and silicon carbide (SIC). Pure sintered SIC is superior to reaction bonded SIC, since reaction bonded SIC has free silicon left in the matrix, resulting in lower chemical resistance and lower strength.

Hard carbon against silicon carbide offers excellent service life for many chemical applications and also offers the advantage of short term operation in marginal lubrication conditions.

Silicon carbide against silicon carbide offers excellent service life for nearly all chemical applications. Its hardness, high thermal conductivity, and strength make it an excellent bearing material. Silicon carbide must be handled carefully to prevent chipping. Silicon carbide against silicon carbide has very limited capability in marginal lubrication conditions.

A. Determination of total head

The total head of a pump can be determined by gauge readings as illustrated in Fig. 1.

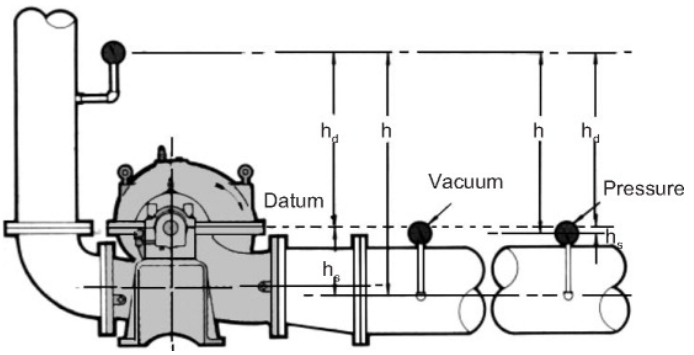


Fig. 1 Determination of Total Head From Gauge Readings

Negative Suction Pressure :

- TDH = Discharge gauge reading converted to feet of liquid + vacuum gauge reading converted to feet of liquid + distance between point of attachment of vacuum gauge and the centerline of the discharge gauge, h, in feet +

$$+ \left(\frac{Vd^2}{2g} - \frac{Vs^2}{2g}\right)$$

Positive Suction Pressure :

- or TDH = Discharge gauge reading converted to feet of liquid-pressure gauge reading in suction line converted to ft. of liquid + distance between center of discharge and suction gauges, h, in feet

$$+ \left(\frac{Vd^2}{2g} - \frac{Vs^2}{2g}\right)$$

In using gauges when the pressure is positive or above atmospheric pressure, any air in the gauge line should be vented off by loosening the gauge until liquid appears. This assures that the entire gauge line is filled with liquid and thus the gauge will read the pressure at the elevation of the centerline of the gauge. However, the gauge line will be empty of liquid when measuring vacuum and the gauge will read the vacuum at the elevation of the point of attachment of the gauge line to the pipe line. These assumptions are reflected in the above definitions.

The final term in the above definitions accounts for a difference in size between the suction and discharge lines. The discharge line is normally smaller than the suction line and thus the discharge velocity is higher. A higher velocity results in a lower pressure since the sum of the pressure head and velocity head in any flowing liquid remains constant. Thus, when the suction and discharge line sizes at the gauge attachment points are different, the resulting difference in velocity head must be included in the total head calculation.

Manometers can also be used to measure pressure. The liquid used in a manometer is normally water or mercury, but any liquid of known specific gravity can be used. Manometers are extremely accurate for determining low pressures or vacuums and no calibration is needed. They are also easily fabricated in the field to suit any particular application. Figs. 2 & 3 illustrate typical manometer set ups.

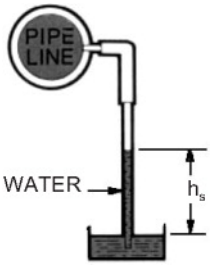


Fig. 2 Manometer Indicating Vacuum

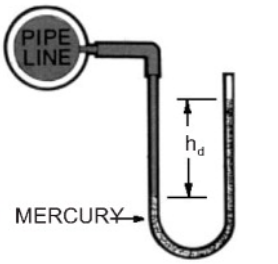


Fig. 3 Manometer Indicating Pressure

B. Measurement of capacity

a.) Magnetic Flow Meter

A calibrated magnetic flow meter is an accurate means of measuring flow in a pumping system. However, due to the expense involved, magnetic flow meters are only practical in small factory test loops and in certain process pumping systems where flow is critical.

b.) Volumetric Measurement

Pump capacity can be determined by weighing the liquid pumped or measuring its volume in a calibrated vessel. This is often practical when pumping into an accurately measured reservoir or tank, or when it is possible to use small containers which can be accurately weighed. These methods, however, are normally suited only to relatively small capacity systems.

c.) Venturi Meter

A venturi meter consists of a converging section, a short constricting throat section and then a diverging section. The object is to accelerate the fluid and temporarily lower its static pressure. The flow is then a function of the pressure differential between the full diameter line and the throat. Fig. 4 shows the general shape and flow equation. The meter coefficient is determined by actual calibration by the manufacturer and, when properly installed, the Venturi Meter is accurate to within plus or minus 1%.

$$Q(GPM) = 5.67\ CD_2^2 \sqrt{\frac{H}{1 - R^4}}$$

C = Instrument Coefficient
D_1 = Entrance Diameter in Inches
D_2 = Throat Diameter in Inches
$R = D_2/D_1$
H = Differential Head in Inches = $h_1 - h_2$

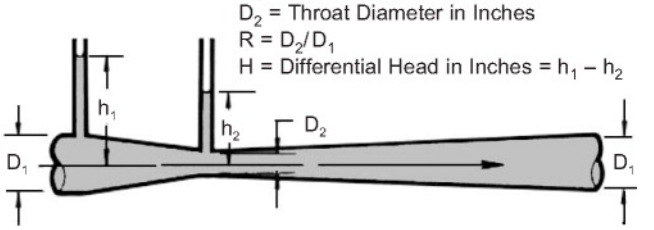


Fig. 4 Venturi Meter

d.) Nozzle

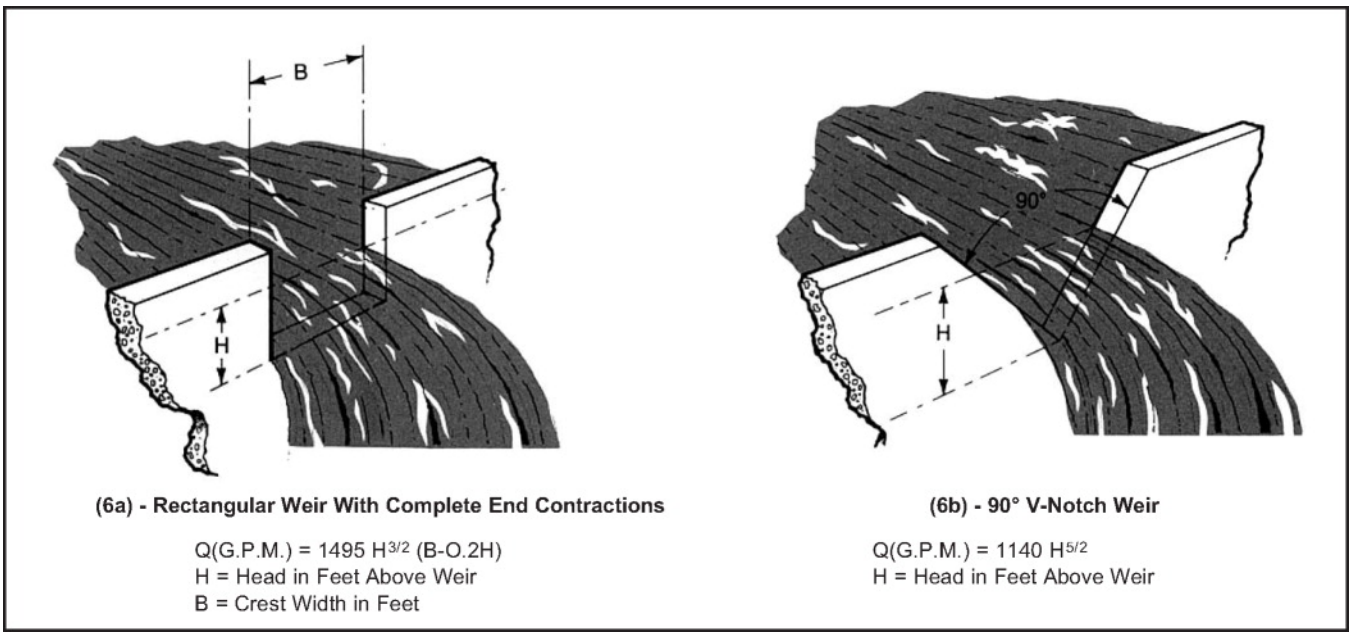
A nozzle is simply the converging portion of a venturi tube with the liquid exiting to the atmosphere. Therefore, the same formula can be used with the differential head equal to the gauge reading ahead of the nozzle. Fig. 5 lists theoretical nozzle discharge flows.

Theoretical Discharge of Nozzles in U.S. GPM

Head		Veloc'y of Disch. Feet per Sec.	Diameter of Nozzle in Inches												
Lbs.	Feet		1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8
10	23.1	38.6	0.37	1.48	3.32	5.91	13.3	23.6	36.9	53.1	72.4	94.5	120	148	179
15	34.6	47.25	0.45	1.81	4.06	7.24	16.3	28.9	45.2	65.0	88.5	116.	147	181	219
20	46.2	54.55	0.52	2.09	4.69	8.35	18.8	33.4	52.2	75.1	102.	134.	169	209	253
25	57.7	61.0	0.58	2.34	5.25	9.34	21.0	37.3	58.3	84.0	114.	149	189	234	283
30	69.3	66.85	0.64	2.56	5.75	10.2	23.0	40.9	63.9	92.0	125.	164.	207	256	309
35	80.8	72.2	0.69	2.77	6.21	11.1	24.8	44.2	69.0	99.5	135.	177.	224	277	334
40	92.4	77.2	0.74	2.96	6.64	11.8	26.6	47.3	73.8	106.	145.	189.	239	296	357
45	103.9	81.8	0.78	3.13	7.03	12.5	28.2	50.1	78.2	113.	153.	200.	253	313	379
50	115.5	86.25	0.83	3.30	7.41	13.2	29.7	52.8	82.5	119.	162.	211.	267	330	339
55	127.0	90.4	0.87	3.46	7.77	13.8	31.1	55.3	86.4	125.	169.	221.	280	346	418
60	138.6	94.5	0.90	3.62	8.12	14.5	32.5	57.8	90.4	130.	177.	231.	293	362	438
65	150.1	98.3	0.94	3.77	8.45	15.1	33.8	60.2	94.0	136.	184.	241.	305	376	455
70	161.7	102.1	0.98	3.91	8.78	15.7	35.2	62.5	97.7	141.	191.	250.	317	391	473
75	173.2	105.7	1.01	4.05	9.08	16.2	36.4	64.7	101.	146.	198.	259.	327	404	489
80	184.8	109.1	1.05	4.18	9.39	16.7	37.6	66.8	104.	150.	205.	267.	338	418	505
85	196.3	112.5	1.08	4.31	9.67	17.3	38.8	68.9	108.	155.	211.	276.	349	431	521
90	207.9	115.8	1.11	4.43	9.95	17.7	39.9	70.8	111.	160.	217.	284.	359	443	536
95	219.4	119.0	1.14	4.56	10.2	18.2	41.0	72.8	114.	164.	223.	292.	369	456	551
100	230.9	122.0	1.17	4.67	10.5	18.7	42.1	74.7	117.	168.	229.	299.	378	467	565
105	242.4	125.0	1.20	4.79	10.8	19.2	43.1	76.5	120.	172.	234	306.	388	479	579
110	254.0	128.0	1.23	4.90	11.0	19.6	44.1	78.4	122.	176.	240	314.	397	490	593
115	265.5	130.9	1.25	5.01	11.2	20.0	45.1	80.1	125.	180.	245.	320.	406	501	606
120	277.1	133.7	1.28	5.12	11.5	20.5	46.0	81.8	128.	184.	251.	327.	414	512	619
125	288.6	136.4	1.31	5.22	11.7	20.9	47.0	83.5	130.	188.	256.	334.	423	522	632
130	300.2	139.1	1.33	5.33	12.0	21.3	48.0	85.2	133.	192.	261.	341.	432	533	645
135	311.7	141.8	1.36	5.43	12.2	21.7	48.9	86.7	136.	195.	266.	347.	439	543	656
140	323.3	144.3	1.38	5.53	12.4	22.1	49.8	88.4	138.	199.	271.	354	448	553	668
145	334.8	146.9	1.41	5.62	12.6	22.5	50.6	89.9	140.	202.	275.	360	455	562	680
150	346.4	149.5	1.43	5.72	12.9	22.9	51.5	91.5	143.	206.	280.	366.	463	572	692
175	404.1	161.4	1.55	6.18	13.9	24.7	55.6	98.8	154.	222.	302.	395.	500	618	747
200	461.9	172.6	1.65	6.61	14.8	26.4	59.5	106.	165.	238.	323.	423	535	660	799
250	577.4	193.0	1.85	7.39	16.6	29.6	66.5	118.	185.	266.	362.	473.	598	739	894
300	692.8	211.2	2.02	8.08	18.2	32.4	72.8	129.	202.	291.	396.	517.	655	808	977
			1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4	4 1/2	5	5 1/2	6
10	23.1	38.6	213	289	378	479	591	714	851	1158	1510	1915	2365	2855	3405
15	34.6	47.25	260	354	463	585	723	874	1041	1418	1850	2345	2890	3490	4165
20	46.2	54.55	301	409	535	676	835	1009	1203	1638	2135	2710	3340	4040	4810
25	57.7	61.0	336	458	598	756	934	1128	1345	1830	2385	3025	3730	4510	5380
30	69.3	66.85	368	501	655	828	1023	1236	1473	2005	2615	3315	4090	4940	5895
35	80.8	72.2	398	541	708	895	1106	1335	1591	2168	2825	3580	4415	5340	6370
40	92.4	77.2	425	578	756	957	1182	1428	1701	2315	3020	3830	4725	5280	6380
45	103.9	81.8	451	613	801	1015	1252	1512	1802	2455	3200	4055	5000	6050	7210
50	115.5	86.25	475	647	845	1070	1320	1595	1900	2590	3375	4275	5280	6380	7600
55	127.0	90.4	498	678	886	1121	1385	1671	1991	2710	3540	4480	5530	6690	7970
60	138.6	94.5	521	708	926	1172	1447	1748	2085	2835	3700	4685	5790	6980	8330
65	150.1	98.3	542	737	964	1220	1506	1819	2165	2950	3850	4875	6020	7270	8670
70	161.7	102.1	563	765	1001	1267	1565	1888	2250	3065	4000	5060	6250	7560	9000
75	173.2	105.7	582	792	1037	1310	1619	1955	2330	3170	4135	5240	6475	7820	9320
80	184.8	109.1	602	818	1070	1354	1672	2020	2405	3280	4270	5410	6690	8080	9630
85	196.3	112.5	620	844	1103	1395	1723	2080	2480	3375	4440	5575	6890	8320	9920
90	207.9	115.8	638	868	1136	1436	1773	2140	2550	3475	4530	5740	7090	8560	10210
95	219.4	119.0	656	892	1168	1476	1824	2200	2625	3570	4655	5900	7290	8800	10500
100	230.9	122.0	672	915	1196	1512	1870	2255	2690	3660	4775	6050	7470	9030	10770
105	242.4	125.0	689	937	1226	1550	1916	2312	2755	3750	4655	5900	7290	8800	10500
110	254.0	128.0	705	960	1255	1588	1961	2366	2820	3840	5010	6350	7840	9470	11300
115	265.5	130.9	720	980	1282	1621	2005	2420	2885	3930	5120	6490	8010	9680	11500
120	277.1	133.7	736	1002	1310	1659	2050	2470	2945	4015	5225	6630	8180	9900	11800
125	288.6	136.4	751	1022	1338	1690	2090	2520	3005	4090	5340	6760	8350	10100	12030
130	300.2	139.1	767	1043	1365	1726	2132	2575	3070	4175	5450	6900	8530	10300	12290
135	311.7	141.8	780	1063	1390	1759	2173	2620	3125	4250	5550	7030	8680	10490	12510
140	323.3	144.3	795	1082	1415	1790	2212	2670	3180	4330	5650	7160	8850	10690	12730
145	334.8	146.9	809	1100	1440	1820	2250	2715	3235	4410	5740	7280	8990	10880	12960
150	346.4	149.5	824	1120	1466	1853	2290	2760	3295	4485	5850	7410	9150	11070	13200
175	404.1	161.4	890	1210	1582	2000	2473	2985	3560	4840	6310	8000	9890	11940	14250
200	461.9	172.6	950	1294	1691	2140	2645	3190	3800	5175	6750	8550	10580	12770	15220
250	577.4	193.0	1063	1447	1891	2392	2955	3570	4250	5795	7550	9570	11820	14290	17020
300	692.8	211.2	1163	1582	2070	2615	3235	3900	4650	6330	8260	10480	12940	15620	18610

NOTE: – The actual quantities will vary from these figures, the amount of variation depending upon the shape of nozzle and size of pipe at the point where the pressure is determined. With smooth taper nozzles the actual discharge is about 94% of the figures given in the tables.

Fig. 5



(6a) - Rectangular Weir With Complete End Contractions

$Q(G.P.M.) = 1495\ H^{3/2}\ (B\text{-}O.2H)$
H = Head in Feet Above Weir
B = Crest Width in Feet

(6b) - 90° V-Notch Weir

$Q(G.P.M.) = 1140\ H^{5/2}$
H = Head in Feet Above Weir

Fig. 31 Weirs

g.) Pitot tube

A pitot tube measures fluid velocity. A small tube placed in the flow stream gives two pressure readings: one receiving the full impact of the flowing stream reads static head + velocity head, and the other reads the static head only (Fig. 7). The difference between the two readings is the velocity head. The velocity and the flow are then determined from the following well known formulas.

$V = C\sqrt{2gh_v}$ where C is a coefficient for the meter determined by calibration, and h_v = velocity head,

Capacity = Area x Average Velocity

Since the velocity varies across the pipe, it is necessary to obtain a velocity profile to determine the average velocity. This involves some error but, when properly applied, a calibrated pitot tube is within plus or minus 2% accuracy.

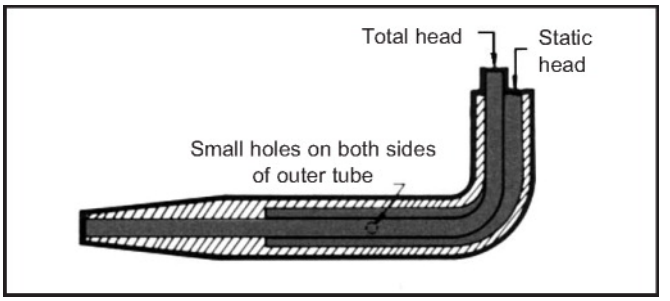


Fig. 7 Pitot Tube

TECH-B-6 Vibration Analysis

Vibration analysis equipment enables you to tell when "normal" vibration becomes "problem" vibration or exceeds acceptable levels. It may also allow you to determine the source and cause of the vibration, thus becoming an effective preventive maintenance and troubleshooting aid.

A vibration analyzer measures the amplitude, frequency and phase of vibration. Also when vibration occurs at several frequencies, it separates one frequency from another so that each individual vibration characteristic can be measured.

The vibration pickup senses the velocity of the vibration and converts it into an electrical signal. The analyzer receives this signal, converting it to the corresponding amplitude and frequency.

The amplitude is measured in terms of peak-to-peak displacement in mils (1 mil = .001") and is indicated on the amplitude meter.

Some instruments are equipped with a frequency meter which gives a direct readout of the predominant frequency of the vibration. Other instruments have tunable filters which allow scanning the frequency scale and reading amplitude at any particular frequency, all others being filtered out.

A strobe light is used to determine the phase of vibration. It can be made to flash at the frequency of the vibration present or at any arbitrary frequency set on an internal oscillator.

A reference mark on a rotating part viewed under the strob light flashing at the vibration frequency may appear as a single frozen (or rotating) mark, or as several frozen (or rotating) marks. The number of marks viewed is useful in determining the source of the vibration. The location of the mark or marks is used in balancing rotating parts.

The first step in vibration analysis is to determine the severity of the vibration, then, if the vibration is serious, a complete set of vibration readings should be taken before attempting to analyze the cause.

The specific maximum allowable vibration values for rotodynamic pumps can be found by referring to the "American National Standard for Rotodynamic Pumps for Vibration Measurements and Allowable Values" (ANSI/HI 9.6.4). The standard pertains to evaluation of vibration measurements on rotodynamic pumps in the field and factory test environments. The standard is based on experiences from pump users and manufactures.

Severity of vibration is a function of amplitude and pump speed; however, it should be noted that a change in severity over a period of time is usually a warning of impending failure. This change is often more important than vibration in the "slightly rough" or "rough" ranges which does not change with time.

Complete pump vibration analysis requires taking vibration readings at each bearing in three planes (horizontal, vertical and axial). Readings at the pump suction and discharge flanges may also be useful in some cases.

After all data has been tabulated, it can be analyzed to determine the most likely cause or causes of vibration and the identifying characteristics of each.

By analyzing the tabulated vibration data one or several causes may be found. Each must be checked, starting with the most likely cause or easiest to check.

For example, assume the axial vibration is 50% or more of the radial vibration and the predominant frequency is the same as the RPM of the pump. The chart indicates probable misalignment or bent shaft. Coupling misalignment is probably the most common single cause of pump vibration and is one of the easiest to check. If after checking, the alignment proves to be good, then inspect for flange loading. Finally, check for a bent shaft. Cavitation in a pump can cause serious vibration. Vibration at random frequencies can also be caused by hydraulic disturbances in poorly designed suction or discharge systems.

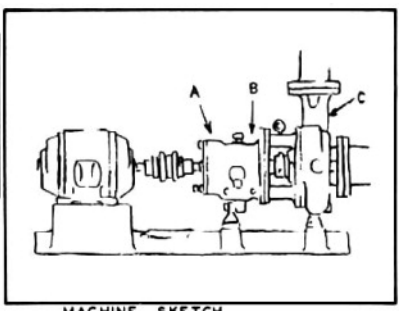
The use of vibration equipment in preventive maintenance involves keeping a vibration history on individual pieces of equipment in a plant. A form similar to that shown in Fig. 4 can be used to record the vibration data on a periodic routine basis. Abrupt changes are a sign of impending failure. A gradual increase in vibration can also be detected and corrective measures can be taken before it reaches a dangerous level.

Cause	Amplitude	Frequency	Phase	Remarks
Unbalance	Largest in radial direction. Proportional to unbalance	1 x RPM	Single reference mark	Unbalance
Misalignment of coupling or bearings and bent shaft	Axial direction vibration 50% or more of radial	1 x RPM normally	single, double, or triple	Easily recognized by large axial vibration. Excessive flange loading can contribute to misalignment
Bad Anti-friction bearings	Unsteady	Very high. Several times RPM	Erratic	Largest high-frequency vibration near the bad bearing.
Mechanical looseness		2 x RPM	Two reference marks. Slightly erratic.	Check grouting and bed plate bolting.
Bad drive belts	Erratic or pulsing	1, 2, 3 & 4 x RPM of belts	Unsteady	Use strobe light to freeze faulty belt.
Electrical	Disappears when power is turned off.	1 or 2 x synchronous frequency	Single or rotating double mark	3600 or 7200 cps for 60 cycle current.
Hydraulic forces		No. of impeller vanes x RPM		Rarely a cause of serious vibration

Fig. 3 Vibration Identification Chart

VIBRATION HISTORY

DATE 10/4
MACHINE GOULDS MODEL 3196
LOCATION
NAME
INSTRUMENT MODEL 600
S N 222 8078
OPERATOR GUSTZ HIGGINS



MACHINE SKETCH

PICKUP POSITION		FILTER OUT MILS	FILTER OUT CPM	FILTER IN MILS	FILTER IN CPM	FILTER IN MILS	FILTER IN CPM	FILTER IN MILS	FILTER IN CPM	FILTER IN IN/SEC	FILTER IN CPM	FILTER IN IN/SEC	FILTER IN CPM
A	H												
	V												
	A												
B	H												
	V												
	A												

Fig. 4 Vibration Data Sheet

TECH-B-7 Vertical Turbine Pumps

Turbine Nomenclature

1 **DATUM OR GRADE -** The elevation of the surface from which the pump is supported.

2 **STATIC LIQUID LEVEL -** The vertical distance from grade to the liquid level when no liquid is being drawn from the well or source.

3 **DRAWDOWN -** The distance between the static liquid level and the liquid level when pumping at required capacity.

4 **PUMPING LIQUID LEVEL -** The vertical distance from grade to liquid level when pumping at rated capacity. Pumping liquid level equals static water level plus drawdown.

5 **SETTING -** The distance from grade to the top of the pump bowl assembly.

6 **TPL (TOTAL PUMP LENGTH) -** The distance from grade to lowest point of pump.

7 **RATED PUMP HEAD -** Lift below discharge plus head above discharge plus friction losses in discharge line. This is the head for which the customer is responsible and does not include any losses within the pump.

8 **COLUMN AND DISCHARGE HEAD FRICTION LOSS -** Head loss in the pump due to friction in the column assembly and discharge head. Friction loss is measured in feet and is dependent upon column size, shaft size, setting, and discharge head size. Values given in appropriate charts in Data Section.

9 **BOWL HEAD -** Total head which the pump bowl assembly will deliver at the rated capacity. This is curve performance.

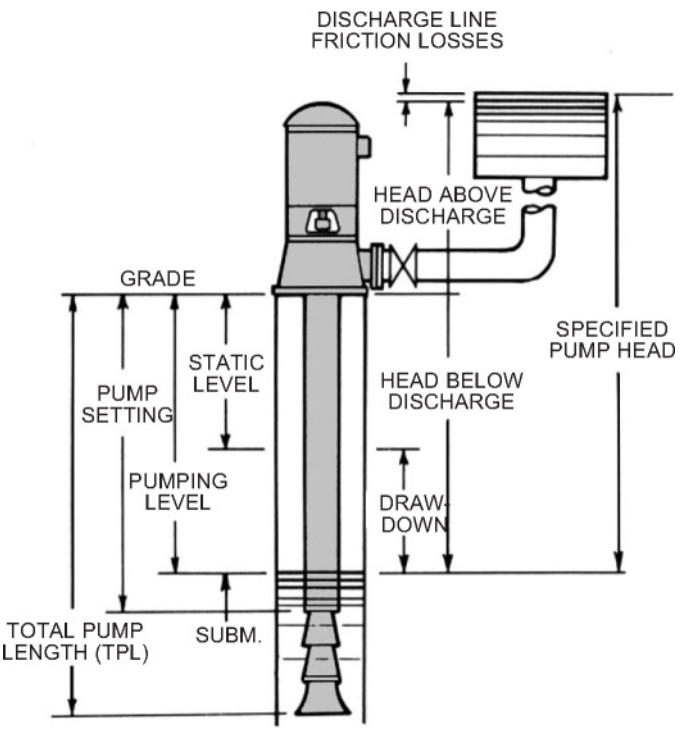
10 **BOWL EFFICIENCY-** The efficiency of the bowl unit only. This value is read directly from the performance curve.

11 **BOWL HORSEPOWER-** The horsepower - required by the bowls only to deliver a specified capacity against bowl head.

$$\text{BOWL HP} = \frac{\text{Bowl Head x Capacity}}{\text{3960 x Bowl Efficiency}}$$

12 **TOTAL PUMP HEAD -** Rated pump head plus column and discharge head loss. **NOTE** : This is new or final bowl head.

13 **SHAFT FRICTION LOSS -** The horsepower required to turn the lineshaft in the bearings. These values are given in appropriate table in Data Section.



14. PUMP BRAKE HORSEPOWER - Sum of bowl horsepower plus shaft loss (and the driver thrust bearing loss under certain conditions).

15. TOTAL PUMP EFFICIENCY (WATER TO WATER) -The efficiency of the complete pump, less the driver, with all pump losses taken into account.

$$\text{Efficiency} = \frac{\text{Specified Pump Head x Capacity}}{\text{3960 x Brake Horsepower}}$$

16. OVERALL EFFICIENCY (WIRE TO WATER) - The efficiency of the pump and motor complete. Overall efficiency = total pump efficiency × motor efficiency.

17. SUBMERGENCE - Distance from liquid level to suction bell.

Vertical Turbine Pumps - Calculating Axial Thrust

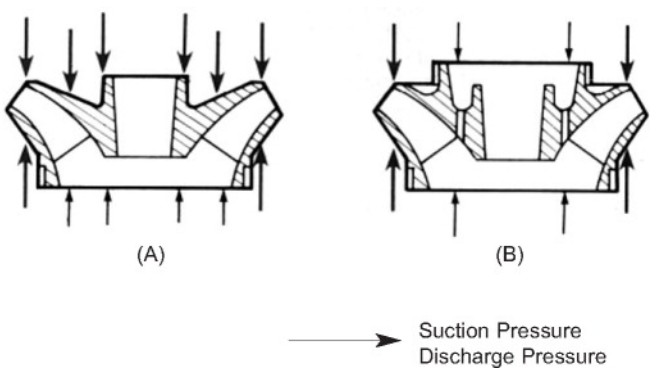
Under normal circumstances Vertical Turbine Pumps have a thrust load acting parallel to the pump shaft. This load is due to unbalanced pressure, dead weight and liquid direction change. Optimum selection of the motor bearing and correct determination of required bowl lateral for deep setting pumps require accurate knowledge of both the magnitude and direction (usually down) of the resultant of these forces. In addition, but with a less significant role, thrust influences shaft H.P. rating and shaft critical speeds.

IMPELLER THRUST

Impeller Thrust in the downward direction is due to the unbalanced discharge pressure across the eye area of the impeller. See diagram A.

Counteracting this load is an upward force primarily due to the change in direction of the liquid passing through the impeller. The resultant of these two forces constitutes impeller thrust. Calculating this thrust using a thrust constant (K) will often produce only an approximate thrust value because a single constant cannot express the upthrust component which varies with capacity.

To accurately determine impeller thrust, thrust-capacity curves based on actual tests are required. Such curves now exist for the "A" Line. To determine thrust, the thrust factor "K" is read from the thrust-capacity curve at the required capacity and given RPM. "K" is then multiplied by the Total Pump Head (Final Lab Head) times Specific Gravity of the pumped liquid. If impeller thrust is excessively high, the impeller can usually be hydraulically balanced. This reduces the value of "K". Balancing is achieved by reducing the discharge pressure above the impeller eye by use of balancing holes and rings. See diagram B.



Although hydraulic balancing reduces impeller thrust, it also decreases efficiency by one to five points by providing an additional path for liquid recirculation. Of even greater concern is that should the hydraulic balancing holes become clogged, (unclean fluids, fluids with solid content, intermittent services, etc.), the impeller thrust will increase and possibly cause the driver to fail. Hydraulically balanced impellers cannot be used in applications requiring rubber bowl bearings because the flutes on the inside diameter of the bearings provide an additional path to the top side of the impeller, thus creating an additional down thrust.

Hydraulically balanced impellers should be used as a ''last resort" for those situations where the pump thrust exceeds the motor thrust bearing capabilities.

DEAD WEIGHT

In addition to the impeller force, dead weight (shaft plus impeller weight less the weight of the liquid displaced) acts downward. On pumps with settings less than 50 feet, dead weight may be neglected on all but the most critical applications as it represents only a small part of the total force. On deeper setting pumps, dead weight becomes significant and must be taken into account.

We normally only take shaft weight into consideration as dead weight, the reason being that impeller weight less its liquid displacement weight is usually a small part of the total.

SHAFT SLEEVES

Finally, there can be an upward force across a head shaft sleeve or mechanical seal sleeve. In the case of can pumps with suction pressure, there can be an additional upward force across the impeller shaft area. Again, for most applications, these forces are small and can be neglected; however, when there is a danger of upthrusts or when there is high discharge pressure (above 600 psi) or high suction pressure (above 400 psi) these forces should be considered.

MOTOR BEARING SIZING

Generally speaking a motor for a normal thrust application has, as standard, a bearing adequate for shutoff thrust. When practical, motor bearings rated for shutoff conditions are preferred. For high thrust applications (when shutoff thrust exceeds the standard motor bearing rating) the motor bearing may be sized for the maximum anticipated operating range of the pump.

Should the pump operate below minimum flow for a short period of time, anti-friction bearings such as angular contact or spherical roller can handle the overload. It should be remembered, however, that bearing life is approximately inversely proportional to the cube of the load. Should the load double, motor bearing life will be cut to ⅛ of its original value. Although down thrust overloading is possible, the pump must never be allowed to operate in a continuous upthrust condition even for a short interval without a special motor bearing equipped to handle it. Such upthrust will fail the motor bearing.

CALCULATING MOTOR BEARING LOAD

As previously stated, for short setting non-hydraulic balanced pumps below 50 feet with discharge pressures below 600 psi and can pumps with suction pressures below 100 psi, only impeller thrust need be considered.

Under these conditions:	Where:
Motor Bearing Load (lbs.)	Impeller Thrust (lbs.)
$T_{imp} = KH_L \times SG$	K=Thrust factors (lbs./ft.)
	H_L, = Lab Head (ft.)
	SG = Specific Gravity

For more demanding applications, the forces which should be considered are impeller thrust plus dead weight minus any sleeve or shaft area force.

In equation form:

$$\text{Motor Bearing Load} = T_{imp} + Wt^{(1)} - \text{sleeve force}^{(2)} - \text{shaft area force}^{(3)} = T_t$$

CALCULATING AXIAL THRUST – CONTINUED				
Shaft Dia (in)	Shaft Dead Wt. (lbs/ft.) Open Lineshaft	Shaft Dead Wt. (lbs/ft.) Closed Lineshaft	Shaft Area (in^2)	Sleeve Area (in)
1	2.3	2.6	.78	1.0
$1\ ^3/_{16}$	3.3	3.8	1.1	1.1
1½	5.3	6.0	1.8	1.1
$1\ ^{11}/_{16}$	6.7	7.6	2.2	1.5
$1\ ^{15}/_{16}$	8.8	10.0	2.9	1.8
$2\ ^3/_{16}$	11.2	12.8	3.7	2.0

1 Wt.= Shaft Dead Wt. × Setting In Ft.

2 Sleeve Force=Sleeve area × Discharge pressure

3 Shaft Area Force = Shaft area × Suction pressure

*Oil Lube shaft does not displace liquid above the pumping water level and therefore has a greater net weight.

THRUST BEARING LOSS

Thrust bearing loss is the loss of horsepower delivered to the pump at the thrust bearings due to thrust. In equation form:

$$L_{TB} = .0075 \left(\frac{BHP}{100}\right)\left(\frac{T_t}{1000}\right)$$

where:

L_{TB} = Thrust bearing loss (HP)

BHP = Brake horsepower

T_t = Motor Bearing Load (Lbs.)

$= T_{imp} + Wt^{(1)} - \text{sleeve force}^{(2)} - \text{shaft area force}^{(3)}$

Vertical Turbine Bearing Material Data

(For specific applications where a given bearing material is specified and these limitations are exceeded, refer to factory.)

	Material Description	Temperature and Specific Gravity Limits	Remarks
1. **	Standard Bronze (Federalloy III) 7% Tin/2-4% Zinc /85-89% Cu	-50 to 180°F Min. S. G. of 0.6	General purpose material for fresh/salt water light abrasive services up to 50 ppm. This is a non-leaded bronze material that will not dezincify in seawater because of low zinc content. Not suitable in ammonia, hydrogen sulfide and acetylene services.
2. **	Resin Impregnated Carbon	-50 to 300°F All gravities	Good corrosion resistant material suitable for light abrasive services up to 10 ppm. Special materials available for temperatures beyond 300°F. Good for low specific gravity fluids (e.g. ethane, propane, butane, ethylene) because the carbon is self-lubricating.
3.	Metal (e.g. Nickel) impregnated carbon bearings	-380° to 700°F All gravities	Excellent corrosion resistant except for strong oxidizing solutions (1) . Suitable for abrasive services up to 50 ppm. Special materials available for severe acid services. Good for low specific gravity fluids because the carbon is self-lubricating.
4.	Teflon (metal backed) 25% Graphite with 75% Teflon	-50° to 250°F All gravities	Excellent corrosion resistant except for strong oxidizing solutions (1) . Suitable for abrasive services up to 5 ppm. (Glass filled Teflon also available.) Limited applications - Call V.P.O.
5.	Cast Iron ASTM-A-48 CL30 (I. D. Electroless Nickel Coated)	32° to 180°F Min. S.G. of 0.6	Limited to mildly caustic (2) and light abrasive services up to 10 ppm & some petroleum products (e.g. tar, heavy crude) with good lubricity.
6. **	Rubber (Nitrile Butadiene or Neoprene) with phenolic (3) or metal backing	32° to 150°F	First choice in abrasive fresh/salt water services up to 5000 ppm. Shafting should also be hardfaced for abrasive content above 100 ppm. Bearings must be wet prior to start-up if non-submerged ("dry column") length is greater than 50 ft. **Do not** use in oil, hydrocarbon services, and strong oxidizing agent(1). Contact the factory If the pumpage is other than fresh/salt water. **Do not** use for stuffing box or mechanical seal housing bushings; instead, use standard bronze for light abrasive service up to 50 ppm or hard faced bearing and shaft over 50 ppm. **Do not** use with hydraulically balanced impellers.
7. **	Stainless shell with hardfacing	-100° to 300°F Min. S.G. of 0.6	Alternate for corrosive/abrasive services up to 5000 ppm. Coating or hardfacing material is typically chromium oxide. Contact factory if the bearing shell and/or coating need to be upgraded for better corrosion/abrasion resistance. **Always** use in combination with hardfaced shaft journals.
8.	Boron diffusion coated	up to 400°F	Recommended only for geothermal-brine services **without** the present of oxygen. Hard-faced coated surfaces typically in the range of Rc75. High temp. chemical vapor deposition (CVD). Hardness penetrates into various parent material (substrates), and will not flake, chip, or separate under severe applications (with no O_2 presence).
9.	30% carbon fiber reinforced and compression molded PEEK	-80° to 300°F	Good for services that are corrosive + high temp + abrasives up to 250 ppm. Good chemical resistance (not as good as carbon and Teflon.) Low coefficient of friction and impact/ thermal shock resistance. Not suitable for strong acids, halogens or hot solvents services. Difficult to machine.
10.	Continuous carbon fiber reinforced PEEK	-80° to 600°F	Good for services that are corrosive + high temp + abrasives up to 1,000 ppm. Good chemical resistance (not as good as carbon and Teflon.) Low coefficient of friction and impact/ thermal shock resistance. Not suitable for strong acids, halogens or hot solvents services. Difficult to machine. This material is very difficult to install for high temperature (over 300°F) service.
11.	Nitronic 60	-50° to 300°F Min. S.G. of 0.6	For seawater service. Good for abrasives up to 50 ppm. For use **ONLY** with nitronic 50 shaft.
12.	Thordon	32° to 150°F Min. S.G. of 0.6	Snap rings must be used. Absorbs water, tends to swell. Used at customer request only.

** Denotes bearing materials which are included in Prism cost database.
(1) Example of strong oxidizing agents: hydrochloric acid HCl, nitric acid HNO_3, and sulfuric acid H_2SO_4(hot).
(2) Common name for sodium hydroxide NaOH is lye or caustic soda.
(3) Rubber with phenolic backing will be furnished unless other backing is specified by customer.

TECH-B-8 Self Priming Pump System Guidelines

Self-priming pumps are inherently designed to allow the pump to re-prime itself typically under lift conditions. These pumps are very effective to the end user in that they will eliminate the need for foot valves, vacuum and ejector pumps which can become clogged or be impractical to use for prolonged or remote operation. Although the pump itself is designed to accomplish this task, it is important to understand the principle of how self-priming is achieved so that the piping system can be designed so as not to conflict with this function.

A self-priming pump, by definition, is a pump which will clear its passages of air if it becomes air bound and resume delivery of the pumpage without outside attention. To accomplish this, a charge of liquid sufficient to prime the pump must be retained in the casing (See Fig. A) or in an accessory priming chamber. When the pump starts, the rotating impeller creates a partial vacuum; air from the suction piping is then drawn into this vacuum and is entrained in the liquid drawn from the priming chamber. This air-liquid mixture is then pumped into the air separation chamber (within the casing) where the air is separated from the liquid with the air being expelled out the discharge piping (Fig. B) and the liquid returning to the priming chamber. This cycle is repeated until all of the air from the suction piping has been expelled and replaced by pumpage and the prime has been established (Fig. C).

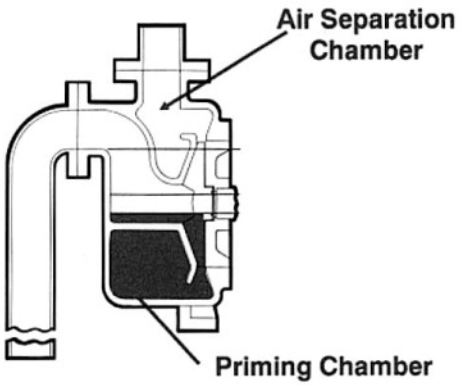


Fig. A

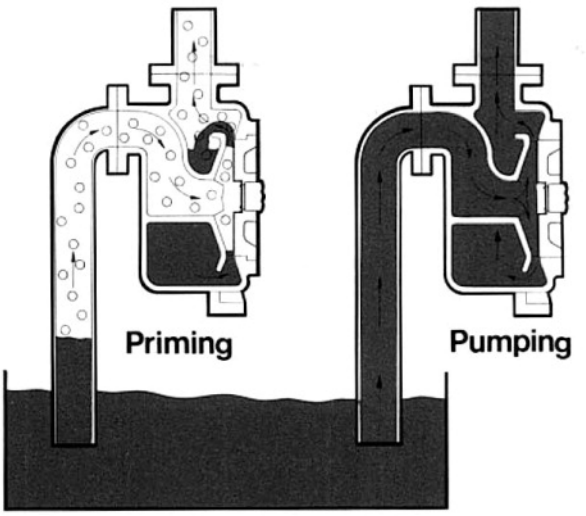


Fig. B Fig. C

The following considerations should be made when designing a piping system for which a self-priming pump is to be used:

- Care should be exercised to insure that adequate liquid is retained in the priming chamber. For outdoor/remote installations a heating element may be required to prevent freezing. For dirty services a strainer may be required to keep solids from accumulating in the priming chamber, thus displacing priming liquid.
- The static lift and suction piping should be minimized to keep priming time to a minimum. Excessive priming time can cause liquid in the priming chamber to vaporize before prime is achieved.
- All connections in the suction piping should be leak-free as air could be sucked in, thus extending/compromising priming of the pump. (Pumps sealed with packing should be flushed to prevent air from being introduced.)
- A priming bypass line (See Fig. D) should be installed so that back pressure is not created in the discharge piping during priming which would prevent the pump from priming itself. (Self-priming pumps are not good air compressors!)
- The suction piping should be designed such that no high points are created where air can be trapped/accumulated which can prevent priming. Historically this has been problematic on top unloading of rail cars. (See Fig. E)

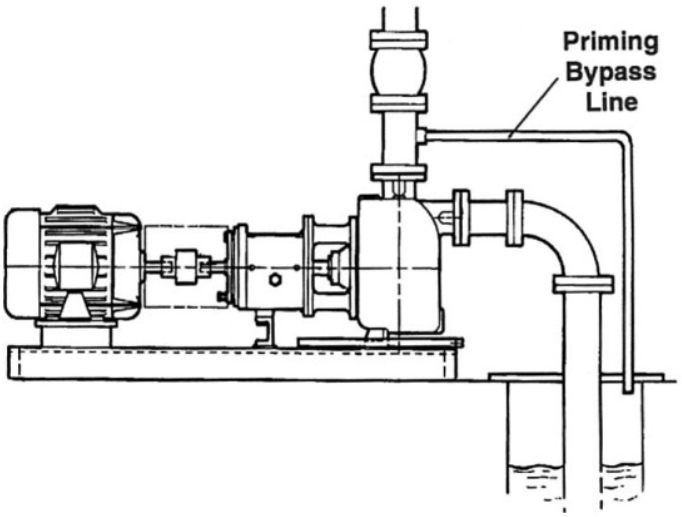


Fig. D

Goulds Model 3796 self-priming process pump is outlined in Section CHEM 1-E .

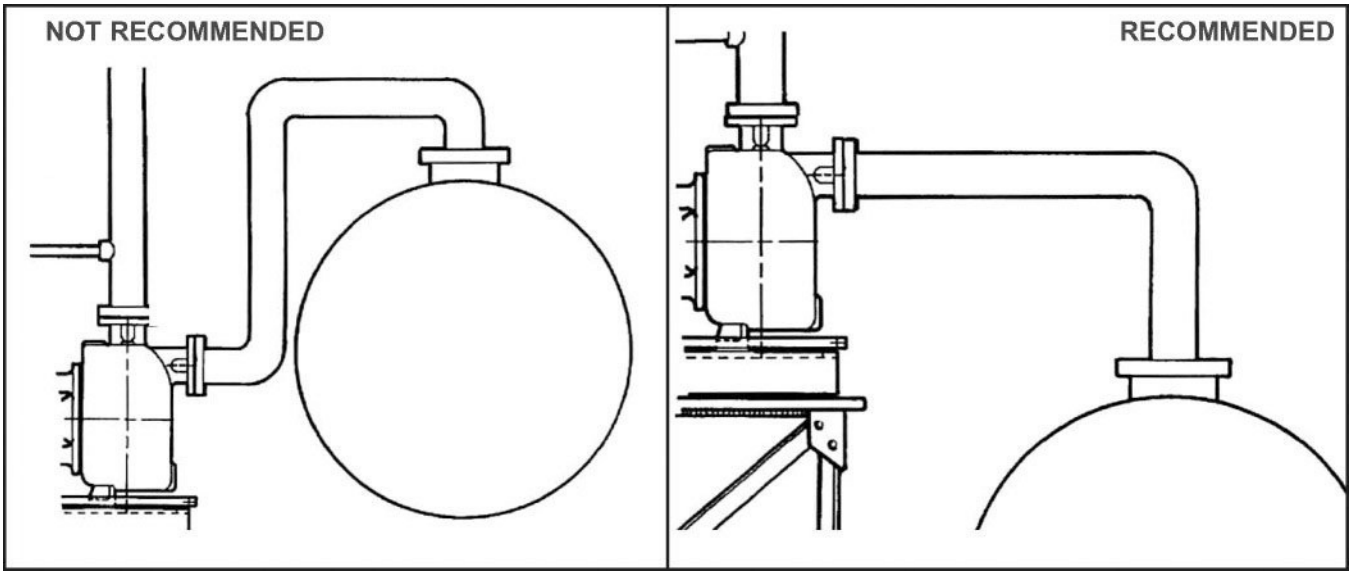


Fig. E Tank Car Unloading

TECH-B-9 Priming Time Calculations

Priming time data for each Model 3796 pump size and speed is displayed on the individual performance curves where priming time is plotted versus effective static lift for maximum, minimum and intermediate impeller diameters. This data is for suction piping of the same nominal diameter as the pump suction, i.e. 3" piping and 3" pump suction, and must be corrected for suction pipe diameters different from the pump suction and for suction pipe lengths greater than the effective static lift.

To calculate the total priming time for a given system:

1 Select the correct size and speed pump from the performance curve for the given rating.

2 Calculate the **NPSH Available** for the system. The available NPSH must be **equal to or greater than the NPSH Required** by the selected pump at the rating point.

$$NPSH_A = P - (L_s + V_p + h_f)$$

where: P = Pressure on surface of liquid in feet absolute
L_s = Maximum static lift in feet from free surface of the liquid to the centerline of the impeller.
V_p = Vapor pressure of the liquid at maximum pumping temperature in feet absolute.
h_f = Suction pipe friction loss in feet at the required capacity.

3 Determine the effective static lift.

$$L_{es} = Ls \times Sp.\ Gr.$$

where: L_{es} = Effective static lift in feet.
L_s = Maximum static lift in feet from free surface of the liquid to the centerline of the pump suction, or the highest point in the suction piping, whichever is greater.
Sp. Gr. = Specific gravity of the liquid.

4 Enter the priming time curve at the effective static lift calculated in Step 3. Proceed across to the impeller diameter selected for the specified rating and then downward to the bottom coordinate to determine the priming time (PT_{Les}) to achieve the given lift.

5. Insert the priming time from Step 4 into the following formula to calculate the total system priming time:

Priming Time - Seconds

$$PT_T = PT_{Les} \times \frac{SPL}{L_{es}} \times \left(\frac{D_p}{D_s}\right)^2$$

where: PT_T = Total system priming time.

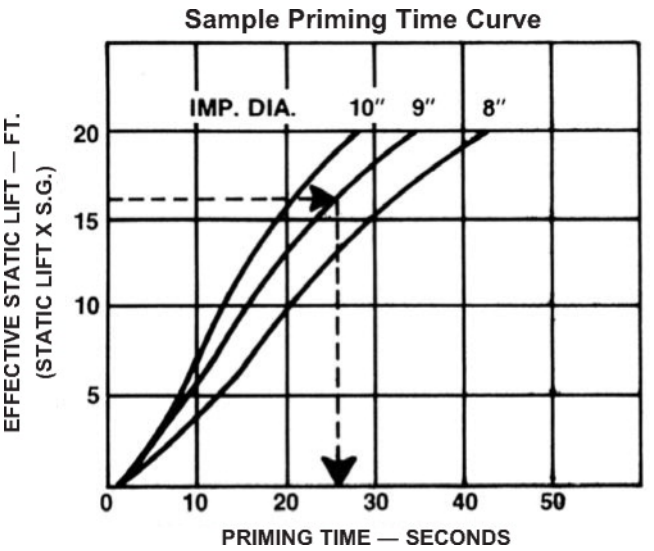
PT_{Les} = Priming time in seconds for the effective static lift (Step 4.)

SPL = Total suction pipe length above the free surface of the liquid in feet.

L_{es} = Effective static lift.

D_p = Nominal pipe diameter.

D_s = Nominal pump suction diameter.



TECH-C-1 Friction Loss for Water – Sched 40 Steel Pipe

U.S. Gallons per Minute	⅛ In. (0.269" I.D.)			¼ In. (0.364" I.D.)			⅜ In. (0.493" I.D.)			½ In. (0.622" I.D.)			U.S. Gallons per Minute
	V (Ft./Sec.)	$\frac{V^2}{2g}$	h_f (Ft./100 ft.)	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
0.2	1.13	0.020	2.72										0.2
0.4	2.26	0.079	16.2	1.23	0.024	3.7							0.4
0.6	3.39	0.178	33.8	1.85	0.053	7.6	1.01	0.016	1.74				0.6
0.8	4.52	0.317	57.4	2.47	0.095	12.7	1.34	0.028	2.89				0.8
1.0	5.65	0.495	87.0	3.08	0.148	19.1	1.68	0.044	4.30	1.06	0.017	1.86	1.0
1.5	8.48	1.12	188	4.62	0.332	40.1	2.52	0.099	8.93	1.58	0.039	2.85	1.5
2.0	11.3	1.98	324	6.17	0.591	69.0	3.36	0.176	15.0	2.11	0.069	4.78	2.0
2.5				7.17	0.923	105	4.20	0.274	22.6	2.64	0.108	7.16	2.5
3.0				9.25	1.33	148	5.04	0.395	31.8	3.17	0.156	10.0	3.0
3.5				10.79	1.81	200	5.88	0.538	42.6	3.70	0.212	13.3	3.5
4.0				12.33	2.36	259	6.72	0.702	54.9	4.22	0.277	17.1	4.0
4.5				13.87	2.99	326	7.56	0.889	68.4	4.75	0.351	21.3	4.5
5				15.42	3.69	398	8.40	1.10	83.5	5.28	0.433	25.8	5
6							10.1	1.58	118	6.34	0.624	36.5	6
7							11.8	2.15	158	7.39	0.849	48.7	7
8							13.4	2.81	205	8.45	1.11	62.7	8
9							15.1	3.56	258	9.50	1.40	78.3	9
10							16.8	4.39	316	10.6	1.73	95.9	10
12										12.7	2.49	136	12
14										14.8	3.40	183	14

U.S. Gallons per Minute	¾ In. (0.824" I.D.)			1 In. (1.049" I.D.)			1 ¼ In. (1.3880" I.D.)			1 ½ In. (1.610" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
4	2.41	0.090	4.21	1.48	0.034	1.29							4
5	3.01	0.141	6.32	1.86	0.053	1.93							5
6	3.61	0.203	8.87	2.23	0.077	2.68	1.29	0.026	0.70				6
7	4.21	0.276	11.8	2.60	0.105	3.56	1.50	0.035	0.93				7
8	4.81	0.360	15.0	2.97	0.137	4.54	1.72	0.046	1.18	1.26	0.025	0.56	8
9	5.42	0.456	18.8	3.34	0.173	5.65	1.93	0.058	1.46	1.42	0.031	0.69	9
10	6.02	0.563	23.0	3.71	0.214	6.86	2.15	0.071	1.77	1.58	0.039	0.83	10
12	7.22	0.810	32.6	4.45	0.308	9.62	2.57	0.103	2.48	1.89	0.056	1.16	12
14	8.42	1.10	43.5	5.20	0.420	12.8	3.00	0.140	3.28	2.21	0.076	1.53	14
16	9.63	1.44	56.3	5.94	0.548	16.5	3.43	0.183	4.20	2.52	0.99	1.96	16
18	10.8	1.82	70.3	6.68	0.694	20.6	3.86	0.232	5.22	2.84	0.125	2.42	18
20	12.0	2.25	86.1	7.42	0.857	25.1	4.29	0.286	6.34	3.15	0.154	2.94	20
25	15.1	3.54	134	9.29	1.34	37.4	5.37	0.448	9.66	3.94	0.241	4.50	25
30	18.1	5.06	187	11.1	1.93	54.6	6.44	0.644	13.6	4.73	0.347	6.26	30
35				13.0	2.62	73.3	7.52	0.879	18.5	5.52	0.473	8.38	35
40				14.8	3.43	95.0	8.58	1.14	23.5	6.30	0.618	10.8	40
45				16.7	4.33	119	9.66	1.45	29.5	7.10	0.783	13.5	45
50				18.6	5.35	146	10.7	1.79	36.0	7.88	0.965	16.4	50
60				22.3	7.71	209	12.9	2.57	51.0	9.46	1.39	23.2	60
70				26.0	10.5	283	15.0	3.50	68.8	11.0	1.89	31.3	70
80							17.2	4.58	89.2	12.6	2.47	40.5	80
90							19.3	5.79	112	14.2	3.13	51.0	90
100							21.5	7.15	138	15.8	3.86	62.2	100
120							25.7	10.3	197	18.9	5.56	88.3	120
140										22.1	7.56	119	140

U.S. per Minute	2 In. (2.067" I.D.)			21/2 In. (2.469" I.D.)			3 In. (3.068" I.D.)			3½ In. (3.548" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
30	2.87	0.128	1.82	2.01	0.063	0.75							30
35	3.35	0.174	2.42	2.35	0.085	1.00							35
40	3.82	0.227	3.10	2.68	0.112	1.28							40
50	4.78	0.355	4.67	3.35	0.174	1.94	2.17	0.073	0.66				50
60	5.74	0.511	6.59	4.02	0.251	2.72	2.60	0.105	0.92	1.95	0.059	0.45	60
80	7.65	0.909	11.4	5.36	0.447	4.66	3.47	0.187	1.57	2.60	0.105	0.77	80
100	9.56	1.42	17.4	6.70	0.698	7.11	4.34	0.293	2.39	3.25	0.164	1.17	100
120	11.5	2.05	24.7	8.04	1.00	10.0	5.21	0.421	3.37	3.89	0.236	1.64	120
140	13.4	2.78	33.2	9.38	1.37	13.5	6.08	0.574	4.51	4.54	0.321	2.18	140
160	15.3	3.64	43.0	10.7	1.79	17.4	6.94	0.749	5.81	5.19	0.419	2.80	160
180	17.2	4.60	54.1	12.1	2.26	21.9	7.81	0.948	7.28	5.84	0.530	3.50	180
200	19.1	5.68	66.3	13.4	2.79	26.7	8.68	1.17	8.90	6.49	0.655	4.27	200
220	21.0	6.88	80.0	14.7	3.38	32.2	9.55	1.42	10.7	7.14	0.792	5.12	220
240	22.9	8.18	95.0	16.1	4.02	38.1	10.4	1.69	12.6	7.79	0.943	6.04	240
260	24.9	9.60	111	17.4	4.72	44.5	11.3	1.98	14.7	8.44	1.11	7.04	260
280	26.8	11.1	128	18.8	5.47	51.3	12.2	2.29	16.9	9.09	1.28	8.11	280
300	28.7	12.8	146	20.1	6.28	58.5	13.0	2.63	19.2	9.74	1.47	9.26	300
350				23.5	8.55	79.2	15.2	3.57	26.3	11.3	2.00	12.4	350
400				26.8	11.2	103	17.4	4.68	33.9	13.0	2.62	16.2	400
500				33.5	17.4	160	21.7	7.32	52.5	16.2	4.09	25.0	500
600							26.0	10.5	74.8	19.5	5.89	35.6	600
700							30.4	14.3	101	22.7	8.02	48.0	700
800							34.7	18.7	131	26.0	10.5	62.3	800
1000										32.5	16.44	96.4	1000

U.S. Gallons per Minute	4 In. (4.026" I.D.)			5 In. (5.047" I.D.)			6 In. (6.065" I.D.)			8 In. (7.981" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
140	3.53	0.193	1.16	2.25	0.078	0.38							140
160	4.03	0.253	1.49	2.57	0.102	0.49							160
180	4.54	0.320	1.86	2.89	0.129	0.61							180
200	5.04	0.395	2.27	3.21	0.160	0.74	2.22	0.077	0.30				200
240	6.05	0.569	3.21	3.85	0.230	1.03	2.66	0.110	0.42				240
280	7.06	0.774	4.30	4.49	0.313	1.38	3.11	0.150	0.56				280
320	8.06	1.01	5.51	5.13	0.409	1.78	3.55	0.196	0.72				320
360	9.07	1.28	6.92	5.77	0.518	2.22	4.00	0.240	0.90				360
400	10.1	1.58	8.47	6.41	0.639	2.72	4.44	0.307	1.09	2.57	0.102	0.28	400
450	11.3	2.00	10.5	7.23	0.811	3.42	5.00	0.388	1.37	2.89	0.129	0.35	450
500	12.6	2.47	13.0	8.02	0.999	4.16	5.55	0.479	1.66	3.21	0.160	0.42	500
600	15.1	3.55	18.6	9.62	1.44	5.88	6.66	0.690	2.34	3.85	0.230	0.60	600
700	17.6	4.84	25.0	11.2	1.96	7.93	7.77	0.939	3.13	4.49	0.313	0.80	700
800	20.2	6.32	32.4	12.8	2.56	10.2	8.88	1.23	4.03	5.13	0.409	1.02	800
900	22.7	8.00	40.8	14.4	3.24	12.9	9.99	1.55	5.05	5.77	0.518	1.27	900
1000	25.2	9.87	50.2	16.0	4.00	15.8	11.1	1.92	6.17	6.41	0.639	1.56	1000
1200	30.2	14.2	72.0	19.2	5.76	22.5	13.3	2.76	8.76	7.70	0.920	2.20	1200
1400	35.3	19.3	97.6	22.5	7.83	30.4	15.5	3.76	11.8	8.98	1.25	2.95	1400
1600				25.7	10.2	39.5	17.8	4.91	15.4	10.3	1.64	3.82	1600
1800				28.8	12.9	49.7	20.0	6.21	19.4	11.5	2.07	4.79	1800
2000				32.1	16.0	61.0	22.2	7.67	23.8	12.8	2.56	5.86	2000
2400							26.6	11.0	34.2	15.4	3.68	8.31	2400
2800							31.1	15.0	46.1	18.0	5.01	11.2	2800
3200							35.5	19.6	59.9	20.5	6.55	14.5	3200
3600										23.1	8.28	18.4	3600
4000										25.7	10.2	22.6	4000

U.S. Gallons per Minute	10 In. (10.020" I.D.)			12 In. (11.938" I.D.)			14 In. (13.124" I.D.)			16 In. (15.000" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
800	3.25	0.165	0.328										800
900	3.66	0.208	0.410	2.58	0.103	0.173							900
1000	4.07	0.257	0.500	2.87	0.128	0.210	2.37	0.087	0.131				1000
1200	4.88	0.370	0.703	3.44	0.184	0.296	2.85	0.126	0.185				1200
1400	5.70	0.504	0.940	4.01	0.250	0.395	3.32	0.171	0.247				1400
1600	6.51	0.659	1.21	4.59	0.327	0.609	3.79	0.224	0.317	2.90	0.131	0.163	1600
1800	7.32	0.834	1.52	5.16	0.414	0.636	4.27	0.283	0.395	3.27	0.166	0.203	1800
2000	8.14	1.03	1.86	5.73	0.511	0.776	4.74	0.349	0.483	3.63	0.205	0.248	2000
2500	10.2	1.62	2.86	7.17	0.799	1.19	5.93	0.546	0.738	4.54	0.320	0.377	2500
3000	12.2	2.32	4.06	8.60	1.15	1.68	7.11	0.786	1.04	5.45	0.461	0.535	3000
3500	14.2	3.13	5.46	10.0	1.55	2.25	8.30	1.07	1.40	6.35	0.627	0.718	3500
4000	16.3	4.12	7.07	11.5	2.04	2.92	9.48	1.40	1.81	7.26	0.820	0.921	4000
4500	18.3	5.21	8.88	12.9	2.59	3.65	10.7	1.77	2.27	8.17	1.04	1.15	4500
5000	20.3	6.43	10.9	14.3	3.19	4.47	11.9	2.18	2.78	9.08	1.28	1.41	5000
6000	24.4	9.26	15.6	17.2	4.60	6.39	14.2	3.14	3.95	10.9	1.84	2.01	6000
7000	28.5	12.6	21.1	20.1	6.26	8.63	16.6	4.28	5.32	12.7	2.51	2.69	7000
8000	32.5	16.5	27.5	22.9	8.17	11.2	19.0	5.59	6.90	14.5	3.28	3.498	8000
9000	36.6	20.8	34.6	25.8	10.3	14.1	21.3	7.08	8.7	16.3	4.15	4.38	9000
10,000				28.7	12.8	17.4	23.7	8.74	10.7	18.2	5.12	5.38	10,000
12,000				34.4	18.3	24.8	28.5	12.6	15.2	21.8	7.38	7.69	12,000
14,000				40.1	25.0	33.5	33.2	17.1	20.7	25.4	10.0	10.4	14,000
16,000							37.9	22.4	26.8	29.0	13.1	13.5	16,000
18,000							42.7	28.3	33.9	32.7	16.6	17.2	18,000
20,000										36.3	20.5	21.2	20,000

U.S. Gallons per Minute	18 In. (16.876" I.D.)			20 In. (18.812" I.D.)			24 In. (22.624" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
2000	2.87	0.128	0.139							2000
3000	4.30	0.288	0.297	3.46	0.186	0.174				3000
4000	5.74	0.512	0.511	4.62	0.331	0.298	3.19	0.158	0.120	4000
5000	7.17	0.799	0.781	5.77	0.517	0.455	3.99	0.247	0.181	5000
6000	8.61	1.15	1.11	6.92	0.745	0.645	4.79	0.356	0.257	6000
8000	11.5	2.05	1.93	9.23	1.32	1.11	6.38	0.633	0.441	8000
10,000	14.3	3.20	2.97	11.5	2.07	.70	7.98	0.989	0.671	10,000
12,000	17.2	4.60	4.21	13.8	2.98	2.44	9.58	1.42	0.959	12,000
14,000	20.1	6.27	5.69	16.2	4.06	3.29	11.2	1.94	1.29	14,000
16,000	22.9	8.19	7.41	18.5	5.30	4.26	12.8	2.53	1.67	16,000
18,000	25.8	10.4	9.33	20.8	6.71	5.35	14.4	3.21	2.10	18,000
20,000	28.7	12.8	11.5	23.1	8.28	6.56	16.0	3.96	2.58	20,000
22,000	31.6	15.5	13.9	25.4	10.0	7.91	17.6	4.79	3.10	22,000
24,000	34.4	18.4	16.5	27.7	11.9	9.39	19.2	5.70	3.67	24,000
26,000	37.3	21.6	19.2	30.0	14.0	11.0	20.7	6.69	4.29	26,000
28,000	40.2	25.1	22.2	32.3	16.2	12.7	22.3	7.76	4.96	28,000
30,000	43.0	28.8	25.5	34.6	18.6	14.6	23.9	8.91	5.68	30,000
34,000				39.2	23.9	18.7	27.1	11.4	7.22	34,000
38,000				43.9	29.9	23.2	30.3	14.3	9.00	38,000
42,000							33.5	17.5	11.0	42,000
46,000							36.7	20.9	13.2	46,000
50,000							39.9	24.7	15.5	50,000

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U.S. Gallons per Minute	30 In.			36 In.			42 In.			U.S. Gallonsper Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
5,000	2.43	0.0917	0.0535							5,000
6,000	2.91	0.132	0.0750							6,000
7,000	3.40	0.180	0.100							7,000
8,000	3.89	0.235	0.129	2.52	0.0988	0.0442				8,000
9,000	4.37	0.297	0.161	2.84	0.125	0.0551				9,000
10,000	4.86	0.367	0.196	3.15	0.154	0.0670				10,000
12,000	5.83	0.528	0.277	3.78	0.222	0.0942	2.78	0.120	0.0441	12,000
14,000	6.80	0.719	0.371	4.41	0.303	0.126	3.24	0.163	0.0591	14,000
16,000	7.77	0.939	0.478	5.04	0.395	0.162	3.71	0.213	0.0758	16,000
18,000	8.74	1.19	0.598	5.67	0.500	0.203	4.17	0.270	0.0944	18,000
20,000	9.71	1.47	0.732	6.30	0.618	0.248	4.63	0.333	0.115	20,000
25,000	12.1	2.29	1.13	7.88	0.965	0.378	5.79	0.521	0.176	25,000
30,000	14.6	3.30	1.61	9.46	1.39	0.540	6.95	0.750	0.250	30,000
35,000	17.0	4.49	2.17	11.03	1.89	0.724	8.11	1.02	0.334	35,000
40,000	19.4	5.87	2.83	12.6	2.47	0.941	9.26	1.33	0.433	40,000
45,000	21.9	7.42	3.56	14.1	3.13	1.18	10.42	1.69	0.545	45,000
50,000	24.3	9.17	4.38	15.8	3.86	1.45	11.6	2.08	0.668	50,000
60,000	29.1	13.2	6.23	18.9	5.56	2.07	13.9	3.00	0.946	60,000
70,000	34.0	18.0	8.43	22.1	7.56	2.81	16.2	4.08	1.27	70,000
80,000	38.9	23.5	11.0	25.2	9.88	3.66	18.5	5.33	1.66	80,000
90,000				28.4	12.5	4.59	20.8	6.75	2.08	90,000
100,000				31.5	15.4	5.64	23.2	8.33	2.57	100,000
120,000				37.8	22.2	8.05	27.8	12.0	3.67	120,000
140,000							32.4	16.3	4.98	140,000
160,000							37.1	21.3	6.46	160,000
180,000							41.7	27.0	8.12	180,000

U.S. Gallons per Minute	48 In.			54 In.			60 In.			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
16,000	2.84	0.125	0.0391							16,000
18,000	3.19	0.158	0.0488							18,000
20,000	3.55	0.195	0.0598	2.80	0.122	0.0333				20,000
25,000	4.43	0.305	0.0910	3.50	0.191	0.0504	2.84	0.125	0.0301	25,000
30,000	5.32	0.440	0.128	4.20	0.274	0.0713	3.40	0.180	0.0424	30,000
35,000	6.21	0.598	0.172	4.90	0.374	0.0958	3.97	0.245	0.0567	35,000
40,000	7.09	0.782	0.222	5.60	0.488	0.124	4.54	0.320	0.0730	40,000
45,000	7.98	0.989	0.278	6.30	0.618	0.155	5.11	0.405	0.0916	45,000
50,000	8.87	1.221	0.341	7.00	0.762	0.189	5.67	0.500	0.112	50,000
60,000	10.64	1.76	0.484	8.40	1.098	0.267	6.81	0.720	0.158	60,000
70,000	12.4	2.39	0.652	9.81	1.49	0.358	7.94	0.980	0.213	70,000
80,000	14.2	3.13	0.849	11.21	1.95	0.465	9.08	1.28	0.275	80,000
90,000	16.0	3.96	1.06	12.6	2.47	0.586	10.21	1.62	0.344	90,000
100,000	17.7	4.89	1.30	14.0	3.05	0.715	11.3	2.00	0.420	100,000
120,000	21.3	7.03	1.87	16.8	4.39	1.02	13.6	2.88	0.600	120,000
140,000	24.8	9.57	2.51	19.6	5.98	1.38	15.9	3.92	0.806	140,000
160,000	28.4	12.5	3.26	22.4	7.81	1.80	18.2	5.12	1.04	160,000
180,000	31.9	15.8	4.11	25.2	9.88	2.26	20.4	6.48	1.32	180,000
200,000	35.5	19.5	5.05	28.0	12.2	2.77	22.7	8.00	1.62	200,000
250,000				35.0	19.1	4.32	28.4	12.5	2.52	250,000
300,000				42.0	27.4	6.19	34.0	18.0	3.60	300,000
350,000							39.7	24.5	4.88	350,000

TECH-C-2 Resistance Coefficients for Valves and Fittings

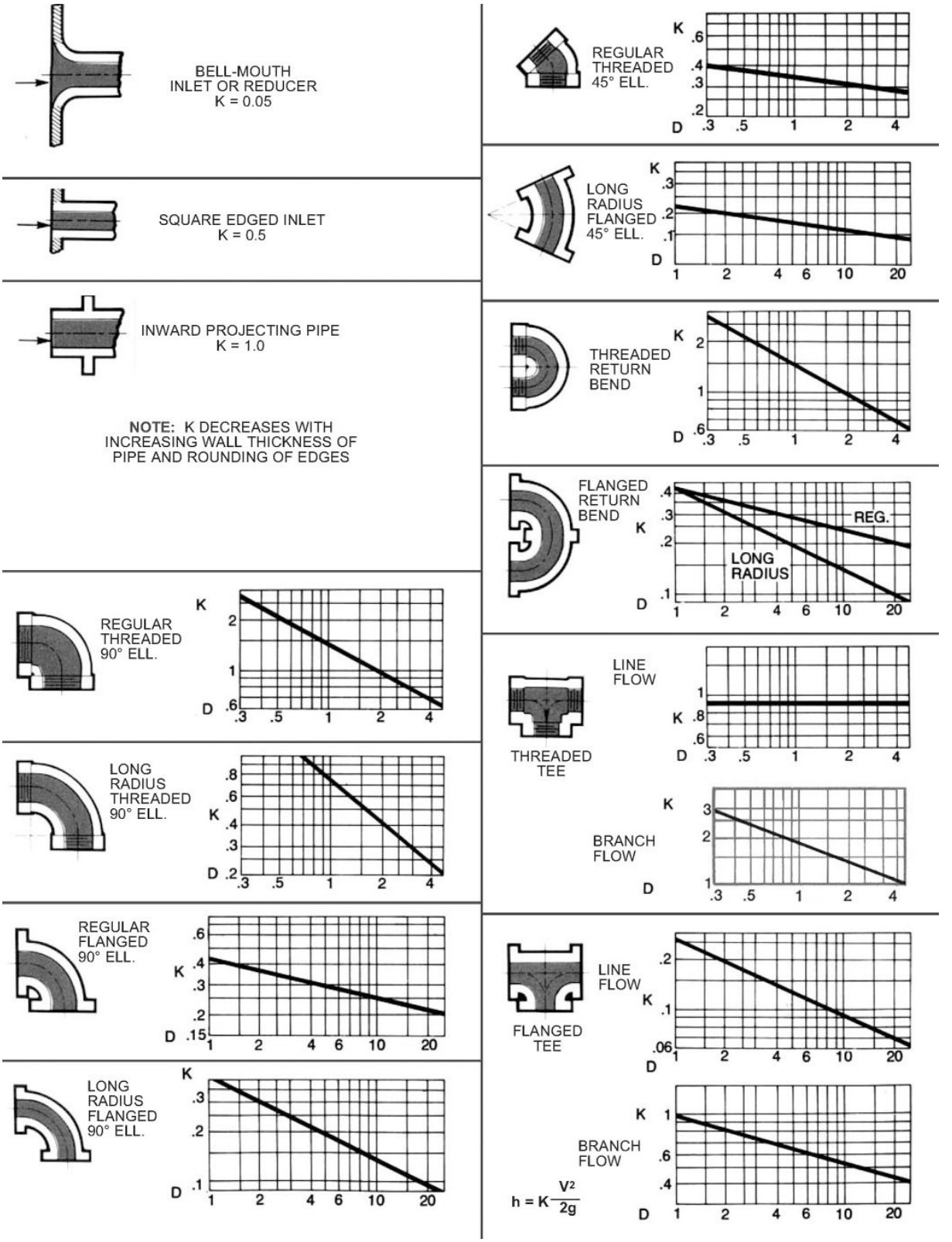


Chart 1
Where:
h = Frictional Resistance in Feet of Liquid g = 32.17 Feet/Second/Second
V = Average Velocity in Feet/Second in a Pipe of Corresponding Diameter
g = 32.17 Feet/Second/Second
K = Resistance Coefficient For Valve or Fitting

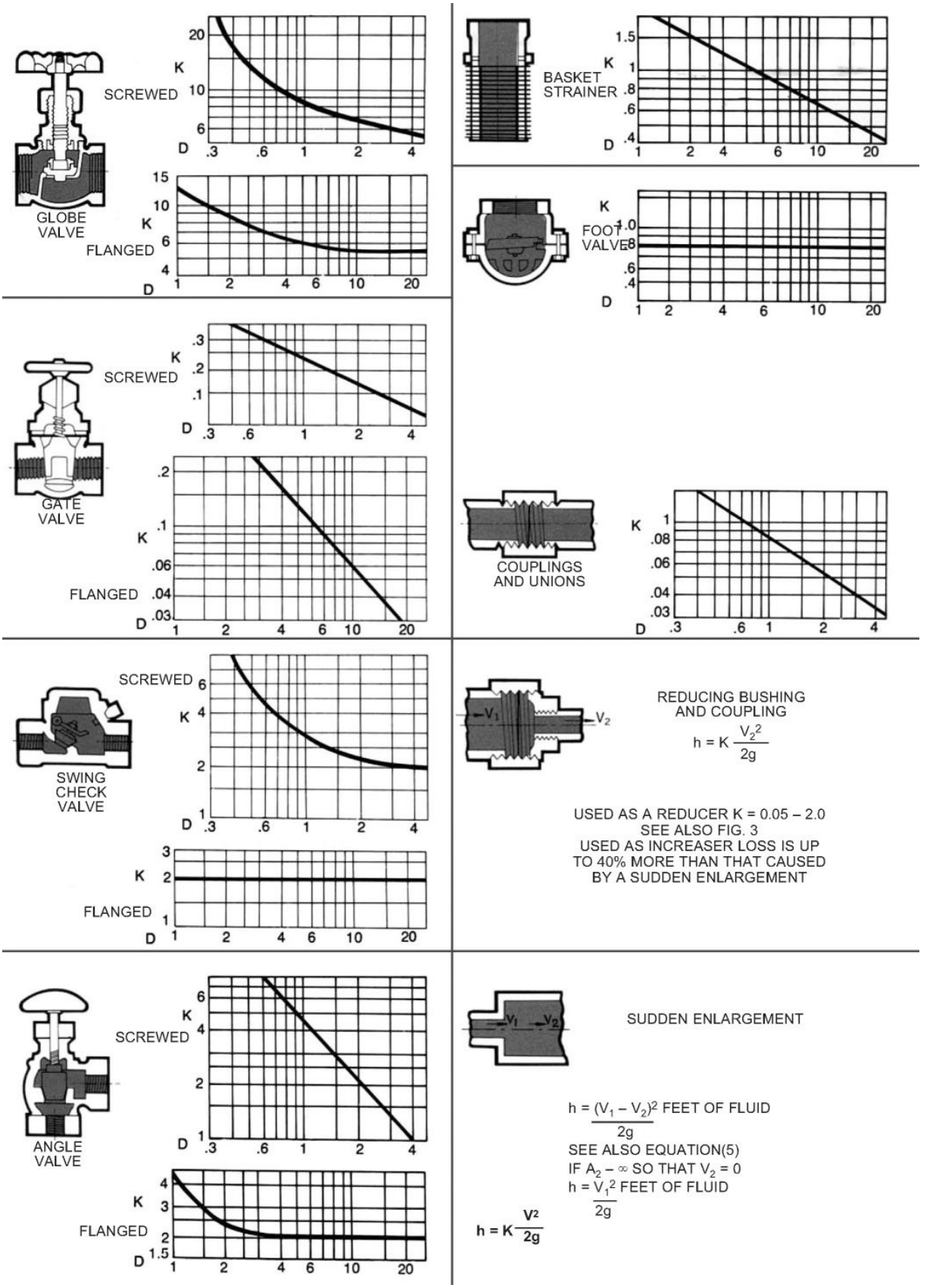
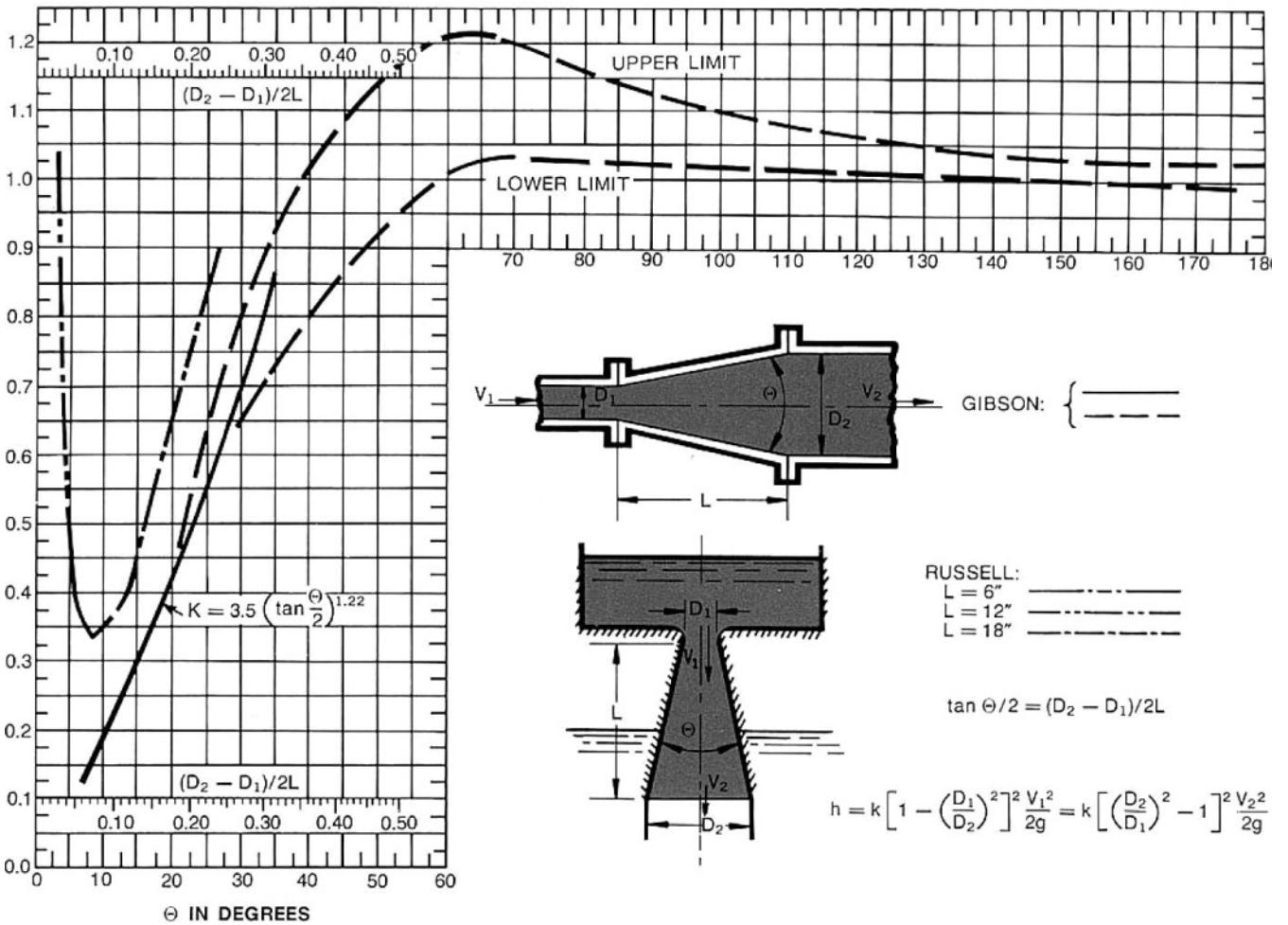


Chart 2 Reprinted from PIPE FRICTION MANUAL, Third Edition, Copyright 1961 by Hydraulic Institute.

TECH-C-3 Resistance Coefficients for Increasers and Diffusers



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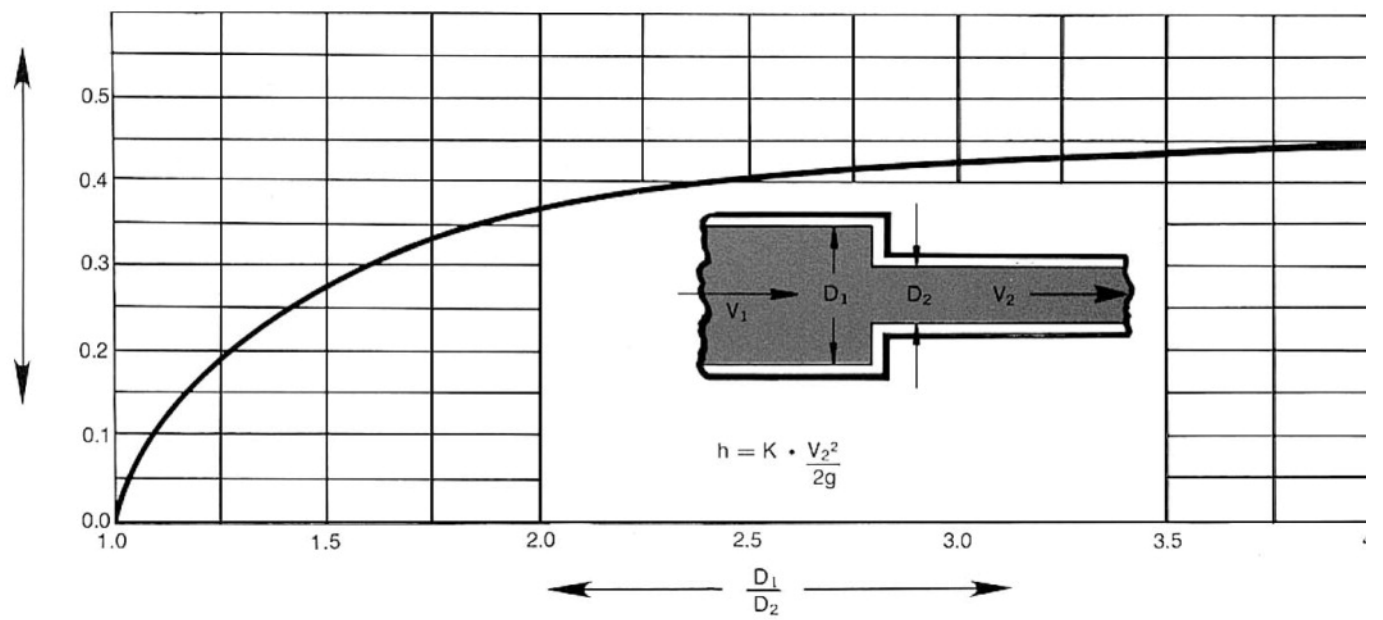
TECH-C-4 Resistance Coefficients for Reducers



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TECH-C-5 Properties of Water at Various Temperatures from 32° to 705.4°F

Temp. F	Temp. C	SPECIFIC GRAVITY60 F Reference	Wt. in Lb/Cu Ft	Vapor Pressure Psi Abs	Vapor Pressure * Feet Abs. (At Temp.)
32	0	1.002	62.42	0.0885	0.204
40	4.4	1.001	62.42	0.1217	0.281
45	7.2	1.001	62.40	0.1471	0.340
50	10.0	1.001	62.38	0.1781	0.411
55	12.8	1.000	62.36	0.2141	0.494
60	15.6	1.000	62.34	0.2653	0.591
65	18.3	.999	62.31	0.3056	0.706
70	21.1	.999	62.27	0.3631	0.839
75	23.9	.998	62.24	0.4298	0.994
80	26.7	.998	62.19	0.5069	1.172
85	29.4	.997	62.16	0.5959	1.379
90	32.2	.996	62.11	0.9682	1.167
95	35.0	.995	62.06	0.8153	1.890
100	37.8	.994	62.00	0.9492	2.203
110	43.3	.992	61.84	1.275	2.965
120	48.9	.990	61.73	1.692	3.943
130	54.4	.987	61.54	2.223	5.196
140	60.0	.985	61.39	2.889	6.766
150	65.5	.982	61.20	3.718	8.735
160	71.1	.979	61.01	4.741	11.172
170	76.7	.975	60.79	5.992	14.178
180	82.2	.972	60.57	7.510	17.825
190	87.7	.968	60.35	9.339	22.257
200	93.3	.966	60.13	11.526	27.584
212	100.0	.959	59.81	14.696	35.353
220	104.4	.956	59.63	17.186	41.343
240	115.6	.948	59.10	24.97	60.77
260	126.7	.939	58.51	35.43	87.05
280	137.8	.929	58.00	49.20	122.18
300	148.9	.919	57.31	67.01	168.22
320	160.0	.909	56.66	89.66	227.55
340	171.1	.898	55.96	118.01	303.17
360	182.2	.886	55.22	153.04	398.49
380	193.3	.874	54.47	195.77	516.75
400	204.4	.860	53.65	247.31	663.42
420	215.6	.847	52.80	308.83	841.17
440	226.7	.833	51.92	381.59	1056.8
460	237.8	.818	51.02	466.9	1317.8
480	248.9	.802	50.00	566.1	1628.4
500	260.0	.786	49.02	680.8	1998.2
520	271.1	.766	47.85	812.4	2446.7
540	282.2	.747	46.51	962.5	2972.5
560	293.3	.727	45.3	1133.1	3595.7
580	304.4	.704	43.9	1325.8	4345.
600	315.6	.679	42.3	1524.9	5242.
620	326.7	.650	40.5	1786.6	6341.
640	337.8	.618	38.5	2059.7	7689.
660	348.9	.577	36.0	2365.4	9458.
680	360.0	.526	32.8	2708.1	11878.
700	371.1	.435	27.1	3039.7	16407.
705.4	374.1	.319	19.9	3206.2	23187.

* Vapor pressure in feet of water (Abs.) Converted from PSIA using sp. gr. at temperature.

TECH-C-6 Atmospheric Pressure, Barometric Reading and Boiling Point of Water at Various Altitudes

Altitude		Barometric Reading		Atmospheric Pressure		Boiling Pt. Of Water°F
Feet	Meters	In. Hg.	Mm. Hg.	psia	Ft. Water	
− 1000	− 304.8	31.0	788	15.2	35.2	213.8
− 500	− 152.4	30.5	775	15.0	34.6	212.9
0	0.0	29.9	760	14.7	33.9	212.0
+ 500	+ 152.4	29.4	747	14.4	33.3	211.1
+ 1000	304.8	28.9	734	14.2	32.8	210.2
1500	457.2	28.3	719	13.9	32.1	209.3
2000	609.6	27.8	706	13.7	31.5	208.4
2500	762.0	27.3	694	13.4	31.0	207.4
3000	914.4	26.8	681	13.2	30.4	206.5
3500	1066.8	26.3	668	12.9	29.8	205.6
4000	1219.2	25.8	655	12.7	29.2	204.7
4500	1371.6	25.4	645	12.4	28.8	203.8
5000	1524.0	24.9	633	12.2	28.2	202.9
5500	1676.4	24.4	620	12.0	27.6	201.9
6000	1828.8	24.0	610	11.8	27.2	201.0
6500	1981.2	23.5	597	11.5	26.7	200.1
7000	2133.6	23.1	587	11.3	26.2	199.2
7500	2286.0	22.7	577	11.1	25.7	198.3
8000	2438.4	22.2	564	10.9	25.2	197.4
8500	2590.8	21.8	554	10.7	24.7	196.5
9000	2743.2	21.4	544	10.5	24.3	195.5
9500	2895.6	21.0	533	10.3	23.8	194.6
10000	3048.0	20.6	523	10.1	23.4	193.7
15000	4572.0	16.9	429	8.3	19.2	184.0

TECH-C-7 Saturation: Temperatures

Steam Data

Temp. Ft	Abs. press.	Specific Volume			Enthalpy			Entropy			Temp Ft
	Lb Sq. In. v_f	Sat. Liquid v_f	Evap v_{fg}	Sat. Vapor v_f	Sat. Liquid h_{fg}	Evap h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sfg s_{fg}	Sat Vapor s_g	
32	0.08854	0.01602	3306	3306	0.00	1075.8	1075.8	0.0000	2.1877	2.1877	**32**
35	0.09995	0.01602	2947	2947	3.02	1074.1	1077.1	0.0061	2.1709	2.1770	**35**
40	0.12170	0.01602	2444	2444	8.05	1071.3	1079.3	0.0162	2.1435	2.1597	**40**
45	0.14752	0.01602	2036.4	2036.4	13.06	1068.4	1081.5	0.0262	2.1167	2.1429	**45**
50	0.17811	0.01603	1703.2	1703.2	18.07	1065.6	1083.7	0.0361	2.0903	2.1264	**50**
60	0.2563	0.01604	1206.6	1206.7	28.06	1059.9	1088.0	0.0555	2.0393	2.0948	**60**
70	0.3631	0.01606	867.8	867.9	38.04	1054.3	1092.3	0.0745	1.9902	2.0647	**70**
80	0.5069	0.01608	633.1	633.1	48.02	1048.6	1096.6	0.0932	1.9428	2.0360	**80**
90	0.6982	0.01610	468.0	468.0	57.99	1042.9	1100.9	0.1115	1.8972	2.0087	**90**
100	0.9492	0.01613	350.3	350.4	67.97	1037.2	1105.2	0.1295	1.8531	1.9826	**100**
110	1.2748	0.01617	265.3	265.4	77.94	1031.6	1109.5	0.1471	1.8106	1.9577	**110**
120	1.6924	0.01620	203.25	203.27	87.92	1025.8	1113.7	0.1645	1.7694	1.9339	**120**
130	2.2225	0.01625	157.32	157.34	97.90	1020.0	1117.9	0.1816	1.7296	1.9112	**130**
140	2.8886	0.01629	122.99	123.01	107.89	1041.1	1122.0	0.1984	1.6910	1.8894	**140**
150	3.718	0.01634	97.06	97.07	117.89	1008.2	1126.1	0.2149	1.6537	1.8685	**150**
160	4.741	0.01639	77.27	77.29	127.89	1002.3	1130.2	0.2311	1.6174	1.8485	**160**
170	5.992	0.01645	62.04	62.06	137.90	996.3	1134.2	0.2472	1.5822	1.8293	**170**
180	7.510	0.01651	50.21	50.23	147.92	990.2	1138.1	0.2630	1.5480	1.8109	**180**
190	9.339	0.01657	40.94	40.96	157.95	984.1	1142.0	0.2785	1.5147	1.7932	**190**
200	11.526	0.01663	33.62	33.64	167.99	977.9	1145.9	0.2938	1.4824	1.7762	**200**
210	14.123	0.01670	27.80	27.82	178.05	971.6	1149.7	0.3090	1.4508	1.7598	**210**
212	14.696	0.01672	26.78	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566	**212**
220	17.186	0.01677	23.13	23.15	188.13	965.2	1153.4	0.3239	1.4201	1.7440	**220**
230	20.780	0.01684	19.365	19.382	198.23	958.8	1157.0	0.3387	1.3901	1.7288	**230**
240	24.969	0.01692	16.306	16.323	208.34	952.2	1160.5	0.3531	1.3609	1.7140	**240**
250	29.825	0.01700	13.804	13.821	218.48	945.5	1164.0	0.3675	1.3323	1.6998	**250**
260	35.429	0.01709	11.746	11.763	228.64	938.7	1167.3	0.3817	1.3043	1.6860	**260**
270	41.858	0.01717	10.044	10.061	238.84	931.8	1170.6	0.3958	1.2769	1.6727	**270**
280	49.203	0.01726	8.628	8.645	249.06	924.7	1173.8	0.4096	1.2501	1.6597	**280**
290	57.556	0.01735	7.444	7.461	259.31	917.5	1176.8	0.4234	1.2238	1.6472	**290**
300	67.013	0.01745	6.449	6.446	269.59	910.1	1179.7	0.4369	1.1980	1.6350	**300**
320	89.66	0.01765	4.896	4.914	290.28	894.9	1185.2	0.4637	1.1478	1.6115	**320**
340	118.01	0.01787	3.770	3.788	311.13	879.0	1190.1	0.4900	1.0992	1.5891	**340**
360	153.04	0.01811	2.939	2.957	332.18	862.2	1194.4	0.5158	1.0519	1.5677	**360**
380	195.77	0.01836	2.317	2.335	353.45	844.6	1198.1	0.5413	1.0059	1.5471	**380**
400	247.31	0.01864	1.8447	1.8633	374.97	826.0	1201.0	0.5664	0.9608	1.5272	**400**
420	308.83	0.01894	1.4811	1.5000	396.77	806.3	1203.1	0.5912	0.9166	1.5078	**420**
440	381.59	0.01926	1.1979	1.2171	418.90	785.4	1204.3	0.6158	0.8730	1.4887	**440**
460	466.9	0.0196	0.9748	0.9944	441.4	763.2	1204.6	0.6402	0.8298	1.4700	**460**
480	566.1	0.0200	0.7972	0.8172	464.4	739.4	1203.7	0.6645	0.7868	1.4513	**480**
500	680.8	0.0204	0.6545	0.6749	487.8	713.9	1201.7	0.6887	0.7438	1.4325	**500**
520	812.4	0.0209	0.5385	0.5594	511.9	686.4	1198.2	0.7130	0.7006	1.4136	**520**
540	962.5	0.0215	0.4434	0.4649	536.6	656.6	1193.2	0.7374	0.6568	1.3942	**540**
560	1133.1	0.0221	0.3647	0.3868	562.2	624.2	1186.4	0.7621	0.6121	1.3742	**560**
580	1325.8	0.0228	0.2989	0.3217	588.9	588.4	1177.3	0.7872	0.5659	1.3532	**580**
600	1542.9	0.0236	0.2432	0.2668	617.0	548.5	1165.5	0.8131	0.5176	1.3307	**600**
620	1786.6	0.0247	0.1955	0.2201	646.7	503.6	1150.3	0.8398	0.4664	1.3062	**620**
640	2059.7	0.0260	0.1538	0.1798	678.6	452.0	1130.5	0.8679	0.4110	1.2789	**640**
660	2365.4	0.0278	0.1165	0.1442	714.2	390.2	1104.4	0.8987	0.3485	1.2472	**660**
680	2708.1	0.0305	0.0810	0.1115	757.3	309.9	1067.2	0.9351	0.2719	1.2071	**680**
700	3093.7	0.0369	0.0392	0.0761	823.3	172.1	995.4	0.9905	0.1484	1.1389	**700**
705.4	3206.2	0.0503	0	0.0503	902.7	0	902.7	1.0580	0	1.0580	**705.4**

TECH-C-8 Saturation: Pressures

Steam Data

Abs. press. Lb Sq. In P	Temp Liquid t	Specific Volume		Enthalpy			Entropy			Internal Energy			Abs press. Lb. Sq. In.p
		Sat Vapor v_f	Sat. Liquid v_g	Sat. Liquid h_r	Evap h_{fg}	Sat Vapor. h_g	Sat. Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Sat. Liquid u_f	Evap u_{fg}	Sat Vapor u_g	
1.0	101.74	0.01614	333.6	69.70	1036.3	1106.0	0.1326	1.8456	1.9782	69.70	974.6	1044.2	**1.0**
2.0	126.08	0.01623	173.73	93.99	1022.2	1116.2	0.1749	1.7451	1.9200	93.98	957.9	1051.9	**2.0**
3.0	141.48	0.01630	118.71	109.37	1031.2	1122.6	0.2008	1.6855	1.8863	109.36	947.3	1056.7	**3.0**
4.0	152.97	0.01636	90.63	120.86	1006.4	1127.3	0.2198	1.6427	1.8625	120.85	939.3	1060.2	**4.0**
5.0	162.24	0.01640	73.52	130.13	1001.0	1131.1	0.2347	1.6094	1.8441	130.12	933.0	1063.1	**5.0**
6.0	170.06	0.01645	61.98	137.96	996.2	1134.2	0.2472	1.5820	1.8292	137.94	927.5	1065.4	**6.0**
7.0	176.85	0.01649	53.64	144.76	992.1	1136.9	0.2581	1.5586	1.8167	144.74	922.7	1067.4	**7.0**
8.0	182.86	0.01653	47.34	150.79	988.5	1139.3	0.2674	1.5383	1.8057	150.77	918.4	1069.2	**8.0**
9.0	188.28	0.01656	42.40	156.22	985.2	1141.4	0.2759	1.5203	1.7962	156.19	914.6	1070.8	**9.0**
10	193.21	0.01659	38.42	161.17	982.1	1143.3	0.2835	1.5041	1.7876	161.14	911.1	1072.2	**10**
14.696	212.00	0.01672	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566	180.02	897.5	1077.5	**14.696**
15	213.03	0.01672	26.29	181.11	969.7	1150.8	0.3135	1.4115	1.7549	181.06	896.7	1077.8	**15**
20	227.96	0.01683	20.089	196.16	960.1	1156.3	0.3356	1.3962	1.7319	196.10	885.8	1081.9	**20**
30	250.33	0.01701	13.746	218.82	945.3	1164.1	0.3680	1.3313	1.6993	218.73	869.1	1087.8	**30**
40	267.25	0.01715	10.498	236.03	933.7	1169.7	0.3919	1.2844	1.6763	235.90	856.1	1092.0	**40**
50	281.01	0.01727	8.515	250.09	924.0	1174.1	0.4110	1.2474	1.6585	249.93	845.4	1095.3	**50**
60	292.71	0.01738	7.175	262.09	915.5	1177.6	0.4270	1.2168	1.6438	261.90	836.0	1097.9	**60**
70	302.92	0.01748	6.206	272.61	907.9	1180.6	0.4409	1.1906	1.6315	272.38	827.8	1100.2	**70**
80	312.03	0.01757	5.472	282.02	901.1	1183.1	0.4531	1.1676	1.6207	281.76	820.3	1102.1	**80**
90	320.27	0.01766	4.896	290.56	894.7	1185.3	0.4641	1.1471	1.6112	290.27	813.4	1103.7	**90**
100	327.81	0.01774	4.432	298.40	888.8	1187.2	0.4740	1.1286	1.6026	298.08	807.1	1105.2	**100**
120	341.25	0.01789	3.728	312.44	877.9	1190.4	0.4916	1.0962	1.5878	312./05	795.6	1107.6	**120**
140	353.02	0.01802	3.220	324.82	868.2	1193.0	0.5069	1.0682	1.5751	324.35	785.2	1109.6	**140**
160	363.53	0.01815	2.834	335.93	859.2	1195.1	0.5204	1.0436	1.5640	335.39	775.8	1111.2	**160**
180	373.06	0.01827	2.532	346.03	850.8	1196.9	0.5325	1.0217	1.5542	345.42	767.1	1112.5	**180**
200	381.79	0.01839	2.288	355.36	843.0	1198.4	0.5435	1.0018	1.5453	354.68	759.0	1113.7	**200**
250	400.95	0.01865	1.8438	376.00	825.1	1201.1	0.5676	0.9588	1.5263	375.14	740.7	1115.8	**250**
300	417.33	0.01890	1.5433	393.84	809.1	1202.8	0.5879	0.9225	1.5104	392.79	724.3	1117.1	**300**
350	431.72	0.01913	1.3260	409.69	794.2	1203.9	0.6056	0.8910	1.4966	408.55	709.6	1118.0	**350**
400	444.59	0.0193	1.1613	424.0	780.5	1204.5	0.6214	0.8630	1.4844	422.6	695.9	1118.5	**400**
450	456.28	0.0195	1.0320	437.2	767.4	1204.6	0.6356	0.8378	1.4734	435.5	683.2	1118.7	**450**
500	467.01	0.0197	0.9278	449.4	755.0	1204.4	0.6487	0.8147	1.4634	447.6	671.0	1118.6	**500**
550	476.93	0.0199	0.8422	460.8	743.1	1203.9	0.6608	0.7934	1.4542	458.8	659.4	1118.2	**550**
600	486.21	0.0201	0.7698	471.6	731.6	1203.2	0.6720	0.7734	1.4454	469.4	648.3	1117.7	**600**
700	503.10	0.0205	0.6554	491.5	709.7	1201.2	0.6925	0.7371	1.4296	488.8	627.5	1116.3	**700**
800	518.23	0.0209	0.5687	509.7	688.9	1198.6	0.7108	0.7054	1.4235	506.6	607.8	1114.4	**800**
900	531.98	0.0212	0.5006	526.6	668.8	1195.4	0.7275	0.6744	1.4020	523.1	589.0	1112.1	**900**
1000	544.61	0.0216	0.4456	542.4	649.4	1191.8	0.7430	0.6467	1.3897	538.4	571.0	1109.4	**1000**
1100	556.31	0.0220	0.4001	557.4	630.4	1187.8	0.7575	0.6205	1.3780	552.9	553.5	1106.4	**1100**
1200	567.22	0.0223	0.3619	571.7	611.7	1183.4	0.7711	0.5956	1.3667	566.7	536.3	1103.0	**1200**
1300	577.46	0.0227	0.3293	585.4	593.2	1178.6	0.7840	0.5719	1.3559	580.0	519.4	1099.4	**1300**
1400	587.10	0.0231	0.3012	598.7	574.7	1173.4	0.7963	0.5491	1.3454	592.7	502.7	1095.4	**1400**
f **1500**	596.23	0.0235	0.2765	611.6	556.3	1167.9	0.8082	0.5269	1.3351	605.1	486.1	1091.2	**1500**
2000	635.82	0.0257	0.1878	671.7	463.4	1135.1	0.8619	0.4230	1.2849	662.2	403.4	1065.6	**2000**
2500	668.13	0.0287	0.1307	730.6	360.5	1091.1	0.9126	0.3197	1.2322	717.3	313.3	1030.6	**2500**
3000	695.36	0.0346	0.0858	802.5	217.8	1020.3	0.9731	0.1885	1.1615	783.4	189.3	972.7	**3000**
3206.2	705.40	0.0503	0.0503	902.7	0	902.7	1.0580	0	1.0580	872.9	0	872.9	**3206.2**

TECH-D-1 Viscosity

The viscosity of a fluid is that property which tends to resist a shearing force. It can be thought of as the internal friction resulting when one layer of fluid is made to move in relation to another layer.

Consider the model shown in Fig. 1, which was used by Isaac Newton in first defining viscosity. It shows two parallel planes of fluid of area A separated by a distance dx and moving in the same direction at different velocities V_1 and V_2.

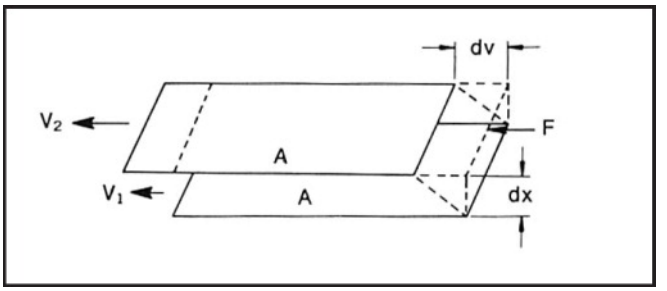

Fig. 1

The velocity distribution will be linear over the distance dx, and experiments show that the velocity gradient, $\frac{dv}{dx}$ is directly proportional to the force per unit area, $\frac{f}{a}$

$\frac{f}{A} = n \times \frac{dv}{dx}$ Where *n* is constant for a given liquid and is called its viscosity.

The velocity gradient, $\frac{dv}{dx}$, describes the shearing experienced by the intermediate layers as they move with respect to each other. Therefore, it can be called the "rate of shear." S. Also, the force per unit area, $\frac{F}{A}$, can be simplified and called the "shear force" or "shear stress," F. With these simplified terms, viscosity can be defined as follows:

$$F = n \times S$$

$$\text{Viscosity} = n = \frac{F}{S} = \frac{\text{shear stress}}{\text{rate of shear}}$$

Isaac Newton made the assumption that all materials have, at a given temperature, a viscosity that is independent of the rate of shear. In other words, a force twice as large would be required to move a liquid twice as fast. Fluids which behave this way are called Newtonian fluids. There are, of course, fluids which do not behave this way, in other words their viscosity is dependent on the rate of shear. These are known as Non-Newtonian fluids.

Fig. 2 shows graphically the relationships between shear Stress (F,) rate of shear (S,) and viscosity (n) for a Newtonian liquid. The viscosity remains constant as shown in sketch 2, and in absolute units, the viscosity is the inverse slope of the line in sketch 1. Water and light oils are good examples of Newtonian liquids.

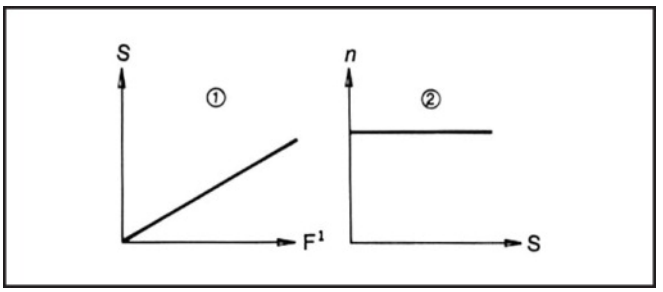

Fig. 2 Newtonian Liquid

Fig. 3 shows graphically the three most common types of Non-Newtonian liquids. Group A shows a decreasing viscosity with an increasing rate of shear. This is known as a **pseudo-plastic** material. Examples of this type are grease, molasses, paint, soap, starch, and most emulsions. They present no serious pumping problems since they tend to thin out with the high rates of shear present in a pump.

Group B shows a **dilatant** material or one in which the viscosity increases with an increasing rate of shear. Clay slurries and candy compounds are examples of dilatant liquids. Pumps must be selected with extreme care since these liquids can become almost solid if the shear rate is high enough. The normal procedure would be to oversize the pump somewhat and open up the internal clearances in an effort to reduce the shear rate

Group C shows a **plastic** material, The viscosity decreases with increasing rate of shear. However, a certain force must be applied before any movement is produced. This force is called the yield value of the material. Tomato catsup is a good example of this type of material. It behaves similar to a pseudo-plastic material from a pumping standpoint

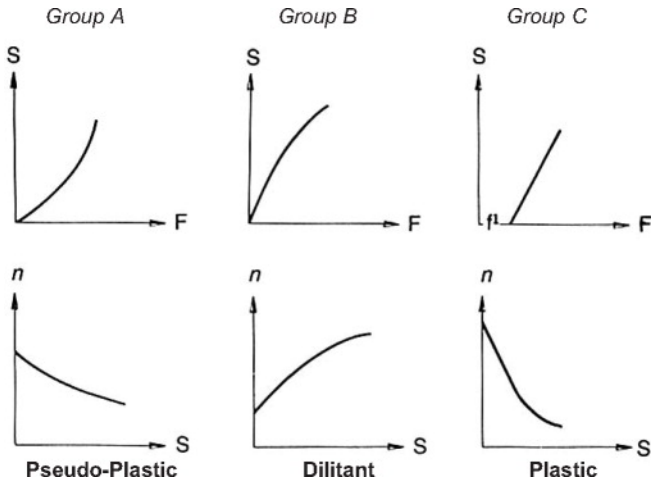

Fig. 3 Non-Newtonian Liquids

The viscosity of some Non-Newtonian liquids is dependent upon time as well as shear rate. In other words, the viscosity at any particular time depends upon the amount of previous agitation or shearing of the liquid. A liquid whose viscosity decreases with time at a given shear rate is called a thixotropic liquid. Examples are asphalts, glues, molasses, paint, soap, starch, and grease. Liquids whose viscosity increases with time are called rheopectic liquids, but they are seldom encountered in pumping applications.

There are two basic viscosity parameters: dynamic (or absolute) viscosity and kinematic viscosity. Dynamic viscosities are given in terms of force required to move a unit area a unit distance. This is usually expressed in pound-seconds per square foot in the English system which is equal to slugs per foot-second. The Metric system is more commonly used, however, in which the unit is the dyne-second per square centimeter called the Poise. This is numerically equal to the gram per centimeter-second. For convenience, numerical values are normally expressed in centipoise, which are equal to one-hundredth of a poise.

Most pipe friction charts and pump correction charts list kinematic viscosity. The basic unit of kinematic viscosity is the stoke which is equal to a square centimeter per second in the Metric system. The corresponding English unit is square foot per second. The centistoke which is one-hundredth of a stoke is normally used in the charts. The following formula is used to obtain the kinematic viscosity when the dynamic or absolute viscosity is known:

$$\text{centistokes} = \frac{\text{centipoise}}{\text{sp. gr.}}$$

There are numerous types of viscometers available for determining liquid viscosities, most of which are designed for specific liquids or viscosity ranges. The Saybolt viscometers are probably the most widely used in the United States. The Saybolt Universal Viscometer measures low to medium viscosity, and the Saybolt Furol Viscometer measures high viscosities. The corresponding units are the SSU (Seconds Saybolt Universal) and the SSF (Seconds Saybolt Furol). These units are found on most pipe friction and pump correction charts in addition to centistokes. A conversion chart for these and other units is shown in Tables. 4A and 4B.

TECH-D-2A Viscosity Conversion Table

The following table will give an approximate comparison of various viscosity ratings so that if the viscosity is given in terms other than Saybolt Universal, it can be translated quickly by following horizontally to the Saybolt Universal column.

Seconds Saybolt Universal ssu	Kine-matic Viscosity Centi-stokes*	Seconds Saybolt Furol ssf	Seconds Red-wood 1 (Stan-dard)	Seconds Red-wood 2 (Admir-alty)	Degrees Engler	Degrees Barbey	Seconds Parlin Cup #7	Seconds Parlin Cup #10	Seconds Parlin Cup #15	Seconds Parlin Cup #20	Seconds Ford Cup #3	Seconds Ford Cup #4
31	1.00	-	29	-	1.00	6200	-	-	-	-	-	-
35	2.56	-	32.1	-	1.16	2420	-	-	-	-	-	-
40	4.30	-	36.2	5.10	1.31	1440	-	-	-	-	-	-
50	7.40	-	44.3	5.83	1.58	838	-	-	-	-	-	-
60	10.3	-	52.3	6.77	1.88	618	-	-	-	-	-	-
70	13.1	12.95	60.9	7.60	2.17	483	-	-	-	-	-	-
80	15.7	13.70	69.2	8.44	2.45	404	-	-	-	-	-	-
90	18.2	14.44	77.6	9.30	2.73	348	-	-	-	-	-	-
100	20.6	15.24	85.6	10.12	3.02	307	-	-	-	-	-	-
150	32.1	19.30	128	14.48	4.48	195	-	-	-	-	-	-
200	43.2	23.5	170	18.90	5.92	144	40	-	-	-	-	-
250	54.0	28.0	212	23.45	7.35	114	46	-	-	-	-	-
300	65.0	32.5	254	28.0	8.79	95	52.5	15	6.0	3.0	30	20
400	87.60	41.9	338	37.1	11.70	70.8	66	21	7.2	3.2	42	28
500	110.0	51.6	423	46.2	14.60	56.4	79	25	7.8	3.4	50	34
600	132	61.4	508	55.4	17.50	47.0	92	30	8.5	3.6	58	40
700	154	71.1	592	64.6	20.45	40.3	106	35	9.0	3.9	67	45
800	176	81.0	677	73.8	23.35	35.2	120	39	9.8	4.1	74	50
900	198	91.0	762	83.0	26.30	31.3	135	41	10.7	4.3	82	57
1000	220	100.7	896	92.1	29.20	28.2	149	43	11.5	4.5	90	62
1500	330	150	1270	138.2	43.80	18.7	-	65	15.2	6.3	132	90
2000	440	200	1690	184.2	58.40	14.1	-	86	19.5	7.5	172	118
2500	550	250	2120	230	73.0	11.3	-	108	24	9	218	147
3000	660	300	2540	276	87.60	9.4	-	129	28.5	11	258	172
4000	880	400	3380	368	117.0	7.05	-	172	37	14	337	230
5000	1100	500	4230	461	146	5.64	-	215	47	18	425	290
6000	1320	600	5080	553	175	4.70	-	258	57	22	520	350
7000	1540	700	5920	645	204.5	4.03	-	300	67	25	600	410
8000	1760	800	6770	737	233.5	3.52	-	344	76	29	680	465
9000	1980	900	7620	829	263	3.13	-	387	86	32	780	520
10000	2200	1000	8460	921	292	2.82	-	430	96	35	850	575
15000	3300	1500	13700	-	438	2.50	-	650	147	53	1280	860
20000	4400	2000	18400	-	584	1.40	-	860	203	70	1715	1150

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$$\text{*Kinematic Viscosity (in centistokes)} = \frac{\text{Absolute Viscosity (in centipoises)}}{\text{Density}}$$

When the Metric System terms centistokes and centipoises are used, the density is numerically equal to the specific gravity. Therefore, the following expression can be used which will be sufficiently accurate for most calculations:

$$\text{*Kinematic Viscosity (in centistokes)} = \frac{\text{Absolute Viscosity (in centipoises)}}{\text{Specific Gravity}}$$

When the English System units are used, the density must be used rather than the specific gravity.

For values of 70 centistokes and above, use the following conversion:

SSU = centistokes x 4.635

Above the range of this table and within the range of the viscosimeter, multiply the particular value by the following approximate factors to convert to SSU:

Viscosimeter	Factor	Viscosimeter	Factor
Saybolt Furol	10.	Parlin cup #15	98.2
Redwood Standard	1.095	Parlin cup #20	187.0
Redwood Admiralty	10.87	Ford cup #4	17.4
Engler – Degrees	34.5		

TECH-D-2B Viscosity Conversion Table

The following table will give an approximate comparison of various viscosity ratings so that if the viscosity is given in terms other than Saybolt Universal, it can be translated quickly by following horizontally to the Saybolt Universal column.

Seconds Saybolt Universal ssu	Kine-matic Viscosity Centi-stokes*	Approx. Seconds Mac Michael	Approx. Gardner Holt Bubble	Seconds Zahn Cup #1	Seconds Zahn Cup #2	Seconds Zahn Cup #3	Seconds Zahn Cup #4	Seconds Zahn Cup #5	Seconds Demmier Cup #1	Seconds Demmier Cup #10	Approx. Seconds Stormer 100 gpm Load	Seconds Pratt and Lambert "F"
31	1.00	-	-	-	-	-	-	-	-	-	-	-
35	2.56	-	-	-	-	-	-	-	-	-	-	-
40	4.30	-	-	-	-	-	-	-	1.3	-	-	-
50	7.40	-	-	-	-	-	-	-	2.3	-	2.6	-
60	10.3	-	-	-	-	-	-	-	3.2	-	3.6	-
70	13.1	-	-	-	-	-	-	-	4.1	-	4.6	-
80	15.7	-	-	-	-	-	-	-	4.9	-	5.5	-
90	18.2	-	-	-	-	-	-	-	5.7	-	6.4	-
100	20.6	125	-	38	18	-	-	-	6.5	-	7.3	-
150	32.1	145	-	47	20	-	-	-	10.0	1.0	11.3	-
200	43.2	165	A	54	23	-	-	-	13.5	1.4	15.2	-
250	54.0	198	A	62	26	-	-	-	16.9	1.7	19	-
300	65.0	225	B	73	29	-	-	-	20.4	2.0	23	-
400	87.0	270	C	90	37	-	-	-	27.4	2.7	31	7
500	110.0	320	D	-	46	-	-	-	34.5	3.5	39	8
600	132	370	F	-	55	-	-	-	41	4.1	46	9
700	154	420	G	-	63	22.5	-	-	48	4.8	54	9.5
800	176	470	-	-	72	24.5	-	-	55	5.5	62	10.8
900	198	515	H	-	80	27	18	-	62	6.2	70	11.9
1000	220	570	I	-	88	29	20	13	69	6.9	77	12.4
1500	330	805	M	-	-	40	28	18	103	10.3	116	16.8
2000	440	1070	Q	-	-	51	34	24	137	13.7	154	22
2500	550	1325	T	-	-	63	41	29	172	17.2	193	27.6
3000	660	1690	U	-	-	75	48	33	206	20.6	232	33.7
4000	880	2110	V	-	-	-	63	43	275	27.5	308	45
5000	1100	2635	W	-	-	-	77	50	344	34.4	385	55.8
6000	1320	3145	X	-	-	-	-	65	413	41.3	462	65.5
7000	1540	3760	-	-	-	-	-	75	481	48	540	77
8000	1760	4170	Y	-	-	-	-	86	550	55	618	89
9000	1980	4700	-	-	-	-	-	96	620	62	695	102
10000	2200	5220	Z	-	-	-	-	-	690	69	770	113
15000	3300	7720	Z2	-	-	-	-	-	1030	103	1160	172
20000	4400	10500	Z3	-	-	-	-	-	1370	137	1540	234

Fig. 4B

Above the range of this table and within the range of the viscosimeter multiply the particular value by the following approximate factors to convert to SSU:

Viscosimeter	Factor
Mac Michael	1.92 (approx.)
Demmier #1	14.6
Demmier #10	146.
Stormer	13. (approx.)

TECH-D-3 Determination of Pump Performance When Handling Viscous Liquids

The American National Standard (Guideline) for Effects of Liquid Viscosity on Rotodynamic (Centrifugal and Vertical) Pump Performance (ANSI/HI 9.6.7-2010) should be used in the absence of past experience. The standard provides methods for calculating the reduction in performance of a rotodynamic pump pumping a fluid more viscous than water. The referenced Standard may be purchased from: http://webstore.ansi.org/

TECH-D-4A Viscosity of Common Liquids

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Liquid	* Sp Gr at 60 F	VISCOSITY		At F
		SSU	Centistokes	
Freon	1.37 to 1.49 @ 70 F		.27-.32	70
Glycerine (100%)	1.26 @ 68F	2,950 813	648 176	68.6 100
Glycol:				
Propylene	1.038 @ 68F	240.6	52	70
Triethylene	1.125@ 68 F	185.7	40	70
Diethylene	1.12	149.7	32	70
Ethylene	1.125	88.4	17.8	70
Hydrochloric Acid(31.5)	1.05 @ 68 F		1.9	68
Mercury	13.6		.11 11	70 100
Phenol (Carbonic Acid)	.95 to 1.08	65	11.7	65
Silicate of soda	40 Baumé 42 Baumé	365 637.6	79 138	100 100
Sulfric Acid (100%)	1.83	75.7	14.6	68
FISH AND ANIMAL OILS: Bone Oil	.918	220 **65**	47.5 11.6	130 212
Cod Oil	.928	**150** 95	32.1 19.4	100 130
Lard	.96	**287** 160	62.1 34.3	100 130
Lard Oil	.912 to .925	**190 to 220** 112 to 128	41 to 47.5 23.4 to 27.1	100 130
Menhaddden Oil	.933	**140** 90	29.8 18.2	100 130
Neatsfoot Oil	.917	**230** 130	49.7 27.5	100 130
Sperm Oil	.883	**110** 78	23.0 15.2	100 130
Whale Oil	.925	**163 to 184** 97 to 112	35 to 39.6 19.9 to 23.4	100 130
Mineral Oils: Automobile Crankcase Oils (Average Midcontinent Parrafin Base) SAE 10	** .880 to .935	165 to 240 **90 to 120**	35.4 to 51.9 18.2 to 25.3	100 130
SAE 20	** .880 to .935	240 to 400 **120 to 185**	51.9 to 86.6 25.3 to 39.9	100 130
SAE 30	** .880 to .935	400 to 580 **185 to 255**	86.6 to 125.5 **39.9 to 55.1**	100 130
SAE 40	** .880 to .935	580 to 950 **255 to 80**	125.5 to 205.6 55.1 to 15.6	100 130 210
SAE 50	** .880 to .935	950 to 1,600 **80 to 105**	205.6 to 352 15.6 to 21.6	100 210
SAE 60	** .880 to .935	1,600 to 2,300 **105 to 125**	352 to 507 21.6 to 26.2	100 210
SAE 70	** .880 to .935	2,300 to 3,100 **125 to 150**	507 to 682 26.2 to 31.8	100 210
SAE 10W	** .880 to .935	**5,000 to 10,000**	1,100 to 2,200	0
SAE 20W	** .880 to .935	**10,000 to 40,000**	2,200 TO 8,800	0
Automobile Transmission Lubricants: SAE 80	** .880 to .935	100,000 max	22,000 max	0
SAE 90	** .880 to .935	**800 To 1,500** 300 to 500	173.2 to 324.7 64.5 to 108.2	100 130
SAE 140	** .880 to .935	950 to 2,300 **120 to 200**	205.6 to 507 25.1 to 42.9	130 210
SAE 250	** .880 to .935	Over 2,300 Over 200	Over 507 Over 42.9	130 210
Crude Oils: Texas, Oklahoma	.81 to .916	40 to 783 34.2 to 210	4.28 to 169.5 2.45 to 4.53	60 100

Liquid	* Sp Gr at 60 F	VISCOSITY		At F
		SSU	Centistokes	
Wyoming, Montana	.86 to .88	74 to 1,215 46 to 320	14.1 to 263 6.16 to 69.3	60 100
California	.78 to .92	40 to 4,480 34 to 700	4.28 to 1,063 2.4 to 151.5	60 100
Pennsylvania	.8 to .85	46 to 216 38 to 86	6.16 to 46.7 3.64 to 17.2	60 100
Diesel Engine Lubricating Oils (Based on Average Midcontinent Parafin Base): Federal Specification No. 9110	** .880 to .935	165 to 240 **90 to 120**	35.4 to 51.9 18.2 to 25.3	100 130
Federal Specification No.9170	** .880 to .935	300 to 410 **140 to 180**	64.5 to 88.8 29.8 to 38.8	100 130
Federal Specification No. 9250	** .880 to .935	470 to 590 **200 to 255**	101.8 to 127.8 43.2 to 55.1	100 130
Federal Specification No. 9370	** .880 to .935	800 to 1,100 **320 to 430**	173.2 to 238.1 69.3 to 93.1	100 130
Federal Specification No. 9500	** .880 to .935	490 to 600 **92 to 105**	106.1 to 129.9 18.54 to 21.6	130 210
Diesel Fuel Oils: No. 2 D	** .82 to .95	32.6 to 45. 39	2 to 6 1 to 3.97	100 130
No.3 D	** .82 to .95	**45.5 to 65** 39 to 48	6 to 11.75 3.97 to 6.78	100 130
No.4 D	** .82 to .95	**140 max** 70 max	29.8 max 13.1 max.	100 130
No.5 D	** .82 to .95	**400 max** 165 max	86.6 max 35.2 max	122 160
Fuel Oils: No. 1	** .82 to .95	34 to 40 **32 to 35**	2.39 to 4.28 2.69	70 100
No. 2	** .82 to .95	36 to 50 **33 to 40**	3.0 to 7.4 2.11 to 4.28	70 100
No.3	** .82 to .95	**35 to 45** 32.8 to 39	2.69 to .584 2.06 to 3.97	100 130
No.5A	** .82 to .95	**50 to 125** 42 to 72	7.4 to 26.4 4.91 to 13.73	100 130
No.5B	** .82 to .95	125 to 400 72 to 310	26.4 to 86.6 13.63 to 67.1	100 122 130
No.6	** .82 to .95	**450 to 3,000** 175 to 780	97.4 to 660 37.5 to 172	122 160
Fuel Oil – Navy Specification	** .989 max	**110 to 225** 63 to 115	23 to 48.6 11.08 to 23.9	122 160
Fuel Oil – Navy II	1.0 max	**1,500 max** 480 max	324.7 max 104 max	122 160
Gasoline	.68 to .74		.46 to .88 .40 to .71	60 100
Gasoline (Natural)	76.5 degrees API		.41	68
Gas Oil	28 degrees Api	73 50	13.9 7.4	70 100
Insulating Oil: Transformer, switches and Circuit breakers		115 max **65 max**	24.1max 11.75 max	70 100
Kerosene	.78 to .82	35 32.6	2.69 2	68 100
Machine Lubricating Oil (Average Pennsylvania Parafin Base): Federal Specification No.8	** .880 to .935	112 to 160 **70 to 90**	23.4 to 34.3 13.1 to 18.2	100 130
Federal Specification No. 10	** .880 to .935	160 to 235 **90 to 120**	34.3 to 50.8 18.2 to 25.3	100 130
Federal Specification No. 20	** .880 to .935	235 to 385 **120 to 185**	50.8 to 83.4 25.3 to 39.9	100 130
Federal Specification No. 30	** .880 to .935	385 to 550 185 to 255	83.4 to 119 39.9 to 55.1	100 130
Mineral Lard Cutting Oil: Federal Specification Grade 1		**140 to 190** 86 to 110	29.8 to 41 17.22 to 23	100 130
Federal Specification Grade 2		**190 to 220** 110 to 125	41 to 47.5 23 to 26.4	100 130
Petrolatum	.825	100 77	20.6 14.8	130 160

Liquid	* Sp Gr at 60 F	VISCOSITY		At F
		SSU	Centistokes	
Turbine Lubricating Oil: Federal Specification (Penn Base)	.91 Average	400 to 440 **185 to 205**	86.6 to 95.2 39.9 to 44.3	100 130
VEGETABLE OILS: Castor Oil	.96 @ 68 F	1,200 to 1,500 **450** to 600	259.8 to 324.7 97.4 to 129.9	100 130
China Wood Oil	.943	**1,425** 580	308.5 125.5	69 100
Cocoanut Oil	.925	**140 to 148** 76 to 80	29.8 to 31.6 14.69 to 15.7	100 130
Corn Oil	.924	135 **54**	28.7 8.59	130 212
Cotton Seed Oil	.88 to .925	**176** 100	37.9 20.6	100 130
Linseed Oil, Raw	.925 to .939	**143** 93	30.5 18.94	100 130
Olive Oil	.912 to .918	**200** 115	43.2 24.1	100 130
Palm Oil	.924	**221** 125	47.8 26.4	100 130
Peanut Oil	.920	**195** 112	42 23.4	100 130
Rape Seed Qil	.919	**250** 145	54.1 31	100 130
Rosin Oil	.980	**1,500** 600	324.7 129.9	100 130
Rosin (Wood)	1.09 Avg	500 to **20,000** 1,000 to 50,000	108.2 to 4,400 216.4 to 11,000	200 190
Sesame Oil	.923	**184** 110	39.6 23	100 130
Soja Bean Oil	.927 to.98	**165** 96	35.4 19.64	100 130
Turpentine	.86 to .87	33 32.6	2.11 2.0	60 100
SUGARS, SYRUPS, MOLASSES, ETC. Corn Syrups	1.4 TO 1.47	5,000 to 500,000 1,500 to 60,000	1,100 to 110,000 324.7 to 13,200	100 130
Glucose	1.35 to 1.44	35,000 to 100,000 4,000 to 11,000	7,700 to 22,000 880 to 2420	100 150
Honey (Raw)		340	73.6	100
Molasses "A" (First)	140.6 to 146	1,300 to 23,00 700 to 8,000	281.1 to 5,070 151.5 to 1,760	100 130
Molasses"B" (Second)	1.43 to 1.48	6,400 to 60,000 3,000 to 15,000	1,410 to 13,200 660 to 3,300	100 130
Molasses "C" (Blackstrap or final)	1.46 to 1.49	17,000 to 250,000 6,000 to 75,000	2,630 to 5,500 1,320 to 16,500	100 130
Sucrose Solutions(Sugar Syrups) 60 Brix	1.29	230 92	49.7 18.7	70 100
62 Brix	1.30	310 111	67.1 23.2	70 100
64 Brix	1.31	440 148	95.2 31.6	70 100
66 Brix	1.326	650 195	140.7 42.0	70 100
68 Brix	1.338	1,000 275	216.4 59.5	70 100
70 Brix	1.35	1,650 400	364 86.6	70 100
72 Brix	1.36	2,700 640	595 138.6	70 100
74 Brix	1.376	5,500 1,100	1,210 238	70 100
76 Brix	1.39	10,000 2,000	2,200 440	70 100
TARS: Tar-Coke Oven	1.12+	3,000 to 8,000 650 to 1,400	600 to 1,760 140.7 to 308	71 100
Tar-Gas House	1.16 to 1.30	15,000 to 300,000 2,000 to 20,000	3,300 to 66,000 440 to 4,400	70 100

Liquid	* Sp Gr at 60 F	VISCOSITY		At F
		SSU	Centistokes	
Road Tar: Grade RT-2	1.07+	**200 to 300** 55 to 60	43.2 to 64.9 8.77 to 10.22	122 212
Grade RT-4	1.08+	**400 to 700** 65 to 75	86.6 to 154 11.63 to 14.28	122 212
Grade RT-6	109+	**1,000 to 2,000** 85 to 125	216.4 to 440 16.83 to 26.2	122 212
Grade RT-8	1.13+	**3,000 to 8,000** 150 to 225	660 to 1,760 31.8 to 48.3	122 212
Grade RT-10	1.14+	**20,000 to 60,000** 250 to 400	4,400 to 13,200 53.7 to 86.6	122 212
Grade RT-12	1.15+	114,000 to 456,000 **500 to 800**	25,000 to 75,000 108.2 to 173.2	122 212
Pine Tar	1.06	2,500 500	559 108.2	100 132
MISCELLANEOUS Corn Starch Solutions: 22 Baumé	1.18	150 130	32.1 27.5	70 100
24 Baumé	1.20	600 440	129.8 95.2	70 100
25 Baumé	1.21	1400 800	303 173.2	70 100
Ink- Printers	1.00 to 1.38	2,500 to 10,000 1,100 to 3,000	550 to 2,200 238.1 to 660	100 130
Tallow	.918 Avg.	56	9.07	212
Milk	1.02 to 1.05		1.13	68
Varnish – Spar	.9	1425 650	313 143	68 100
Water- Fresh	1.0		1.13 .55	60 130

* Unless otherwise noted.
** Depends on origin or percent and type of solvent.

TECH-D-4B Physical Properties of Common Liquids

Liquid	Sp. Gr. 60° F (16°C)	Melting Point °F (°C)	Boiling Point °F (°C)	pH At 77° F (25°C)	VISCOSITY							
					SSU				Centipoise			
					40°F	80°F	120°F	160°F	4°C	27°C	49°C	71°C
Acetic Acid	1.05	63	244						1.6	1.2	.8	.6
Glacial		(17)	(118)									
8.8% (1N)				2.4								
.88% (.1N)	1.01			2.9								
.09 (.01N)				3.4								
Acetone	.79	- 137 (-94)	133 (56)						.4	.3	.3	.2
Alum, 0.6% (0.1N)				3.2								
Ammonia 100%	.77	-108 (-78)	-27 (-33)						.14	.1	.08	.06
26%	.91								1.8	1.2		
1.7% (1N)				11.6								
.17% (0.1N)				11.1								
.02% (.01N)				10.6								
Asphalt												
Unblended	1.1-1.5							(12,000 at 250°F)				
RS1	1.0					155-1,000	160	85		86	34	17
RC2	1.0						2,400-5,000					
RC5	1.0					500,000	45,000	8,000				
Emulsion	1.0					1,000-7,000						
Benzene	.84	42 (6)	176 (80)						.8	.6	.5	.3
Benzoic Acid 0.1% (.01N)				3.1								

Liquid	Sp. Gr. 60° F (16°C)	Melting Point °F (°C)	Boiling Point °F (°C)	pH At 77° F (25°C)	VISCOSITY							
					SSU				Centipoise			
					40°F	80°F	120°F	160°F	4°C	27°C	49°C	71°C
Black liquor,												
50%	1.3						5,000	(80-150 at 250°F)				(15-37 at 121°C)
70%	1.5							(6,300 at 250°F)				1,400 at 121°C)
Borax	1.7	167 (75)										
1% (0.1N)				9.2								
Boric Acid		338 (171)										
0.2% (0.1N)				5.2								
Butane	.59									.18		
Calcium												
Carbonate Sat.				9.4								
Calcium Chloride												
25%	1.23	-21 (-29)							4.5	2.1	.9	.5
Calcium Hydroxide Sat. (Slaked Lime)				12.4								
Carbolic Acid (Phenol)	1.07	109 (43)	360 (182)			60			14.5	7.3	3.9	2.1
Carbonic Acid Sat.				3.8								
Carbon Tetrachloride	1.58	-95 (-71)	170 (77)						1.3	.9	.7	.6
Citric Acid .6% (1n)				2.2								
Corn Oil	.92						135					
Corn Starch,												
22° Baumé	1.18					150	130					
25° Baumé	1.21					1,400	800					
Corn Syrup	1.4						5,000-500,000					
Cotton Seed Oil	.9						176					
Crude Oil												
Pennsylvania	.8					200	86					
Wyoming	.9					1,100	320					
48° API	.79									2.8		
32.6° API	.86									20.0		
Dowtherm A	.99	54 (12)	500 (260)									
Dowtherm C	1.1	70 (21)	600 (316)									
Ethane	.37									(.05 at 16° C)		
Ethyl Alcohol	.79	- 173 (- 144)	173 (78)						1.6	1.0	.7	.5
Ethyl Alcohol 95%	.81								2.0	1.3	.8	.6
Ethylene Glycol	1.1	9 (- 13)	387 (198)		185	86	53	39	44	19	9	4
Ethyl Acetate 100%	.9									.49		
Formic Acid, 1.22 100%	122	47 (8)	213 (100)						2.4	1.5	-	.8
.5% (.1N)	1.0	-	-	2.3								
Fuel Oil												
No. 1 (Kerosene)	.81				40	36	31	30	3.3	2.1	1.4	0.9
No. 2	.86				43	36	33	32	4.6	2.6	1.6	1.2
No. 3	.89				84	52	41	37	15	7	4	3
No. 6 (Bunker C)	.96					4,500-20,000	680-1,900	180-500		1,00	155	40
Diesel 2D	.82-.95				100	53	40	35				
3D	.82-.95				200	80	50	40				

Liquid	Sp. Gr. 60° F (16°C)	Melting Point °F (°C)	Boiling Point °F (°C)	pH At 77° F (25°C)	VISCOSITY							
					SSU				Centipoise			
					40°F	80°F	120°F	160°F	4°C	27°C	49°C	71°C
5D	.82-.95				15,000	2,000	400	160				
Gasoline	.6-.7				30				.7	.6	.4	.3
Glucose	1.4						35,000-100,000					
Glycerine (Glycerol)	1.26	64	554		25,000	3,100	700	230	6,260	490	130	56
50%	1.13	(18)	(290)						11	5.4	2.8	1.5
Hydrochloric Acid, 38%	1.20	- 13 (-25)										
31.5%	1.15	-115 (-46)							2.5	1.8	1.4	1.1
3.6% (1N)				0.1								
.36% (0.1N)				1.1								
.04% (.01N)				2.0								
Jet Fuel	.7-.8				35							
Lactic Acid		63 (17)	252 (122)									
		–	–	2.4								
Methyl Alcohol 80%	.80	- 144	149						.8	.5	.4	
	.82	(-98)	(65)						1.0	.7	.5	.4
Milk, 3.5%	1.03			6.3-6.6						1.1		
Molasses A	1.40					10,000	2,600-60,000					
Molasses C	1.49					300,000	25,000-250,000					
Nitric Acid,	1.50	-44 (-44)	187 (86)						1.4	1.0	.8	.6
95%												
60%	1.37	-9 (-23)							3.4	2.2	1.5	1.0
Oil, 5W					550	160	74	51	110	30	12	7
10W	.9				1,500	265	120	64	170	50	22	11
20W	.9				2,900	500	170	80	580	98	33	14
30W	.9				5,000	870	260	110	1,200	200	60	25
50W	.9				23,000	3,600	720	225	-	400	100	45
70W	.9				120,000	10,000	1,800	500	-	4,000	-	-
Oleic Acid	0.89	13 (-11)	547 (286)							26		
Olive Oil	.9				1,500	320	150	80				
Palmetic Acid	0.85	146 (63)	520 (271)									
Parafin	.9	100 (38)	660 (349)									
Peanut Oil	.9				1,200	300	150	80				
Propane	.51									.12		
Propylene Gylcol	1.0					241						
Potassium Hydroxide												
5.7% (1N)				14.0								
0.57% (0.1N)				13.0								
0.06% (0.01N)				12.0								
Rosin	1.09							500-20,000				
Sodium Bicarbonate 0.4% (0.1N)				8.4								
Sodium Chloride, 25%	1.19								3.3	2.1	1.3	.9
Sodium Hydroxide, 50%	1.53				950	240	84	46	250	77	26	10
30%	1.33					58				10	4.5	2.5
4% (1N)				14.0								
0.4% (0.1N)				13.0								
.04% (.01N)				12.0								

Liquid	Sp. Gr. 60° F (16°C)	Melting Point °F (°C)	Boiling Point °F (°C)	pH At 77° F (25°C)	VISCOSITY							
					SSU				Centipoise			
					40°F	80°F	120°F	160°F	4°C	27°C	49°C	71°C
Stearic Acid	.85	157 (69)	721 (383)									
Sucrose, 60%	1.29	10 (- 12)	218 (103)		500	150	68		156	41	14	7
40 %	1.18	25 (-4)	214 (101)						120	5	2.5	1.6
Sugar Syrup												
60 Brix	1.29					230	92					
70 Brix	1.35					1,650	400					
76 Brix	1.39					10,000	2,000					
Sulfur	2.06	239	832						(11 at	(9 at	(22 at	(16,000
Molten		(115)	(445)						123°C)	159°C)	160°C)	at 184°C)
Sulfric Acid 110% (Fuming, Oleum)		92 (33)	342 (172)		280	100	55		82	41	22	12
100%	1.83	50 (10)				75						
98%	1.84	37 (3)	554 (290)		118	68	45	37	46	23	12	6
60%	1.50	-83 (-64)	282 (139)						8.9	5.8	3.9	2.7
20%	1.14	8 (-13)	218 (103)						2.5	1.4	0.8	0.6
4.9% (1N)				0.3								
.49% (.1N)				1.2								
.05 (.01N)				2.1								
Toluene	.86	-139 (-95)	231 (111)						.8	.6	.4	.4
Trichloroethylene	1.62	-99 (-72)	189 (87)						.7	.6	.5	.4
Turpentine	.86	140 (60)	320 (160)		34	33	32	32	1.9	1.4	.9	.7
Vinegar				2.4-3.4								
Water	1.0	32 (0)	212 (100)	6.5-8.0	32				1.6	.9	.6	.4
Wines		1.03			2.8-3.8							

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TECH-D-5 Friction Loss for Viscous Liquids. Loss in Feet of Liquid per 100 Feet of New Schedule 40 Steel Pipe

GPM	Nom Pipe Size	Kinematic Viscosity – Seconds Saybolt Universal													
		Water	100	200	300	400	500	600	800	1000	1500	2000	3000	5000	10,000
	½	10.0	25.7	54.4	83	108	135	162	218	273	411	545	820	1350	-
3	¾	2.50	8.5	17.5	26.7	35.5	44	53	71	88	131	176	265	440	880
	1	0.77	3.2	6.6	10.2	13.4	16.6	20.0	26.6	34	50	67	100	167	-
	¾	6.32	14.1	29.3	44	59	74	88	117	147	219	293	440	740	1470
5	1	1.93	5.3	11.0	16.8	22.4	28	33	44	56	83	111	167	-	-
	1¼	0.51	1.8	3.7	5.5	7.6	9.5	11.1	14.8	18.5	28	37	56	94	187
	1	6.86	11.2	22.4	33.5	45	56	66	89	112	165	223	-	-	-
10	1¼	1.77	3.6	7.5	11.2	14.9	19.1	22.4	30	37	55	74	112	190	-
	1½	0.83	1.9	4.2	6.0	8.1	10.2	12.3	16.5	20.3	31	41	62	102	207
	1	14.6	26	34	50	67	85	104	137	172	-	-	-	-	-
15	1¼	3.72	6.4	11.3	16.9	22.4	29	34	45	57	84	112	167	-	-
	1½	1.73	2.8	6.2	9.2	12.4	15.3	18.4	25	30	46	61	92	152	-
	1	25.1	46	46	67	90	111	133	180	220	-	-	-	-	-
20	1½	2.94	5.3	8.1	12.2	16.2	20.3	25	33	40	61	81	122	203	
	2	0.87	1.5	3.0	4.4	6.0	7.4	9.0	11.9	14.8	22.4	30	45	74	147
	1½	6.26	11.6	12.2	18.2	24.3	30	37	50	61	91	122	182	-	-
30	2	1.82	3.2	4.4	6.7	9.0	11.1	13.2	17.8	22.2	33	45	67	178	222
	2½	0.75	1.4	2.2	3.2	4.4	5.5	6.5	8.8	10.9	16.6	22.0	33	55	110
	1½	10.8	19.6	20.8	24	32	40	50	65	81	121	162	243	400	810
40	2	3.10	5.8	5.8	9.0	11.8	14.8	17.7	24	30	44	59	89	148	-
	2½	1.28	2.5	3.0	4.4	5.8	7.4	8.8	11.8	14.6	22.2	29	44	73	145
	2	6.59	11.6	13.4	13.4	17.8	22.2	27	36	45	67	89	134	220	-
60	2½	2.72	5.1	5.5	6.5	8.8	10.9	13.1	17.8	22.0	34	44	66	109	220
	3	0.92	1.8	1.8	2.8	3.7	4.6	5.6	7.3	9.2	13.8	18.5	27	46	92
	2½	4.66	8.3	9.7	9.7	11.8	14.6	17.6	24	29	44	58	87	145	-
80	3	1.57	3.0	3.2	3.7	4.8	6.2	7.3	9.7	12.2	18.3	24	37	61	122
	4	0.41	0.83	0.83	1.2	1.7	2.1	2.5	3.3	4.2	6.2	8.3	12.5	20.6	41
	2½	7.11	12.2	14.1	14.8	14.8	18.5	22	29	36	55	73	109	183	-
100	3	2.39	4.4	5.1	5.1	6.2	7.6	9.1	12.1	15.2	23	31	46	77	150
	4	0.62	1.2	1.3	1.5	2.1	2.5	3.1	4.1	5.1	7.8	10.4	15.5	26	51
	3	3.62	6.5	7.8	8.1	8.1	9.7	11.5	15.3	19.4	29	39	58	97	193
125	4	0.94	1.8	2.1	2.1	2.6	3.2	3.9	5.2	6.4	9.8	12.7	19.3	32	65
	6	0.12	0.25	0.28	0.39	0.52	0.63	0.78	1.0	1.3	1.9	2.6	3.9	6.4	13.0
	3	5.14	9.2	10.4	11.5	11.5	11.5	13.7	18.4	23	35	46	69	115	230
150	4	1.32	2.4	2.9	2.9	3.1	3.9	4.6	6.2	7.8	11.5	15.4	23	39	78
	6	0.18	0.34	0.39	0.46	0.62	0.77	0.9	1.2	1.5	2.3	3.0	4.6	7.6	15.2
	3	6.9	11.7	13.8	15.8	15.8	15.8	15.9	21.4	27	40	53	80	133	-
175	4	1.76	3.2	4.0	4.0	4.0	4.6	5.4	7.4	9.2	13.7	18.2	28	46	92
	6	0.23	0.44	0.52	0.54	0.7	0.9	1.1	1.4	1.8	2.6	3.5	5.3	8.8	17.8
	3	8.90	15.0	17.8	20.3	20.3	20.3	20.3	25	31	46	61	91	152	-
200	4	2.27	4.2	5.1	5.1	5.1	5.1	6.2	8.3	10.4	15.5	20.6	31	51	103
	6	0.30	0.58	0.69	0.69	0.81	1.0	1.2	1.6	2.0	3.0	3.9	6.2	9.9	20.1
	4	3.46	6.0	7.4	8.0	8.0	8.0	8.0	10.2	12.9	19.4	26	39	64	130
250	6	0.45	0.83	0.99	1.0	1.0	1.2	1.5	2.1	2.5	3.7	5.1	7.6	12.5	-
	8	0.12	0.21	0.28	0.28	0.35	0.42	0.51	0.67	0.83	1.2	1.7	2.5	4.2	8.3
	6	1.09	8.5	9.9	11.6	11.6	11.6	11.6	12.4	15.5	23	31	46	77	155
300	8	0.28	1.2	1.4	1.5	1.5	1.5	1.8	2.5	3.0	4.6	6.0	9.1	15.0	30
	10	0.09	0.30	0.39	0.39	0.42	0.51	0.61	0.82	1.0	1.5	2.0	3.0	5.1	9.9
	6	1.09	1.9	2.3	2.5	2.8	2.8	2.8	3.2	3.9	6.0	8.1	12.1	20.1	-
400	8	0.28	0.53	0.62	0.67	0.67	0.67	0.81	1.1	1.3	2.0	2.8	4.1	6.7	13.5
	10	0.09	0.18	0.21	0.23	0.23	0.28	0.32	0.43	0.53	0.81	1.1	1.6	2.8	5.3
	4	4.89	4.2	5.1	5.3	5.5	6.0	6.2	6.2	6.2	9.0	12.0	18.5	-	-
600	6	0.64	1.1	1.3	1.4	1.5	1.5	1.5	1.7	2.0	3.0	3.9	6.2	9.9	20
	8	0.16	0.37	0.42	0.46	0.51	0.51	0.51	0.65	0.81	1.2	1.6	2.4	4.2	8.1
	6	4.03	6.5	8.1	8.5	9.2	9.7	11.1	11.1	11.1	12.0	16.0	-	-	-
800	8	1.02	1.8	2.2	2.3	2.5	2.8	2.8	2.8	2.8	3.9	5.3	8.2	13.4	-
	10	0.33	0.60	0.69	0.78	0.88	0.92	0.92	0.92	1.1	1.6	2.1	3.2	5.3	10.9
	8	1.56	2.5	3.2	3.5	3.7	4.2	4.4	4.4	4.4	5.1	6.7	10.2	16.6	-
1000	10	0.50	0.88	1.0	1.2	1.3	1.4	1.4	1.4	1.4	2.0	2.8	4.0	6.7	13.4
	12	0.21	0.39	0.46	0.51	0.55	0.58	0.58	0.58	0.67	1.0	1.3	2.0	3.5	6.7

TECH-D-6 Pumping Liquids with Entrained Gas

Pump applications in many industrial processes involve handling liquid and gas mixtures. The entrained gas may be an essential part of an industrial process, or it may be unwanted. The Pulp and Paper industry, for example, injects from between 4% and 10% air into a dilute pulp slurry as part of the ink removal process in a flote cell used in paper recycling. Many chemical and petrochemical processes also involve pumping a two phase flow. Unwanted entrained gas can result from excess agitation or vortexing due to inadequate submergence on the suction of a pump.

The proper selection of a centrifugal pump for liquid and gas (two phase) mixtures is highly dependent on the amount of gas and the characteristics of the liquid. The presence of entrained gases will reduce the output of centrifugal pumps and can potentially cause loss of prime. Conventional pump designs can be used for low percentages by volume (up to 4%), while special modified impellers can be used effectively for up to 10% gas by volume. Performance corrections are required in all cases with gas content above approximately 2%. Gas concentrations above 10% can also be handled, but only with special design pumps (pumps with inducers, vortex pumps, or pumps with gas extraction).

Virtually any type of centrifugal pump can handle some amount of entrained gas. The problem to be addressed is the tendency for the gas to accumulate in the pump suction inhibiting flow and head generation. If gas continues to accumulate, the pump may lose prime.

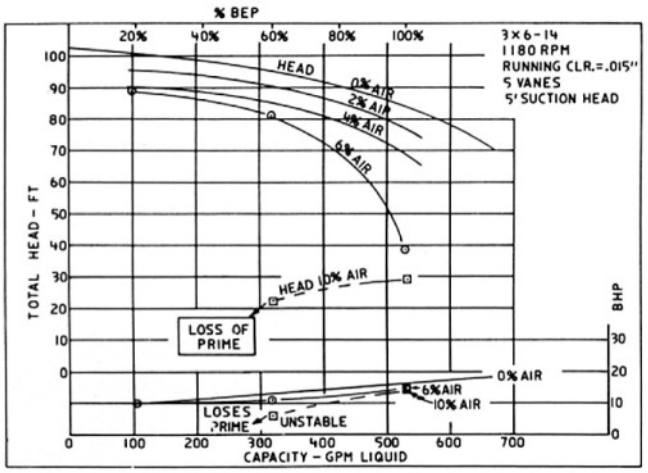


Fig. 1 Head and Power vs Capacity Zero to Ten Percent Air by Volume for Normal Running Clearance

Fig. 1 shows how the performance of a standard end suction pump is affected by various amounts of air. With a minor performance correction, this type of pump is reasonably efficient in handling up to approximately 4% entrained gas.

As the percentage of gas exceeds 4% by volume, the performance of a conventional pump begins to degrade drastically (Fig. 1) until the pump becomes unstable, eventually losing prime. It has been found beneficial to increase the impeller running clearance (0.090 to 0.180 in.) allowing for greater leakage. This is effective in preventing loss of prime with gas concentrations up to 10%. Fig. 2 shows a standard end suction open impeller pump with clearances opened for gas handling.

Numerous tests have been conducted in an effort to quantify the performance corrections for various gas concentrations for both standard pumps and pumps with open clearances. The performance corrections are affected by many variables, including pump specific speed, operating speed, impeller design and number of vanes, operating point on the curve, and suction pressure. Performance correction charts are not presented here due to the numerous variables, but Goulds Applications Engineers can make recommendations and selections for most specific applications.

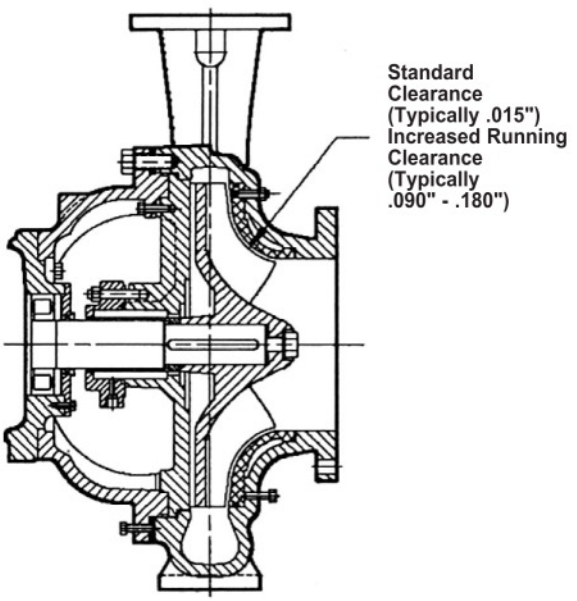


Fig. 2 Open Impeller End Suction Pump with Normal Running Clearance and Increased Running Clearance.

TECH-D-7A Solids and Slurries - Definition of Terms

APPARENT VISCOSITY

The viscosity of a non-Newtonian slurry at a particular rate of shear, expressed in terms applicable to Newtonian fluids.

CRITICAL CARRYING VELOCITY

The mean velocity of the specific slurry in a particular conduit, above which the solids phase remains in suspension, and below which solid-liquid separation occurs.

EFFECTIVE PARTICLE DIAMETER

The single or average particle size used to represent the behavior of a mixture of various sizes of particles in a slurry. This designation is used to calculate system requirements and pump performance.

FRICTION CHARACTERISTIC

A term used to describe the resistance to flow which is exhibited by solid-liquid mixtures at various rates of flow.

HETEROGENEOUS MIXTURE

A mixture of solids and a liquid in which the solids are net uniformly distributed.

HOMOGENEOUS FLOW (FULLY SUSPENDED SOLIDS)

A type of slurry flow in which the solids are thoroughly mixed in the flowing stream and a negligible amount of the solids are sliding along the conduit wall.

HOMOGENEOUS MIXTURE

A mixture of solids and a liquid in which the solids are uniformly distributed.

NON-HOMOGENEOUS FLOW (PARTIALLY SUSPENDED SOLIDS)

A type of slurry flow in which the solids are stratified, with a portion of the solids sliding along the conduit wall. Sometimes called "heterogeneous flow" or "flow with partially suspended solids."

NON-SETTLING SLURRY

A slurry in which the solids will not settle to the bottom of the containing vessel or conduit, but will remain in suspension, without agitation, for long periods of time.

PERCENT SOLIDS BY VOLUME

The actual volume of the solid material in a given volume of slurry, divided by the given volume of slurry, multiplied by 100.

PERCENT SOLIDS BY WEIGHT

The weight of dry solids in a given volume of slurry, divided by the total weight of that volume of slurry, multiplied by 100.

SALTATION

A condition which exists in a moving stream of slurry when solids settle in the bottom of the stream in random agglomerations which build up and wash away with irregular frequency.

SETTLING SLURRY

A slurry in which the solids will move to the bottom of the containing vessel or conduit at a discernible rate, but which will remain in suspension if the slurry is agitated constantly.

SETTLING VELOCITY

The rate at which the solids in a slurry will move to the bottom of a container of liquid that is not in motion. (Not to be confused with the velocity of a slurry that is less than the critical carrying velocity as defined above.)

SQUARE ROOT LAW

A rule used to calculate the approximate increase in critical carrying velocity for a given slurry when pipe size is increased. It states:

$$V_L = V_s = \left(\frac{D_L}{D_s}\right)^{1/2}$$

Where:

V_L = Critical carrying velocity in larger pipe

D_L = Diameter of larger pipe

V_s = Critical carrying velocity in smaller pipe

D_s = Diameter of smaller pipe

This rule should not be used when pipe size is decreased.

VISCOSITY TYPES

(For definitions of the various types of viscosities applicable to slurries, see Rheological Definitions.)

YIELD VALUE (STRESS)

The stress at which many non-Newtonian slurries will start to deform and below which there will be no relative motion between adjacent particles in the slurry.

TECH-D-7B Solids and Slurries - Slurry Pump Applications

Determining the *when* to use a slurry style centrifugal pump can be a challenging decision. Often the cost of a slurry pump is many times that of a standard water pump and this can make the decision to use a slurry pump very difficult. One problem in selecting a pump type is determining whether or not the fluid to be pumped is actually a slurry. We can define a slurry as any fluid which contains more solids than that of potable water. Now, this does not mean that a slurry pump must be used for every application with a trace amount of solids, but at least a slurry pump should be considered.

Slurries to be handled by centrifugal pumps may be placed into 4 categories, numbered 1, 2, 3 and 4. Class 1 slurries are least severe in terms of wear and effect on pump performance, while class 4 slurries produce the most rapid, severe pump wear and require the greatest correction to clear water performance. The class of the slurry in question is determined using the following method:

1 Determine the following:
- a. Slurry d50 (50% passing solids diameter)
- b. Slurry Sm (mixture specific gravity)
- c. Miller abrasivity index of solids (Miller numbers for common materials are listed in the table found in Fig. F)

2 Adjust the slurry specific gravity for Miller number effect:

$$S_{M-ADJUSTED} = \frac{S_M M}{112}$$

Where M = Miller abrasivity index of solids in question (based on ASTM G75-95)

3 Use Fig. 1 below to determine which class the slurry in question falls into.

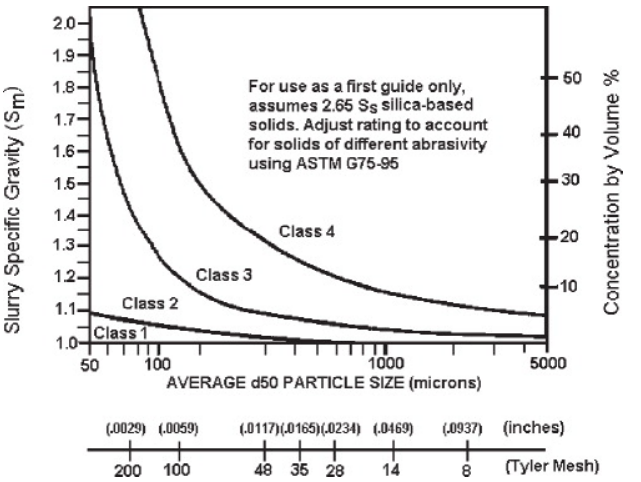


Fig. 1 Slurry Classification Graph (Courtesy of Hydraulic Institute, www.pumps.org)

Slurry pumps sold by ITT IP/Goulds Pumps are categorized as follows:

Class 1	Class 1 and 2	Class 3	Class 4
AF	AF	XHD	XHD
HS	HS	SRL-C	SRL-XT
HSUL	HSUL	SRL-CM	SRL-XTM
VHS	VHS	RX	RXA
JC	JC		CW 5500
JCU	JCU		5500S
VJC	VJC		5500LS
CV 3196	CWX		CKX
	SRL-S		
	SRL		

While selecting a pump from a higher rating for a lower rated duty is acceptable (e.g. using a class 4 rated 5500 in a class 1 rated duty to fill a gap in JC hydraulics), it is not recommended to use a lighter duty pump in a heavy service (e.g. using a class 1 rated JC in a class 4 service).

Other considerations in selecting a slurry pump are:

- Particle shape/angularity (angular or rounded?)
- Particle velocity and direction
- Maximum solids size
- Presence of "tramp" solids (e.g. unintended metal or wood scraps)
- Slurry pH and chloride content
- Petroleum or hydrocarbon content
- Froth/entrained air content
- Derating due to slurry effects on pump head and efficiency

SLURRY PUMP DESIGN

Design Feature	Benefit	Compromise
Thick Wear Sections	Longer component life	Heavier, more expensive parts
Larger Impellers	Slower pump speeds longer	Heavier, more expensive parts component life
Specialty Materials	Longer component life	Expensive parts
Specialty Materials	Longer component life	Expensive parts
Semi Volute or Concentric Casing	Improved pump life	Loss in efficiency
Extra Rigid	Improved bearing lives	More expensive Power Ends shafts and bearings

Although selecting the proper slurry pump for a particular application can be quite complex, the selection task can be broken down into a simplified three-step process:

1 Determine which group of possible pump selections best matches your specific application.

2 Plot the system curve depicting the required pump head at various capacities.

3 Correct pump performance for slurry effects (if necessary).

4 Match the correct pump performance curve with the system curve.

Slurry pumps can be broken down into two main categories: the rubber-lined pump and the hard metal pump. Because of the elastomer lining, the rubber-lined pumps have a somewhat limited application range. Below is a general guideline which helps distinguish when to apply the rubber-lined pumps.

Rubber Lined	Hard Metal Pump
Solids < 1/4 inch (6mm) for SRL, SRL-C, Solids < 1/2" (13mm) SRL-XT	Solids > 1/4 inch (13mm)
Temperature < 300° F (150°C)	Temperature < 250° F (120°C)
Low Head service < 150 feet (46m)	Heads above 150 feet (46m)
Rounded particles	Sharp/Jagged particles
Complete pH range	pH range from 4 to 12 Hydrocarbon based slurry

It should be noted, however, that a hard metal pump can also be used for some services that are outlined for the rubber-lined pump. After a decision has been made whether to use a hard metal pump or a rubber-lined pump, it is then time to select a particular pump model. A pump model should be selected by reviewing the application and determining which model pump will work best in the service.

NOTES:

The Model HS pump is a unique pump in that it is a recessed impeller or "vortex" pump. This style pump is well suited to handle light pulpy or fibrous slurries. The recessed impeller used in the HS family of pumps will pass large stringy fibers and should be considered when pump plugging is a concern.

The Model AF is a specialized pump with an axial flow design. This design of pump is built specifically for high flow, low head applications.

In general, slurry pumps have been designed to handle fluids with abrasive solids and will give extended lives over standard water or process pumps. Although many features have been designed into the slurry pump, there are still two factors which directly relate to the pump's life that can be determined. The first choice to make is determining the metallurgy of the pump. In most cases, a hard metal slurry pump will be constructed of some hardened metal with a Brinell hardness of at least 500. Goulds standard slurry pump material is a 28% chrome iron with a minimum hardness of 600 Brinell. This material is used for most abrasive services and can also be used in some corrosive fluids as well. If a more corrosive resistant material is required, then the pump may be constructed out of a duplex Stainless Steel such as CD4MCu. Please check with your nearest Goulds sales office if you are unsure what material will be best suited for a particular application.

PUMP RUNNING SPEED

The other factor that can be controlled by the sales or end user engineer is the pump running speed. The running speed of a slurry pump is one of the most important factors which determines the life of the pump. Through testing, it has been proven that a slurry pump's wear rate is proportional to the speed of the pump raised to the 2½ power

EXAMPLE:

If Pump (A) is running at 1000 RPM and

Pump (B) is running at 800 RPM,

then the life factor for Pump (B) as compared to Pump (A) is $(1000/800)^{2.5}$ or Pump (B) will last 1.75 times as long as Pump (A).

With the above ratio in mind, it can be shown that by cutting a slurry pump speed in half, you get approximately 6 times the wear life. For this reason, most slurry pumps are V-belt driven with a full diameter impeller. This allows the pump to run at the slowest possible running speed and, therefore, providing the maximum pump life.

WHY USE A V-BELT DRIVE?

In most ANSI pump applications it is a reasonable practice to control condition point by trimming the impeller and direct connecting the motor. However, this is not always sound practice in slurry applications. The abrasive solids present, wear life is enhanced by applying the pump at the slowest speed possible.

Another situation where V-belts are beneficial is in the application of axial flow pumps. Axial flow pumps cannot be trimmed to reduce the

condition point because they depend on close clearances between the vane tips and the casing for their function. The generally low RPM range for axial flow application also makes it beneficial to use a speed reduction from the point of view of motor cost.

The types of V-belt drives available for use in pump applications are termed fixed speed, or fixed pitch, and variable speed. The fixed pitch drive consists of two sheaves; each machined to a specific diameter, and a number of belts between them to transmit the torque. The speed ratio is roughly equal to the diameter ratio of the sheaves. The variable speed drive is similar to the fixed speed except that the motor sheave can be adjusted to a range of effective or *pitch* diameters to achieve a band of speed ratios. This pitch adjustment is made by changing the width of the *V* grooves on the sheave. Variable speed drives are useful in applications where an exact flow rate is required or when the true condition point is not well defined at the time that the pump is picked.

V-belt drives can be applied up to about 500 horsepower, but pump applications are usually at or below 350 HP.

TECH-D-7C Solids and Slurries - Useful Formulas

a. The formula for specific gravity of a solids-liquids mixture or slurry, S_m is:

$$S_m = \frac{S_s \times S_1}{S_s + C_w (S_1 - S_s)}$$

where,

S_m = specific gravity of mixture or slurry

S_1 = specific gravity of liquid phase

S_s = specific gravity of solids phase

C_w = concentration of solids by weight

C_v = concentration of solids by volume

EXAMPLE: if the liquid has a specific gravity of 1.2 and the concentration of solids by weight is 35% with the solids having a specific gravity of 2.2, then:

$$S_m = \frac{2.2 \times 1.2}{2.2 + .35\ (1.2 - 2.2)} = 1.43$$

b. Basic relationships among concentration and specific gravities of solid liquid mixtures are shown below:

In Terms of	S_s, S_m, S_1	C_v	C_w
C_v	$\frac{S_m - S_1}{S_s - S_1}$		$C_w \frac{S_m}{S_s}$
C_w	$\frac{(S_m - S_1)}{(S_s - S_1)} \times \frac{S_s}{S_m}$	$C_v \frac{S_s}{S_m}$	

Where pumps are to be applied to mixtures which are both corrosive and abrasive, the predominant factor causing wear should be identified and the materials of construction selected accordingly. This often results in a compromise and in many cases can only be decided as a result of test or operational experience.

For any slurry pump application, a complete description of the mixture components is required in order to select the correct type of pump and materials of construction.

$$C_W = \frac{\text{weight of dry solids}}{\text{weight of dry solids + weight of liquid phase}}$$

$$C_v = \frac{\text{volume of dry solids}}{\text{volume of dry solids + volume of liquid phase}}$$

See nomograph for the relationship of concentration to specific gravity of dry solids in water shown in Fig. B.

c. Slurry flow requirements can be determined from the expression:

$$Q_m = \frac{4 \times \text{dry solids (tons per hour)}}{C_w = S_m}$$

where,

Q_m = slurry flow (U.S. gallons per minute)

1 ton = 2000 lbs.

EXAMPLE: 2,400 tons of dry solids is processed in 24 hours in water with a specific gravity of 1.0 and the concentration of solids by weight is 30% with the solids having a specific gravity of 2.7 then:

$$S_m = \frac{2.7 \times 1.0}{2.7 + .3\ (1\text{-}2.7)} = .123$$

$$Q_m = \frac{4 \times 100}{.3 \times 1.23} = 1{,}084\ U.S.\ GPM$$

d. Abrasive wear: Wear on metal pumps increases rapidly when the particle hardness exceeds that of the metal surfaces being abraded. If an elastomer lined pump cannot be selected, always select metals with a higher relative hardness to that of the particle hardness. There is little to be gained by increasing the hardness of the metal unless it can be made to exceed that of the particles. The effective abrasion resistance of any metal will depend on its position on the Mohs or Knoop hardness scale or Miller abrasivity index. The relationships of various common ore minerals and metals is shown in Fig. A.

Wear increases rapidly when the particle size increases. The life of the pump parts can be extended by choosing the correct materials of construction.

Sharp angular particles cause about twice the wear of rounded particles.

Hard irons are used to resist erosion and, to a lesser extent, impact wear.

Castable ceramic materials have excellent resistance to cutting erosion but impeller tip velocities are usually restricted to 100 ft./sec.

Elastomer lined pumps offer the best wear life for slurries with solids under ¼" for the SRL/SRL-C and under ½" for the SRL-XT.

Several elastomers are available for different applications. Hypalon is acceptable in the range of 1-14 pH. There is a single stage head limitation of about 150' due to tip speed limitations of elastomer

impellers, and of about 190' with metal impellers and elastomer liners due to liner degradation issues.

See the Classification of Pumps according to Solids Size chart (Fig. C) and Elastomer Quick Selection Guide (Section TECH-B-2) for more information.

Approximate Comparison of Hardness Values of Common Ores and Minerals

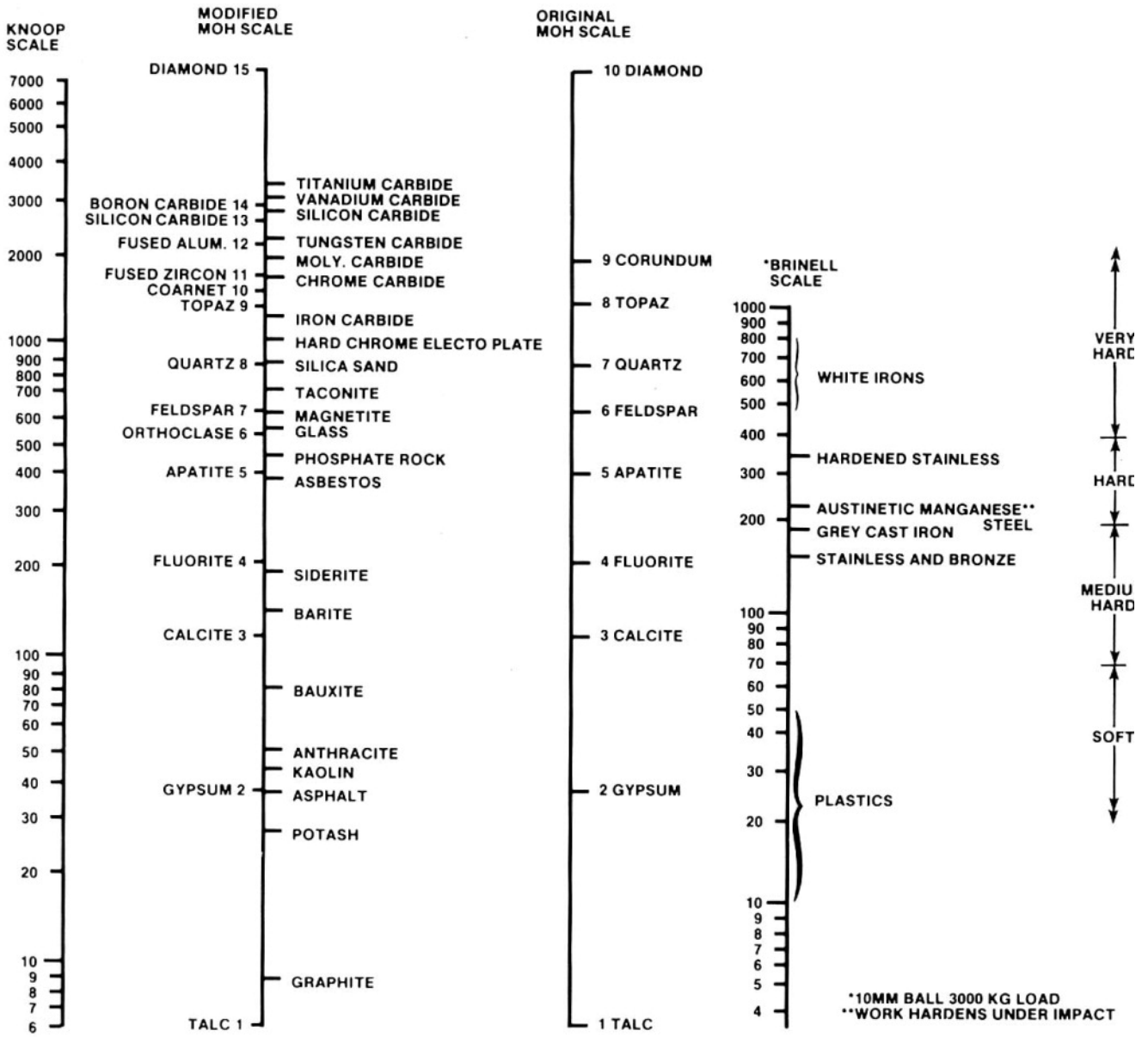


Fig. A

Nomograph of the Relationship of Concentration to Specific Gravity in Aqueous Slurries

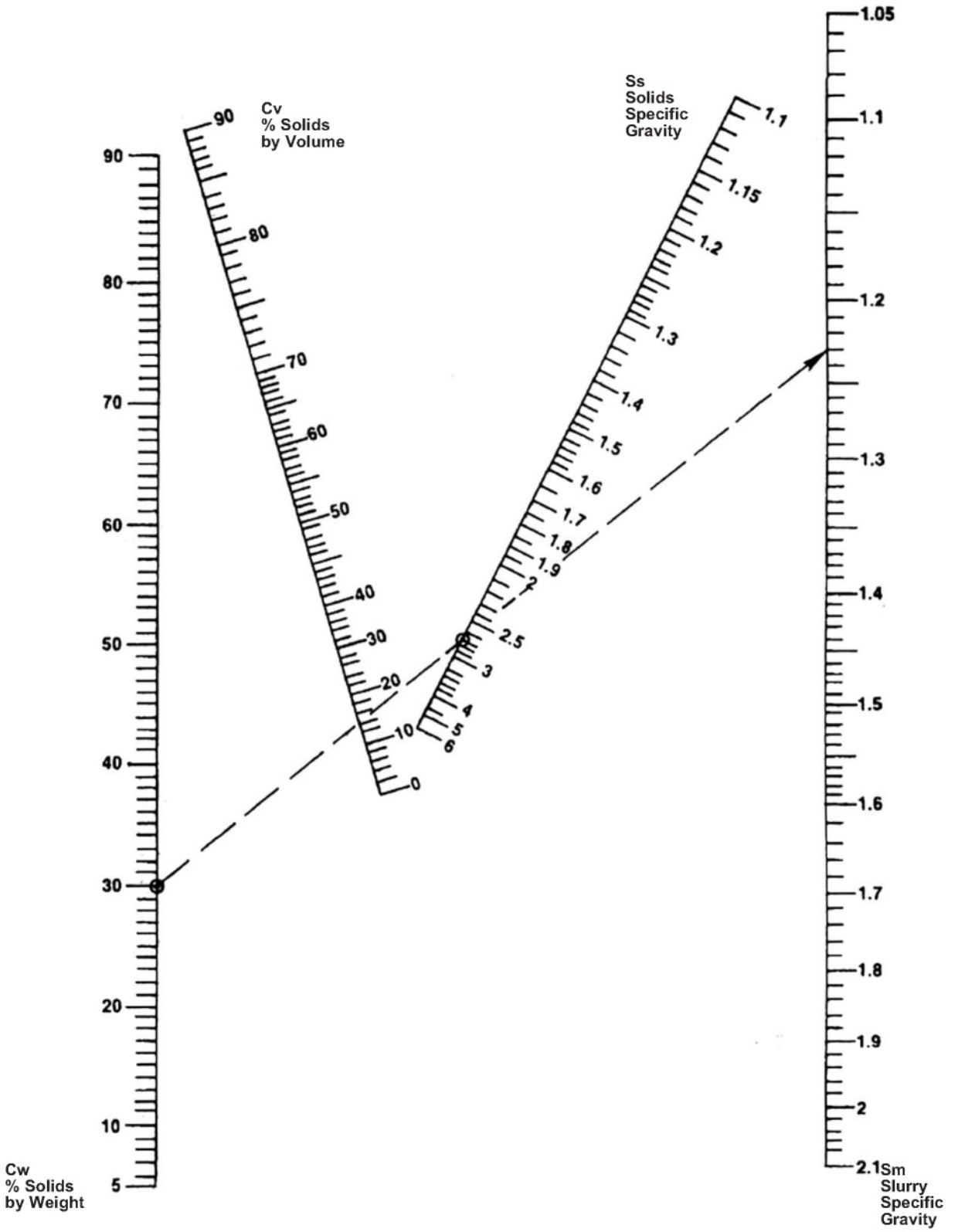


Fig. B

Solids and Slurries

Classification of Pumps According to Solid Size

Tyler Standard Sieve Series			Grade
Aperture		Mesh	
Inch	mm		
160	4060	-	Very large boulders
80	2030	-	Large boulders
40	1016	-	Medium boulders
20	508	-	Small boulders
10	254	-	Large cobbles
3	76.2	-	Small cobbles
2	50.8	-	
1.5	38.1	-	Very coarse gravel
1.050	26.67	-	Coarse Gravel
.883	22.43	-	
.742	18.85	-	
.624	15.85	-	Medium Gravel
.524	13.33	-	
.441	11.20	-	
.371	9.423	-	
.321	7.925	2.	Fine Gravel
.263	6.680	3	
.221	5.613	3.5	
.185	4.699	4	
.156	3.962	5	Very Fine Gravel
.131	3.327	6	
.110	2.794	7	
.093	2.362	8	
.078	1.981	9	Very Coarse Sand
.065	1.651	10	
.055	1.397	12	
0.46	1.168	14	Coarse Sand
0.39	.991	16	
0.328	.833	20	
0.276	.701	24	Medium Sand
.0232	.589	28	
.0195	.495	32	
.0164	0.417	35	
.0138	.351	42	
.116	.295	48	
.0097	.248	60	Fine Sand
.0082	.204	65	
.0069	.175	80	
.0058	.147	100	
.0049	.124	115	
.0041	.104	150	
.0035	.089	170	Silt Slimes
.0029	.074	200	
.0024	.061	250	
.0021	.053	270	
.0017	.043	325	
.0015	.038	400	
-	.025	*500	
-	.020	*625	
-	.10	*1250	
-	.005	*2500	
-	.001	*12500	Mud Clay
-	.0005		
-	.0024		

Austenetic Manganese Steel

Hard Iron XHD / 5500

Rubber Lined SRL - XT

Rubber Lined SRL - C

Rubber Lined SRL SRL-C

Ceramic Lined

Pulverized

Dredge Pump

Sand & Gravel Pump

Severe Duty Slurry Pump

Sand Pump

Slurry Pump

* Theoretical values Micron = .001 mm

NOTE: This tabulation is for general guidance only since the selection of pump type and materials of construction also depends on the total head to be generated and the abrasivity of the slurry i.e. concentration, solids specific gravity, etc.

Fig. C

Standard Screen Sizes Comparison Chart

U.S. Bureau of Standard Screens			Tyler Screens				British Standard Screens			I.M.M. Screens		
	Aperture			Aperture				Apeture			Aperture	
Mesh	Inches	mm	Mesh	Inches	mm	Mesh Double Tyler Series	Mesh	Inches	mm	Mesh	Inches	mm
			2 1/2	.321	7.925							
3	.265	6.73	3	.263	6.680							
3 1/2	.223	5.66		.221	5.613	3 1/2						
4	.187	4.76	4	.185	4.699							
5	.157	4.00		.156	3.962	5						
6	.132	3.36	6	.131	3.327		5	.1320	3.34			
7	.111	2.83		.110	2.794	7	6	.1107	2.81			
8	.0937	2.38	8	.093	2.362		7	.0949	2.41	5	.100	2.54
10	.0787	2.00		.078	1.981	9	8	.0810	2.05			
12	.0661	1.68	10	.065	1.651		10	0.660	1.67			
										8	.062	1.574
14	.0555	1.41		.055	1.397	12	12	.0553	1.40			
										10	.050	1.270
16	.0469	1.19	14	.046	1.168		14	.0474	1.20			
										12	.0416	1.056
18	.0394	1.00		.039	.991	16	16	.0395	1.00			
20	.0331	.84	20	.0328	.883		18	.0336	.85			
										16	.0312	.792
25	.0280	.71		.0276	.701	24	22	.0275	.70			
										20	.025	.635
30	.0232	.59	28	.0232	.589		25	.0236	.60			
35	.0197	.50		.0195	.495	32	30	.0197	.50	25	.020	.508
40	.0165	.42	35	.0164	.417		36	.0166	.421	30	.0166	.421
45	.0138	.35		.0138	.351	42	44	.0139	.353	35	.0142	.361
										40	.0125	.317
50	.0117	.297	48	.0116	.295		52	.0166	.295			
60	.0098	.250		.0097	.246	60	60	.0099	.252	50	.01	.254
70	.0083	.210	65	.0082	.208		72	.0083	.211	60	.0083	.211
80	.0070	.177		.0069	.175	80	85	.0070	.177	70	.0071	.180
100	.0059	.149	100	.0058	.147		100	.0060	.152	80	.0062	.157
										90	.0055	.139
120	.0049	.125		.0049	.124	115	120	.0049	.125	100	.0050	.127
140	.0041	.105	150	.0041	.104		150	.0041	.105	120	.0042	.107
170	.0035	.088		.0035	.088	170	170	.0035	.088	150	.0033	.084
200	.0029	.074	200	.0029	.074		200	.0030	.076	170	.0029	.074
230	.0024	.062		.0024	.061	250	240	.0026	.065	200	.0025	.063
270	.0021	.053	270	.0021	.053		300	.0021	.053			
325	.0017	.044		.0017	.043	325						
			400	.0015	.037							

Fig. D

Solids and Slurries

Specific Gravities of Rocks, Minerals and Ores

Material	Specific Gravity	Mohs Hardness
Aluminum	2.55- 2.75	1-2
Amber	1.06-1.11	
Ambylgonite	3-3.1	5.5-6
Andesine	2.66- 2.94	6-6.5
Aragonite, CaCO3	2.94-2.95	3.5-4
Argentite	7.2-7.4	2-2.5
Asbestos	2.1-2.4	2
Asphaltum	1.1-1.5	
Asphalt Rock	2.41	
Barite	4.5	3-3.5
Basalt	2.4-3.1	8-9
Bauxite	2.55-2.73	
Bentonite	1.6	
Bertrandite	2.6	6
Beryl	2.66- 2.83	7.5-8
Biotite	2.7-3.1	2.5-3
Bone	1.7-2	
Borax	1.71-1.73	2-2.5
Bornite	5.06-5.08	3
Braggite	10	
Braunite	4.72- 4.83	6-6.5
Brick	1.4-2.2	
Calcite	2.72-2.94	3
Carnotite	2.47	1-2
Cassiterite	6.99-7.12	6-7
Carbon, Amorphous Graphitic	1.88-2.25	
Celluloid	1.4	
Cerussite	6.5- 6.57	3-3.5
Chalcocite	5.5-5.8	2.5-3
Chalcopyrite	4.1-4.3	3.5-4
Chalk	1.9-2.8	
Charcoal, Pine	0.28-0.44	
Charcoal, Oak	0.47-0.57	
Chromite	4.5	5.5
Chrysoberyl	3.65-3.85	8.5
Cinnabar	8.09	2-2.5
Clay	1.8-2.6	2
Coal, Anthracite	1.4-1.8	2
Coal, Bituminous	1.2-1.5	
Coal, Lignite	1.1-1.4	
Cobaltite	6.2	5.5
Coke	1-1.7	
Colemanite	1.73	4.5
Columbite	5.15-5.25	6
Copper	8.95	2.5-3
Cork	0.22-0.26	
Covellite	4.6-4.76	1.5-2
Cuprite	6	3.5-4
Diabase	2.94	
Diatomaceous Earth	0.4-0.72	
Diorite	2.86	
Dolomite	2.8-2.86	3.5-4
Enargite	4.4-4.5	3
Epidote	3.25-3.5	6
Feldspar	2.55-2.75	
Fluorite	3.18	4
Fly Ash	2.07	
Galena	7.3-7.6	2.5-2.75
Glass	2.4-2.8	7
Goethite	3.3-4.3	5-5.5
Gold	19.3	2.5-3
Granite	2.6-2.9	
Graphite	2.2-2.72	1-2
Gravel, Dry	1.55	4-5
Gravel, Wet	2	
Gypsum	2.3-2.37	2
Halite	2.2	2.5
Hausmannite	4.83-4.85	5.5
Helvite	3.2-3.44	6
Hematite	4.9-5.3	5-6

Material	Specific Gravity	Mohs Hardness
Hessite	8.24- 8.45	2-3
Ice	0.917	
Ilmenite	4.68-4.76	5-6
Iron, Slag	2.5-3	
Lepidolite	2.8-2.9	2.5-4
Lime, slaked	1.3- 1.4	
Limestone	2.4-2.7	2-5
Limonite	3.6-4	
Linnaeite	4.89	
Magnetite	4.9-5.2	5.5-6.5
Manganite	4.3-4.4	4
Marble	2.5-2.78	4
Marl	2.23	
Millerite	5.3-5.7	3-3.5
Monazite	5.1	5
Molybdenite	4.62-4.73	1-1.5
Muscovite	2.77- 2.88	2.5-3
Niccolite	7.784	5-5.5
Orpiment	3.5	1.5-2
Pentlandite	4.8	2.5-3
Petalite	2.412-2.422	6.5
Phosophite	3.21	
Phosphorus, white	1.83	
Polybasite	6-6.2	2.3
	Porphyry	2.6-2.9
Potash	2.2	
Powellite	4.21-4.25	3.5-4
Proustiie	5.57	2-2.5
Psilomelane	4.71	5-6
Pumice	0.37-0.9	
Pyragyrite	5.85	2.5
Pyrites	4.95-5.1	3.5-4.5
Pyrolusite	4.8	6-6.5
Quartz	2.5-2.8	7-8
Quartzite	2.68	7
Realgar	3.56	1.5-2
Rhodochrosite	3.7	3.5-4
Rhodonite	3.57-3.76	5.5-6.5
Rutile	4.2-5.5	6-6.5
Sand (see Quartz)	1.7-3.2	7
Sandstone	2-3.2	7
Scheelite	6.08-6.12	4.5-5
Schist	2.6-3	
Serpentine	2.5	2.5-3.5
Shale	1.6-2.9	
Siderite	3.9-4	4-4.5
Silica, fused trans.	2.21	
Slag, Furnace	2-3.9	
Slate	2.8-2.9	
Smaltite	6.48	
Soapstone, talc	2.6-2.8	2
Sodium Nitrate	2.2	
Sperrylite	10.58	6-7
Spodumene	3.03-3.22	6.5-7
Sphalerite	3.9-4.1	3.5-4
Stannite	4.3-4.5	4
Starch	1.53	
Stibnite	4.61-4.65	2
Sugar	1.59	
Sulfur	1.93-2.07	1.5-2.5
Sylvanite	8.161	1.5-2
Taconite	3.18	
Tallow, beef	0.94	
Tantalite	7.9-8	6.5
Tetrahedrite	4.6-5.1	3-4.5
Titanite	3.5	
Trap Rock	2.79	
Uraninite	8-11	5-6
Witherite	4.29-4.3	3.5
Wolframite	7.12-7.51	4-4.5
Zinc Blende	4.02	4
Zincite	5.64-5.68	4

Fig. E

Solids and Slurries

Miller Number Data

Miller Number	Material	Miller Number	Material	Miller Number	Material
15	Kaolin	49	Ash (fly)	112	Clean Sand
22	Coal (clean)	56	Shale, Raw Coal	194	Pyrite
34	Limestone	70	Copper Conc.	219	Tailings (various)
35	Clay	84	Magnite	287	Copper Ore
39	Bauxite	90	Phosphate		
41	Gypsum	103	Iron Ore		

Fig. F

Hardness Conversion Table for Carbon and Alloy Steels

Brinell Hardness Number (Carbide Ball)	Rockwell Hardness Numbers					Tensile Strength	
	C Scale	A Scale	15N Scale Superficial	B Scale	30T Scale Superficial	ksl	MPa
	66	84.5	92.5				
722	64	83.4	91.8				
688	62	82.3	91.1				
654	60	81.2	90.2				
615	58	80.1	89.3				
577	56	79	88.3			313	2160
543	54	78	87.4			292	2010
512	52	76.8	86.4			273	1880
481	50	75.9	85.5			255	1760
455	48	74.7	84.5			238	1640
443	47	74.1	83.9			229	1580
432	46	73.6	83.5			221	1520
421	45	73.1	83			215	1480
409	44	72.5	82.5			208	1430
400	43	72	82			201	1390
309	42	71.5	81.5			194	1340
381	41	70.9	80.9			188	1300
371	40	70.4	80.4			182	1250
362	39	69.9	79.9			177	1220
353	38	69.4	79.4			171	1180
344	37	68.9	78.8			166	1140
336	36	68.4	78.3			161	1110
327	35	67.9	77.7			156	1080
319	34	67.4	77.2			152	1050
311	33	66.8	76.6			149	1030
301	32	66.3	76.1			146	1010
294	31	65.8	75.6			141	970
286	30	65.3	75			138	950
279	29	64.6	74.5			135	930
271	28	64.3	73.9			131	900
264	27	63.8	73.3			128	880
258	26	63.3	72.8			125	860
253	25	62.8	72.2			123	850
247	24	62.4	71.6			119	820
243	23	62	71			117	810
240				100	83.1	116	800
234				99	82.5	114	785
222				97	81.1	104	715
210				95	79.8	100	690
200				93	78.4	94	650
195				92	77.8	92	635
185				90	76.4	89	615
176				88	75.1	86	590
169				86	73.8	83	570

Fig. G

Solids and Slurries

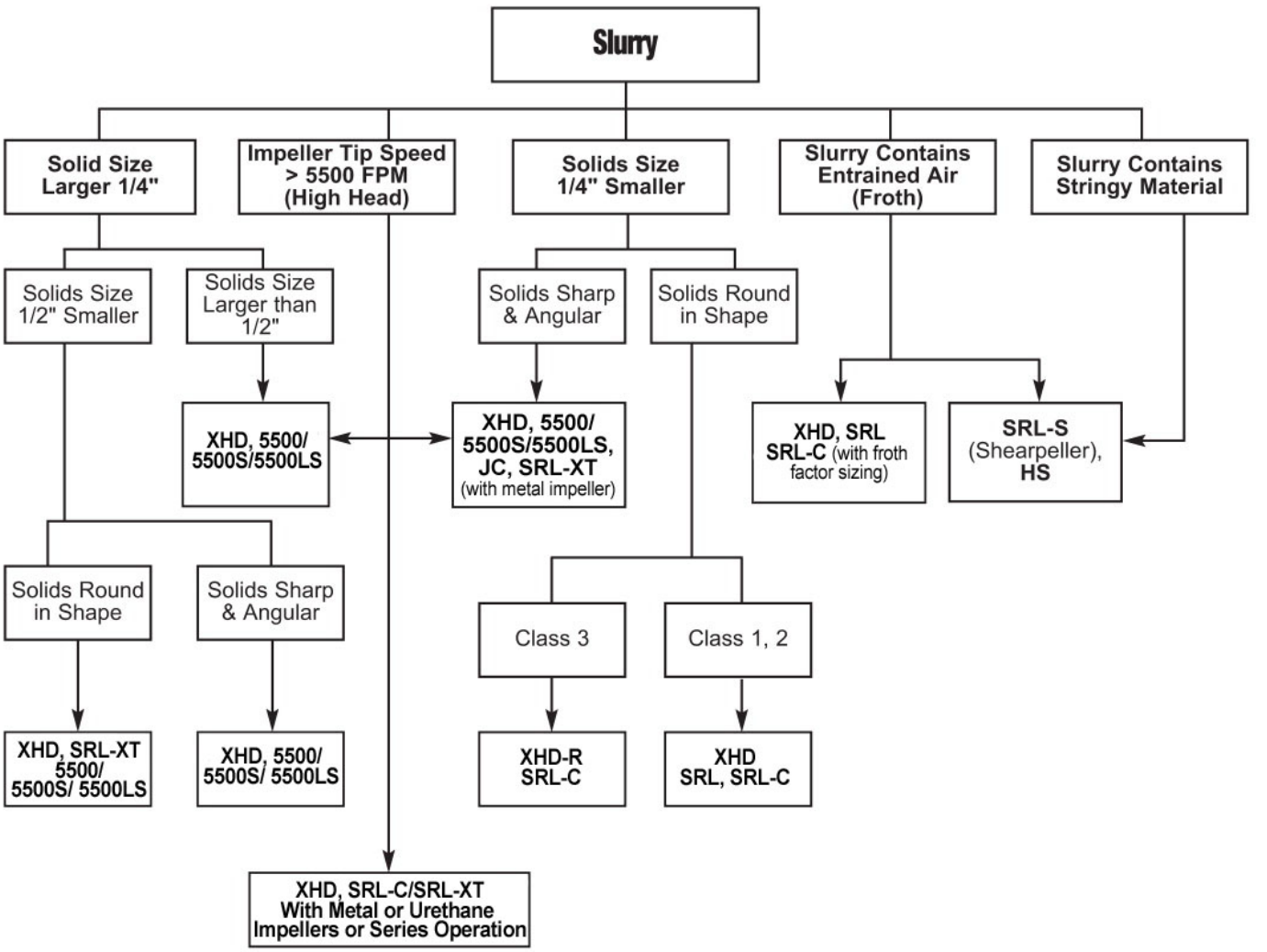
Slurry Pump Materials

MTL CODE	COMMON NAME	ASTM NUMBER	BRINELL HARDNESS	CHARACTERISTICS AND TYPICAL APPLICATIONS	pH RANGE
1002	Cast Iron	A48 Cl. 35B	196-228	Offers moderate resistance to abrasion and corrosion. It is suitable for light slurry applications, particularly those for intermittent service.	6-9
1228	HC600	A532 Cl. III Type A	550-650	Hardened HC600 (High Chromium Iron)	5-12
1245	316SS	A743 GR. CF-8M	159-190	Used for high corrosive, mildly abrasive applications.	3-11
1247	CD4MCu	A734 Gr. CD4MCu	224-325	This is a high strength corrosion resistant alloy for mildly abrasive applications.	

MTL CODE	PRINCIPAL ALLOYING ELEMENTS (%, Bal Fe)						
	Cr	Ni	C	Mn	Si	Mo	Others
1002	-	-	3.25-3.35	0.45-0.70	1.70-1.90	-	-
1228	23.0-28.0	15 Max	2.3-3.0	0.5-1.5	1.0 Max	1.5 Max	-
1245	18.0-21.0	9.0-12.0	0.08 Max	1.5 Max	2.0 Max	2.0-3.0	-
1247	25.0-27.0	5.0-6.0	0.4 Max	-	-	2.0	Cu 3.0

Fig. H

Slurry Pump Application Guidelines



TECH-D-7D Abrasive Slurries and Pump Wear

THE EFFECTS OF OPERATING AT DIFFERENT ZONES ON THE PUMP CHARACTERISTIC CURVE

The rate of wear is directly affected by the system operating point relative to the selected pump's best efficiency point. Operating the pump outside of the recommended range relative to the BEP can cause excessive wear due to recirculation or high velocity within the pump that would not be present if the pump was sized properly relative to the system.

The following chart specifies the recommended operating range as a % of BEP (by flow) by slurry class:

	Slurry Class 1	Slurry Class 2	Slurry Class 3	Slurry Class 4
Recommended operating point (% BEP)	30-130%	40-120%	50-110%	60-100%

In addition to operating range, wear in slurry pumps is also dependent upon tip speed and the resulting head generated by the pump in question. As impeller tip speed increases, wear due to slurry abrasion and erosion increases. The following tables provide guidelines for total head generated per pump and maximum tip speed by slurry class:

	Slurry Class 1	Slurry Class 2	Slurry Class 3	Slurry Class 4
Recommended operating point (% BEP)	30-130%	40-120%	50-110%	60-100%

	Slurry Class 1	Slurry Class 2	Slurry Class 3	Slurry Class 4
Metal pump maximum impeller tip speed, ft/min (m/s)	8500 (43)	7500 (38)	6500 (33)	5500 (28)
Elastomer pump maximum impeller tip speed, ft/min (m/s)	6000 (31)	5500 (28)	5000 (26)	4500 (23)
Elastomer liner, metal impeller maximum impeller tip speed, ft/min (m/s)	6250 (32)	5750 (29)	5250 (27)	4750 (24)

Check maximum operating speed of pump and impeller prior to selecting operating point.

An additional application rule is that slurry pumps with elastomer liners and metal impellers should not be applied to duties requiring more than 190 ft (58m) of head per stage. If more than 190 ft of head per stage is required, an all-metal pump should be selected.

Overcapacity Operation: The velocities within the pump are usually very high and recirculation occurs causing excessive wear. The radial hydraulic loads on the impeller increase.

Recommended Operation: The velocities within the pump are reduced (but not enough to cause settlement). Recirculation is minimal and the flow in the suction nozzle should be axial (no induced vortex). The radial hydraulic loads are minimized.

Reduced Capacity Operation: The velocities within the pump are low, separation and recirculation occurs, causing excessive wear. Reducing the capacity should be limited because a certain minimum velocity must be maintained to avoid settling out; with the consequence of increased wear and clogging. The hydraulic radial loads will increase and the pump efficiency will decrease.

Shut Valve Operation: This is the point of zero flow, and pump should not be operated at this point for any length of time. Wear and tear will be rapid due to separation and recirculation, the hydraulic forces will be at their highest, and settlement and plugging will occur. The pump will rapidly heat up, which is particularly serious in rubber constructed pumps.

PRINCIPAL WEAR AREAS

As the abrasive mixture passes through the pump, all the wetted surfaces which come in contact will be subject to varying degrees of wear. It is very important to note that the performance of a conventional centrifugal pump, which has been misapplied to a slurry service, will be significantly effected by a relatively small degree of abrasive wear.

The areas most prone to wear, in order of increasing severity, are:

1 Suction sideplate, particularly at the nozzle region.

2 Impeller, particularly at the eye vane inlets, suction side impeller shroud, and the vane tips.

3 Casing cutwater and side walls adjacent to the impeller tip.

4 Stuffing box packing and sleeve.

In the case of a conventional pump with radial wear rings on the impeller, this is where the worst wear occurs.

On severely abrasive services where there are high concentrations of hard, larger, sharp particles, the suction side liner life can be increased if it is rotated periodically to equalize the effects of wear. Regular impeller adjustment also assists in mitigating suction side liner wear.

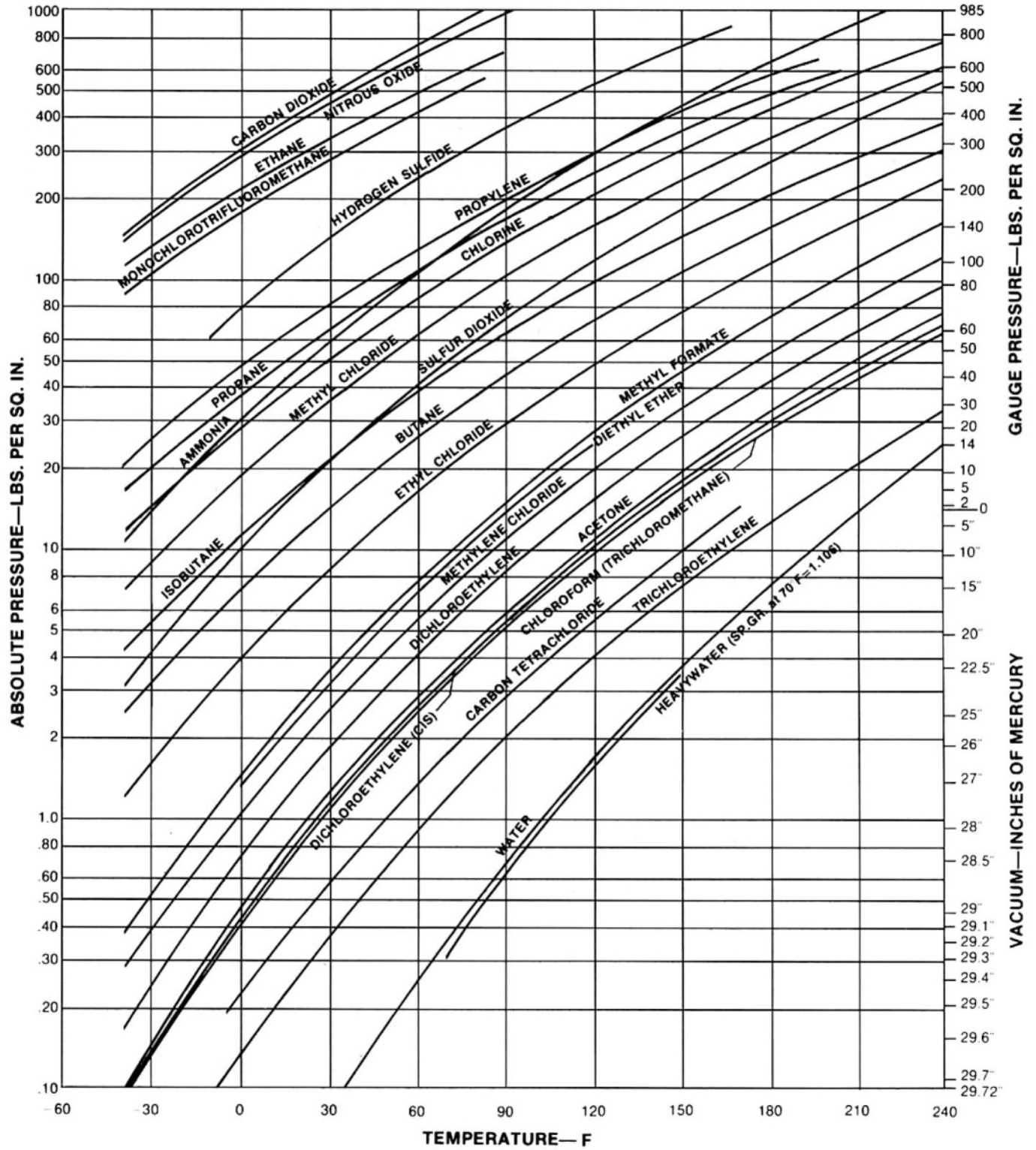
In hard iron pumps applied to severely abrasive service, the relative wear rates of the suction side liner, casing, and impeller are in the order of 3 to 1.5 to 1, e.g. the life of the casing is three times that of a suction side wear plate.

Recognizing that due to the nature of the mixtures being pumped, the complete elimination of wear is impossible, the life of the parts can be appreciably prolonged and the cost of maintenance reduced by a good pump design and selection, e.g.:

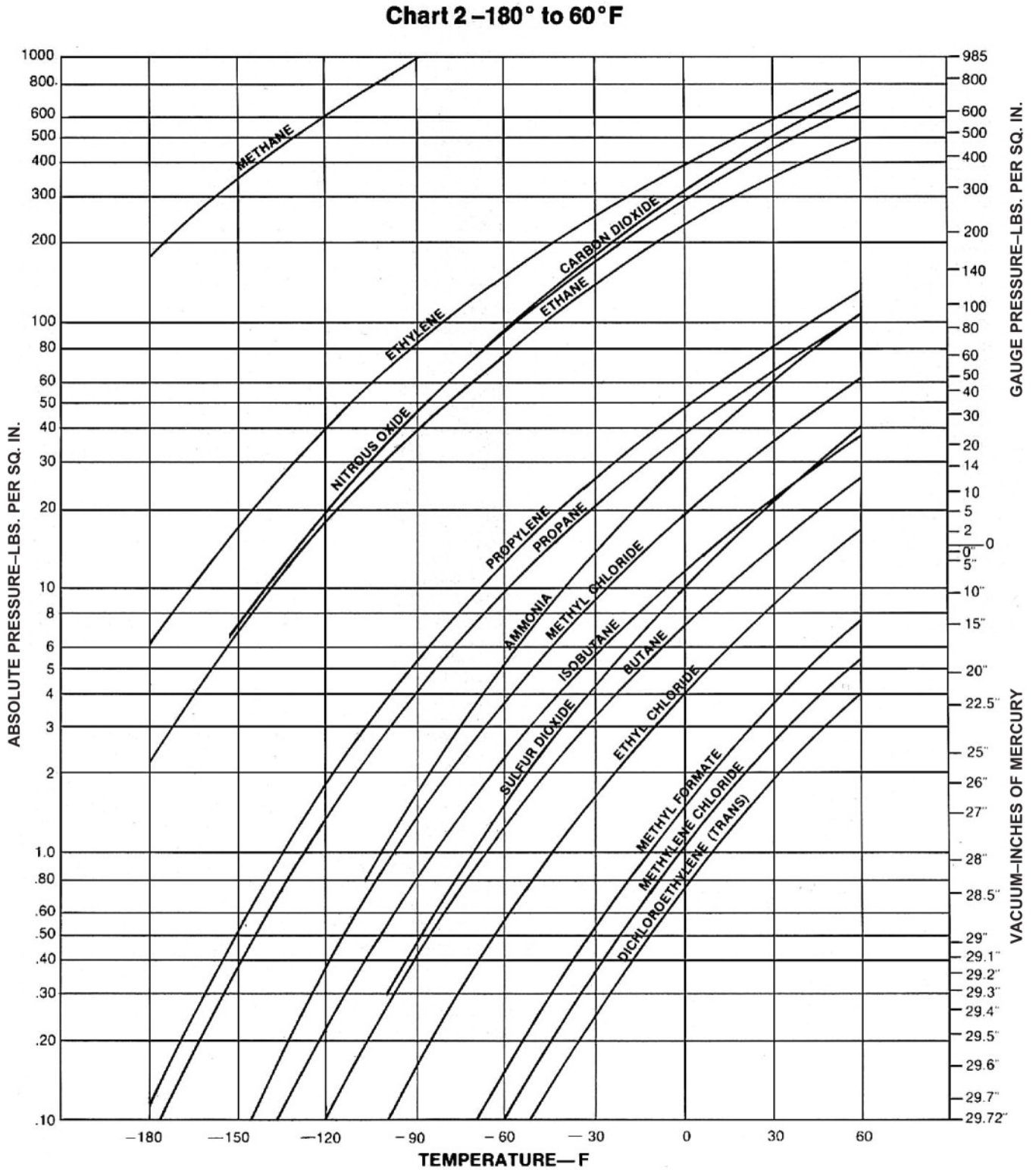
- Construct the pump with good abrasion resistant materials
- Provide generous wear allowances on all parts subject to excessive wear
- Adopt a hydraulic design which will minimize the effects causing wear
- Adopt a mechanical design which is suitable for the materials of construction and has ready access to the parts for renewal
- Limit the head to be generated and select a low speed pump
- Adjust pump regularly to compensate for wear

TECH-D-8 Vapor Pressure – Various Liquids

Chart 1 –60° to 240°F



TECH-D-8 Vapor Pressure – Various Liquids



TECH-E-1 Paper Stock Discussion

Centrifugal pumps are used with complete success in handling paper stock and other fibrous suspensions. However, the nature of a stock suspension requires certain special considerations. All of the factors affecting pump operation discussed below must be carefully considered for a good installation.

SUCTION PIPING

The stock must be delivered freely to the impeller for the pump to operate. The suction pipe should be as short and direct as possible. The suction pipe and entrance from the stock chest should never be smaller than the pump suction connection, and should be level with no air pockets. Always keep the direction of flow in a straight line.

Inadequate suction design with undersize pipe and excessive fittings can prevent the pump from delivering rated capacity, or from operating at all on high consistency stocks.

SUCTION HEAD

Stock pumps will not operate when a vacuum is required to maintain flow into the pump. Thus, there must be a static suction head sufficient to overcome suction line friction losses.

PERCENT CONSISTENCY

The consistency of a pulp and water suspension is the percent by weight of pulp in the mixture. Oven Dry (O.D.) consistency is the amount of pulp left in a sample after drying in an oven at 212°F. Air Dry (A.D.) consistency is an arbitrary convention used by papermakers, and is the amount of pulp left in a sample after drying in atmosphere. Air Dry stock contains 10% more moisture than Bone Dry stock, i.e. 6% O.D. is 6.67% A.D.

Traditional paper stock pumps will handle stock up to approximately 6% O.D. consistency. The absolute maximum limit is a function of many factors including stock fiber length, pulping process, degree of refining, available suction head, etc. In certain situations, consistencies as high as 8% O.D. can be successfully handled with a standard paper stock pump.

Recent testing on various types of stock has indicated that pump performance is the same as on water for stock consistencies up to 6% O.D. In other words, water curves can be used to select stock pumps, as the capacity, head and efficiency are the same as for water.

Medium consistency paper stock is a term generally used to describe stock between 7% and 15% O.D. consistency. Pumping of medium consistency paper stock with a centrifugal pump is possible, but requires a special design due to the fiber network strength and the inherently high air content.

AIR IN STOCK

Entrained air is detrimental to good operation of any centrifugal pump, and can result in reduced capacity, increased erosion and shaft breakage. Obviously every effort must be made to prevent the over-entrainment of air throughout the process.

EXCESSIVE DISCHARGE THROTTLING

While it is realized that excess capacity is normally required over the paper machine output in tons per day, "over-selection" of pumps on the basis of capacity and head usually results in the necessity of throttling the pump at the valve in the discharge line. Since the valve is normally located adjacent to the pump, the restriction of the valve and the high velocity within the valve will result in some dehydration and cause vibration due to slugs of stock. Vibration at the valve due to throttling is transmitted to the pump and may reduce the normal life of the pump-rotating element.

Centrifugal pumps operating at greatly reduced capacity have more severe loading internally due to hydraulic radial thrust. Hence pumps selected too greatly oversize in both capacity and head have the combination of the vibration due to throttling plus the greater internal radial load acting to reduce the life of the rotating element. As a general rule, stock pumps should not be operated for extended periods at less than one quarter of their capacity at maximum efficiency. If a variable speed drive is not feasible for some reason, when excessive throttling is required, one of the two methods below should be employed.

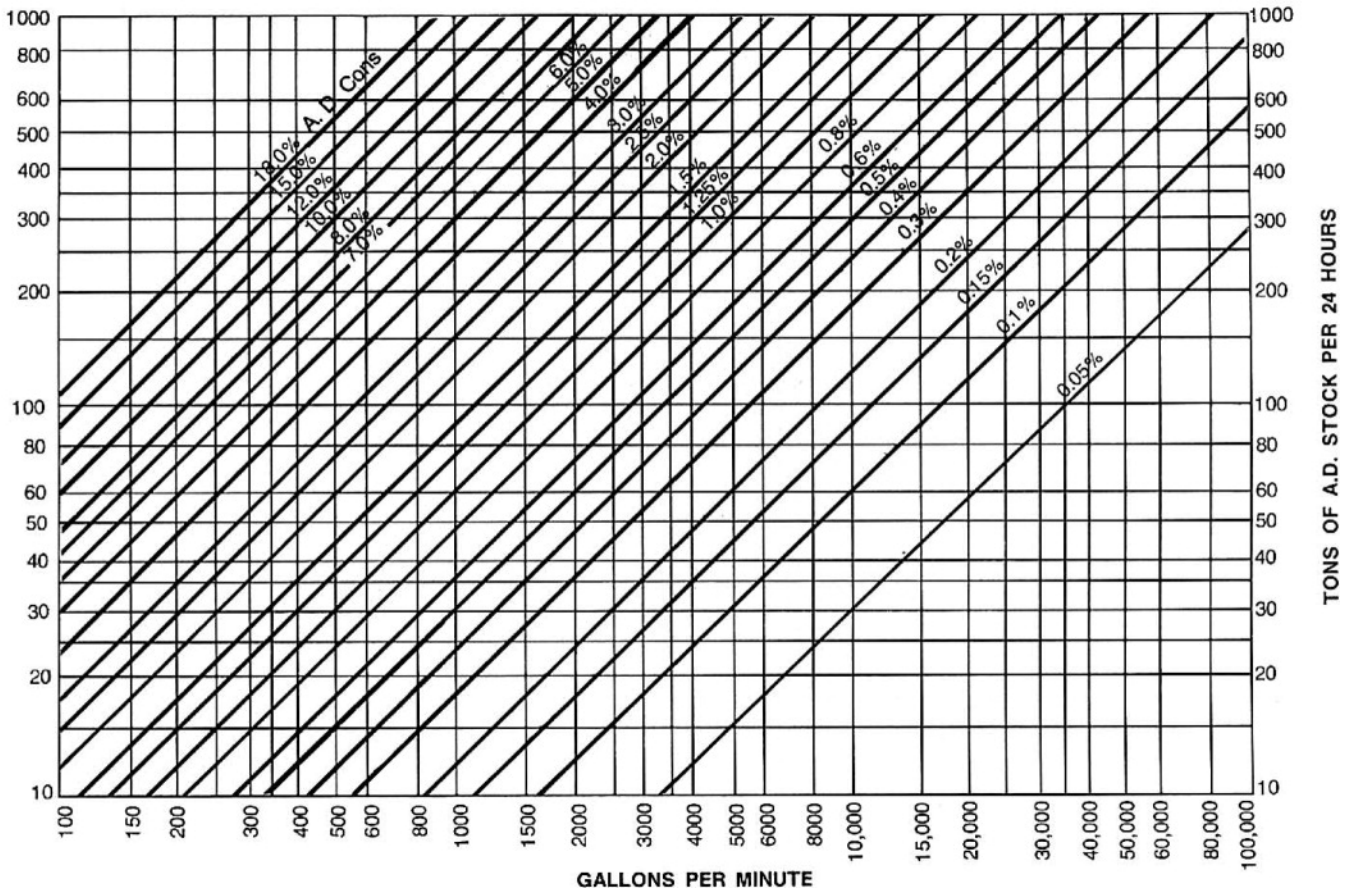
1. Review capacity requirements and check the static and friction head required for the capacity desired. Reduce the impeller diameter to meet the maximum operating conditions. This will also result in considerable power saving.
2. Install a by-pass line upstream from the discharge valve back to the suction chest below the minimum chest level, if possible, and at a point opposite the chest opening to the pump suction. This by-pass line should include a valve for flow regulation. This method is suggested where mill production includes variation in weight of sheet.

FILLERS AND ADDITIVES

The presence of fillers and chemical additives such as clay, size and caustics can materially increase the ability of paper stock to remain in suspension. However, overdosing with additives such as alum may cause gas formation on the stock fibers resulting in interruption of pumping.

TECH-E-2 Conversion Chart of Mill Output in Tons per 24 Hours

To U.S. Gallons per Minute of Paper Stock of Various Densities



EXAMPLE:

Find the capacity in gallons per minute of a pump handling 4% stock for a mill producing 200 tons per 24 hours.

Enter chart at 200 tons per day, read horizontally to 4% stock, then downward to find pump capacity of 840 GPM.

TECH-E-2.1 Definitions/Conversion Factors

A.D. = Air Dry stock (Contains 10% Water)

O.D. = Oven Dry stock (All Water Removed) Also Called Bone Dry (B.D.)

A.D. = 1.11 × O.D.

O.D. = 0.90 × A.D.

A.D. T/D = 1.11 O.D. T/D

O.D. T/D = 0.90 × A.D. T/D

A.D. Consistency = 1.11 × O.D. Consistency

O.D. Consistency = 0.90 × A.D. Consistency

T/D or TPD or S. T/D = Short Tons Per Day

One Short Ton = 2000 lbs.

M. T/D = Metric Tons per Day

One Metric Ton = 2205 lbs.

A.D.S. T/D = Air Dry Short Tons/Day

A.D.M. T/D = Alr Dry Metric Tons/Day

S. T/D = 1.1025 × M. T/D

$$\frac{\text{Production in A. D. S. T/D} \times 15}{\text{\% O.D. Cons.}} = \text{Flow in GPM}$$

$$\frac{\text{Production in A. D. S. T/D} \times 16.67}{\text{\% A.D. Cons.}} = \text{Flow in GPM}$$

TECH-E-3 Friction Loss of Pulp Suspensions in Pipe

I. INTRODUCTION

In any stock piping system, the pump provides flow and develops hydraulic pressure (head) to overcome the differential in head between two points. This total head differential consists of pressure head, static head, velocity head and total friction head produced by friction between the pulp suspension and the pipe, bends, and fittings. The total friction head is the most difficult to determine because of the complex, nonlinear nature of the friction loss curve. This curve can be affected by many factors.

The following analytical method for determining pipe friction loss is based on the published TAPPI Technical Information Sheet (TIS) 408-4 (Reference 1), and is applicable to stock consistencies (oven-dried) from 2 to 6 percent. Normally, stock consistencies of less than 2% (oven-dried) are considered to have the same friction loss characteristic as water.

The method for determining friction loss of pulp suspensions in pipe, as presented here, is intended to supersede the various methods previously issued.

II. BACKGROUND

Fig. 1 and Fig. 2 show typical friction loss curves for two different consistencies ($C_2 > C_1$) of chemical pulp and mechanical pulp, respectively.

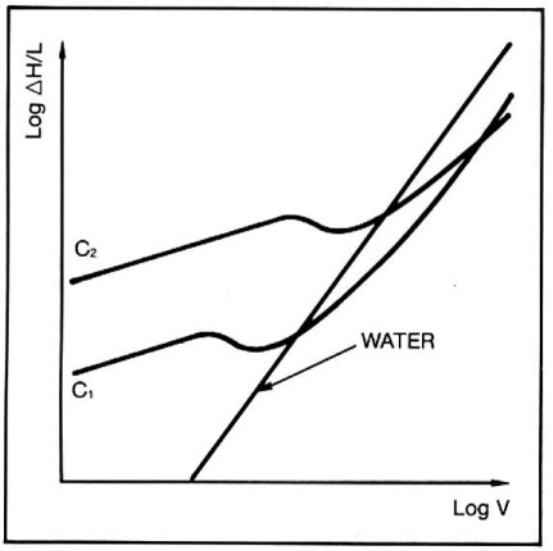


Fig. 1 – Friction loss curves for chemical pulp ($C_2 > C_1$).

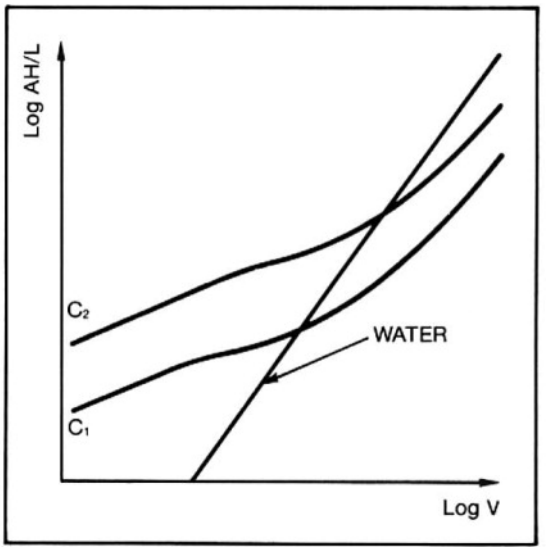


Fig. 2 – Friction loss curves for mechanical pulp ($C_2 > C_1$).

The friction loss curve for chemical pulp can be conveniently divided into three regions, as illustrated by the shaded areas of Fig. 3.

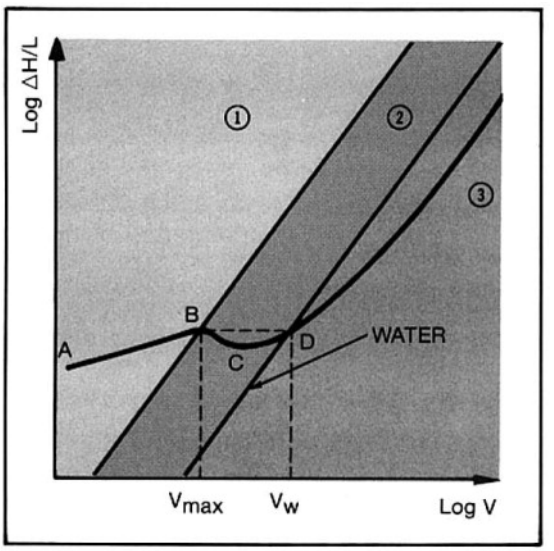


Fig. 3 – Friction loss curves for chemical pulp, shaded to show individual regions.

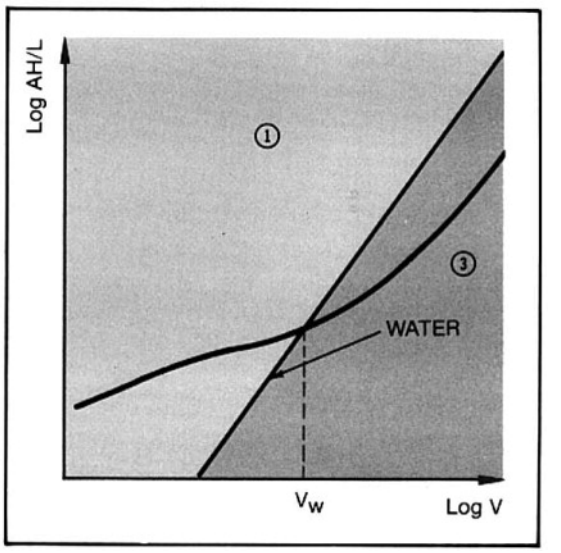


Fig. 4 – Friction loss curves for mechanical pulp, shaded to show individual regions.

These regions shown in Fig. 3 may be described as follows:

Region 1 (Curve AB) is a linear region where friction loss for a given pulp is a function of consistency, velocity, and pipe diameter. The velocity at the upper limit of this linear region (Point B) is designated V_{max}.

Region 2 (Curve BCD) shows an initial decrease in friction loss (to Point C) after which the friction loss again increases. The intersection of the pulp friction loss curve and the water friction loss curve (Point D) is termed the onset of drag reduction. The velocity at this point is designated V_w.

Region 3 (Curve DE) shows the friction loss curve for pulp fiber suspensions below the water curve. This is due to a phenomenon called drag reduction. Reference 2 describes the mechanisms which occur in this region.

Regions 2 and 3 are separated by the friction loss curve for water, which is a straight line with a slope approximately equal to 2.

The friction loss curve for mechanical pulp, as illustrated in Fig. 4, is divided into only two regions:

Regions 1 and 3. For this pulp type, the friction loss curve crosses the water curve at V_w and there is no true V_{max}.

III. DESIGN PARAMETERS

To determine the pipe friction loss component for a specified design basis (usually daily mass flow rate), the following parameters must be defined:

a) **Pulp Type** - Chemical or mechanical pulp, long or short fibered, never dried or dried and reslurried, etc. This is required to choose the proper coefficients which define the pulp friction curve.

b) **Consistency, C (oven-dried)** - Often a design constraint in an existing system. **NOTE:** If air-dried consistency is known, multiply by 0.9 to convert to oven-dried consistency.

c) **Internal pipe diameter, D** - Lowering D reduces initial capital investment, but increases pump operating costs. Once the pipe diameter is selected, it fixes the velocity for a prespecified mass flow rate.

d) **Bulk velocity, V** - Usually based on a prespecified daily mass flow rate. Note that both V and D are interdependent for a constant mass flow rate.

e) **Stock temperature, T** - Required to adjust for the effect of changes in viscosity of water (the suspending medium) on pipe friction loss.

f) **Freeness** - Used to indicate the degree of refining or to define the pulp for comparison purposes.

g) **Pipe material** - Important to specify design correlations and compare design values.

IV. PIPE FRICTION ESTIMATION PROCEDURE

The bulk velocity (V) will depend on the daily mass flow rate and the pipe diameter (D) selected. The final value of V can be optimized to give the lowest capital investment and operating cost with due consideration of future demands or possible system expansion.

The bulk velocity will fall into one of the regions previously discussed. Once it has been determined in which region the design velocity will occur, the appropriate correlations for determining pipe friction loss value(s) may be selected. The following describes the procedure to be used for estimating pipe friction loss in each of the regions.

Region 1 The upper limit of Region 1 in Figure 3 (Point B) is designated V_{max}. The value of V_{max} is determined using Equation [1] and data given in Table I or IA.

$$V_{max} = K' C^{\sigma} \text{ (ft/s)}, \quad [1]$$

where K' = numerical coefficient (constant for a given pulp) is obtained from Table I or IA.

C = consistency (oven-dried, expressed as a percentage, *not* decimally), and

σ = exponent (constant for a given pulp), obtained from Table I or IA.

If the proposed design velocity (V) is less than V_{max}, the value of flow resistance ($\Delta H/L$) may be calculated using Equation [2] and data given in Table II or IIA, and the appendices.

$$\Delta H/L = F\,K\,V^{\alpha}\,C^{\beta}\,D^{\gamma} \text{ (ft/100 ft)}, \quad [2]$$

where F = factor to correct for temperature, pipe roughness, pulp type, freeness, or safety factor (refer to Appendix D),

K = numerical coefficient (constant for a given pulp), obtained from Table II or IIA,

V = bulk velocity (ft/s),

C = consistency (oven-dried, expressed as a percentage, *not* decimally),

D = pipe inside diameter (in), and

α, β, γ = exponents (constant for a given pulp), obtained from Table II or IIA.

For mechanical pulps, there is no true V_{max}. The upper limit of the correlation equation (Equation [2]) is also given by Equation [1]. In this case, the upper velocity is actually V_w.

Region 2 The lower limit of Region 2 in Fig. 3 (Point B) is V_{max} and the upper limit (Point D) is V_w. The velocity of the stock at the onset of drag reduction is determined using Equation [3]

$$V_W = 4.00\,C^{1.40} \text{ (ft/s)}, \quad [3]$$

where C = consistency (oven-dried, expressed as a percentage, *not* decimally).

If V is between V_{max} and V_w, Equation [2] may be used to determine $\Delta H/L$ at the maximum point (V_{max}). Because the system must cope with the worst flow condition, $\Delta H/L$ at the maximum point (V_{max}) can be used for all design velocities between V_{max} and V_w.

Region 3 A conservative estimate of friction loss is obtained by using the water curve. $(\Delta H/L)_w$ can be obtained from a Friction Factor vs. Reynolds Number plot (Reference 3, for example), or approximated from the following equation (based on the Blasius equation).

$$(\Delta H/L)_w = 0.58.\,V^{1.75}\,D^{-1.25} \text{ (ft/100 ft)}, \quad [4]$$

where V = bulk velocity (ft/s), and

D = pipe diameter (in).

Previously published methods for calculating pipe friction loss of pulp suspensions gave a very conservative estimate of head loss. The method just described gives a more accurate estimate of head loss due to friction, and has been used successfully in systems in North America and world-wide.

Please refer to Appendix A for equivalent equations for use with metric (SI) units. Tables I and IA are located in Appendix B; Tables II and IIA are located in Appendix C. Pertinent equations, in addition to those herein presented, are located in Appendix D. Example problems are located in Appendix E.

V. HEAD LOSSES IN BENDS AND FITTINGS

The friction head loss of pulp suspensions in bends and fittings may be determined from the basic equation for head loss, Equation 5.

$$H = K V_1^2 / 2g \text{ (ft)}, \quad 5$$

where K = loss coefficient for a given fitting,

V_1 = inlet velocity (ft/s), and

g = acceleration due to gravity (32.2 ft/s^2).

Values of K for the flow of water through various types of bends and fittings are tabulated in numerous reference sources (Reference 3, for example). The loss coefficient for valves may be obtained from the valve manufacturer.

The loss coefficient for pulp suspensions in a given bend or fitting generally exceeds the loss coefficient for water in the same bend or fitting. As an approximate rule, the loss coefficient (K) increases 20 percent for each 1 percent increase in oven-dried stock consistency. Please note that this is an approximation; actual values of K may differ, depending on the type of bend or fitting under consideration (4).

APPENDIX A

When metric (SI) units are utilized, the following replace the corresponding equations in the main text.

$$V_{max} = K' C^{\sigma} \text{ (m/s)} \quad 1M$$

where K′ = bulk velocity (ft/s), and

C = consistency (oven-dried, expressed as a percentage, *not* decimally), and

σ = exponent (constant for a given pulp), obtained from Table I or IA.

$$\Delta H/L = F K V^{\alpha} C^{\beta} D^{\gamma} \text{ (m/100m)}, \quad 2M$$

where F = factor to correct for temperature, pipe roughness, pulp type, freeness, or safety factor (refer to Appendix D),

K = numerical coefficient (constant for a given pulp), obtained from Table II or IIA,

V = bulk velocity (m/s),

C = consistency (oven-dried, expressed as a percentage, *not* decimally),

D = pipe inside diameter (mm), and

α, β, γ = exponents (constant for a given pulp), obtained from Table II or IIA.

$$V_W = 1.22 C^{1.40} \text{ (m/s)}, \quad 3M$$

where C = consistency (oven-dried, expressed as a percentage, *not* decimally).

$$(\Delta H/L)_w = 264 V^{1.75} D^{-1.25} \text{ (m/100m)}, \quad 4M$$

where V = bulk velocity (m/s), and

D = pipe inside diameter (mm).

$$H = K V_1^2 / 2g \text{ (m)}, \quad 5M$$

where K = loss coefficient for a given fitting,

V_1 = inlet velocity (m/s), and

g = acceleration due to gravity (9.81 m/s^2).

APPENDIX B

TABLE I Data for use with Equation 1 or Equation 1M to determine velocity limit, V_{max} (1).

Pulp Type	Pipe Material	K′	σ
Unbeaten aspen sulfite never dried	Stainless Steel	0.85 (0.26)	1.6
Long fibered kraft never dried CSF = 725 (6)	PVC	0.98 (0.3)	1.85
	Stainless Steel	0.89 (0.27)	1.5
Long fibered kraft never dried CSF = 650 (6)	PVC	0.85 (0.26)	1.9
Long fibered kraft never dried CSF = 550 (6)	PVC	0.75 (0.23)	1.65
Long fibered kraft never dried CSF = 260 (6)	PVC	0.75 (0.23)	1.8
Bleached kraft plne dried and reslurried (6)	PVC	0.79 (0.24)	1.5
	Stainless Steel	0.59 (0.18)	1.45
Long fibered kraft dried and reslurried (6)	PVC	0.49 (0.15)	1.8
Kraft birch dried and reslurried (6)	PVC	0.69 (0.21)	1.3
Stone groundwood CSF = 114	PVC	4.0 (1.22)	1.40
Refiner groundwood CSF = 150	PVC	4.0 (1.22)	1.40
Newsprint broke CSF = 75	PVC	4.0 (1.22)	1.40
Refiner groundwood (hardboard)	PVC	4.0 (1.22)	1.40
Refiner groundwood (insulating board)	PVC	4.0 (1.22)	1.40
Hardwood NSSC CSF = 620	PVC	0.59 (0.18)	1.8

NOTES:

1 When metric (SI) units are utilized, use the value of K′ given in parentheses. When the metric values are used, diameter (D) must be in millimeters (mm) and velocity (V) in meters per second (m/s).

2 Original data obtained in stainless steel and PVC pipe. PVC is taken to be hydraulically smooth pipe.

3 Stainless steel may be hydraulically smooth although some manufacturing processes may destroy the surface and hydraulic smoothness is lost.

4 For cast iron and galvanized pipe, the K′ values will be reduced. No systematic data are available for the effects of surface roughness.

5 If pulps are not identical to those shown, some engineering judgement is required.

6 Wood is New Zealand Kraft pulp.

TABLE IA Data (5, 6) for use with Equation 1 or Equation 1M determine velocity limit, V_{max} .

Pulp Type (5)	Pipe Material	K′	σ
Unbleached sulphite	Copper	0.98 (0.3)	1.2
Bleached sulphite	Copper	0.98 (0.3)	1.2
Kraft	Copper	0.98 (0.3)	1.2
Bleached straw	Copper	0.98 (0.3)	1.2
Unbleached straw	Copper	0.98 (0.3)	1.2

Estimates for other pulps based on published literature.

Pulp Type (5, 6)	Pipe Material	K′	σ
Cooked groundwood	Copper	0.75 (0.23)	1.8
Soda	Steel	4.0 (1.22)	1.4

NOTE: When metric (SI) units are utilized, use the value of K′ given in parentheses. When the metric values are used, diameter (D) must be millimeters (mm) and velocity (V) in meters per second (m/s)

APPENDIX C

TABLE II Data for use with Equation 2 or Equation 2M to determine head loss, ΔH/L (1).

Pulp Type	K	α	β	γ
Unbeaten aspen sulfite never dried	5.30 (235)	0.36	2.14	-1.04
Long fibered kraft never dried CSF = 725 (5)	11.80 (1301)	0.31	1.81	-1.34
Long fibered kraft never dried CSF = 650 (5)	11.30 (1246)	0.31	1.81	-1.34
Long fibered kraft never dried CSF = 550 (5)	12.10 (1334)	0.31	1.81	-1.34
Long fibered kraft never dried CSF = 260 (5)	17.00 (1874)	0.31	1.81	-1.34
Bleached kraft pine dried and reslurried (5)	8.80 (970)	0.31	1.81	-1.34
Long fibered kraft dried and reslurried (5)	9.40 (1036)	0.31	1.81	-1.34
Kraft birch dried and reslurried (5)	5.20 (236)	0.27	1.78	-1.08
Stone groundwood CSF = 114	3.81 (82)	0.27	2.37	-0.85
Refiner groundwood CSF = 150	3.40 (143)	0.18	2.34	-1.09
Newspaper broke CSF = 75	5.19 (113)	0.36	1.91	-0.82
Refiner groundwood CSF (hardboard)	2.30 (196)	0.23	2.21	-1.29
Refiner groundwood CSF (insulating board)	1.40 (87)	0.32	2.19	-1.16
Hardwood NSSF CSF = 620	4.56 (369)	0.43	2.31	-1.20

NOTES:

1 When metric (SI) units are utilized, use the value of K given in parentheses. When the metric values are used, diameter (D) must be in millimeters (mm) and velocity must be in meters per second (m/s).

2 Original data obtained in stainless steel and PVC pipe (7,8,9).

3 No safety factors are included in the above correlations.

4 The friction loss depends considerably on the condition of the inside of the pipe surface (10).

5 Wood is New Zealand Kraft pulp.

TABLE IIA Data (5, 6) for use with Equation 2 or Equation 2M to determine head loss, ΔH/L.

Pulp Type (5)	K	α	β	*y*
Unbleached sulfite	12.69 (1438)	0.36	1.89	-1.33
Bleached sulfite	11.40 (1291)	0.36	1.89	-1.33
Kraft	11.40 (1291)	0.36	1.89	-1.33
Bleached straw	11.40 (1291)	0.36	1.89	-1.33
Unbleached straw	5.70 (646)	0.36	1.89	-1.33

Estimates for other pulps based on published literature.

Pulp Type (5, 6)	K	α	β	*y*
Cooked groundwood	6.20 (501)	0.43	2.13	-1.20
Soda	6.50 (288)	0.36	1.85	-1.04

NOTE: When metric (SI) units are utilized, use the value of K given in parentheses. When the metric values are used, diameter (D) must be millimeters (mm) and velocity (V) in meters per second (m/s)

APPENDIX D

The following gives supplemental information to that provided in the main text.

1. Capacity (flow), Q —

$$Q = \frac{16.65\ (T.P.D.)}{C}\ \text{(U.S. GPM)}, \qquad \text{(i)}$$

where T.P.D. = mill capacity (short tons per day), and

C = consistency (oven-dried, expressed as a percentage, *not* decimally).

If SI units are used, the following would apply:

$$Q = \frac{1.157\ (10^{-3})\ (T.P.D.)}{C}\ (m^3/s), \qquad \text{(iM)}$$

where T.P.D. = mill capacity (metric tons per day), and

C = consistency (oven-dried, expressed as a percentage, *not* decimally).

2. Bulk velocity, V —

$$V = \frac{0.321\ Q}{A}\ \text{(ft/s), or} \qquad \text{(ii)}$$

$$V = \frac{0.4085\ Q}{D^2}\ \text{(ft/s)}, \qquad \text{(iii)}$$

where Q = capacity (U.S. GPM)

A = inside area of pipe (in^2), and

D = inside diameter of pipe (in)

The following would apply if SI units are used:

$$V = \frac{1\ (10^6)\ Q}{A}\ \text{(m/s), or} \qquad \text{(iiM)}$$

$$V = \frac{1.273\ (10^6)\ Q}{D^2}\ \text{(m/s)}, \qquad \text{(iiiM)}$$

where Q = capacity (m^3/s),

A = inside area of pipe (mm^2), and

D = inside diameter of pipe (mm).

3. Multiplication Factor, F (included in Equation 2) —

$$F = F_1 \bullet F_2 \bullet F_3 \bullet F_4 \bullet F_5, \qquad \text{(iv)}$$

.

where F_1 = correction factor for temperature. Friction loss calculations are normally based on a reference pulp temperature of 95° F (35°C). The flow resistance may be increased or decreased by 1 percent for each 1.8°F (1°C) below or above 95°F (35°C), respectively. This may be expressed as follows:

$$F_1 = 1.528 - 0.00556\ T, \qquad \text{(v)}$$

where T = pulp temperature (°F), or

$$F_1 = 1.35 - 0.01\ T, \qquad \text{(vM)}$$

where T = pulp temperature (°C).

F_2 = = correction factor for pipe roughness. This factor may vary due to manufacturing processes of the piping, surface roughness, age, etc. Typical values for PVC and stainless steel piping are listed below:
$F_2 = 1.0$ for PVC piping,
$F_2 = 1.25$ for stainless steel piping.
Please note that the above are typical values; experience and/or additional data may modify the above factors.

F_3 = correction factor for pulp type. Typical values are listed below:
$F_3 = 1.0$ for pulps that have never been dried and reslurried,
$F_3 = 0.8$ for pulps that have been dried and reslurried.
NOTE: This factor has been incorporated in the numerical coefficient, K, for the pulps listed in Table II. When using Table II, F_3 should *not* be used.

F_4 = correction factor for beating. Data have shown that progressive beating causes, initially, a small decrease in friction loss, followed by a substantial increase. For a kraft pine pulp initially at 725 CSF and $F_4 = 1.0$, beating caused the freeness to decrease to 636 CSF and F_4 to decrease to 0.96. Progressive beating decreased the freeness to 300 CSF and increased F_4 to 1.37 (see K values in Table II). Some engineering judgement may be required.

F_5 = design safety factor. This is usually specified by company policy with consideration given to future requirements.

APPENDIX E

The following are three examples which illustrate the method for determination of pipe friction loss in each of the three regions shown in Figure 3.

Example 1.

Determine the friction loss (per 100 ft of pipe) for 1000 U.S. GPM of 4.5% oven-dried unbeaten aspen sulfite stock, never dried, in 8 inch schedule 40 stainless steel pipe (pipe inside diameter = 7.981 in). Assume the pulp temperature to be 95° F.

Solution:

a) The bulk velocity, V, is

$$V = \frac{0.4085\ Q}{D^2}, \qquad \text{(ii)}$$

and Q = flow = 1000 U.S. GPM.

D = pipe inside diameter = 7.981 in.

$$V = \frac{0.4085\ (1000)}{7.981^2} = 6.41\ \text{ft/s}.$$

b) It must be determined in which region (1, 2, or 3) this velocity falls. Therefore, the next step is to determine the velocity at the upper limit of the linear region, V_{max}.

$$V_{max} = K' C^{\sigma}, \qquad 1$$

and K′ = numerical coefficient = 0.85 (from Appendix B, Table I),

C = consistency = 4.5%,

σ = exponent = 1.6 (from Appendix B, Table I).

$V_{max} = 0.85\ (4.5^{1.6}) = 9.43$ ft/s.

c) Since V_{max} exceeds V, the friction loss, $\Delta H/L$, falls within the linear region, Region 1. The friction loss is given by the correlation:

$$\Delta H/L = F\ K\ V^{\alpha}\ C^{\beta}\ D^{\gamma} \qquad 2$$

and F = correction factor = $F_1 \bullet F_2 \bullet F_3 \bullet F_4 \bullet F_5$,

F_1 = correction factor for pulp temperature. Since the pulp temperature is 95° F,

$F_1 = 1.0$,

F_2 = correction factor for pipe roughness. For stainless steel pipe,

$F_2 = 1.25$ (from Appendix D),

F_3 = correction factor for pulp type. Numerical coefficients for this pulp are contained in Appendix C, Table II, and have already incorporated this factor.

F_4 = correction factor for beating. No additional beating has taken place, therefore

$F_4 = 1.0$ (from Appendix D),

F_5 = design safety factor. This has been assumed to be unity.

$F_5 = 1.0$.

$F = (1.0)(1.25)(1.0)(1.0)(1.0) = 1.25$,

K = numerical coefficient = 5.30 (from Appendix C, Table II),

α, β, y = exponents = 0.36, 2.14, and -1.04, respectively (from Appendix C, Table II),

V, C, D have been evaluated previously.

$\Delta H/L = (1.25)(5.30)(6.41^{0.36})(4.5^{2.14})(7.981^{-1.04})$

$= (1.25)(5.30)(1.952)(25.0)(0.1153)$

= 37.28 ft head loss/100 ft of pipe.

This is a rather substantial head loss, but may be acceptable for short piping runs. In a large system, the economics of initial piping costs versus power costs should be weighed, however, before using piping which gives a friction loss of this magnitude.

Example 2.

Determine the friction loss (per 100 ft of pipe) of 2500 U.S. GPM of 3% oven-dried bleached kraft pine, dried and reslurried, in 12 inch schedule 10 stainless steel pipe (pipe inside diameter = 12.39 in). Stock temperature is 125°F.

Solution:

a) V, the bulk velocity, is

$$V = \frac{0.4085\ Q}{D^2}, \qquad \text{(ii)}$$

$$= \frac{0.4085\ (2500)}{12.39^2} = 6.65 \text{ ft/s.}$$

b) The velocity at the upper limit of the linear region, V_{max}, is

$$V_{max} = K' C^{\sigma}, \qquad [1]$$

and K′ = 0.59 (from Appendix B, Table I),

= 1.45 (from Appendix B, Table I).

$V_{max} = 0.59 (3.0^{1.45}) = 2.90$ ft/s.

c) Region 1 (the linear region) has been eliminated, since the bulk velocity, V, exceeds Vmax.

The next step requires calculation of V_w.

$$V_W = 4.00\ C^{1.40} \qquad [3]$$

$$= 4.00\ (3.0^{1.40}) = 18.62 \text{ ft/s.}$$

d) V exceeds V_{max}, but is less than V_w, indicating that it falls in Region 2. The friction loss in this region is calculated by substituting V_{max} into the equation for head loss, Equation [2].

$$\Delta H/L = F\ K\ (V_{max})^{\alpha} C^{\beta} D^{y},$$

$$\text{and } F_1 \cdot F_2 \cdot F_3 \cdot F_4 \cdot F_5; \qquad \text{(iv)}$$

$$F_1 = 1.528 - 0.00556T, \qquad \text{(v)}$$

and T = stock temperature = 125° F

$F_1 = 1.528 - 0.00556 (125) = 0.833$,

$F_2 = 1.25$ (from Appendix D),

$F_3 = F_4 = F_5 = 1.0$,

$F = 0.833 (1.25) (1.0) = 1.041$,

K = 8.80 (from Appendix C, Table II),

α, β, y = 0.31,1.81, and -1.34, respectively (from Appendix C, Table II),

V_{max}, C, and D have been defined previously.

$\Delta H/L = 1.041 (8.80) (2.90^{0.31}) (3.0^{1.81}) (12.39^{-1.34})$

$= 1.041 (8.80) (1.391) (7.304) (0.03430)$

= 3.19 ft head loss/100 ft of pipe.

Example 3.

Determine the friction loss (per 100 ft of pipe) for 2% oven-dried bleached kraft pine, dried and reslurried, through 6 inch schedule 40 stainless steel pipe (inside diameter = 6.065 in). The pulp temperature is 90° F; the flow rate 1100 U.S. GPM.

Solution:

a)The bulk velocity is

$$V = \frac{0.4085\ Q}{D^2}, \qquad \text{(ii)}$$

$$= \frac{0.4085\ (1100)}{6.065^2} = 12.22 \text{ ft/s.}$$

b) It must be determined in which region (1, 2 or 3) this velocity falls. To obtain an initial indication, determine V_{max}.

$$V_{max} = K' C^{\sigma}, \qquad [1]$$

and K′ = 0.59 (from Appendix B, Table I),

$\sigma = 1.45$ (from Appendix B, Table I).

$V_{max} = 0.59 (2.0^{1.45}) = 1.61$ ft/s.

c) Since V exceeds V_{max}, Region 1 (the linear region) is eliminated. To determine whether V lies in Region 2 or 3, the velocity at the onset of drag reduction, V_w, must be calculated.

$$V_W = 4.00\ C^{1.40} \qquad [3]$$

$$= 4.00\ (2.0^{1.40}) = 10.56 \text{ ft/s.}$$

d) V exceeds V_w, indicating that it falls in Region 3.

The friction loss is calculated as that of water flowing at the same velocity.

$$(\Delta H/L)_w = 0.579\ V^{1.75}\ D^{-1.25}, \qquad [4]$$

$$= 0.579\ (12.22^{1.75})\ (6.065^{-1.25})$$

$$= 4.85 \text{ ft head loss/100 ft of pipe.}$$

This will be a conservative estimate, as the actual friction loss curve for pulp suspensions under these conditions will be below the water curve.

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TECH-E-4 Pump Types Used in the Pulp & Paper Industry

Mill Area	Typical Services	Typical Pump Construction	Pump Type	Goulds Model
Woodyard	Log Flume Log/Chip Pile Spray Chip Washer	Al/316SS Trim Al/316SS trim Al/316SS Trim	Mixed Flow Vertical Turbine Stock ANSI Double Suction	MF VIT 3175, 3180/85 3196 3409, 3410, 3420
Pulp Mill	Shower Supply Dilution Supply Screen Supply Cleaner Supply Decker Supply Hi/Med. Density Storage Transfer Medium Consistency Storage Chip Chute Circulation Wash Liquor Circulation Condensate White Liquor Circulation	Al/31SS Al316SS Al316SS 316SS 316SS/317SS 316SS/317SS Various 316SS/317SS CD4MCu 316SS Al/316SS CD4MCu	Stock ANSI Double Suction Medium Consistency Hi Temp/Press Stock	3175, 3180/85 3196 3409, 3410, 3420 3500, 3500XD 3181/86
Bleach Plant	Brown Stock Storage Bleach Tower Storage Bleach Chemical Mixing High Density Storage Chemical Feed Washer Supply Washer Shower Water Dilution Water Medium Consistency O_2 Reactor ClO_2 Generator Circulation	316SS 316SS 317SS, 254 SMO, Titanium 316SS/317SS 316SS 316SS 316SS 316SS 316SS Titanium	Stock ANSI Medium Consistency Axial Flow Non-metallic	3175, 3180/85 3196 3500, 3500XD AF NM 3196
Stock Prep	Refiner Supply Deflaker Supply Machine Chest Supply	316SS 316SS 316SS	Stock ANSI	3175, 3180/85 3196
Paper Machine (Dry End)	Fan Pumps Couch Pit Saveall Sweetner Shower	Al/316SS Trim, All 316SS Al/316SS Trim, All 316SS Al/316SS Trim, All 316SS Al/316SS Trim, All 316SS A/316SS Trim, All 316SS	Double Suction Stock Low Flow High Pressure Two-Stage	3409, 3410, 3420 3175, 3180/85 LF3196 3355, 3393 3316
Paper Machine (Dry End)	Dryer Drainage Condensate Trim Squirt Broke Chest	Al/316SS Trim, Al/316SS Trim Al/316SS Trim Al/316SS Trim	ANSI Low Flow Stock	3196 LF 3196 3175, 3180/85
Coater	Coating Slurries Kaolin Clay (Fillers)	316SS/CD4MCu 316SS/CD4MCu	ANSI Medium Duty Slurry	3196 JC
Kraft Recovery	Weak Black Liquor Evaporator Circulation Concentrated Black Liquor Condensate Injection Black Liquor Transfer Pumps Smelt Spout Cooling Water Collection Weak Wash Scrubber Green Liquor (Storage Transfer) Lime Mud Dregs	316SS 316SS 316SS 316SS 316SS CD4MCu Al/316SS Trim Al/316SS Trim 316SS/CD4MCu/28% Chrome 316SS/CD4MCu/28% Chrome 316SS/CD4MCu/28% Chrome 316SS/CD4MCu/28% Chrome	ANSI Stock Medium Duty Slurry High Temp/Pressure Stock Two-Stage	3196 3175, 3180/85 JC 3181/86 3316
Utility (Power House)	Feedwater Condensate Deaerator Booster	CS/Chrome Trim/All Chrome 316SS 316SS	Multi-Stage ANSI High Pressure Vertical Can	3355, 3393, 3600 3196 3700 VIC
Miscellaneous	Mill Water Supply Sump Pumps	Al/316SS Trim Al/316SS Trim	Double Suction Vertical Turbine Self-Priming Vertical Sumps Vertical Sump; Recessed Submersible	3409, 3410, 3420 VIT 3796 3171, VJC VJC HSU
Recycle	Hole/Slot Screen Supply Rejects Float Cell Medium Consistency Storage Hydro Pulper Dilution Water	316SS/CD4MCu 316SS/CD4MCu 316SS 316SS/317SS 316SS/CD4MCu Al/316SS Trim	Stock Recessed ANSI Medium Consistency	3175, 3180/85 CV 3196,HS 3196 3500, 3500 XD

TECH-F-1 Standard Weights and Dimensions of Mechanical Joint Cast Iron Pipe, Centrifugally Cast

Extracted from USA Standard Cast Iron Pipe Flanges and Flanged Fittings (USAS B16. 1–1967), with the permission of the publisher. The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, New York 10017.

Chart 1

Nom. Size & (Outside Diam), In.	Thickness, In.	Wall Weight Per Foot *	Average Thickness Class
3 (3.96)	0.32	11.9	22
	0.35	12.9	23
	0.38	13.8	24
4 (4.80)	0.35	16.1	22
	0.38	17.3	23
	0.41	18.4	24
	0.44	19.6	25
6 (6.90)	0.38	25.4	22
	0.41	27,2	23
	0.44	29.0	24
	0.48	31.3	25
	0.52	33.6	26
8 (9.05)	0.41	36.2	22
	0.44	38.6	23
	0.48	41.8	24
	0.52	45.0	25
	0.56	48.1	26
	0.60	51.2	27
10 (11.10)	0.44	48.0	22
	0.48	52.0	23
	0.52	55.9	24
	0.56	59.9	25
	0.60	63.8	26
	0.65	68.6	27
12 (13.20)	0.48	62.3	22
	0.52	67.1	23
	0.56	59.9	25
	0.60	76.6	25
	0.65	82.5	26
	0.70	88.3	27
	0.76	95.2	28
14 (15.30)	0.48	73.6	21
	0.51	77.8	22
	0.55	83.4	23
	0.59	89.0	24
	0.64	95.9	25
	0.69	102.7	26
	0.75	110.9	27
	0.81	118.9	28

Nom. Size & (Outside Diam), In.	Thickness, In.	Wall Weight Per Foot *	Average Thickness Class
16 (17.40)	0.50	87.6	21
	0.54	94.0	22
	0.58	100.3	23
	0.63	108.3	24
	0.68	116.2	25
	0.73	124.0	26
	0.79	133.3	27
	0.85	142.7	28
18 (19.50)	0.54	106.0	21
	0.58	113.2	22
	0.63	122.2	23
	0.68	131.0	24
	0.73	140.0	25
	0.79	150.6	26
	0.85	161.0	27
	0.92	173.2	28
20 (21.60)	0.57	124.2	21
	0.62	134.2	22
	0.67	144.2	23
	0.72	154.1	24
	0.78	165.9	25
	0.84	177.6	26
	0.91	191.2	27
	0.98	214.8	28
24 (25.80)	0.63	164.2	21
	0.68	176.2	22
	0.73	188.2	23
	0.79	202.6	24
	0.85	216.8	25
	0.92	233.2	26
	0.99	249.7	27
	1.07	268.2	28

* Based on 20 Ft. Laying Length of Mech. Joint Pipe including Bell.

TECH-F-2 125 Lb. & 250 Lb. Cast Iron Pipe Flanges and Flanged Fittings

Nominal Pipe Size	Diam. of Flange	Thickness of Flange (Min.)	Diam. of Bolt Circle	Number of Bolts	Diam. of Bolts	Diam. of Drilled Bolt Holes	Length of Bolts
1	4¼	7/16	3⅛	4	½	⅝	1¾
1¼	4⅝	½	3½	4	½	⅝	2
1½	5	9/16	3⅞	4	½	⅝	2
2	6	⅝	4¾	4	⅝	¾	2¼
2½	7	11/16	5½	4	⅝	¾	2½
3	7½	¾	6	4	⅝	¾	2½
3½	8½	13/16	7	8	⅝	¾	2¾
4	9	15/16	7½	8	⅝	¾	3
5	10	15/16	8½	8	¾	⅞	3
6	11	1	9½	8	¾	⅞	3¼
8	13½	1⅛	11¾	8	¾	⅞	3½
10	16	1 3/16	14¼	12	⅞	1	3¾
12	19	1¼	17	12	⅞	1	3¾
14	21	1⅜	18¾	12	1	1⅛	4¼
16	23½	1 7/16	21½	16	1	1⅛	4½
18	25	1 9/16	22¾	16	1⅛	1¼	4¾
20	27½	1 11/16	25	20	1⅛	1¼	5
24	32	1⅞	29½	20	1¼	1⅜	5½
30	38¾	2⅛	36	28	1¼	1⅜	6¼
36	46	2⅜	42¾	32	1½	1⅜	7
42	53	2⅝	49½	36	1½	1⅜	7½
48	59½	2¾	56	44	1½	1⅜	7¾

Chart 2 American Standard Class 125 Cast Iron Pipe Flanges (ASA B16.1)

Nominal Pipe Size	Diam. of Flange	Thickness of Flange [3] (Min.)	Diam. of Bolt Circle	Number of Bolts	Diam. of Bolts	Diam. of Drilled Bolt Holes [1]	Length of Bolts [2]
1	4⅞	11/16	3½	¾	4	⅝	2½
1¼	5¼	¾	3⅞	¾	4	⅝	2½
1½	6⅛	13/16	4½	⅞	4	¾	2¾
2	6½	⅞	5	¾	8	⅝	2¾
2½	7½	1	5⅞	⅞	8	¾	3¼
3	8¼	1⅛	6⅝	⅞	8	¾	3½
3½	9	1 3/16	7¼	⅞	8	¾	3½
4	10	1¼	7⅞	⅞	8	¾	3¾
5	11	1⅜	9¼	⅞	8	¾	4
6	12½	1 7/16	10⅝	⅞	12	¾	4
8	15	1⅝	13	1	12	⅞	4½
10	17½	1⅞	15¼	1⅛	16	1	5¼
12	20½	2	17¾	1¼	16	1⅛	5½
14	23	2⅛	20¼	1¼	20	1⅛	6
16	25½	2¼	22½	1⅜	20	1¼	6¼
18	28	2⅜	24¾	1⅜	24	1¼	6½
20	30½	2½	27	1⅜	24	1¼	6¾
24	36	2¾	32	1⅝	24	1½	7¾
* 30	43	3	39¼	2	28	1½	8½
* 36	50	3⅜	46	2¼	32	2	9½
* 42	57	3 11/16	52 3/2	2¼	36	2	10¼
* 48	65	4	60¾	2¼	40	2	10¾

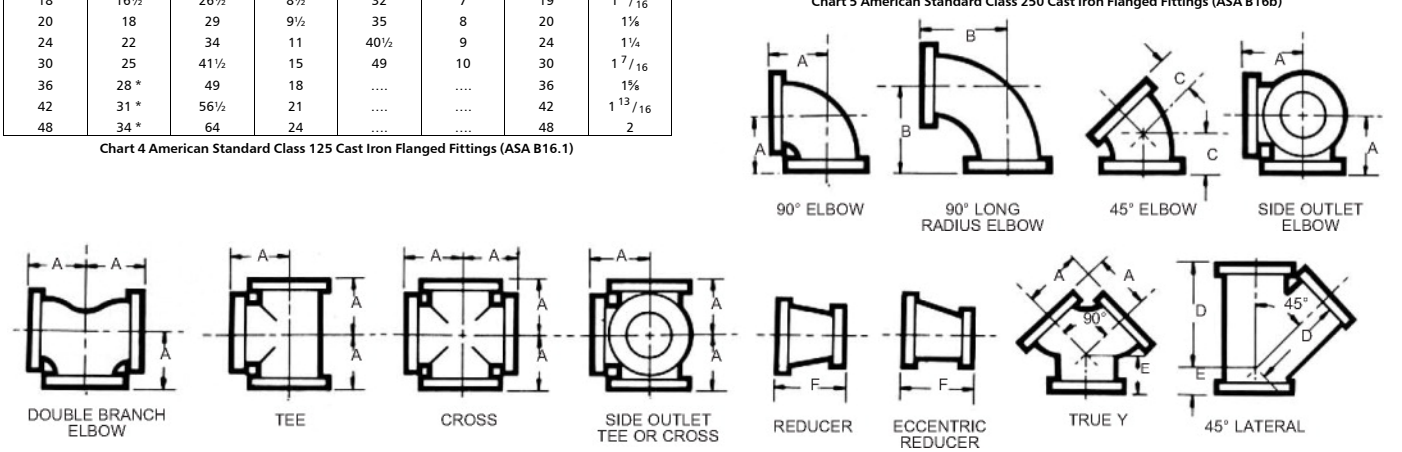
Chart 3 American Standard Class 250 Cast Iron Pipe Flanges (ASA B16b)

Nominal Pipe Size	Center to Face					Face to Face F	Body Wall Thickness
	A	B	C	D	E		
1	3½	5	1¾	5¾	1¾	....	5/16
1¼	3¾	5½	2	6¼	1¾	....	5/16
1½	4	6	2¼	7	2	....	5/16
2	4½	6½	2½	8	2 ½	5	5/16
2½	5	7	3	9½	2½	5½	5/16
3	5½	7¾	3	10	3	6	⅜
3½	6	8½	3½	11½	3	6½	7/16
4	6½	9	4	12	3	7	½
5	7½	10¼	4½	13½	3½	8	½
6	8	11½	5	14½	3½	9	9/16
8	9	14	5½	17½	4½	11	⅝
10	11	16½	6½	20½	5	14	¾
12	12	19	7½	24½	5½	14	13/16
14	14	21½	7½	27	6	16	⅞
16	15	24	8	30	6½	18	1
18	16½	26½	8½	32	7	19	1 1/16
20	18	29	9½	35	8	20	1⅛
24	22	34	11	40½	9	24	1¼
30	25	41½	15	49	10	30	1 7/16
36	28 *	49	18	....	....	36	1⅝
42	31 *	56½	21	....	....	42	1 13/16
48	34 *	64	24	....	....	48	2

Chart 4 American Standard Class 125 Cast Iron Flanged Fittings (ASA B16.1)

Nominal Pipe Face Size	Inside of Diam. of Fitting (Min.)	Wall Thickness of Body *	Diam. Raised Face	Center to Face					Face to Face F
				A	B	C	D	E	
2	2	7/16	4 3/16	5	6 ½	3	9	2½	5
2½	2½	½	4 15/16	5½	7	3½	10½	2½	5½
3	3	9/16	5 11/16	6	7¾	3½	11	3	6
3½	3½	9/16	6 5/16	6½	8½	4	12½	3	6 ½
4	4	⅝	6 15/16	7	9	4½	13½	3	7
5	5	11/16	8 5/16	8	10¼	5	15	3½	8
6	6	¾	9 11/16	8½	11½	5½	17½	4	9
8	8	1 3/16	11 15/16	10	14	6	20½	5	11
10	10	1 5/16	14 1/6	11½	16 ½	7	24	5½	12
12	12	1	16 7/16	13	19	8	27½	6	14
14	13¼	1⅛	18 15/16	15	21½	8½	31	6½	16
16	15¼	1¼	21 1/16	16½	24	9½	34½	7½	18
18	17	1⅜	23 5/16	18	26½	10	37½	8	19
20	19	1½	25 9/16	19½	29	10½	40½	8 ½	20
24	23	1⅝	30¼	22½	34	12	47½	10	24

Chart 5 American Standard Class 250 Cast Iron Flanged Fittings (ASA B16b)



TECH-F-3 Steel Pipe, Dimensions and Weights

Size: Nom. & (Outside Diam.), In. *	Wall Thickness, In.	Weight per Foot, Plain Ends, Lb.	Schedule No.	
⅛ (0.405)	0.068	0.24	40	S
	0.095	0.31	80	XS
¼ (0.540)	0.088	0.42	40	S
	0.119	0.54	80	XS
⅜ (0.675)	0.091	0.57	40	S
	0.126	0.74	80	XS
½ (0.840)	0.109	0.85	40	S
	0.147	1.09	80	XS
	0.188	1.31	160	
	0.294	1.71		XXS
¾ (1.050)	0.113	1.13	40	S
	0.154	1.47	80	XS
	0.219	1.94	160	
	0.308	2.44		XXS
1 (1.315)	0.133	1.68	40	S
	0.179	2.17	80	XS
	0.250	2.84	160	
	0.308	2.44		XXS
1¼ (1.660)	0.140	2.27	40	S
	0.191	3.00	80	XS
	0.250	3.76	160	
	0.382	5.21		XXS
1½ (1.900)	0.145	2.72	40	S
	0.200	3.63	80	XS
	0.281	4.86	160	
	0.400	6.41		XXS
2 (2.375)	0.154	3.65	40	S
	0.218	5.02	80	XS
	0.344	7.46	160	
	0.436	9.03		XXS
2½ (2.875)	0.203	5.79	40	S
	0.276	7.66	80	XS
	0.375	10.01	160	
	0.552	13.70		XXS
	0.216	7.58	40	S
3 (3.500)	0.300	10.25	80	XS
	0.438	14.31	160	
	0.600	18.58		XXS
3½ (4.000)	0.226	9.11	40	S
	0.318	12.51	80	XS
4 (4.500)	0.237	10.79	40	S
	0.337	14.98	80	XS
	0.438	18.98	120	
	0.531	22.52	160	
	0.674	27.54		XXS
5 (5.563)	0.258	14.62	40	S
	0.375	20.78	80	XS
	0.500	27.04	120	
	0.625	32.96	160	
	0.750	38.55		XXS
6 (6.625)	0.280	18.97	40	S
	0.432	28.57	80	XS
	0.562	36.42	120	
	0.719	45.34	160	
	0.864	53.16		XXS
8 (8.625)	0.250	22.36	20	
	0.277	24.70	30	
	0.322	28.55	40	S
	0.406	35.66	60	
	0.500	43.39	80	XS
	0.594	50.93	100	
	0.719	45.34	160	
	0.812	67.79	140	
	0.875	72.42		XXS
	0.906	74.71	160	
10 (10.750)	0.250	28.04	20	
	0.307	34.24	30	
	0.365	40.48	40	S
	0.500	54.74	60	XS
	0.594	64.40	80	
	0.719	77.00	100	
	0.844	89.27	120	
	1.000	104.13	140	XXS
	1.125	115.65	160	

Size: Nom. & (Outside Diam.), In. *	Wall Thickness, In.	Weight per Foot, Plain Ends, Lb.	Schedule No.	
12 (12.750)	0.250	33.38	20	
	0.330	43.77	30	
	0.375	49.56		S
	0.406	53.56	40	
	0.500	65.42		XS
	0.562	73.22	60	
	0.688	88.57	80	
	0.844	107.29	100	
	1.000	125.49	120	XXS
	1.125	139.68	140	
14 (14.000)	1.312	160.33	160	
	0.250	36.71	10	
	0.312	45.68	20	
	0.375	54.57	30	S
	0.438	63.37	40	
	0.500	72.09		XS
	0.594	85.01	60	
	0.750	106.13	80	
	0.938	130.79	100	
	1.094	150.76	120	
	1.250	170.22	140	
	1.406	189.15	160	
16 (16.000)	0.250	42.05	10	
	0.312	52.36	20	
	0.375	62.58	30	S
	0.500	82.77	40	XS
	0.656	107.54	60	
	0.844	136.58	80	
	1.031	164.86	100	
	1.219	192.40	120	
	1.438	223.57	140	
	1.594	245.22	160	
18 (18.000)	0.250	47.39	10	
	0.312	59.03	20	
	0.375	70.59		S
	0.438	82.06	30	
	0.500	93.45		XS
	0.562	104.76	40	
	0.750	138.17	60	
	0.938	170.84	80	
	1.156	208.00	100	
	1.375	244.14	120	
	1.562	274.30	140	
	1.781	308.55	160	
20 (20.000)	0.250	47.39	10	
	0.375	78.60	20	S
	0.500	93.45		XS
	0.594	123.06	40	
	0.812	166.50	60	
	1.031	208.92	80	
	1.281	256.15	100	
	1.500	296.37	120	
	1.750	341.10	140	
	1.969	379.14	160	
22 (22.000)	0.250	58.07	10	
	0.375	86.61	20	S
	0.500	114.81	30	XS
	0.875	197.42	60	
	1.125	250.82	80	
	1.375	302.88	100	
	1.625	353.61	120	
	1.875	403.01	140	
	2.125	451.07	160	
24 (24.000)	0.250	63.41	10	
	0.375	94.62	20	S
	0.250	63.41	10	
	0.375	94.62	20	S
	0.500	125.49		XS
	0.562	140.80	30	
	0.688	171.17	40	
	0.969	238.29	60	
	1.219	296.53	80	
	1.531	367.45	100	
	1.812	429.50	120	
	2.062	483.24	140	
	2.344	542.09	160	

TECH-F-4 150 Lb. and 300 Lb. Steel Pipe Flanges and Fittings

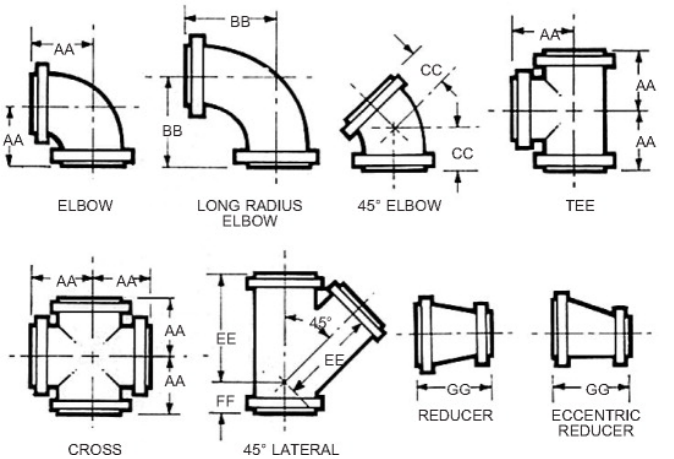
Extracted from USA Standard Cast Iron Pipe Flanges and Flanged Fittings (USAS, B16. 5-1968), with the permission of the publisher, The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York NY 10017.

Nominal Pipe Size	Diam. of Flange O	Thickness of Flange (Min.) *	Diam. of Bolt Circle	Diam. of Bolt Holes	Number of Bolts	Diam. of Bolts	Length of (with 1¼16" Raised Face)
½	3½	7/16	2⅜	⅝	4	½	1¾
¾	3⅞	½	2¼	⅝	4	½	2
1	4¼	9/16	3⅛	⅝	4	½	2
1¼	4⅝	⅝	3½	⅝	4	½	2 ¼
1½	5	11/16	3⅞	⅝	4	½	2¼
2	6	¾	4¾	¾	4	⅝	2¾
2½	7	⅞	5½	¾	4	⅝	3
3	7½	15/16	6	¾	4	⅝	3
3½	8½	15/16	7	¾	8	⅝	3
4	9	15/16	7½	¾	8	⅝	3
5	10	15/16	8½	⅞	8	¾	3¼
6	11	1	9½	⅞	8	¾	3¼
8	13½	1⅛	11¾	⅞	8	¾	3½
10	16	13/16	14¼	1	12	⅞	3¾
12	19	1¼	17	1	12	⅞	4
14	21	1⅜	18¾	1⅛	12	1	4¼
16	23½	17/16	21¼	1⅛	16	1	4½
18	25	19/16	22¾	1¼	16	1⅛	4¾
20	27½	111/16	25	1¼	20	1⅛	5¼
24	32	1⅞	29½	⅜	20	1¼	5¾

Chart 6 150 Lb. Steel Pipe Flanges

Nominal Pipe Size	AA	BB	CC	EE	FF	GG
1	3½	5	1¾	5¾	1¾	4½
1¼	3¾	5½	2	6¼	1¾	4½
1½	4	6	2¼	7	2	4½
2	4½	6½	2½	8	2½	5
2½	5	7	3	9½	2½	5½
3	5½	7¾	3	10	3	6
3½	6	8½	3½	11½	3	6½
4	6½	9	4	12	3	7
5	7½	10¼	4½	13½	3½	8
6	8	11½	5	14½	3½	9
8	9	14	5½	17½	4½	11
10	11	16½	6½	20½	5	12
12	12	19	7½	24½	5½	14
14	14	21½	7½	27	6	16
16	15	24	8	30	6½	18
18	16½	26½	8½	32	7	19
20	18	29	9½	35	8	20
24	22	34	11	40½	9	24

Chart 8 150 Lb. Steel Flanged Fittings



Nominal Pipe Size	Flange Diam.	Flange Thickness (Min.) *	Bolt Circle Diam.	Diam. of Bolt Holes	No .of Bolts	Size of Bolts
1	4⅞	11/16	3½	¾	4	⅝
1¼	5¼	¾	3⅞	¾	4	⅝
1½	6⅛	13/16	4½	7⅛8	4	¾
2	6½	⅞	5	_	8	⅝
2½	7½	1	5⅞	⅞	8	¾
3	8¼	1⅛	6⅝	⅞	8	¾
3½	9	13/16	7¼	⅞	8	¾
4	10	1¼	7⅞	⅞	8	¾
5	11	1⅜	9¼	⅞	8	¾
8	15	1⅝	13	1	12	⅞
10	17½	1⅞	15¼	1⅛	16	1
12	20½	2	17¾	1¼	16	1⅛
14	23	2⅛	20¼	1¼	20	1⅛
16	25½	2¼	22½	1⅜	20	1¼
18	28	2 ⅜	24¾	1⅜	24	1¼
20	30½	2½	27	1⅜	24	1¼
24	36	2¾	32	1⅝	24	1½

Chart 7 300 Lb. Steel Pipe Flanges

Nominal Pipe Size	AA	BB	CC	EE	FF	GG
1	4	5	2¼	6½	2	4½
1¼	4¼	5½	2½	7¼	2¼	4½
1½	4½	6	2¾	8½	2½	4½
2	5	6½	3	9	2½	5
2½	5½	7	3½	10½	2½	5½
3	6	7¾	3½	11	3	6
3½	6½	8½	4	12½	3	6½
4	7	9	4½	13½	3	7
5	8	10¼	5	15	3½	8
6	8½	11½	5½	17½	4	9
8	10	14	6	20½	5	11
10	11½	16½	7	24	5½	12
12	13	19	8	27½	6	14
14	15	21½	8½	31	6½	16
16	16½	24	9½	34¾	7½	18
18	18	26½	10	37½	8	19
20	19½	29	10½	40½	8½	20
24	22½	34	12	47½	10	24

Chart 9 300 Lb. Steel Flanged Fittings

* A raised face of 1/16 inch is included in (a) minimum thickness of flanges, and (b) "center to contact surface" dimension of fitting. Where facings other then 1/16 inch raised face are used, the "center to contact surface" dimensions shall remain unchanged.

TECH-F-5 150 Lb. ANSI/Metric Flange Comparison

Flange Nom. I.D.	Outside Diameter			Bolt Circle			Thickness (Min.)			Bolt Hole			Bolts Quantity			Bolt Size			Raised Face Diameter		
	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS
	150 lb.	10 Bar	10 K	150 lb.	10 Bar	10 K	150 lb.	10 Bar	10 K	150 lb.	10 Bar	10 K	150 lb.	10 Bar	10 K	150 lb.	10 Bar	10 K	150 lb.	10 Bar	10 K
1.00	4.25	4.53	4.92	3.12	3.35	3.54	0.56	0.63	0.55	0.62	0.55	0.75	4	-	-	0.5	-	-	2.00	2.68	2.64
25	108	115	125	79	85	90	14	16	14	16	14	19	-	4	4	-	M12	M16	51	68	67
1.50	5.00	5.91	5.51	3.88	4.33	4.13	0.69	0.71	0.63	0.62	0.71	0.75	4	-	-	0.5	-	-	2.88	3.46	3.19
40	127	150	140	98	110	105	17	18	16	16	18	19	-	4	4	-	M16	M16	73	88	81
2.00	6.00	6.50	6.10	4.75	4.92	4.72	0.75	0.79	0.63	0.75	0.71	0.75	4	-	-	0.62	-	-	3.62	4.02	3.78
50	52	165	155	121	125	120	19	20	16	19	18	19	-	4	4	-	M16	M16	92	102	96
2.50	7.00	7.28	6.89	5.50	5.71	5.51	0.88	0.79	0.71	0.75	0.71	0.75	4	-	-	0.62	-	-	4.12	4.80	4.57
65	178	185	175	140	145	140	22	20	18	19	18	19	-	8	4	-	M16	M16	105	122	116
3.00	7.50	7.87	7.28	6.00	6.30	5.91	0.94	0.79	0.71	0.75	0.71	0.75	4	-	-	0.62	-	-	5.00	5.24	4.96
80	191	200	185	152	160	150	24	20	18	19	18	19	-	8	8	-	M16	M16	127	133	126
3.50	8.50	0.00	7.68	7.00	0.00	6.30	0.94	0.00	0.71	0.75	0.00	0.75	8	-	-	0.62	-	-	5.50	0.00	5.35
90	216	0	195	178	0	160	24	0	18	19	0	19	-	-	8	-	-	M16	140	0	136
4.00	9.00	8.66	8.27	7.50	7.09	6.89	0.94	0.87	0.71	0.75	0.71	0.75	8	-	-	0.62	-	-	6.19	6.22	5.94
100	229	220	210	191	180	175	24	22	18	19	18	19	-	8	8	-	M16	M16	157	158	151
6.00	11.00	11.22	11.02	9.50	9.45	9.45	1.00	0.94	0.87	0.88	0.87	0.91	8	-	-	0.75	-	-	8.50	8.35	8.35
150	279	285	280	241	240	240	25	24	22	22	22	23	-	8	8	-	M20	M20	216	212	212
8.00	13.50	13.39	12.99	11.75	11.61	11.42	1.12	0.94	0.87	0.88	0.87	0.91	8	-	-	0.75	-	-	10.62	10.55	10.31
200	343	340	330	298	295	290	28	24	22	22	22	23	-	8	12	-	M20	M20	270	268	262
10.00	16.00	15.55	15.75	14.25	13.78	13.98	1.19	1.02	0.94	1.00	0.87	0.98	12	-	-	0.88	-	-	12.75	12.60	12.76
250	406	395	400	362	350	355	30	26	24	25	22	25	-	12	12	-	M20	M22	324	320	324
12.00	19.00	17.52	17.52	17.00	15.75	15.75	1.25	1.10	0.94	1.00	0.87	0.98	12	-	-	0.88	-	-	15.00	14.57	14.49
300	483	445	445	432	400	400	32	28	24	25	22	25	-	12	16	-	M20	M22	381	370	368
14.00	21.00	19.88	19.29	18.75	18.11	17.52	1.38	1.18	1.02	1.12	0.87	0.98	12	-	-	1.00	-	-	16.25	16.93	16.26
350	533	505	490	476	460	445	35	30	26	28	22	25	-	16	16	-	M20	M22	413	430	413
16.00	23.50	22.24	22.05	21.25	20.28	20.08	1.44	1.26	1.10	1.12	1.02	1.06	16	-	-	1.00	-	-	18.50	18.98	18.70
400	597	565	560	540	515	510	37	32	28	28	26	27	-	16	16	-	M24	M24	470	482	475
18.00	25.00	24.21	24.41	22.75	22.24	22.24	1.56	1.38	1.18	1.25	1.02	1.06	16	-	-	1.12	-	-	21.00	20.94	20.87
450	635	615	620	578	565	565	40	35	30	32	26	27	-	20	20	-	M24	M24	533	532	530
20.00	27.50	26.38	26.57	25.00	24.41	24.41	1.69	1.50	1.18	1.25	1.02	1.06	20	-	-	1.12	-	-	23.00	23.03	23.03
500	699	670	675	635	620	620	43	38	30	32	26	27	-	20	20	-	M24	M24	584	585	585
24.00	32.00	30.71	31.30	29.50	28.54	28.74	1.88	1.65	1.26	1.38	1.16	1.30	20	-	-	1.25	-	-	27.25	26.97	27.17
600	813	780	795	749	725	730	48	42	32	35	29.5	33	-	20	24	-	M27	M30	692	685.0	690
30.00	38.75	0.00	38.19	36.00	0.00	35.43	2.12	0.00	1.42	1.38	0.00	1.30	28	-	-	1.25	-	-	33.75	0.00	33.66
750	984	0	970	914	0	900	54	0	36	35	0	33	-	0	24	-	-	M30	857	0	855
36.00	46.00	43.90	44.09	42.75	41.34	41.34	2.38	1.34	1.50	1.62	1.28	1.30	32	-	-	1.50	-	-	40.25	39.57	39.57
900	1168	1115	1120	1086	1050	1050	60	34	38	41	32.5	33	-	28	28	-	M30	M30	1022	1005.0	1005
42.00	53.00	48.43	48.62	49.50	45.67	45.67	2.62	1.34	1.57	1.62	1.40	1.54	36	-	-	1.50	-	-	47.00	43.70	43.70
1000	1230	1230	1235	1257	1160	1160	67	34	40	41	35.5	39	-	28	28	-	M33	M36	1194	1110.0	1110
48.00	59.50	57.28	57.68	56.00	54.33	54.33	2.75	1.50	1.73	1.62	1.54	1.54	44	-	-	1.50	-	-	53.50	52.36	52.17
1200	1230	1455	1465	1422	1380	1380	70	38	44	41	39	39	-	32	32	-	M36	M36	1359	1330	1325

TECH-F-6 300 Lb. ANSI/Metric Flange Comparison

Flange Nom. I.D.	Outside Diameter			Bolt Circle			Thickness (Min.)			Bolt Hole			Bolts Quantity			Bolt Size			Raised Face Diameter		
	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS	ANSI	ISO	JIS
	300 lb.	16 Bar	16 K	300 lb.	16 Bar	16 K	300 lb.	16 Bar	16 K	300 lb.	16 Bar	16 K	300 lb.	16 Bar	16 K	300 lb.	16 Bar	16 K	300 lb.	16 Bar	16 K
1.00	4.88	4.53	4.92	3.50	3.35	3.54	0.69	0.63	0.55	0.75	0.55	0.75	4	-	-	0.62	-	-	2.00	2.68	2.64
25	124	115	125	90	85	90	17	16	14	19	14	19	-	4	4	-	M12	M16	51	68	67
1.50	6.12	5.91	5.51	4.50	4.33	4.13	0.81	0.71	0.63	0.88	0.71	0.75	4	-	-	0.75	-	-	2.88	3.46	3.19
40	156	150	140	114	110	105	21	18	16	22	18	19	-	4	4	-	M16	M16	73	88	81
2.00	6.50	6.50	6.10	5.00	4.92	4.72	0.88	0.79	0.63	0.75	0.71	0.75	8	-	-	0.62	-	-	3.62	4.02	3.78
50	165	165	155	127.0	125	120	22	20	16	19	18	19	-	4	8	-	M16	M16	92	102	96
2.50	7.50	7.28	6.89	5.88	5.71	5.51	1.00	0.79	0.71	0.88	0.71	0.75	8	-	-	0.75	-	-	4.12	4.80	4.57
65	191	185	175	149	145	140	25	20	18	22	18	19	-	8	8	-	M16	M16	105	122	116
3.00	8.25	7.87	7.87	6.62	6.30	6.30	1.12	0.79	0.79	0.88	0.71	0.91	8	-	-	0.75	-	-	5.00	5.24	5.20
80	210	200	200	169	160	160	29	20	20	22	18	23	-	8	8	-	M16	M20	127	133	132
3.50	9.00	0.00	8.27	7.25	0.00	6.69	1.19	0.00	0.79	0.88	0.00	0.91	8	-	-	0.75	-	-	5.50	0.00	5.71
90	229	-	210	184	-	170	30	-	20	22	-	23	-	-	8	-	-	M20	140	0	145
4.00	10.00	8.66	8.86	7.88	7.09	7.28	1.25	0.87	0.87	0.88	0.71	0.91	8	-	-	0.75	-	-	6.19	6.22	6.30
100	254	220	225	200	180	185	32	22	22	22	18	23	-	8	8	-	M16	M20	157	158	160
6.00	12.50	11.22	12.01	10.62	9.54	10.24	1.44	0.94	0.94	0.88	0.87	0.98	12	-	-	0.75	-	-	8.50	8.35	9.06
150	381	285	305	270	240	260	37	24	24	22	22	25	-	8	12	-	M20	M22	216	212	230
8.00	15.00	13.39	13.78	13.00	11.61	12.01	1.62	1.02	1.02	1.00	0.87	0.98	12	-	-	0.88	-	-	10.62	10.55	10.83
200	381	340	350	330	295	305	41	26	26	25	22	25	-	12	12	-	M20	M22	270	268	275
10.00	17.50	15.94	16.93	15.25	13.98	14.96	1.88	1.10	1.10	1.12	1.02	1.06	16	-	-	1.00	-	-	12.75	12.60	13.58
250	445	405	430	387	355	380	48	28	28	28	26	27	-	12	12	-	M24	M24	324	320	345
12.00	20.50	18.11	18.90	17.75	16.14	16.93	2.00	1.26	1.18	1.25	1.02	1.06	16	-	-	1.12	-	-	15.00	14.57	15.55
300	521	460	480	451	410	430	51	32	30	32	26	27	-	12	16	-	M24	M24	381	370	395
14.00	23.00	20.47	21.26	20.25	18.50	18.90	2.12	1.38	1.34	1.25	1.02	1.30	20	-	-	1.12	-	-	16.25	16.93	17.32
350	584	520	540	514	470	480	54	35	34	32	26	33	-	16	16	-	M24	M30	413	430	440
16.00	25.50	22.83	23.82	22.50	20.67	21.26	2.25	1.50	1.50	1.38	1.16	1.30	20	-	-	1.25	-	-	18.50	18.98	19.49
400	648	580	605	572	525	540	57	38	38	35	29.5	33	-	16	16	-	M27	M30	470	482	495
18.00	28.00	25.20	26.57	24.75	23.03	23.82	2.38	1.65	1.57	1.38	1.16	1.30	24	-	-	1.25	-	-	21.00	20.94	22.05
450	711	640	675	629	585	605	60	42	40	35	29.5	33	-	20	20	-	M27	M30	533	532	560
20.00	30.50	28.15	28.74	27.00	25.59	25.98	2.50	1.81	1.65	1.38	1.28	1.30	24	-	-	1.25	-	-	23.00	23.03	24.21
500	775	715	730	686	650	660	64	46	42	35	32.5	33	-	20	20	-	M30	M30	584	585	615
24.00	36.00	33.07	33.27	32.00	30.31	30.31	2.75	2.05	1.81	1.62	1.40	1.54	24	-	-	1.50	-	-	27.25	26.97	28.35
600	914	840	845	813	770	770	70	52	46	41	35.5	39	-	20	24	-	M33	M36	692	685.0	720
30.00	43.00	0.00	40.16	39.25	0.00	36.81	3.00	0.00	2.05	1.88	0.00	1.65	28	-	-	1.75	-	-	33.75	0.00	34.65
750	1092	0	1020	997	0	935	76	0	52	48	0	42	-	0	24	-	0	M39	857	0	880
36.00	50.00	44.29	46.65	46.00	41.34	42.91	3.38	2.99	2.28	2.12	1.54	1.89	32	-	-	2.00	-	-	40.25	39.57	40.55
900	1270	1125	1185	1168	1050	1090	86	76	58	54	39	48	-	28	28	-	M36	M45	1022	1005.0	1030
42.00	57.00	49.41	51.97	52.75	46.06	47.64	3.69	3.31	2.44	2.12	1.65	2.20	36	-	-	2.00	-	-	47.00	43.70	44.88
1000	1448	1255	1320	1340	1170	1210	94	84	62	54	42	56	-	28	28	-	M39	M52	1194	1110.0	1140
48.00	65.00	58.46	60.24	60.75	54.72	55.91	4.00	3.86	2.76	2.12	1.89	2.20	40	-	-	2.00	-	-	58.44	52.36	53.15
1200	1651	1485	1530	1543	1390	1420	102	98	70	54	48	56	-	32	32	-	M45	M52	1484	1330	1350

TECH-F-7 Weights and Dimensions of Steel & Wrought Iron Pipe Recommended for Use as Permanent Well Casings

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Size In.	Steel Pipe, Black or Galvanized				
	Diameter - In.		Thickness In.	Weight Per Foot - Lb[1]	
	External	Internal		Plain Ends (Calculated)	With Threads and Couplings (Nominal)[2]
6	6.625	6.065	0.280	18.97	19.18
8	8.625	8.249	0.188	16.90	17.80
8	8.625	8.071	0.277	24.70	25.55
8	8.625	7.981	0.322	28.55	29.35
10	10.750	10.192	0.279	31.20	32.75
10	10.750	10.136	0.307	34.24	35.75
10	10.750	10.020	0.365#	40.48	41.85
12	12.750	12.090	0.330	43.77	45.45
12	12.750	12.000	0.375#	49.56	51.15
14	14.000	13.500	0.250	36.71	
14	14.000	13.250	0.375#	54.57	57.00
16	16.000	15.376	0.312	52.36	
16	16.000	15.250	0.375#	62.58	65.30
18	18.000	17.376	0.312	59.03	
18	18.000	17.250	0.375#	70.59	73.00
20	20.000	19.376	0.312	65.71	
20	20.000	19.250	0.375#	78.60	81.00
22	22.000	21.376	0.312	72.38	
22	22.000	21.250	0.375	86.61	
22	22.000	21.000	0.500	114.81	
24	24.000	23.376	0.312	79.06	
24	24.000	23.250	0.375	94.62	
24	24.000	23.000	0.500#	125.49	
26	26.000	25.376	0.312	85.73	
26	26.000	25.000	0.500#	136.17	
28	28.000	27.376	0.312	92.41	
28	28.000	27.000	0.500#	146.85	
30	30.000	29.376	0.312	99.08	
30	30.000	29.000	0.500#	157.53	
32	32.000	31.376	0.312	105.76	
32	32.000	31.000	0.500#	168.21	
34	34.000	33.376	0.312	112.43	
34	34.000	33.000	0.500#	178.89	
36	36.000	35.376	0.312	119.11	
36	36.000	35.000	0.500#	189.57	

#Thickness indicated is believed to be best practice. If soil and water conditions are unusually favorable, lighter pipe may be used if permitted in the purchaser's specifications.
[1] Manufacturing weight tolerance is 10 percent over and 3.5 percent under nominal weight for pipe 6-20 in. in size and +/- percent of nominal weight for larger sizes.
[2] Nominal weights of pipe with threads and couplings (based on lengths of 20 ft. including coupling) are shown for purposes of specification. Thread data are contained in the various standards covering sizes which can be purchased with threads.

Size In.	Wrought-Iron Pipe, Black or Galvanized				
	Diameter - In.		Thickness In.	Weight Per Foot - Lb[1]	
	External	Internal		Plain Ends (Calculated)	With Threads and Couplings (Nominal)[2]
6	6.625	6.053	0.286	18.97	19.45
8	8.625	7.967	0.329	28.55	29.35
10	10.750	10.005	0.372	40.48	41.85
12	12.750	11.985	0.383	49.56	51.15
14	14.000	13.234	0.383	54.56	57.00
16	16.000	15.324	0.383	62.58	65.30
18	18.000	17.165	0.417	76.84	81.20
20	20.000	19.125	0.438	89.63	94.38
20	20.000	19.000	0.500 *	102.10	106.62
22	22.000	21.125	0.438	98.77	
22	22.000	21.000	0.500 *	112.57	
24	24.000	23.125	0.438	107.96	
24	24.000	23.000	0.500 *	123.04	
26	26.000	25.125	0.438	117.12	
26	26.000	25.000	0.500 *	133.51	
28	28.000	27.125	0.438	126.27	
28	28.000	27.000	0.500 *	143.99	
30	30.000	29.125	0.438	135.42	
30	30.000	29.000	0.500 *	154.46	

[1]Manufacturing weight tolerance is 10 percent over and 3.5 percent under nominal weight for pipe ~20 in. in size and +10 percent of nominal weight for larger sizes.
[2]Based on length of 20 ft. including coupling. Threaded pipe has 8 threads per inch.
* Thickness indicated is believed to be best practice. If soil and water conditions are unusually favorable tighter pipe may be used if permitted in the purchaser's specifications.
Welded joints advocated for pipe larger than 20 in. in diameter; also for smaller diameter pipe, where applicable, to obtain clearance and maintain uniform grout thickness.

TECH-F-8 Capacities of Tanks of Various Dimensions

Chart 10 Capacity of Round Tanks (per foot of depth)

Diam.	Gals.	Area Sq. Ft.	Diam.	Gals.	Area Sq. Ft.	Diam.	Gals.	Area Sq. Ft.	Diam.	Gals.	Area Sq. Ft.
1′	5.87	.785	4′ 2″	102.00	13.635	10′	587.52	78.54	21′ 6″	2715.80	363.05
1′ 1″	6.89	.922	4′ 3″	106.12	14.186	10′ 3″	617.26	82.52	21′ 9″	2779.30	371.54
1′ 2″	8.00	1.069	4′ 4″	110.32	14.748	10′ 6″	640.74	86.59	22′	2843.60	380.13
1′ 3″	9.18	1.277	4′ 5″	114.61	15.321	10′ 9″	678.95	90.76	22′ 3′	2908.60	388.82
1′ 4″	10.44	1.396	4′ 6″	118.97	15.90	11′	710.90	95.03	22′ 6′	2974.30	397.61
1′ 5″	11.79	1.576	4′ 7″	123.42	16.50	11′ 3″	743.58	99.40	22′ 9″	3040.80	406.49
1′ 6″	13.22	1.767	4′ 8″	127.95	17.10	11′ 6″	776.99	103.87	23′	3108.00	415.48
1′ 7″	14.73	1.969	4′ 9″	132.56	17.72	11′ 9″	811.14	108.43	23′ 3″	3175.90	424.56
1′ 8″	16.32	2.182	4′ 10″	137.25	18.35	12′	846.03	113.10	23′ 6″	3244.60	433.74
1′ 9″	17.99	2.405	4′ 11″	142.02	18.99	12′ 3″	881.65	117.86	23′ 9″	3314.00	443.01
1′ 10″	19.75	2.640	5′	146.91	19.64	12′ 6″	918.00	122.72	24′	3384.10	452.39
1′ 11″	21.58	2.885	5′ 1″	151.81	20.30	12′ 9″	955.09	127.68	24′ 3″	3455.00	461.86
2′	23.50	3.142	5′ 2″	156.83	20.97	13′	992.91	132.73	24′ 6″	3526.60	471.44
2′ 1″	25.50	3.409	5′ 3″	161.94	21.65	13′ 3″	1031.50	137.89	24′ 9″	3598.90	481.11
2′ 2″	27.58	3.687	5′ 4″	167.11	22.34	13′ 6″	1070.80	142.14	25′	3672.00	490.87
2′ 3″	29.74	3.976	5′ 5″	172.38	23.04	13′ 9″	1110.80	148.49	25′ 3″	3745.80	500.74
2′ 4″	31.99	4.276	5′ 6″	177.71	23.76	14′	1151.50	153.94	25′ 6″	3820.30	510.71
2′ 5″	34.31	4.587	5′ 7″	183.14	24.48	14′ 3″	1193.00	159.48	25′ 9″	3895.60	527.77
2′ 6″	36.72	4.909	5′ 8″	188.66	25.22	14 ′6″	1235.30	165.13	26′	3971.60	530.93
2′ 7″	39.21	5.241	5′ 9″	194.25	25.97	14′ 9″	1278.20	170.87	26′ 3″	4048.40	541.19
2′ 8″	41.78	5.585	5′ 10″	199.92	26.73	15′	1321.90	176.71	26′ 6″	4125. 90	551.55
2′ 9″	44.43	5.940	5′ 11″	205.67	27.49	15′ 3″	1366.40	182.65	26′ 9″	4204.10	562.00
2′ 10″	47.16	6.305	6″	211.51	28.27	15′ 6″	1411.50	188.69	27′	4283.00	572.66
2′ 11″	49.98	6.681	6′ 3″	229.50	30.68	15′ 9″	1457.40	194.83	27′ 3″	4362.70	583.21
3′	52.88	7.069	6′ 6″	248.23	35.18	16′	1504.10	201.06	27′ 6″	4443.10	593.96
3′ 1″	55.86	7.467	6′ 9″	267.69	35.78	16′ 3″	1551.40	207.39	27′ 9″	4524.30	604.81
3′ 2″	58.92	7.876	7′	287.88	38.48	16′ 6″	1599.50	213.82	28′	4606.20	615.75
3′ 3″	62.06	8.296	7′ 3″	308.81	41.28	16′ 9″	1648.40	220.35	28′ 3″	4688.80	626.80
3′ 4″	65.28	8.727	7′ 6″	330.48	44.18	19′	2120.90	283.53	28′ 6″	4772.10	637.94
3′ 5″	68.58	9.168	7′ 9″	352.88	47.17	19′ 3″	2177.10	291.04	28′ 9″	4856.20	649.18
3′ 6″	71.97	9.621	8′	376.01	50.27	19′ 6″	2234.00	298.65	29′	4941.00	660.52
3′ 7″	75.44	10.085	8′ 3″	399.80	53.46	19′ 9″	2291.70	306.35	29′ 3″	5026.60	671.96
3′ 8″	78.99	10.559	8′ 6″	424.48	56.75	20′	2350.10	314.16	29′ 6″	5112.90	683.49
3′ 9″	82.62	11.045	8′ 9″	449.82	60.13	20′ 3″	2409.20	322.06	29′ 9″	5199.90	695.13
3′ 10″	86.33	11.541	9″	475.89	63.62	20′ 6″	2469.10	330.06	30′	5287.70	706.86
3′ 11″	90.13	12.048	9′ 3″	502.70	67.20	20′ 9″	2529.60	338.16	30′ 3″	5376.20	718.69
4′	94.00	12.566	9′ 6″	530.24	70.88	21′	2591.00	346.36	30′ 6″	5465.40	730.62
4′ 1″	97.96	13.095	9′ 9″	558.51	74.66	21′ 3″	2653.00	346.36	30′ 9″	5555.40	742.64

To find the capacity of tanks greater than shown above, find a tank of one-half the size desired, and multiply its capacity by four, or find one one-third the size desired and multiply its capacity by 9.

Chart 11 Capacity of Square Tanks

Dimensions in Feet	Contents in Gallons for Depth in Feet of:							
	1′	4′	5′	6′	8′	10′	11′	12′
4 × 4	119.68	479.	598.	718.	957.	1197.	1316.	1436.
5 × 5	187.00	748.	935.	1202.	1516.	1870	2057.	2244
6 × 6	269.28	1077.	1346.	1616.	2154.	2693.	2968	3231.
7 × 7	366.52	1466.	1833.	2199.	2922.	3665.	4032.	4398
8 × 8	478.72	1915.	2394.	2872.	3830.	4787.	5266.	5745.
9 × 9	605.88	2424.	3029.	3635.	4847.	6059.	6665.	7272.
10 × 10	748.08	2992.	3740.	4488.	5984.	7480.	8228.	8976.
11 × 11	905.08	3620.	4525.	5430.	7241.	9051.	9956.	10861.
12 × 12	1077.12	4308.	5386	6463.	8617.	10771	11848.	12925.

To find the capacity of a depth not given, multiply the capacity for one foot by the required depth in feet.

Capacities of Tanks of Various Dimensions

Chart 12 Cylindrical Tanks Set Horizontally and Partially Filled

Diam-eter	Gallons Per Foot of Length When Tank is Filled								
	1/10	1/5	3/10	2/5	½	3/5	7/10	4/5	9/10
1 ft.	.3	.8	1.4	2.1	2.9	3.6	4.3	4.9	5.5
2 ft	1.2	3.3	5.9	8.8	11.7	14.7	17.5	20.6	22.2
3 ft.	2.7	7.5	13.6	19.8	26.4	33.0	39.4	45.2	50.1
4 ft.	4.9	13.4	23.8	35.0	47.0	59.0	70.2	80.5	89.0
5 ft.	7.6	20.0	37.0	55.0	73.0	92.0	110.0	126.0	139.0
6 ft.	11.0	30.0	53.0	78.0	106.0	133.0	158.0	182.0	201.0
7 ft	15.0	41.0	73.0	107.0	144.0	181.0	215.0	247.0	272.0
8 ft.	19.0	52.0	96.0	140.0	188.0	235.0	281.0	322.0	356.0
9 ft.	25.0	67.0	112.0	178.0	238.0	298.0	352.0	408.0	450.0
10 ft.	30.0	83.0	149.0	219.0	294.0	368.0	440.0	504.0	556.0
11 ft.	37.0	101.0	179.0	265.0	356.0	445.0	531.0	610.0	672.0
12 ft .	44.0	120.0	214.0	315.0	423.0	530.0	632.0	741.0	800.0
13 ft.	51.0	141.0	250.0	370.0	496.0	621.0	740.0	850.0	940.0
14 ft.	60.0	164.0	291.0	430.0	576.0	722.0	862.0	989.0	1084.0
15 ft.	68.0	188.0	334.0	494.0	661.0	829.0	988.0	1134.0	1253.0

Chart 13 Capacities, in U.S. Gallons of Cylinders of Various Diameters and Lengths

Diam. In.	Length of Cylinder																			
	1"	1'	5'	6'	7'	8'	9'	10'	11'	12'	13'	14'	15	16'	17'	18'	20'	22'	24'	Diam.In.
1		0.04	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.80	0.88	0.96	1
2	0.01	0.16	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.56	2.72	2.88	3.20	3.52	3.84	2
3	0.03	0.37	1.84	2.20	2.56	2.92	3.30	3.68	4.04	4.40	4.76	5.12	5.48	5.84	6.22	6.60	7.36	8.08	8.80	3
4	0.05	0.65	3.26	3.92	4.58	5.24	5.88	6.52	7.18	7.84	8.50	9.16	9.82	10.5	11.1	11.8	13.0	14.4	15.7	4
5	0.08	1.02	5.10	6.12	7.14	8.16	9.18	10.2	11.2	12.2	13.3	14.3	15.3	16.3	17.3	18.4	20.4	22.4	24.4	5
6	0.12	1.47	7.34	8.80	10.3	11.8	13.2	14.7	16.1	17.6	19.1	20.6	22.0	23.6	25.0	26.4	29.4	32.2	35.2	6
7	0.17	2.00	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	40.0	44.0	48.0	7
8	0.22	2.61	13.0	15.6	18.2	20.8	23.4	26.0	28.6	31.2	33.8	36.4	39.0	41.6	44.2	46.8	52.0	57.2	62.4	8
9	0.28	3.31	16.5	19.8	23.1	26.4	29.8	33.0	36.4	39.6	43.0	46.2	49.6	52.8	56.2	60.0	66.0	72.4	79.2	9
10	0.34	4.08	20.4	24.4	28.4	32.6	36.8	40.8	44.8	48.8	52.8	56.8	61.0	65.2	69.4	73.6	81.6	89.6	97.6	10
11	0.41	4.94	24.6	29.6	34.6	39.4	44.4	49.2	54.2	59.2	64.2	69.2	74.0	78.8	83.8	88.8	98.4	104.	118.	11
12	0.49	5.88	29.4	35.2	41.0	46.8	52.8	58.8	64.6	70.4	76.2	82.0	87.8	93.6	99.6	106	118.	129.	1411	12
13	0.57	6.90	34.6	41.6	48.6	55.2	62.2	69.2	76.2	83.2	90.2	97.2	104.	110.	117.	124.	138.	152.	166.	13
14	0.67	8.00	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.	112.	120.	128.	136.	144.	160.	176.	192.	14
15	0.77	9.18	46.0	55.2	64.4	73.6	82.8	92.0	101.	110.	120.	129.	138.	147.	156.	166.	184.	202.	220.	15
16	0.87	10.4	52.0	62.4	72.8	83.2	93.6	104.	114	125.	135.	146.	156.	166.	177.	187.	208.	229.	250.	16
17	0.98	11.8	59.0	70.8	81.6	94.4	106.	118.	130.	142.	153.	163.	177.	189.	201.	212.	236.	260.	283.	17
18	1.10	13.2	66.0	79.2	92.4	106.	119.	132.	145.	158.	172.	185.	198.	211.	224.	240.	264.	290.	317.	18
19	1.23	14.7	73.6	88.4	103.	118.	132.	147.	162.	177.	192.	206.	221.	235.	250.	265.	294.	324.	354.	19
20	1.36	16.3	81.6	98.0	114.	130	147.	163.	180.	196.	212.	229	245.	261.	277.	294.	326.	359.	392.	20
21	1.50	18.0	90.0	108	126	144.	162.	180.	198.	216.	238.	252.	270.	288.	306.	324.	360.	396.	432.	21
22	1.65	19.8	99.0	119.	139.	158.	178.	198.	218.	238.	257.	277.	297.	317.	337.	356.	396.	436.	476.	22
23	1.80	21.6	108.	130.	151.	173.	194.	216.	238.	259.	281.	302.	324.	346.	367.	389.	432.	476.	518.	23
24	1.96	23.5	118.	141.	165.	188.	212.	235.	259.	282.	306.	330.	353.	376.	400.	424	470.	518.	564.	24
25	2.12	25.5	128.	153.	179.	204	230.	255.	281.	306.	332.	358.	383.	408.	434.	460.	510.	562.	612.	25
26	2.30	27.6	138.	166.	193.	221.	248.	276.	304.	331.	359.	386.	414.	442.	470.	496.	552.	608.	662.	26
27	2.48	29.7	148.	178.	208.	238.	267.	297.	326.	356.	386.	416.	426.	476.	504.	534.	594.	652.	712.	27
28	2.67	32.0	160	192.	224.	256.	288.	320.	352.	384.	416.	448.	480.	512.	544.	576.	640.	704.	768.	28
29	2.86	34.3	171.	206.	240.	274.	309.	343.	377.	412.	446.	480.	514.	548.	584.	618.	686.	754.	824.	29
30	3.06	36.7	183	220.	257.	294.	330.	367.	404.	440.	476.	514.	550.	588.	624.	660.	734.	808.	880.	30
32	3.48	41.8	209	251.	293.	334.	376.	418.	460.	502.	544.	586.	628.	668.	710.	752.	836.	920.	1004.	32
34	3.93	47.2	236.	283.	330.	378.	424.	472.	520.	566.	614.	660.	708.	756.	802.	848.	944.	1040.	1132.	34
36	4.41	52.9	264.	317.	370.	422.	476.	528.	582.	634.	688.	740.	792.	844.	898.	952.	1056.	1164.	1268.	36

TECH-G-1 Motor Enclosures

The selection of a motor enclosure depends upon the ambient and surrounding conditions. The two general classifications of motor enclosures are open and totally enclosed. An open motor has ventilating openings which permit passage of external air over and around the motor windings. A totally enclosed motor is constructed to prevent the free exchange of air between the inside and outside of the frame, but not sufficiently enclosed to be termed air-tight.

These two categories are further broken down by enclosure design, type of insulation, and/or cooling method. The most common of these types are listed below.

Open Drip Proof - An open motor in which all ventilating openings are so constructed that drops of liquid or solid particles falling on the motor at any angle from 0 to 15 degrees from vertical cannot enter the machine. This is the most common type and is designed for use in nonhazardous, relatively clean, industrial areas.

Encapsulated - A dripproof motor with the stator windings completely surrounded by a protective coating. An encapsulated motor offers more resistance to moisture and/or corrosive environments than an ODP motor.

Totally Enclosed, Fan-Cooled - An enclosed motor equipped for external cooling by means of a fan integral with the motor, but external to the enclosed parts. TEFC motors are designed for use in extremely wet, dirty, or dusty areas.

Explosion-Proof, Dust-Ignition-Proof - An enclosed motor whose enclosure is designed to withstand an explosion of a specified dust, gas, or vapor which may occur within the motor and to prevent the ignition of this dust, gas, or vapor surrounding the motor. A motor manufacturer should be consulted regarding the various classes and groups of explosion-proof motors available and the application of each.

Motor insulation is classified according to the total allowable temperature. This is made up of a maximum ambient temperature plus a maximum temperature rise plus allowances for hot spots and service factors. Class B insulation is the standard and allows for a total temperature of 130°C. The maximum ambient is 40°C, and the temperature rise is 70°C, for ODP motors and 75°C for TEFC motors.

TECH-G-2 NEMA Frame Assignments

SINGLE-PHASE MOTORS
Horizontal and Vertical

open type

Design L, 60 cycles, class B insulation system, open type, 1.15 service factor.

hp	speed, rpm		
	3600	1800	1200
¾	-	-	145T
1	-	143T	182T
1½	143T	145T	184T
2	145T	182T	-
3	182T	184T	-
5	184T	213T	-
7½	213T	215T	-

POLYPHASE SQUIRREL-CAGE MOTORS
Horizontal and Vertical

open type

Designs A and B - class B insulation system, open type 1.15 service factor, 60 cycles.

hp	speed, rpm			
	3600	1800	1200	900
½	-	-	-	143T
¾	-	-	143T	145T
1	-	143T	145T	182T
1½	143T	145T	182T	184T
2	145T	145T	184T	213T
3	145T	182T	213T	215T
5	182T	184T	215T	254T
7½	184T	213T	254T	256T
10	213T	215T	256T	284T
15	215T	254T	284T	286T
20	254T	256T	286T	324T
25	256T	284T	324T	326T
30	284TS	286T	326T	364T
40	286TS	324T	364T	365T
50	324TS	326T	365T	404T
60	326TS	364TS	404T	405T
75	364TS	365TS	405T	444T
100	365TS	404TS	444T	445T
125	404TS	405TS	445T	-
150	405TS	444TS	-	-
200	444TS	454TS	-	-
250	445TS *	-	-	-

* The 250 hp rating at the 3600 rpm speed has a 1.0 service factor

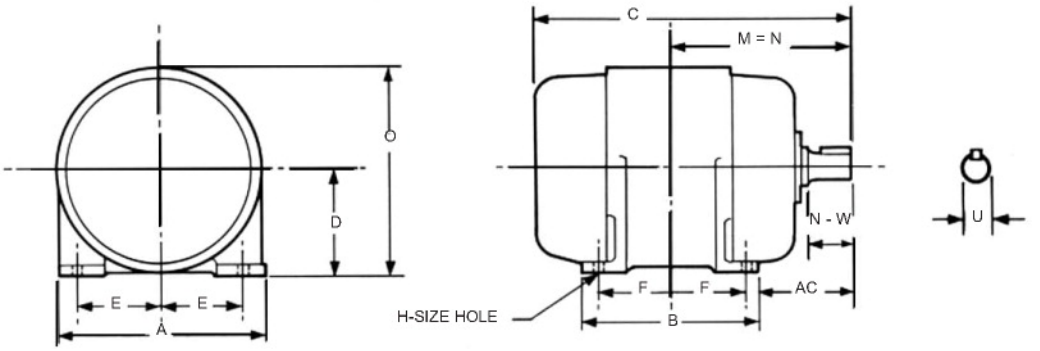
fan cooled

Designs A and B - class B insulation system totally-enclosed fan-cooled type, 1.00 service factor, 60-cycles.

hp	speed, rpm			
	3600	1800	1200	900
½	-	-	-	143T
¾	-	-	143T	145T
1	-	143T	145T	182T
1½	143T	145T	182T	184T
2	145T	145T	184T	213T
3	182T	182T	213T	215T
5	184T	184T	215T	254T
7½	213T	213T	254T	256T
10	215T	215T	256T	284T
15	254T	254T	284T	286T
20	256T	256T	286T	324T
25	284TS	284T	324T	326T
30	286TS	286T	326T	364T
40	324TS	324T	364T	365T
50	326TS	326T	365T	404T
60	364TS	364TS	404T	405T
75	365TS	365TS	405T	444T
100	405TS	405TS	444T	445T
125	444TS	444TS	445T	-
150	445TS	445TS	-	-

TECH-G-3 NEMA Frame Dimensions

IPP44 TOTALLY ENCLOSED & FLAMEPROOF
(Similar to NEMA TEFC & Explosion Proof)



Motor Frame	H.P. (Open)			H.P. (Enclosed)					A	B	C (Approx.)		D	E	F	H	O (Approx.)		U	Keyway	V	AC	Bolts		Wt. (Approx.)	
	900	1200	1800	3600	900	1200	1800	3600	Max.	Max.	Open	Encl.					Open	Encl.			Min.		Dia.	Lg.	Open	Encl.
143T	½	¾	1	1½	½	¾	1	1½	7	6	12	12½	3½	2¾	2	11/32	6⅞	7	⅞	3/16 × 3/32	2	4½	¼		40	45
145T	¾	1	1½ - 2	2-3	¾	1	1½- 2	2	7	6	12½	13½	3¾	2¾	2¾	11/32	6⅞	7	⅞	3/16 × 3/32	2	4½	¼		45	50
182T	1	1½	3	5	1	1½	3	3	9	6½	13	14½	4½	3¾	2¼	13/32	9⅛	9¼	1⅛	¼ × ⅛	2½	5½	5/16	1	65	79
184T	1½	2	5	7½	1½	2	5	5	9	7½	14	15½	4½	3¾	2¾	13/32	9⅛	9¼	1⅛	¼ × ⅛	2½	5½	5/16	1	80	95
213T	2	3	7½	10	2	3	7½	7½	10½	7½	16	18	5¼	4¼	2¾	13/32	10¾	10⅞	1⅜	5/16 × 5/32	3⅛	6⅞	5/16	1	120	140
215T	3	5	10	15	3	5	10	10	10½	9	17½	19½	5¼	4¼	3¾	13/32	10¾	10⅞	1⅜	5/16 × 5/32	3⅛	6⅞	5/16	1	140	160
254T	5	7½	15	20	5	7 ½	15	15	12½	10¾	20½	22½	6¼	5	4⅛	17/32	12⅝	12¾	1⅝	⅜ × 3/16	3¾	8¼	⅜	1¼	200	235
256T	7½	10	20	25	7½	10	20	20	12½	12½	22½	24	6¼	5	5	17/32	12⅝	12¾	1⅝	⅜ × 3/16	3¾	8¼	⅜	1¼	235	270
284T	10	15	25		10	15	25		14	12½	23½	25½	7	5½	4¾	17/32	14	14⅜	1⅞	½ × ¼	4⅜	9⅝	⅜	1½	295	370
284TS				30				25	14	12½	22	24½	7	5½	4¾	17/32	14	14⅜	1⅝	⅜ × 3/16	3	8	⅜	1½	255	340
286T	15	20	30		15	20	30		14	14	25	27	7	5½	5½	17/32	14	14⅜	1⅞	½ × ¼	4⅜	9⅝	⅜	1½	340	405
286TS				40				30	14	14	23½	26	7	5½	5½	17/32	14	14⅜	1⅝	⅜ × 3/16	3	8	⅜	1½	295	395
324T	20	25	40		20	25	40		16	14	26	28½	8	6¼	5¼	21/32	16	16⅝	2⅛	½ × ¼	5	10½	½	1¾	440	520
324TS				50				40	16	14	24½	27	8	6¼	5¼	21/32	16	16⅝	1⅞	½ × ¼	3½	9	½	1¾	445	500
326T	25	30	50		25	30	50		16	15½	27½	30	8	6¼	6	21/32	16	16⅝	2⅛	½ × ¼	5	10½	½	1¾	435	580
326TS				60				50	16	15½	26	28½	8	6¼	6	21/32	16	16⅝	1⅞	½ × ¼	3½	9	½	1¾	480	560
364T	30	40			30	40			18	15¼	29	33	9	7	5⅝	21/32	18	18½	2⅜	⅝ × 5/16	5⅝	11¾	½	1¾	605	755
364TS			60	75			60	60	18	15¼	27	31	9	7	5⅝	21/32	18	18½	1⅞	½ × ¼	3½	9⅝	½	1¾	670	740
365T	40	50			40	50			18	16¼	30	34	9	7	6⅛	21/32	18	18½	2⅜	⅝ × 5/16	5⅝	11¾	½	1¾	665	835
365TS			75	100			75	75	18	16¼	28	32	9	7	6⅛	21/32	18	18½	1⅞	½ × ¼	3½	9⅝	½	1¾	730	820
404T	50	60			50	60			20	16¼	32½	37	10	8	6⅛	13/16	20	20⅝	2⅜	¾ × ⅜	7	13⅜	⅝	2¼	830	1050
404TS			100	125					20	16¼	29½	34	10	8	6⅛	13/16	20	20⅝	2⅛	½ × ¼	4	10⅜	⅝	2¼	870	1050
405T	60	75			60	75			20	17¾	34	38½	10	8	6⅞	13/16	20	20⅝	2⅜	¾ × ⅜	7	13⅜	⅝	2¼	930	1160
405TS			125	150			100	100	20	17¾	31	35½	10	8	6⅞	13/16	20	20⅝	2⅛	½ × ¼	4	10⅜	⅝	2¼	950	1150
444T	75	100			75	100			22	18½	38	42½	11	9	7¼	13/16	22⅜	23⅛	3⅜	⅞ × 7/16	8¼	16	⅝	2¼	1165	1440
444TS			150	200			125	125	22	18½	34	38½	11	9	7¼	13/16	22⅜	23⅛	2⅜	⅝ × 5/16	4½	12¼	⅝	2¼	1050	1440
445T	100	125			100	125			22	20½	40	44½	11	9	8¼	13/16	22⅜	23⅛	3⅜	⅞ × 7/16	8¼	16	⅝	2¼	1370	1650
445TS			200	250			150	150	22	20½	36	41	11	9	8¼	13/16	22⅜	23⅛	2⅜	⅝ × 5/16	4½	12¼	⅝	2¼	1250	1615
447T									22	23¼	43½	48	11	9	10	13/16	22⅜	23⅛	3⅜	⅞ × 7/16	8¼	16	⅝	2¼	1800	2260
447TS									22	23¼	40½	46½	11	9	10	13/16	22⅜	23⅛	2⅜	⅝ × 5/16	4½	12¼	⅝	2¼	1800	2260
56									6½	3 ⅞	10½		3½	2 7/16	1½	11/32	6⅞		⅝	3/16 × 3/32	1⅞	4⅝	¼	1		
182	½	¾	1	1½	½	¾	1	1½	9	6½	12½	14½	4½	3¾	2¼	13/32	9	9	⅞	3/16 × 3/32	2	5	5/16	1	60	70
184	¾	1-1½	1½-2	2-3	¾	1-1½	1½-2	2-3	9	7½	13½	15½	4½	3¾	2¾	13/32	9	9	⅞	3/16 × 3/32	2	5	5/16	1	70	80
213	1-1½	2	3	5	1-1½	2	3	5	10½	7½	15½	17½	5¼	4¼	2¾	13/32	10½	10⅝	1⅛	½ × ⅛	2¾	6½	5/16	1	105	125
215	2	3	5	7½	2	3	5	7½	10½	9	17	19	5¼	4¼	3½	13/32	10½	10⅝	1⅛	½ × ⅛	2¾	6½	5/16	1	115	140
254U	3	5	7½	10	3	5	7 ½	10	12½	10¾	20½	22	6¼	5	4⅛	17/32	12⅝	13⅛	1⅜	5/16 × 5/32	3½	8	⅜	1¼	180	210
256U	5	7½	10	15	5	7½	10	15	12½	12½	22½	24	6¼	5	5	17/32	12⅝	13⅛	1⅜	5/16 × 5/32	3½	8	⅜	1¼	210	245
284U	7½	10	15	20	7½	10	15		14	12½	24	25	7	5½	4¾	17/32	14	14⅝	1⅝	⅜ × 3/16	4⅜	9⅝	⅜	1½	280	330
286U	10		20	25	10		20	20	14	14	25½	26½	7	5½	5½	17/32	14	14⅝	1⅝	⅜ × 3/16	4⅜	9⅝	⅜	1½	325	365
324U		15	25			15	25	25	16	14	26½	28	8	6 ¼	5¼	21/32	16	16¾	1⅞	½ × ¼	5⅝	10⅞	½	1¾	380	480
324S				30					16	14	24½	25½	8	6¼	5¼	21/32	16	16¾	1⅝	⅜ × 3/16	3	8½	½	1¾	380	480
326U	15	20	30		15	20	30		16	15½	28	29½	8	6¼	6	21/32	16	16¾	1⅞	½ × ¼	5⅜	10⅞	½	1¾	430	560
326S				40				30	16	15½	26	27	8	6¼	6	21/32	16	16¾	1⅝	⅜ × 3/16	3	8½	½	1¾	430	560
364U	20	25	40		20	25	40		18	15¼	29½	34	9	7	5⅝	21/32	18¼	18¾	2⅛	½ × ¼	6⅛	12¼	½	1¾	525	720
364US				50				40	18	15¼	27	31	9	7	5⅝	21/32	18¼	18¾	1⅞	½ × ¼	3/2	9⅝	½	1¾	670	710
365U	25	30			25	30			18	16¼	30½	35	9	7	6⅛	21/32	18¼	18¾	2⅛	½ × ¼	6⅛	12¼	½	1¾	580	785
365US			50	60			50	50	18	16¼	28	32	9	7	6⅛	21/32	18¼	18¾	1⅞	½ × ¼	3/2	9⅝	½	1¾	730	780
404U	30	40			30	40			20	16¼	32½	37½	10	8	6⅛	13/16	20¼	20⅞	2⅜	⅝ × 5/16	6⅞	13¾	⅝	2¼	725	965
404US			60	75					20	16¼	30	34½	10	8	6⅛	13/16	20¼	20⅞	2⅛	½ × ¼	4	10⅞	⅝	2¼	860	1075
405U	40	50			40	50			20	17¾	34	39	10	8	6⅞	13/16	20¼	20⅞	2⅜	⅝ × 5/16	6⅞	13¾	⅝	2¼	810	1110
405US			75	100			60	60	20	17¾	31½	36	10	8	6⅞	13/16	20¼	20⅞	2⅛	½ × ¼	4	10⅞	⅝	2v	970	1165
444U	50	60			50	60			22	18½	38	43	11	9	7¼	13/16	22¼	23⅛	2⅛	¾ × ⅜	8⅜	16⅛	⅝	2¼	985	1315
444US			100	125			75	75	22	18½	34	38½	11	9	7¼	13/16	22¼	23⅛	2⅛	½ × ¼	4	11¾	⅝	2¼	1175	1355
445U	60	75			60	75			22	20½	40	45	11	9	8¼	13/16	22¼	23⅛	2⅛	¾ × ⅜	8⅜	16⅛	⅝	2¼	1135	1550
445US			125	150			100	100	22	20½	36	40½	11	9	8¼	13/16	22¼	23⅛	2⅛	½ × ¼	4	11¾	⅝	2¼	1340	1620

TECH-G-4 Synchronous and Approximate Full Load Speed of Standard A.C. Induction Motors

NUMBER of POLES	60 CYCLE RPM		50 CYCLE RPM	
	SYNC.	F.L.	SYNC.	F.L.
2	3600	3500	3000	2900
4	1800	1770	1500	1450
6	1200	1170	1000	960
8	900	870	750	720
10	720	690	600	575
12	600	575	500	480
14	515	490	429	410
16	450	430	375	360
18	400	380	333	319
20	360	340	300	285
22	327	310	273	260
24	300	285	240	230
26	277	265	231	222
28	257	245	214	205
30	240	230	200	192

TECH-G-5 Full Load Amperes at Motor Terminals * Average Values for All Speeds and Frequencies

MOTOR HP	SINGLE-PHASE A-C		THREE PHASE A-C INDUCTION TYPE SQUIRREL CAGE & WOUND ROTOR			DIRECT CURRENT	
	115 VOLTS	230 VOLTS **	230 VOLTS **	460 VOLTS	575 VOLTS	120 VOLTS	240 VOLTS
½	9.8	4.9	2.0	1.0	.8	5.2	2.6
¾	13.8	6.9	2.8	1.4	1.1	7.4	3.7
1	16	8	3.6	1.8	1.4	9.4	4.7
1½	20	10	5.2	2.6	2.1	13.2	6.6
2	24	12	6.8	3.4	2.7	17	8.5
3	34	17	9.6	4.8	3.9	25	12.2
5	56	28	15.2	7.6	6.1	40	20
7½	80	40	22	11	9	58	29
10	100	50	28	14	11	76	29
15			42	21	17	112	55
20			54	27	22	148	72
25			68	34	27	184	89
30			80	40	32	220	106
40			104	52	41	292	140
50			130	65	52	360	173
60			154	77	62	430	206
75			192	96	77	536	255
100			240	120	96		350
125			296	148	118		440
150			350	175	140		530
200			456	228	182		710
250			558	279	223		

* These values for full-load current are for running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, in which case the nameplate current rating should be used.
** For full-load currents of 208 and 200 volt motors, increase the corresponding 230 volt motor full-load current by 10 and 15 percent respectively.

TECH-G-6 Motor Terms

AMPERE: a unit of intensity of electric current being produced in a conductor by the applied voltage.

FREQUENCY: the number of complete cycles per second of alternating current, e.g., 60 Hertz.

HORSEPOWER: the rate at which work is done. It is the result of the work done (stated in foot-pounds) divided by the time involved.

INERTIA: the property of physical matter to remain at rest unless acted on by some external force. Inertia usually concerns the driven load.

MOTOR EFFICIENCY: a measure of how effectively the motor turns electrical energy into mechanical energy. Motor efficiency is never 100% and is normally in the neighborhood of 85%.

POWER FACTOR: the ratio of the true power to the volt-amperes in an alternating current circuit or apparatus.

SERVICE FACTOR: a safety factor in some motors which allows the motor, when necessary, to deliver greater than rated horsepower.

SYNCHRONOUS SPEED & SLIP: the speed of an a-c motor at which the motor would operate if the rotor turned at the exact speed of the rotating magnetic field. However, in a-c induction motors, the rotor actually turns slightly slower. This difference is defined as slip and is expressed in percent of synchronous speed. Most induction motors have a slip of 1-3%.

TORQUE: that force which tends to produce torsion or rotation. In motors, it is considered to be the amount of force produced to turn the load, it is measured in lb.-ft.

VOLTAGE: a unit of electro-motive force. It is a force which, when applied to a conductor, will produce a current in the conductor.

APPROXIMATE RULES OF THUMB		MECHANICAL FORMULAS
At 1800 rpm, a motor develops 3 lb.- ft per hp.	At 230 volts, a single- phase motor draws 2.5 amp per hp.	Torque in lb-ft = $\frac{HP \times 5250}{RPM}$
At 1200 rpm, a motor develops 4.5 lb-ft per hp.	At 230 volts, a single- phase motor draws 5 amp per hp.	Hp= $\frac{Torque \times RPM}{5250}$
At 575 volts, a 3-phase motor draws 1 amp per hp.	At 115 volts, a single- phase motor draws 10 amp per hp	RPM = $\frac{120 \times Frequency}{No.\ of\ poles}$
At 460 volts, a 3-phase motor draws 1.25 amp per hp.		

	Average Efficiencies and Power Factors of Electric Motors						
	Efficiency %			Power Factor			Full Load Amps on 3ph 415V
kW	Full Load	¾ Load	½ Load	Full Load	¾ Load	½ Load	
0.75	74	73	69	0.72	0.65	0.53	2.0
1.5	79	78.5	76	0.83	0.78	0.69	3.2
3	82.5	82	80.5	0.85	0.80	0.73	6.0
5.5	84.5	84.5	83.5	0.87	0.82	0.75	10.5
7.5	85.5	85.5	84.5	0.87	0.83	0.76	14
11	87	87	85.5	0.88	0.84	0.77	20
18.5	88.5	88.5	87	0.89	0.85	0.79	33
30	90	89.5	88	0.89	0.86	0.80	52
45	91	90.5	89	0.89	0.86	0.80	77
75	92	91.5	90	0.90	0.87	0.81	126

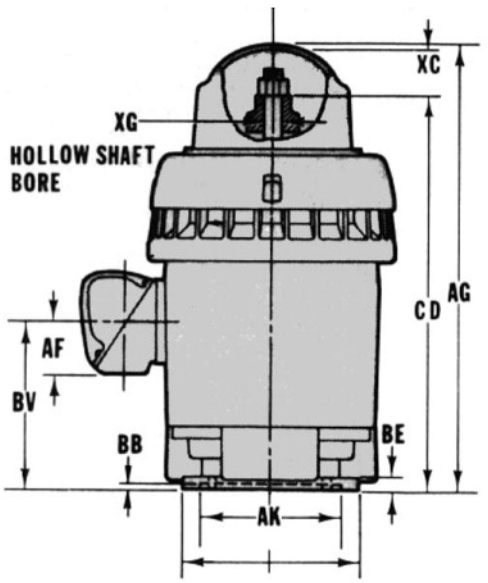
Required Value	Direct Current	Single Phases	Two-Phase 4-Wire	Three Phase
HP Output	$\frac{I \times E \times Eff}{746}$	$\frac{I \times E \times Eff \times PF}{746}$	$\frac{I \times E \times 2 \times Eff \times Pf}{746}$	$\frac{I \times E \times 1.73 \times Eff \times PF}{746}$

TECH-G-7 Electrical Conversion Formulae

TO FIND	DIRECT CURRENT	ALTERNATING CURRENT	
		Single Phase	Three Phase
Amperes when horsepower (input) is known	$\frac{HP \times 746}{E \times Efff}$	$\frac{HP \times 746}{E \times Eff \times P.F.}$	$\frac{HP \times 746}{1.73 \times E \times Eff \times P.F.}$
Amperes when kilowatts is known	$\frac{kW \times 1000}{E}$	$\frac{kW \times 1000}{E \times P.F.}$	$\frac{kW \times 1000}{1.73 \times E \times P.F.}$
Amperes when kva is known		$\frac{kva \times 1000}{E}$	$\frac{kvax\ 1000}{1.73 \times E}$
Kilowatts	$\frac{I \times E}{1000}$	$\frac{I \times E \times P.F.}{1000}$	$\frac{1.73 \times I \times E \times P.F.}{1000}$
Kva		$\frac{I \times E}{1000}$	$\frac{1.73 \times I \times E}{1000}$
P.F.		$\frac{KW}{Kva}$	$\frac{KW}{Kva}$
Horespower (output)	$\frac{I \times E \times Eff}{746}$	$\frac{I \times E \times Eff \times P.F.}{746}$	$\frac{1.73 \times I \times E \times Eff \times P.F.}{746}$

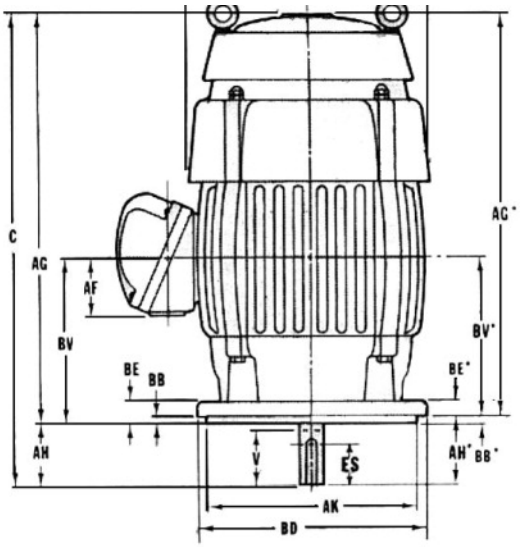
	I = Amperes		Eff= Effiency (decimal)	Kva = Kilovolt- amperes
	E = Volts		P.F = Power Factor	kW = Kilowatts
	HP= Horsepower			

TECH-G-8 Vertical Motors



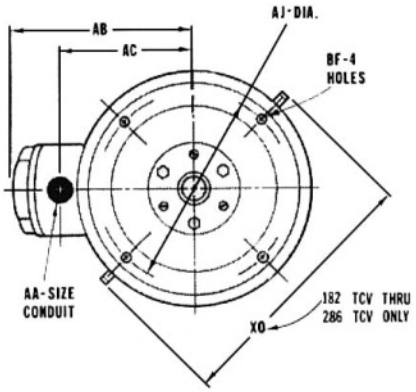
VHS VERTICAL HOLLOWSHAFT

Pump shaft thru motor and coupled below motor with impeller adjustment made at top of motor.

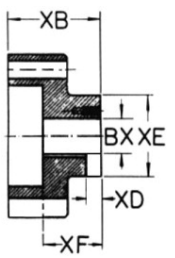


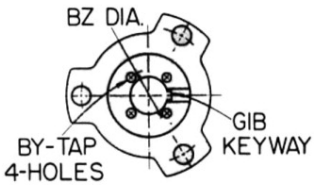
VHS VERTICAL SOLID SHAFT

Pump shaft coupled to shaft extension below motor.Impeller adjustment at coupling



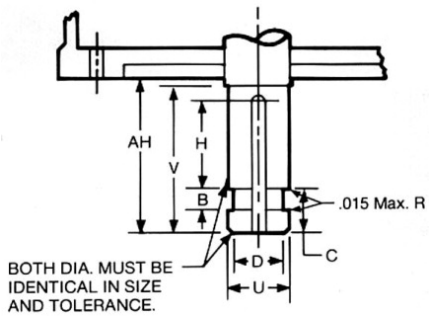
The following dimensions may vary upon vendor selection and design: XC, CD, AG, AF, BV, C.





DIMENSIONS				
Top Shaft Dia.	BX Bore	BZ Dia. BC	SQ Key Size	BY Tap Size
3/4	0.751	1 3/8	3/16	10-32
1	1.001	3/8	1/4	10-32
1 3/16	1.188	1 3/4	1/4	1/4 - 20
1 1/2	1.501	2 1/8	3/8	1/4 - 20
1 15/16	1.938	2 1/2	1/2	1/4 - 20
2 3/16	2.188	3 1/4	1/2	3/8 - 16

VERTICAL HOLLOWSHAFT
NEMA dimensions for common top drive coupling sizes.
NEMA SOLID SHAFT
NEMA DIMENSIONS FOR COMMON SOLID SHAFT EXTENSION SIZES.



DIMENSIONS								
Motor Shaft Dia. U	AH	V	H	B	C	D	Nominal Keyway	Pump Shaft Diameters
7/8	2 3/4	2 3/4	5/8	3/8	3/4	11/16	3/16 × 3/22	7/8
1 1/8	2 3/4	2 3/4	1	3/8	3/4	15/16	1/4 × 1/8	7/8, 1
1 5/8	4 1/2	4 1/4	2 5/8	3/8	3/4	1 1/4	3/8 × 3/16	7/8, 1, 1 3/16, 1 1/2
2 1/8	4 1/2	4 1/4	2 5/8	3/8	3/4	1 3/4	1/2 × 1/4	1, 1 3/16, 1 1/2, 1 15/16
2 5/8	5	5	3 1/2	3/8	3/4	2 1/4	5/8 × 5/16	2 3/16
2 7/8	7	6 1/2	5	1/2	1	2 3/8	3/4 × 3/8	2 3/16, 2 11/16
3 1/8	7	7	4 3/4	3/4	1 1/2	2 5/8	3/4 × 3/8	2 3/16, 11/16, 2 15/16

HEADSHAFT COUPLINGS

WITH VERTICAL HOLLOWSHAFT MOTOR:
Impeller adjustment made on adjusting nut above motor (under motor canopy and bolted to top drive coupling).

1 Sleeve type (lineshaft) coupling.

2 Rigid flanged coupling (Type AR).

3 No coupling-straight shaft
(not recommended due to difficult Installation/disassembly of head and motor).

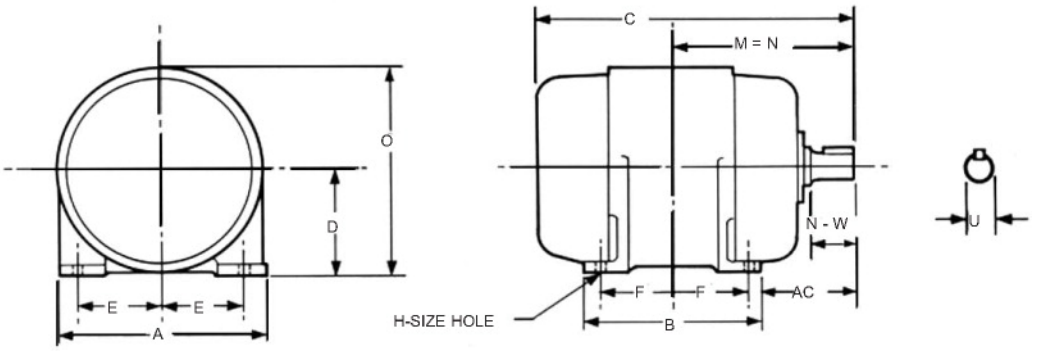
WITH VERTICAL SOLID SHAFT MOTOR:
Impeller adjustment made on adjusting plate of coupling without removal of motor canopy. (VSS motors also provide a lesser tolerance of shaft run-out which coincides with mechanical seal recommendations).

1 Adjustable coupling (Type A).

2 Adjustable spacer coupling
(Type AS-recommended for applications with mechanical seals. The mechanical seal can be removed without disengaging motor).

TECH-G-9 I.E.C. Motor Frames

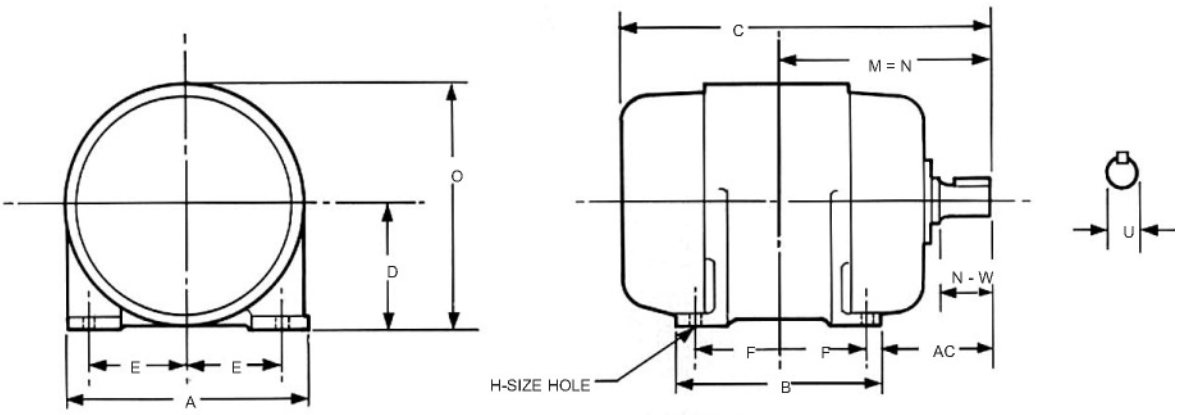
IPP44 TOTALLY ENCLOSED & FLAMEPROOF
(Similar to NEMA TEFC & Explosion Proof)



DIMENSIONS																
I.E.C. Frames	Poles	Units	A Max.	B Max.	C Approx.	D	E	F	H	M & N	O Approx.	U Nominal Tolerance		N & W	AC	Weight Approx.
D80-19	All	mm	157	130	245	80	63	50	10	140	185	19	j6	40	90	10 kg
E80-19		Inches	6⅛	5⅛	10	3.15	2½	2	⅜	5½	7¼	7890		1½	3½	20 Lbs
D90S24	"	mm	180	130	300	90	70	50	10	156	210	24	j6	50	106	20 kg.
E900S24		Inches	7	5⅛	10	3.54	2¾	2	⅜	$6\frac{3}{16}$	8¼	9459		2	$4\frac{3}{16}$	45 kg.
D90L24	"	mm	180	155	320	90	70	63	10	169	210	24	j6	50	106	22 kg.
E90L24		Inches	7	6⅛	12½	3.54	2¾	21½	⅜	$6\frac{11}{16}$	8¼	.9499		2	$4\frac{3}{16}$	50 Lbs.
D100L28	"	mm	205	180	380	100	80	70	12	193	230	28	j6	60	123	30 kg.
E100L28		Inches	8	7	15	3.94	3⅛	2¾	$\frac{15}{32}$	7⅝	9	1.1024		2⅜	4⅞	65 Lbs.
D112M28	"	mm	240	185	380	112	95	70	12	200	250	28	j6	60	130	44 kg.
E112M28		Inches	9½	7¼	15	4.41	3¾	2¾	$\frac{15}{32}$	7⅞	10	1.1024		2⅜	5⅛	100 Lbs
D132S38	"	mm	266	185	440	132	108	70	12	239	290	38	k6	80	169	65 kg.
E132S38		Inches	10½	7¼	17½	5.20	4¼	2¾	$\frac{15}{32}$	9⅜	11½	1.4961		3⅛	6⅝	145 Lbs
D132M38	"	mm	266	225	480	132	108	89	12	258	290	38	k6	80	169	90 kg.
E132M38		inches	10½	8¾	19	5.20	4¼	3½	$\frac{15}{32}$	10⅛	11½	1.4961		3⅛	6⅝	100 Lbs.
D160M42	"	mm	318	267	580	160	127	105	15	323	360	42	k6	110	218	120 kg.
E160M42		Inches	12½	10½	23	6.30	5	4⅛	$\frac{19}{32}$	12¾	14	1.6539		4⅜	8⅝	265 Lbs.
D160L42	"	mm	318	311	620	160	127	127	15	345	360	42	k6	110	218	150 kg.
E160L42		Inches	12½	12¼	24½	6.30	5	5	$\frac{19}{32}$	13⅝	14	1.6539		4⅜	8⅝	330 Lbs
D180M48	"	mm	356	300	650	180	140	121	15	352	400	48	k6	110	231	175 kg.
E180M48		Inches	14	11¾	25½	7.09	5½	4¾	$\frac{19}{32}$	13⅞	15¾	1.8898		4⅜	9⅛	385 Lbs.
D180L48	"	mm	356	340	685	180	140	140	15	371	400	48	k6	110	231	190 kg.
E180L48		Inches	14	13⅜	27	7.09	5½	5½	$\frac{19}{32}$	14⅝	15¾	1.8898		4⅜	9⅛	420 Lbs.
D200L55	"	mm	400	368	760	200	159	153	19	396	440	55	m6	110	243	255 kg.
E200L55		Inches	15¾	14½	30	7.87	6¼	6	¾	15½	17½	2.1654		4⅜	9½	560 Lbs.
D225S55	2	mm	457	370	810	225	178	143	19	402	490	55	m6	110	259	290 kg.
E225S55		Inches	18	14½	32	8.86	7	5⅝	¾	15⅞	19¼	2.1654		4⅜	10¼	640 Lbs
D225M60	4 to 8	mm	457	395	835	225	178	156	19	445	490	60	m6	140	289	350 kg
E225M60		Inches	18	15½	33	8.86	7	6⅛	¾	17½	19¼	2.3622		5½	11⅜	770 Lbs.
D250M60	2	mm	508	426	925	250	203	175	24	483	550	60	m6	140	308	440 kg.
E250M60		Inches	20	16¾	36½	9.84	8	6⅞	$\frac{15}{16}$	19	21⅝	2.3622		5½	12⅛	970 Lbs.
D250M65	4 to 8	mm	508	426	925	250	203	175	24	483	550	65	m6	140	308	440 kg.
E250M65		Inches	20	16¾	36½	9.84	8	6⅞	$\frac{15}{16}$	19	21⅝	2.5591		5½	12⅛	970 Lbs.
D280S65	2	mm	570	470	1000	280	229	184	24	514	630	65	m6	140	330	615 kg
E280S65		Inches	22½	18½	39½	11.02	9	7¼	$\frac{15}{16}$	20¼	24¾	2.5591		5½	13	1355 Lbs.
D280S75	4 to 8	mm	570	470	1000	280	229	184	24	514	630	75	m6	140	330	615 kg.
E280S75		Inches	22½	18½	39½	11.02	9	7¼	$\frac{15}{16}$	20¼	24¾	2.9528		5½	13	1355 Lbs.
D280M65	2	mm	570	520	1060	280	229	210	24	540	630	65	m6	140	330	675 kg.
E280M65		Inches	22½	20½	42	11.02	9	8¼	$\frac{15}{16}$	21¼	24¾	2.5591		5½	13	1500 Lbs.
D280M75	4 to 8	mm	570	520	1060	280	229	210	24	540	630	75	m6	140	330	675 kg.
E280M75		Inches	22½	20½	42	11.02	9	8¼	$\frac{15}{16}$	21¼	24¾	2.9528		5½	113	1500 Lbs.
D315S65	2	mm	635	520	1140	315	254	203	28	559	725	65	m6	140	356	800 kg.
E315S65		Inches	25	20½	45	12.41	10	8	$1\frac{3}{32}$	22	28½	2.5591		5½	14	1760 Lbs.
D315S80	4 to 8	mm	635	520	1140	315	254	203	28	589	725	80	m6	170	386	800 kg.
E315S80		Inches	25	20½	45	12.41	10	8	$1\frac{3}{32}$	23¼	28½	3.1945		611/16	15¼	1760 Lbs
D315S80	2	mm	635	570	1190	315	254	229	28	585	725	65	m6	140	356	900 kg.
E315M65		Inches	25	22½	47	12.41	10	9	$1\frac{3}{32}$	23	28½	2.5591		5½	14	1985 Lbs.
D315M80	4 to 8	mm	635	570	1190	315	254	229	28	615	725	80	m6	170	386	900 kg.
E315M80		Inches	25	22½	47	12.41	10	9	$1\frac{3}{32}$	24¼	28½	3.1495		$6\frac{11}{16}$	15¼	1985 Lbs.

I.E.C. Motor Frames (cont'd)

IP23 ENCLOSED VENTILATED
(Similar to NEMA Open Drip Proof)



DIMENSIONS																
I.E.C. Frames	Poles	Units	A Max.	B Max.	C Approx.	D	E	F	H	M & N	O Approx.	U Nominal Tolerance		N & W	AC	Weight Approx.
C160M48	All	mm	318	267	700	160	127	105	15	323	330	48	k6	110	218	120 kg
		inches	12½	10½	27½	6.30	5	4⅛	19/32	12¾	13	1.8898		4⅜	8⅝	265 Lbs.
C160L48	All	mm	318	311	750	160	127	127	15	345	330	48	k6	110	218	150 kg
		inches	12½	12¼	29½	6.30	5	5	19/32	13⅝	13	1.8898		4⅜	8⅝	330 Lbs.
C180M55	All	mm	356	300	770	180	140	121	15	352	370	55	m6	110	231	200 kg
		inches	14	11¾	30¼	7.09	5½	4¾	19/32	13⅞	14½	2.1654		4⅜	9⅛	440 Lbs.
C180L55	All	mm	356	340	810	180	140	140	15	371	370	55	m6	110	231	210 kg
		inches	14	13⅜	31⅞	7.09	5½	5½	19/32	14⅝	14½	2.1654		4⅜	9⅛	465 Lbs.
C200M60	All	mm	400	326	870	200	159	133	19	406	410	60	m6	140	273	270 kg
		inches	15¾	12⅞	34¼	7.87	6¼	5¼	¾	16	16	2.3622		5½	10¾	595 Lbs.
C200L60	All	mm	400	368	900	200	159	152	19	425	410	60	m6	140	273	285 kg
		inches	15¾	14½	35½	7.87	6¼	6	¾	16¾	16	2.3622		5½	10¾	630 Lbs.
C225M60	2	mm	457	395	970	225	178	156	19	445	490	60	m6	140	289	350 kg
		inches	18	15½	38	8.86	7	6⅛	¾	17½	19¼	2.3622		5½	11⅜	770 Lbs.
C225M65	4 to 8	mm	457	395	970	225	178	156	19	445	490	65	m6	140	289	350 kg
		inches	18	15½	38	8.86	7	6⅛	¾	17½	19¼	2.5591		5½	11⅜	770 Lbs.
C250S65	2	mm	508	388	1100	250	203	154	24	464	550	65	m6	140	308	450 kg
		inches	20	15¼	43¼	9.84	8	6⅛	15/16	18¼	21⅝	2.5591		5½	12⅛	990 Lbs.
C250S75	4 to 8	mm	508	388	1100	250	203	154	24	464	550	75	m6	140	308	450 kg
		inches	20	15¼	43¼	9.84	8	6⅛	15/16	18¼	21 5/6	2.9528		5½	12⅛	990 Lbs.
C250M65	2	mm	508	426	1140	250	203	175	24	483	550	65	m6	140	308	500 kg
		inches	20	16¾	44⅞	9.84	8	6⅞	15/16	19	21⅝	2.5591		5½	12⅛	1100 Lbs.
C250M75	4 to 8	mm	508	426	1140	250	203	175	24	483	550	75	m6	140	308	500 kg
		inches	20	16¾	44⅞	9.84	8	6⅞	15/16	19	21⅝	2.9528		5½	12⅛	1100 Lbs.
C280S65	2	mm	570	470	1265	280	229	184	24	514	630	65	m6	140	330	650 kg
		inches	22½	18½	49¾	11.02	9	7¼	15/16	20¼	24¾	2.5591		5½	13	1435 Lbs.
C280S80	4 to 8	mm	570	470	1265	280	229	184	24	544	630	80	m6	170	360	650 kg
		inches	22½	18½	49¾	11.02	9	7¼	15/16	21 7/16	24¾	3.1496		6 11/16	14 3/16	1435 Lbs.
C280M65	2	mm	570	520	1315	280	229	210	24	540	630	65	m6	140	330	700 kg
		inches	22 ½	20½	51¾	11.02	9	8¼	15/16	21¼	24¾	2.5591		5½	13	1545 Lbs.
C280M80	4 to 8	mm	570	520	1315	280	229	210	24	570	630	80	m6	170	360	700 kg
		inches	22½	20½	51¾	11.02	9	8¼	15/16	22 7/16	24¾	3.1496		6 11/16	14 3/16	1545 Lbs.
C315S70	2	mm	635	520	1475	315	254	203	28	559	725	70	m6	140	356	850 kg
		inches	25	20½	58	12.40	10	8	1 3/32	22	28½	2.7559		5½	14	1875 Lbs.
C315S90	4 to 8	mm	635	520	1475	315	254	203	28	589	725	90	m6	170	386	850 kg
		inches	25	20½	58	12.40	10	8	1 3/32	23¼	28½	3.5433		6 11/16	15¼	1875 Lbs.
C315M7C	2	mm	635	570	1525	315	254	229	28	585	725	70	m6	140	356	950 kg
		inches	25	22½	60	12.40	10	9	1 3/32	23	28½	2.7559		5½	14	2100 Lbs.
C315M90	4 to 8	mm	635	570	1525	315	254	229	28	615	725	90	m6	170	386	950 kg
		inches	25	22½	60	12.40	10	9	1 3/32	24¼	28½	3.5433		6 11/16	15¼	2100 Lbs.

TECH-G-10 TEFC IP55 Metric IEC Motors (Conversion NEMA to Metric)

HP	kW	RPM	FRAME	NEMA Equivalent Frame
1	.75	3000	80	56
1	.75	1500	80	56
1	.75	1000	90S	143T
1.5	1.1	3000	80	56
1.5	1.1	1500	90S	143T
1.5	1.1	1000	90L	145T
2	1.5	3000	90S	143T
2	1.5	1500	90L	145T
2	1.5	1000	100L	182T
3	2.2	3000	90L	145T
3	2.2	1500	100L	182T
3	2.2	1000	112M	184T
4	3.0	3000	100L	182T
4	3.0	1500	100L	182T
4	3.0	1000	132S	213T
5.5	4.0	3000	112M	184T
5.5	4.0	1500	112M	184T
5.5	4.0	1000	132M	215T
7.5	5.5	3000	132S	213T
7.5	5.5	1500	132S	213T
7.5	5.5	1000	132M	215T
10	7.5	3000	132S	213T
10	7.5	1500	132M	215T
10	7.5	1000	160M	254T
15	11	3000	160M	254T
15	11	1500	160M	254T
15	11	1000	160L	256T
20	15	3000	160M	254T
20	15	1500	160L	256T
20	15	1000	180L	284T
25	18.5	3000	160L	256T
25	18.5	1500	180M	284T
25	18.5	1000	200L	326T
30	22	3000	180M	284T
30	22	1500	180L	286T
30	22	1000	200L	326T
40	30	3000	200L	326T
40	30	1500	200L	326T
40	30	1000	225M	365T
50	37	3000	200L	326T
50	37	1500	225S	364T
50	37	1000	250S	404T
60	45	3000	225M	354T
60	45	1500	225M	365T
60	45	1000	250M	405T
75	55	3000	250S	404T
75	55	1500	250S	404T
75	55	1000	280S	444T
100	75	3000	250M	405T
100	75	1500	250M	405T
100	75	1000	280M	445T
125	90	3000	280S	444T
125	90	1500	280S	444T
125	90	1000	315S	504Z
150	110	3000	280M	445T
150	110	1500	280M	445T
150	110	1000	315M	505Z

TECH-H-1 Temperature Conversion Chart (Centigrade (Celsius)-Fahrenheit)

C	F	C	F	C	F	C	F	C	F	C	F
-40	-40.0	+5	+41.0	+40	+104.0	+175	+347	+350	+662	+750	+1382
-38	-36.4	6	42.8	41	105.8	180	356	355	671	800	1472
-36	-32.8	7	44.6	42	107.6	185	365	360	680	850	1562
-34	-29.2	8	46.4	43	109.4	190	374	365	689	900	1652
-32	-25.6	9	48.2	44	111.2	195	383	370	698	950	1742
-30	-22.0	10	50.0	45	113.0	200	392	375	707	1000	1832
-28	-18.4	11	51.8	46	114.8	205	401	380	716	1050	1922
-26	-14.8	12	53.6	47	116.6	210	410	385	725	1100	2012
-24	11.2	13	55.4	48	118.4	215	419	390	734	1150	2102
-22	-7.6	14	57.2	49	120.2	220	428	395	743	1200	2192
-20	-4.0	15	59.0	50	122.0	225	437	400	752	1250	2282
-19	-2.2	16	60.8	55	131.0	230	446	405	761	1300	2372
-18	-0.4	17	62.6	60	140.0	235	455	410	770	1350	2462
-17	+1.4	18	64.4	65	149.0	240	464	415	779	1400	2552
-16	3.2	19	66.2	70	158.0	245	473	420	788	1450	2642
-15	5.0	20	68.0	75	167.0	250	482	425	797	1500	2732
-14	6.8	21	69.8	80	176.0	255	491	430	806	1550	2822
-13	8.6	22	71.6	85	185.0	260	500	435	815	1600	2912
-12	10.4	23	73.4	90	194.0	265	509	440	824	1650	3002
-11	12.2	24	75.2	95	203.0	270	518	445	833	1700	3092
-10	14.0	25	77.0	100	212.0	275	527	450	842	1750	3182
-9	15.8	26	78.8	105	221.0	280	536	455	851	1800	3272
-8	17.6	27	80.6	110	230.0	285	545	460	860	1850	3362
-7	19.4	28	82.4	115	239.0	290	554	465	869	1900	3452
-6	21.2	29	84.2	120	248.0	295	563	470	878	1950	3542
-5	23.0	30	86.0	125	257.0	300	572	475	887	2000	3632
-4	24.8	31	87.8	130	266.0	305	581	480	896	2050	3722
-3	26.6	32	89.6	135	275.0	310	590	485	905	2100	3812
-2	28.4	33	91.4	140	284.0	315	599	490	914	2150	3902
-1	30.2	34	93.2	145	293.0	320	608	495	923	2200	3992
0	32.0	35	95.0	150	302.0	325	617	500	932	2250	4082
+1	33.8	36	96.8	155	311.0	330	626	550	1022	2300	4172
2	35.6	37	98.6	160	320.0	335	635	600	1112	2350	4262
3	47.4	38	100.4	165	329.0	340	644	650	1202	2400	4352
4	39.2	39	102.2	170	338.0	345	653	700	1292	2450	4442

$$\text{Degrees Celsius} = \frac{(\text{Degrees Fahrenheit} - 32) \times 5}{9}$$

$$\text{Degrees Fahrenheit} = \frac{(\text{Degrees Celsius} \times 9) + 32}{5}$$

Degrees Kelvin (K) = Degrees Celsius + 273.15

Degrees Rankine (R) = Degrees Fahrenheit + 459.69

(0 degrees K or R = absolute zero)

TECH-H-2 A.P.I. and Baumé Gravity Tables and Weight Factors

A.P.I Gravity	Baumé Gravity	Specific Gravity	Lbs. Per U.S. Gal.	U.S. Gals. per Lb.
0	10.247	1.0760	8.962	0.1116
1	9.223	1.0679	8.895	0.1124
2	8.198	1.0599	8.828	0.1133
3	7.173	1.0520	8.762	0.1141
4	6.148	1.0443	8.698	0.1150
5	5.124	1.0366	8.634	0.1158
6	4.099	1.0291	8.571	0.1167
7	3.074	1.0217	8.509	0.1175
8	2.049	1.0143	8.448	0.1184
9	1.025	1.0071	8.388	0.1192
10	10.00	1.0000	8.328	0.1201
11	10.99	0.9930	8.270	0.1209
12	11.98	0.9861	8.212	0.1218
13	12.97	0.9792	8.155	0.1226
14	13.96	0.9725	8.099	0.1235
15	14.95	9.9659	8.044	0.1243
16	15.94	0.9593	7.989	0.1252
17	16.93	0.9529	7.935	0.1260
18	17.92	0.9465	7.882	0.1269
19	18.90	0.9402	7.830	0.1277
20	19.89	0.9340	7.778	0.1286
21	20.88	0.9279	7.727	0.1294
22	21.87	0.9218	7.676	0.1303
23	22.86	0.9159	7.627	0.1311
24	23.85	0.9100	7.578	0.1320
25	24.84	0.9024	7.529	0.1328
26	25.83	0.8984	7.481	0.1337
27	26.82	0.8927	7.434	0.1345
28	27.81	0.8871	7.387	0.1354
29	28.80	0.8816	7.341	0.1362
30	29.79	0.8762	7.296	0.1371
31	30.78	0.8708	7.251	0.1379
32	31.77	0.8654	7.206	0.1388
33	32.76	0.8602	7.163	0.1396
34	33.75	0.8850	7.119	0.1405
35	34.73	0.8498	7.076	0.1413
36	35.72	0.8448	7.034	0.1422
37	36.71	0.8398	6.993	0.1430
38	37.70	0.8348	6.951	0.1439
39	38.69	0.8299	6.910	0.1447
40	39.68	0.8251	6.870	0.1456
41	40.67	0.8203	6.830	0.1464
42	41.66	0.8155	6.790	0.1473
43	42.65	0.8109	6.752	0.1481
44	43.64	0.8063	6.713	0.1490
45	44.63	0.8017	6.675	0.1498
46	45.62	0.7972	6.637	0.1507
47	50.61	0.7927	6.600	0.1515
48	50.60	0.7883	6.563	0.1524
49	50.59	0.7839	6.526	0.1532
50	50.58	0.7796	6.490	0.1541

A.P.I Gravity	Baumé Gravity	Specific Gravity	Lbs. Per U.S. Gal.	U.S. Gals. per Lb.
51	50.57	0.7753	6.455	0.1549
52	51.55	0.7711	6.420	0.1558
53	52.54	0.7669	6.385	0.1566
54	53.53	0.7628	6.350	0.1575
55	54.52	0.7587	6.316	0.1583
56	55.51	0.7547	6.283	0.1592
57	56.50	0.7507	6.249	0.1600
58	57.49	0.7467	6.216	0.1609
59	58.48	0.7428	6.184	0.1617
60	59.47	0.7389	6.151	0.1626
61	60.46	0.7351	6.119	0.1634
62	61.45	0.7313	6.087	0.1643
63	62.44	0.7275	6.056	0.1651
64	63.43	0.7238	6.025	0.1660
65	64.42	0.7201	5.994	0.1668
66	65.41	0.7165	5.964	0.1677
67	66.40	0.7128	5.934	0.1685
68	67.39	0.7093	5.904	0.1694
69	68.37	0.7057	5.874	0.1702
70	69.36	0.7022	5.845	0.1711
71	70.35	0.6988	5.817	0.1719
72	71.34	0.6953	5.788	0.1728
73	72.33	0.6919	5.759	0.1736
74	73.32	0.6886	5.731	0.1745
75	74.31	0.6852	5.703	0.1753
76	75.30	0.6819	5.676	0.1762
77	76.29	0.6787	5.649	0.1770
78	77.28	0.6754	5.622	0.1779
79	78.27	0.6722	5.595	0.1787
80	79.26	0.6690	5.568	0.1796
81	80.25	0.6659	5.542	0.1804
82	81.24	0.6628	5.516	0.1813
83	82.23	0.6597	5.491	0.1821
84	83.22	0.6566	5.465	0.1830
85	84.20	0.6536	5.440	0.1838
86	85.19	0.6506	5.415	0.1847
87	86.18	0.6476	5.390	0.1855
88	87.17	0.6446	5.365	0.1864
89	88.16	0.6417	5.341	0.1872
90	89.15	0.6388	5.316	0.1881
91	90.14	0.6360	5.293	0.1889
92	91.13	0.6331	5.269	0.1898
93	92.12	0.6303	5.246	0.1906
94	93.11	0.6275	5.222	0.1915
95	94.10	0.6247	5.199	0.1924
96	95.09	0.6220	5.176	0.1932
97	96.08	0.6193	5.154	0.1940
98	97.07	0.6166	5.131	0.1949
99	98.06	0.6139	5.109	0.1957
100	99.05	0.6112	5.086	0.1966

The relation of Degrees Baumé or A.P.I. to Specific Gravity is expressed by the following formulas:

For liquids lighter than water:

$$\text{Degrees Baumé} = \frac{140}{G} - 130, \qquad G = \frac{140}{130 + \text{Degrees Baumé}}$$

$$\text{Degrees A.P.I.} = \frac{141.5}{G} - 131.5, \qquad G = \frac{141.5}{131.5 + \text{Degrees A.P.I.}}$$

For liquids heavier than water:

$$\text{Degrees Baumé} = 145 - \frac{145}{G}, \qquad G = \frac{145}{145 - \text{Degrees Baumé}}$$

G = Specific Gravity = ratio of the weight of a given volume of oil at 60° Fahrenheit to the weight of the same volume of water at 60° Fahrenheit.

The above tables are based on the weight of 1 gallon (U.S.) of oil with a volume of 231 cubic inches at 60° Fahrenheit in air at 760 m.m. pressure and 50% humidity. Assumed weight of 1 gallon of water at 60° Fahrenheit in air is 8.32828 pounds.

To determine the resulting gravity by missing oils of different gravities:

$$D = \frac{md_1 - nd_2}{m + n}$$

D = Density or Specific Gravity of mixture

m = Proportion of oil of d_1 density

n = Proportion of oil of d_2 density

d_1 = Specific Gravity of m oil

d_2 = Specific Gravity of n oil

TECH-H-3 Approximate Conversion Table for Hardness Numbers Obtained by Different Methods *

Brinell Number 10 mm. Ball 3000 Kg. Load	Rockwell Number		Shore Scieroscope Number	Vickers Pyramid Number
	C-Scale	B-Scale		
682	61.7		84	737
653	60		81	697
633	59		79	674
614	58		78	654
596	57		77	636
578	56		75	615
560	55		73	596
543	54		72	578
527	53		71	561
500	52		69	544
475	50		67	513
451	48		64	484
432	46		62	458
409	44		58	434
390	42		56	412
371	40		54	392
353	38		51	372
336	36		49	354
319	34		47	336
301	32		44	318
286	30		42	302
271	28		41	286
258	26		38	272
247	24		37	260
237	22	99	35	248
226	20	98	34	238
212	16	95	32	222
194	12	92	29	204
179	8	89	27	188
158	2	83	24	166
141		77	21	141
125		70	18	125
110		62		110
99		55		99
89		47		89

* Compiled from various manufacturers' tables.

TECH-H-4 Conversion Factors

English measures - unless otherwise designated, are those used in the United States, and the units of weight and mass are avoirdupois units.

Gallon - designates the U.S. gallon. To convert into the Imperial gallon, multiply the U.S. gallon by 0.83267. Likewise, the word ton designates a short ton — 2,000 pounds.

Properties of water - it freezes at 32°F., and is at its maximum density at 39.2° F. In the multipliers using the properties of water, calculations are based on water at 39.2° F. in a vacuum, weighing 62.427 pounds per cubic foot, or 8.345 pounds per U.S. gallon.

Multiply	By	To Obtain
Acres	43,560	Square feet
Acres	4047	Square meters
Acres	1.562×10^{-3}	Square miles
Acres	4840	Square yards
Acre-feet	43,560	Cubic feet
Acre-feet	325,851	Gallons
Acre-feet	1233,48	Cubic Meters
Atmospheres	1.0332	Atmospheres (metric)
Atmospheres	1.01325	Bars
Atmospheres	76.0	Cms. of mercury
Atmospheres	29.92	Inches of mercury

Multiply	By	To Obtain
Atmospheres	33.90	Feet of water
Atmospheres	10,332	kgs/sq. ft
Atmospheres	14.70	Lbs./ sq. inch
Atmospheres	1.058	Tons/sq. ft.
Atmospheres (metric)	0.9678	Atmospheres
Atmospheres (metric)	980,665.	Bars
Bars	.98692	Atmospheres
Bars	33.456	Feet H^2O @39°F.
Bars	29.530	In. Hg @ 32° F.
Bars	1.0197	kg/cm^2
Bars	2088.6	Pounds/ $ft.^2$

Multiply	By	To Obtain
Bars	14.504	Pounds/in.^{2}
Barrels- oil	42	Gallons- oil
Barrels- beer	31	Gallons- beer
Barrels- whiskey	45	Gallons- whiskey
Barrels/day- oil	0.02917	Gallons/min.- oil
Bags or sacks-cement	94	Pounds/cement
Board feet	144 sq. in. × 1 in.	Cubic inches
British Thermal Units	0.2520	Kilogram- calories
British Thermal Units	777.6	Foot- lbs.
British Thermal Units	3.927×10^4	Horsepower- hrs.
British Thermal Units	107.5	Kilogram- meters
British Thermal Units	2.928×10^4	Kilowatt- hrs.
B.T.U./min.	12.96	Foot-lbs./sec.
B.T.U./min.	0.02356	Horsepower
B.T.U./min.	0.01757	Kilowatts
B.T.U./min.	17.57	Watts
Centares (Centiares)	1	Square meters
Centigrams	0.01	Grams
Centiliters	0.01	Liters
Centimeters	0.3937	Inches
Centimeters	0.01	Meters
Centimeters	10	Millimeters
Centimeters of mercury	0.01316	Atmosphere
Centimeters of mercury	0.013332	Bars
Centimeters of mercury	0.013595	kg/cm^2
Centimeters of mercury	0.4461	Feet of water
Centimeters of mercury	136.0	kgs/sq. meter
Centimeters of mercury	27.85	Lbs./sq. ft.
Centimeters of mercury	0.1934	Lbs./sq. inch
Centimeters/sec.	1.969	Feet/min.
Centimeters/sec.	0.03281	Feet/sec.
Centimeters/sec.	0.036	Kilometers/hr.
Centimeters/sec.	0.6	Meters/min.
Centimeters/sec.	0.02237	Miles/hr.
Centimeters/sec.	3.728×10^{-4}	Miles/min.
Cms./sec./sec.	0.03281	Feet/sec./sec.
Centipoises	0.001	Pascal-second
Centipoises	0.01	Poises
Centistokes	0.01	Sq. cm/sec.
Centistokes	0.01	Stokes
Cubic centimeters	3.531×10^{-5}	Cubic feet
Cubic centimeters	6.102×10^{-2}	Cubic inches
Cubic centimeters	10^{-6}	Cubic meters
Cubic centimeters	1.308×10^{-6}	Cubic yards
Cubic centimeters	2.642×10^{-4}	Gallons
Cubic centimeters	9.999×10^{-4}	Liters
Cubic centimeters	2.113×10^{-3}	Pints (liq.)
Cubic centimeters	1.057×10^{-3}	Quarts (liq.)
Cubic cm/sec.	0.0158502	Gallons/minute
Cubic cm/sec.	0.001	Liters/sec.
Cubic feet	0.1781	Barrels (42 US Gal.)
Cubic feet	2.832×10^{-4}	Cubic cms.
Cubic feet	1728	Cubic inches
Cubic feet	0.02832	Cubic meters
Cubic feet	0.03704	Cubic yards
Cubic feet	7.48052	Gallons
Cubic feet	28.32	Liters
Cubic feet	59.84	Pints (liq.)
Cubic feet	29.92	Quarts (liq.)
Cubic feet/min.	472.0	Cubic cms./sec.

Multiply	By	To Obtain
Cubic feet/min.	0.1247	Gallons/sec.
Cubic feet/min.	0.4719	Liters/sec.
Cubic feet/min.	62.43	Pounds of water/min.
Cubic feet/sec.	0.646317	Millions gals./day
Cubic feet/sec.	448.831	Gallons/min.
Cubic inches	16.39	Cubic centimeters
Cubic inches	5.787×10^{-4}	Cubic feet
Cubic inches	1.639×10^{-5}	Cubic meters
Cubic inches	2.143×10^{-5}	Cubic yards
Cubic inches	4.329×10^{-3}	Gallons
Cubic inches	1.639×10^{-2}	Liters
Cubic inches	0.03463	Pints (liq.)
Cubic inches	0.01732	Quarts (liq.)
Cubic meters	10^6	Cubic centimeters
Cubic meters	35.31	Cubic feet
Cubic meters	61023	Cubic inches
Cubic meters	1.308	Cubic yards
Cubic meters	264.2	Gallons
Cubic meters	999.97	Liters
Cubic meters	2113	Pints (liq.)
Cubic meters	1057	Quarts (liq.)
Cubic meters/hr.	4.40	Gallons/min.
Cubic yards	4.8089	Barrels (42 U.S. Gal.)
Cubic yards	764,554.86	Cubic centimeters
Cubic yards	27	Cubic feet
Cubic yards	46, 656	Cubic inches
Cubic yards	0.7646	Cubic meters
Cubic yards	202.0	Gallons
Cubic yards	764.5	Liters
Cubic yards	1616	Pints (liq.)
Cubic yards	807.9	Quarts (liq.)
Cubic yards/min.	0.45	Cubic feet/sec.
Cubic yards/min.	202.0	Gallons/min.
Cubic yards/min.	3.366	Gallons/sec.
Cubic yards/min.	12.74	Liters/sec.
Decigrams	0.1	Grams
Deciliters	0.1	Liters
Decimeters	0.1	Meters
Degrees (angle)	60	Minutes
Degrees (angle)	0.01745	Radians
Degrees (angle)	3600	Seconds
Degrees/sec	0.01745	Radians/sec.
Degrees/sec	0.1667	Revolutions/min.
Degrees/sec	0.002778	Revolutions/sec.
Dekagrams	10	Grams
Dekaliters	10	Liters
Dekameters	10	Meters
Drams	27.34375	Grains
Drams	0.0625	Ounces
Drams	1.771845	Grams
Fathoms	6	Feet
Feet	30.48	Centimeters
Feet	0.166667	Fathoms
Feet	3.0480×10^{-4}	Kilometers
Feet	304.80	Millimeters
Feet	12	Inches
Feet	0.3048	Meters
Feet	1/3	Yards
Feet of water	0.0295	Atmospheres
Feet of water	0.8826	Inches of

Multiply	By	To Obtain
Feet of water	304.8	kgs./sq. meter
Feet of water	62.43	Lbs./sq. ft.
Feet of water	0.4335	Lbs./sq. inch
Feet/min.	0.5080	Centimeters/sec.
Feet/min.	0.01667	Feet/sec.
Feet/min.	0.01829	Kilometers/hr.
Feet/min.	0.3048	Meters/min.
Feet/min.	0.01136	Miles/hr.
Feet/sec.	30.48	Centimeters/sec.
Feet/sec.	1.09726	Kilometers/hr.
Feet/sec.	0.5924	Knots
Feet/sec.	18.29	Meters/min.
Feet/sec.	0.6818	Miles/hr.
Feet/sec.	0.01136	Miles/min.
Feet/sec./sec.	30.48	Cms./sec./sec.
Feet/sec./sec.	0.3048	Meters/sec./sec.
Feet/sec./sec.	0.0310810	g's (gravity)
Foot- pounds	1.286×10^{-3}	British Thermal Units
Foot- pounds	5.050×10^{-7}	Horsepower-hrs.
Foot- pounds	3.240×10^{-4}	Kilogram- calories
Foot- pounds	0.1383	Kilogram- meters
Foot- pounds	3.766×10^{-7}	Kilowatt- hours
Foot- pounds/min.	2.140×10^{-5}	B.T.U/sec.
Foot- pounds/min.	0.01667	Foot-pounds/sec.
Foot- pounds/min.	3.030×10^{-5}	Horsepower
Foot- pounds/min.	5.393×10^{-3}	Gm.-calories/sec.
Foot- pounds/min.	2.280×10^{-5}	Kilowatts
Foot- pounds/sec.	7.704×10^{-2}	B.T.U/min.
Foot- pounds/sec.	1.818×10^{-3}	Horsepower
Foot- pounds/sec.	1.941×10^{-2}	kg.-calories/min.
Foot- pounds/sec.	1.356×10^{-3}	Kilowatts
G's (Accel. due to grav.)	32.174	Feet/sec.^{2}
G's (Accel. due to grav.)	35.3034	Km/hr.-sec.
G's (Accel. due to grav.)	9.80665	Meters/sec.^{2}
G's (Accel. due to grav.)	21.9371	Miles/hr.-sec.
Gallons	3785	Cubic centimeters
Gallons	0.1337	Cubic feet
Gallons	231	Cubic inches
Gallons	3.785×10^{-3}	Cubic meters
Gallons	4.951×10^{-3}	Cubic yards
Gallons	3.785	Liters
Gallons	8	Pints (liq.)
Gallons	4	Quarts (liq.)
Gallons-Imperial	1.20095	US Gallons
Gallons- US	0.83267	Imperial Gallons
Gallons water	8.345	Pounds of water
Gallons per day	9.284×10^{-5}	Cubic ft./min.
Gallons per day	1.5472×10^{-6}	Cubic ft./sec.
Gallons per day	2.6289×10^{-6}	Cubic meters/min.
Gallons per day	0.09284	Liters/min.
Gallons per hour	0.1337	Cubic ft./hr.
Gallons per hour	0.002228	Cubic ft./min.
Gallons per hour	3.71×10^{-5}	Cubic ft./sec.
Gallons per hour	6.309×10^{-5}	Cubic meters/min.
Gallons per hour	.016667	Gallons/min.
Gallons per hour	2.7778×10^{-4}	Gallons/sec.
Gallons per hour	0.06309	Liters/min.
Gallons/min.	34.286	Barrels (42 US Gal.)/day

Multiply	By	To Obtain
Gallons/min.	1.4286	Barrels (42 US Gal.)/hr.
Gallons/min.	0.02381	Barrels (42 USGal.)/min.
Gallons/min.	1440	Gallons/day
Gallons/min.	2.228×10^{-3}	Cubic feet/sec.
Gallons/min.	0.06308	Liters/sec.
Gallons/min.	8.0208	Cu. ft./hr.
Gallons/sec.	60	Gallons/min.
Gallons/sec.	227.12	Liters/min.
Grains (troy)	0.06480	Grams
Grains (troy)	0.04167	Pennyweights (troy)
Grains (troy)	2.0833×10^{-3}	Ounces
Grains/US gal.	17.118	Parts/million
Grains/US gal.	142.86	Lbs./million gal.
Grains/Imp. gal.	14.254	Parts/million
Grams	980.7	Dynes
Grams	15.43	Grains
Grams	.001	Kilograms
Grams	1000	Milligrams
Grams	0.03527	Ounces
Grams	0.03215	Ounces (troy)
Grams	2.205×10^{-3}	Pounds
Grams/cm.	5.600×10^{-3}	Pounds/ inch
Grams/cu. cm.	62.43	Pounds/cubic foot
Grams/cu. cm.	0.03613	Pounds/cubic inch
Grams/liter	58.416	Grains/gal.
Grams/liter	8.345	Pounds/1000 gals.
Grams/liter	0.06242	Pounds/cubic foot
Grams/liter	1000	Parts/million
Hectares	2.471	Acres
Hectares	1.076×10^{5}	Square feet
Hectograms	100	Grams
Hectoliters	100	Liters
Hectometers	100	Meters
Hectowatts	100	Watts
Horsepower	42.44	B.T.U./min.
Horsepower	33,000	Foot-lbs./min.
Horsepower	550	Foot-lbs./sec.
Horsepower	1.014	Horsepower (metric)
Horsepower	10.547	kg.-calories/min.
Horsepower	0.7457	Kilowatts
Horsepower	745.7	Watts
Horsepower (boiler)	33, 493	B.T.U./hr.
Horsepower (boiler)	9.809	Kilowatts
Horsepower (boiler)	9.2994	B.T.U./sec.
Horsepower (boiler)	9809.5	Watts
Horsepower-hours	2546	B.T.U
Horsepower-hours	1.98×10^{6}	Foot-lbs.
Horsepower-hours	641.6	Kilogram-calories
Horsepower-hours	2.737×10^{5}	Kilogram-meters
Horsepower-hours	0.7457	Kilowatt-hours
Inches	2.540	Centimeters
Inches	0.083333	Feet
Inches	0.0254	Meters
Inches	25.4	Millimeters
Inches	0.0277778	Yards
Inches of mercury	0.03342	Atmospheres
Inches of mercury	0.03386	Bars
Inches of mercury	13.6	Inches H^2O

Multiply	By	To Obtain
Inches of mercury	0.034531	kg/cm^2
Inches of mercury	3374.1	Pascals
Inches of mercury	70.727	$Pounds/ft.^2$
Inches of mercury	0.49116	$Pounds/in.^2$
Inches of mercury	1.133	Feet of water
Inches of mercury	345.3	kgs./sq. meter
Inches of mercury	70.73	Lbs./sq. ft.
Inches of mercury (32° F)	0.491	Lbs./sq. inch
Inches of water	0.002458	Atmospheres
Inches of water	0.07355	Inches of mercury
Inches of water	25.40	kgs./sq. meter
nches of water	0.578	Ounces/sq. inch
Inches of water	5.202	Lbs./sq. foot
Inches of water	0.03613	Lbs./sq. inch
Joules	9.479×10^{-4}	B.T.U
Joules	0.239006	Calories (Thermo)
Joules	0.73756	Foot-lb.f.
Joules	3.725×10^{-7}	HP-hr. (US)
Joules	2.7778×10^{-7}	Kilowatt-hr.
Joules	1	Newton-m
Joules	2.7778×10^{-4}	Watt-hr.
Kilograms	35.274	Ounces (avoir)
Kilograms	32.151	Ounces (troy)
Kilograms	980,665	Dynes
Kilograms	2.205	Lbs.
Kilograms	1.102×10^{-3}	Tons (short)
Kilograms	34.286	Tons (assay)
Kilograms	9.8421×10^{-4}	Tons (long)
Kilograms	0.001	Tons (metric)
Kilograms	10^3	Grams
Kilograms-cal./sec.	3.968	B.T.U./sec.
Kilograms-cal./sec	3086	Foot-lbs./sec.
Kilograms-cal./sec	5.6145	Horsepower
Kilograms-cal./sec	4186.7	Watts
Kilograms/cm	0.96783	Atmospheres
Kilograms/cm	0.980665	Bars
Kilograms/cm	28.959	Inches Hg@ 32° F
Kilograms/cm	14.223	$Pounds/in.^2$
Kilograms-cal./min.	3085.9	Foot-lbs./min.
Kilograms-cal./min	0.09351	Horsepower
Kilograms-cal./min	69.733	Watts
kgs/meter	0.6720	Lbs./foot
kgs/sq. meter	9.678×10^{-5}	Atmospheres
kgs/sq. meter	3.281×10^{-3}	Feet of water
kgs/sq. meter	2.896×10^{-3}	Inches of mercury
kgs/sq. meter	0.2048	Lbs./sq. foot
kgs/sq. meter	1.422×10^{-3}	Lbs./sq. inch
kgs/sq. millimeter	10^6	kgs./sq. meter
Kiloliters	10^3	Liters
Kilometers	10^5	Centimeters
Kilometers	3281	Feet
Kilometers	10^3	Meters
Kilometers	0.6214	Miles
Kilometers	1094	Yards
Kilopascal	.145	$Pounds/in.^2$
Kilometers/hr.	27.78	Centimeters/sec.
Kilometers/hr.	54.68	Feet/min.
Kilometers/hr.	0.9113	Feet/sec.
Kilometers/hr.	.5399	Knots
Kilometers/hr.	16.67	Meters/min.

Multiply	By	To Obtain
Kilometers/hr.	0.6214	Miles/hr.
Kms./hr./sec.	27.78	Cms./sec./sec.
Kms./hr./sec.	0.9113	Ft./sec./sec.
Kms./hr./sec.	0.2778	Meters/sec./sec.
Kilowatts	56.907	B.T.U./min.
Kilowatts	4.425×10^4	Foot-lbs./min.
Kilowatts	737.6	Foot-lbs./sec.
Kilowatts	1.341	Horsepower (US)
Kilowatts	1.3597	Horsepower (metric)
Kilowatts	1000	Joules/sec.
Kilowatts	3412.9	B.T.U/hr.
Kilowatts	0.94827	B.T.U./sec.
Kilowatts	14.34	kg.-calories/min.
Kilowatts	10^3	Watts
Kilowatt-hours	3414.4	B.T.U
Kilowatt-hours	2.655×10^6	Foot-lbs.
Kilowatt-hours	1.341	Horsepower-hrs.
Kilowatt-hours	860.4	Kilogram-calories
Kilowatt-hours	3.671×10^5	Kilogram-meters
Liters	10^3	Cubic centimeters
Liters	0.03531	Cubic feet
Liters	61.02	Cubic inches
Liters	10^{-3}	Cubic meters
Liters	1.308×10^{-3}	Cubic yards
Liters	0.2642	Gallons
Liters	2.113	Pints (liq.)
Liters	1.057	Quarts (liq.)
Liters/min.	5.886×10^{-4}	Cubic ft./sec.
Liters/min.	4.403×10^{-3}	Gals./sec.
$\frac{\text{Lumber width (in) x Thickness (in)}}{12}$	Length (ft.)	Board feet
Meters	100	Centimeters
Meters	3.281	Feet
Meters	39.37	Inches
Meters	10^{-3}	Kilometers
Meters	10^3	Millimeters
Meters	1.094	Yards
Meters/min.	1.667	Centimeters/sec.
Meters/min.	3.281	Feet/min.
Meters/min.	0.05468	Feet/sec.
Meters/min.	0.06	Kilometers/hr.
Meters/min.	0.03728	Miles/hr.
Meters/sec.	196.8	Feet/min.
Meters/sec.	3.281	Feet/sec.
Meters/sec.	3.6	Kilometers/hr.
Meters/sec.	0.06	Kilometers/min.
Meters/sec.	2.287	Miles/hr.
Meters/sec.	0.03728	Miles/min.
$Meters/sec.^2$	3.2808	$Feet/sec.^2$
$Meters/sec.^2$	0.101972	G (gravity)
$Meters/sec.^2$	39.37	$Inches/sec.^2$
$Meters/sec.^2$	134.214	Miles/hr.-min.
Meter-kg. (force)	9.8067	Joules
Microns	10^{-6}	Meters
Miles	1.609×10^5	Centimeters
Miles	5280	Feet
Miles	1.609	Kilometers
Miles	1760	Yards
Miles/hr.	44.70	Centimeters/sec.

Multiply	By	To Obtain
Miles/hr.	88	Feet/min.
Miles/hr.	1.467	Feet/sec.
Miles/hr.	1.609	Kilometers/hr.
Miles/hr.	0.8689	Knots
Miles/hr.	26.82	Meter/min.
Miles/min.	2682	Meters/min.
Miles/min.	88	Feet/sec.
Miles/min.	1.609	Kilometers/min.
Miles/min.	60	Miles/hr.
Milliers	10^3	Kilograms
Milligrams	10^{-3}	Grams
Milliliters	10^{-3}	Liters
Millimeters	0.1	Centimeters
Millimeters	0.03937	Inches
Milligrams/liter	1	Parts/million
Million Gals./day	1.54723	Cubic ft./sec.
Miner's inches	1.5	Cubic ft./min.
Minutes (angle)	2.909×10^{-4}	Radians
Newtons (N)	.225	Pounds-force
Ounces	16	Drams
Ounces	437.5	Grains
Ounces	0.0625	Pounds
Ounces	28.3495	Grams
Ounces	0.9115	Ounces (troy)
Ounces	2.790×10^{-5}	Tons (long)
Ounces	2.835×10^{-5}	Tons (metric)
Ounces (troy)	480	Grains
Ounces (troy)	20	Pennyweights (troy)
Ounces (troy)	0.08333	Pounds (troy)
Ounces (troy)	31.10348	Grams
Ounces (troy)	1.09714	Ounces (avoir)
Ounces (fluid)	1.805	Cubic inches
Ounces (fluid)	0.02957	Liters
Ounces/sq. inch	0.0625	Lbs./sq. inch
Ounces/gal (US)	7.4892	kg/m^3
Ounces/gal (US)	0.25	Ounces/quart
Ounces/gal (US)	0.46753	$Pounds/ft.^3$
Ounces/gal (US)	2.7056×10^{-4}	$Pounds/in.^3$
Parts/million	0.0584	Grains/US gal.
Parts/million	0.07015	Grains/Imp. gal.
Parts/million	8.345	Lbs./million gal.
Pennyweights (troy)	24	Grains
Pennyweights (troy)	1.55517	Grams
Pennyweights (troy)	0.05	Ounces (troy)
Pennyweights (troy)	4.1667×10^{-3}	Pounds (troy)
Pounds	16	Ounces
Pounds	256	Drams
Pounds	7000	Grains
Pounds	0.0005	Tons (short)
Pounds	453.5924	Grams
Pounds	1.21528	Pounds (troy)
Pounds	14.5833	Ounces (troy)
Pounds (troy)	5760	Grains
Pounds (troy)	240	Pennyweights (troy)
Pounds (troy)	12	Ounces (troy)
Pounds (troy)	373.2417	Grams
Pounds (troy)	0.822857	Pounds (avoir.)
Pounds (troy)	13.1657	Ounces (avoir.)
Pounds (troy)	3.6735×10^{-4}	Tons (long)
Pounds (troy)	4.1143×10^{-4}	Tons (short)

Multiply	By	To Obtain
Pounds (troy)	3.7324×10^{-4}	Tons (metric)
Pounds of water	0.01602	Cubic feet
Pounds of water	27.68	Cubic inches
Pounds of water	0.1198	Gallons
Pounds of water/min.	2.670×10^{-4}	Cubic ft./sec
Pounds/cubic foot	0.01602	Grams/cubic cm.
Pounds/cubic foot	16.02	kgs./cubic centimeters
Pounds/cubic foot	5.787×10^{-4}	Lbs./cubic inch
Pounds/cubic inch	27.68	Grams/cubic inch
Pounds/cubic inch	2.768×10^{-4}	kgs./cubic meter
Pounds/cubic inch	1728	Lbs./cubic foot
Pounds/foot	1.488	kgs/meter
Pounds/inch	1152	Grams/cm.
Pounds/sq. in.	0.06895	Bars
Pounds/sq. in.	5.1715	Cm Hg @ 0° C
Pounds/sq. in.	0.070307	$kg./cm^2$
Pounds/sq. in.	6895	$Newtons/m^2$
Pounds/sq. in.	6895	Pascals
Pounds/sq. foot	0.01602	Feet of water
Pounds/sq. foot	4.882	kgs./sq. meter
Pounds/sq. foot	6.944×10^{-3}	Pounds/sq. inch
Pounds/sq. inch	0.06804	Atmospheres
Pounds/sq. inch	2.307	Feet of water
Pounds/sq. inch	2.036	Inches of mercury
Pounds/sq. inch	703.1	kgs./sq. meter
Pounds/sq. foot	4.788×10^{-4}	Bars
Pounds/sq. foot	0.035913	Cm Hg @ 0°C
Pounds/sq. foot	0.014139	In Hg @ 32°C
Pounds/sq. foot	4.8824×10^{-4}	kg/cm^2
Pounds/sq. foot	47.880	$Newtons/m^2$
Pounds/sq. foot	47.880	Pascals
Quadrants (angle)	90	Degrees
Quadrants (angle)	5400	Minutes
Quadrants (angle)	1.571	Radians
Quarts (dry)	67.20	Cubic inches
Quarts (liq.)	57.75	Cubic inches
Quintal, Argentine	101.28	Pounds
Quintal, Brazil	129.54	Pounds
Quintal, Castile, Peru	101.43	Pounds
Quintal, Chile	101.41	Pounds
Quintal, Mexico	101.47	Pounds
Quintal, Metric	220.46	Pounds
Quires	25	Sheets
Radians	57.30	Degrees
Radians	3438	Minutes
Radians	0.637	Quadrants
Radians/sec.	57.30	Degrees/sec.
Radians/sec.	0.1592	Revolutions/sec.
Radians/sec.	9.549	Revolutions/min.
Radians/sec./sec.	573.0	Revs./min./min.
Radians/sec./sec.	0.1592	Revs./sec./sec.
Reams	500	Sheets
Revolutions	360	Degrees
Revolutions	4	Quadrants
Revolutions	6.283	Radians
Revolutions/min.	6	Degrees/sec.
Revolutions/min.	0.1047	Radians/sec.
Revolutions/min.	0.01667	Revolutions/sec.
Revolutions/min./min.	1.745×10^{-3}	Rads./sec./sec.
Revolutions/min./min.	2.778×10^{-4}	Rev./sec./sec.

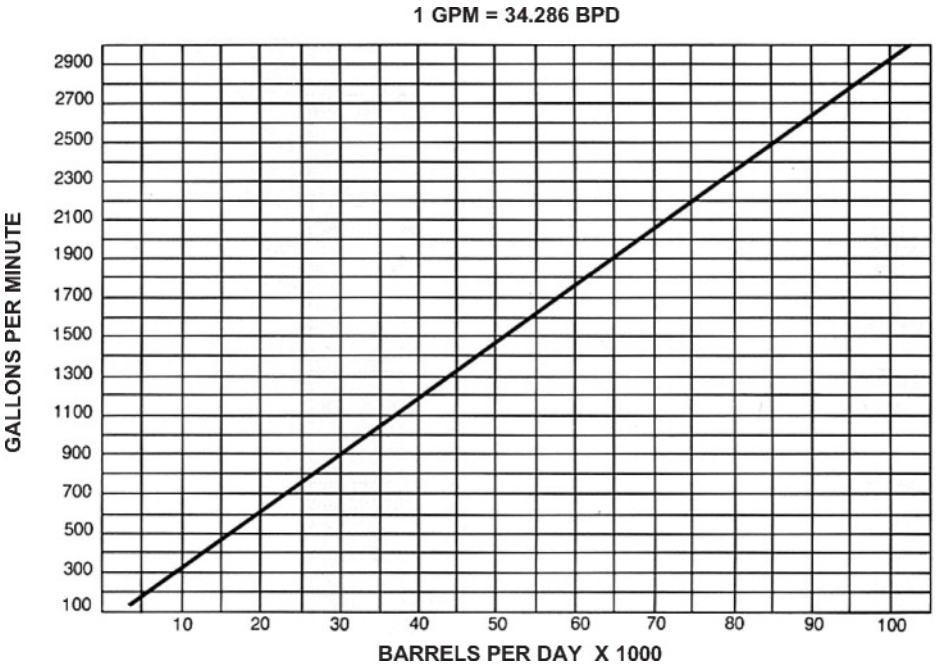
Multiply	By	To Obtain
Revolutions/ sec	360	Degrees/ sec.
Revolutions/ sec	6.283	Radians/ sec.
Revolutions/ sec	60	Revolutions/ min.
Revolutions/sec/sec	6,283	Radians/sec./sec
Revolutions/ sec/sec.	3600	Revs. / min/ min
Seconds (angle)	4.848×10^{-6}	Radians
Square centimeters	1.076×10^{-3}	Square feet
Square centimetera	0.1550	Square inches
Square centimeters	10^{4}	Square meters
Square centimeters	100	Square milimeters
Square feet	2.296×10^{-5}	Acres
Square feet	929.0	Square centimeters
Square feet	144	Square inches
Square feet	0.09290	Square meters
Square feet	3.587×10^{-4}	Square miles
Square feet	1/9	Square yards
$\frac{1}{\text{Sq. ft./ gal. Min}}$	8.0208	Overflow rate (ft. / hr.)
Square inches	6.542	Square centimeters
Square inches	6.944×10^{-3}	Square feet
Square inches	645.2	Square millimeters
Square kilometers	247.1	Acres
Square kilometers	10.76×10^{6}	Square feet
Square kilometers	10^{6}	Square meters
Square kilometers	0.3861	Square miles
Square kilometers	1.196×10^{6}	Square yards
Square meters	2.471×10^{-4}	Acres
Square meters	10.76	Square feet
Square meters	3.861×10^{-7}	Square miles
Square meters	1.196	Square yards
Square miles	640	Acres
Square miles	27.88×10^{6}	Square feet
Square miles	2.590	Square kilometers
Square miles	3.098×10^{6}	Square yards
Square millimeters	0.01	Square centimeters
Square milimeters	1.550×10^{-3}	Square inchea
Square yards	2.066×10^{-4}	Acres
Square yards	9	Square feet

Multiply	By	To Obtain
Square yards	0.8361	Square Meters
Square yards	3.228×10^{-7}	Square miles
Temp. (°C.) + 273	1	Abs. Temp. (° C.)
Temp. (° C.) +17.78	1.8	Temp. (° F.)
Temp. (° F.) + 460	1	Abs. Temp (° F.)
Temp (° F.) -32	5/9	Temp. (° C.)
Tons (long)	1016	Kilogams
Tons (long)	2240	Pounds
Tons (long)	1.12000	Tons (short)
Tons (metric)	10^{3}	Kilogams
Tons (metric)	2205	Pounds
Tons (short)	2000	Pounds
Tons (short)	32,000	Ounces
Tons (short)	907. 1843	Kilograms
Tons (short)	2430.56	Pounds (troy)
Tons (short)	2430.56	Tons (long)
Tons (short)	29166.66	Ounces (troy)
Tons (short)	0.90718	Tons (metric)
Tons of water/ 24 hrs.	83.333	Pounds water/ hr.
Tons of water/24 hrs	0.16643	Gallons/ min.
Tons of water/ 24 hrs	1.3349	Cu. Ft. / hr.
Watts	0.05686	B.T..U/ min
Watts	44.25	Foot- Lbs. / min.
Watts	0.7376	Foot- Lb/sec.
Watts	1.341×10^{-3}	Horsepower (U .S)
Watts	0.001360	Horsepower(metric)
Watts	1	Joules/ sec
Watts	0.01434	Kg- calories/ min.
Watts	10^{-3}	Kilowatts
Watt- hours	3.414	B.T.U
Watt- hours	2655	Foot- Lbs
Watt- hours	1.341×10^{-3}	Horsepower- hrs
Watt- hours	0.8604	Kilogram-calories
Watt- hours	367.1	kilogram- meters
Watt- hours	10^{-3}	Kilowatt- hours
Yards	91.44	Centimeters
Yards	3	Feet
Yards	36	Inches
Yards	0.9144	Meters

TECH-H-5 Quick Convert Tables

AREA		
$inch^2 \times 645.16\text{-} mm^2$	$mm^2 \times .00155 = inch^2$	cm^2 = square centimeter
$inch^2 \times 6.4516 = cm^2$	$cm^2 \times 0.1550 = inch^2$	mm^2 = square millimeter
BENDING MOMENT (Torque)		
in- lbf × 0.113 = N · m	N · m × 8.85 = in-lbs	N · m= Newton- meter
ft- lbf × 1.356 = N · m		
CAPACITY (Volume per Unit Time)		
gpm × 0.2271 = m^3/h	$m^3/h \times 4.403$ = gpm	m^3/h= cubic meter per hour
gpm × 0.638 = liters per second	liters/ second × 15.85 = gpm	
FORCE		
lbf × 0.00448 = kN		kN = kilonewton
HEAD (& NPSH)		
foot × 0.3048 = m	m × 3.28084 = foot	m = meter
LENGTH		
foot × 304.8 = mm	mm × 0.003281 = feet	mm= millimeter
inch × 25.4 = mm	mm 0.03937= inch	m = meter
foot × 0.3048 = m	m × 3.281 = foot	
MASS (Weight)		
ounce × 0.02853 = kg		
pound × 0.4536 = kg	kg × 2.205 = pound	kg = kilogram
ounce × 28.35 = g	g × 0.03527 = ounce	g =gram
POWER		
hp × 0.7457= kW	kW × 1.340483 = hp	kW = kilowatt
PRESSURE		
psi × 0.0703= kg/cm^2	$kg/cm^2 \times 14.233578$ = psi	kg/cm^2 = kilogram/ square centimeter
psi × 6.895 = kPa	kPa × .145= psi	
$kg/cm^2 \times 98.07$ = kPa	kPa × 0.010197=kg/cm^2	kPa = kiloascal
psi × 0.06895 = Bar	Bar × 14.50377 = psi	
TEMPERATURE		
°C= 0.556 (°F –32)	°F = (1.8 × °C) + 32	°C = degrees Celsius
VOLUME		
$ft^3 \times 0.02832 = m^3$	$m^3 \times 35.31 = ft^3$	
Gallon × 0.003785= m^3	$m^3 \times 264$ .17= gallon	m^3 = cubic meter
Quart × 0.9464 = L	L × 1.057 = quart	L = litre
Ounce × 29.57= mL		mL = milliliter
Gallon × 3.7854 = L	L × 0.26418 = gallon	

TECH-H-6 Conversion Chart–Gallons Per Minute to Barrels Per Day



TECH-H-7 Decimal and Millimeter Equivalents of Fractions

Inches		Millimeters	Inches		Millimeters
Fractions	Decimals		Fractions	Decimals	
1/64	.015625	.397	33/64	.515625	13.097
1/32	.03125	.794	17/32	.53125	13.494
3/64	.046875	1.191	35/64	.546875	13.891
1/16	.0625	1.588	9/16	.5625	14.288
5/64	.078125	1.984	37/64	.578125	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.109375	2.778	39/64	.609375	15.487
1/8	.125	3.175	5/8	.625	15.875
9/64	.140625	3.572	41/64	.640625	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.171845	4.366	43/64	.671875	17.066
3/16	.1875	4.763	11/16	.6875	17.463
13/64	.203125	5.159	45/64	.703125	17.859
7/32	.21875	5.556	22/32	.71875	18.256
15/64	.234375	5.953	47/64	.734375	18.653
1/4	.250	6.350	3/4	.750	19.050
17/64	.265625	6.747	49/64	.765625	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64	.296875	7.541	51/64	.796875	20.241
5/16	.3125	7.938	13/16	.8125	20.638
21/64	.328125	8.334	53/64	.828125	21.034
11/32	.34375	8.731	27/32	.84375	21.431
23/64	.359375	9.128	55/64	.859375	21.828
3/8	.375	9.525	7/8	.875	22.225
25/64	.390625	9.922	57/64	.890625	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.421875	10.716	59/64	.921875	23.416
7/16	.4375	11.113	15/16	.9375	23.813
29/64	.453125	11.509	61/64	.953125	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.484375	12.303	63/64	.984375	25.003
1/2	.500	12.700	1	1.000	25.400

TECH-H-8 Atmospheric Pressures and Barometric Readings at Different Altitudes *

Altitude Below or Above Sea Level (Feet)	Barometer Reading Inches Mercury at 32° F	Atmospheric Pressure (PSI)	Equivalent Head of Water (75°) (Feet)	Boiling Point of Water	
				° F	° C
-1000	31.02	15.2	35.2	213.8	101.0
-500	30.47	15.0	34.7	212.9	100.5
0	29.921	14.7	34.0	212.0	100.0
+500	29.38	14.4	33.4	211.1	99.5
+1000	28.86	14.2	32.8	210.2	99.0
1500	28.33	13.9	32.2	209.3	98.5
2000	27.82	13.7	31.6	208.4	98.0
2500	27.31	13.4	31.0	207.4	97.4
3000	26.81	13.2	30.5	206.5	96.9
3500	26.32	12.9	29.9	205.6	96.4
4000	25.84	12.7	29.4	204.7	95.9
4500	25.36	12.4	28.8	203.8	95.4
5000	24.89	12.2	28.3	202.9	94.9
5500	24.43	12.0	27.8	201.9	94.4
6000	23.98	11.8	27.3	201.0	94.4
6500	23.53	11.5	26.7	200.1	93.9
7000	23.09	11.3	26.2	199.2	92.9
7500	22.65	11.1	25.7	198.3	92.4
8000	22.22	10.9	25.2	197.4	91.9
8500	21.80	10.7	24.8	196.5	91.4
9000	21.38	10.5	24.3	195.5	90.8
9500	20.98	10.3	23.8	194.6	90.3
10,000	20.58	10.1	23.4	193.7	89.8
15,000	16.88	8.3	19.1	184	84.4
20,000	13.75	6.7	15.2	-	-
30,000	8.88	4.4	10.2	-	-
40,000	5.54	2.7	6.3	-	-
50,000	3.44	1.7	3.9	-	-

*** Approximate Values**

TECH-I-1 Symptoms and Causes of Hydraulic and Mechanical Pump Failure

Cause	Hydraulic Failure					Mechanical Failure				
	1	2	3	4	5	6	7	8	9	10
	Pump does not deliver liquid	Pump does not deliver sufficient capacity	Pump does not deliver sufficient pressure	Pump delivers flow intermittently	Bearings run hot and/or fail on a regular basis	High rate of mechanical seal failure	Packing has short life	Pump vibrates at higher-than-normal levels	Pump is drawing too much power	Wear of internal wetted parts is accelerated
Pump not primed or prime lost	■	■	■	■						
Suction and/or discharge valves closed or clogged	■	■	■					■		
Suction piping incorrect	■	■	■							
Insufficient NPSH available		■	■			■		■		■
Excessive air entrapped in liquid	■	■	■	■						
Speed (RPM) too low	■	■	■							
Incorrect rotation									■	
Broken impeller or bent vanes		■	■		■			■		
Incorrect impeller or impeller diameter	■	■	■							
System head too high		■								
Instruments give erroneous readings	■	■	■							
Air leaks in suction line				■						
Excessive shaft misalignment					■	■		■		
Inadequate lubrication		■			■					
Lubricant contamination					■					
Inadequate lubricant cooling					■					
Axial thrust or radial loads higher than bearing rating										
Improper coupling lubrication					■			■		
Suction pressure too high					■	■				
Bearing incorrectly installed					■	■		■		
Impeller out of balance					■			■		
Overheating of seal faces						■				
Excessive shaft deflection					■	■		■		
Lack of seal flush at seal faces					■	■				
Incorrect seal installation						■				
Pump is run dry						■				
Pump run off design point					■	■	■	■	■	
Shaft/shaft sleeve worn						■	■			
Packing gland not properly adjusted									■	
Packing not properly installed							■			
Impeller clogged	■							■		
Coupling out of balance					■	■		■		
Baseplate not installed properly					■	■		■		
Pump operating speed too close to system's natural frequency								■		
Bearing failing					■	■		■		
Piping not properly anchored					■	■	■	■		
Pump and/or driver not secured to baseplate					■	■		■		
Specific gravity higher than specified					■	■			■	
Viscosity higher than specified					■	■			■	
Internal clearances too tight								■	■	
Chemicals in liquid other than specified										■
Pump assembled incorrectly			■		■	■	■	■		■
Higher solids concentration than specified										■

TECH-I-2 Troubleshooting Centrifugal Pumps

Problem	Probable Cause	Remedy
No liquid delivered.	Pump not primed.	Reprime pump, check that pump and suction line are full of liquid.
	Suction line clogged.	Remove obstructions.
	Impeller clogged with foreign material.	Back flush pump to clean impeller.
	Wrong direction of rotation.	Change rotation to concur with direction indicated by arrow on bearing housing or pump casing.
	Foot valve or suction pipe opening not submerged enough.	Consult factory for proper depth. Use baffle to eliminate vortices.
	Suction lift too high.	Shorten suction pipe.
Pump not producing rated flow or head.	Air leak through gasket.	Replace gasket.
	Air leak through stuffing box.	Replace or readjust packing/mechanical seal.
	Impeller partly clogged.	Back flush pump to clean impeller.
	Worn suction sideplate or wear rings.	Replace defective part as required.
	Insufficient suction head.	Ensure that suction line shutoff valve is fully open and line is unobstructed.
	Worn or broken impeller.	Inspect and replace if necessary.
Pump starts then stops pumping.	Improperly primed pump.	Reprime pump.
	Air or vapor pockets in suction line.	Rearrange piping to eliminate air pockets.
	Air leak in suction line.	Repair (plug) leak.
Bearings run hot.	Improper alignment.	Re-align pump and driver.
	Improper lubrication.	Check lubricant for suitability and level.
	Lube cooling.	Check cooling system.
Pump is noisy or vibrates.	Improper pump/driver alignment.	Align shafts.
	Partly clogged impeller causing imbalance.	Back-flush pump to clean impeller.
	Broken or bent impeller or shaft.	Replace as required.
	Foundation not rigid.	Tighten hold down bolts of pump and motor or adjust stilts.
	Worn bearings.	Replace.
	Suction or discharge piping not anchored or properly supported.	Anchor per Hydraulic Institute Standards Manual recommendation.
	Pump is cavitating.	System problem.
Excessive leakage from stuffing box/seal chamber.	Packing gland improperly adjusted.	Tighten gland nuts.
	Stuffing box improperly packed.	Check packing and repack box.
	Worn mechanical seal parts.	Replace worn parts.
	Overheating mechanical seal.	Check lubrication and cooling lines.
	Shaft sleeve scored.	Remachine or replace as required.
Motor requires excessive power.	Head lower than rating. Pumps too much liquid.	Consult factory. Install throttle valve, trim impeller diameter.
	Liquid heavier than expected.	Check specific gravity and viscosity.
	Stuffing packing too tight.	Readjust packing. Replace if worn.
	Rotating parts bind.	Check internal wearing parts for proper clearances.

TECH-J-1 Keep Air Out of Your Pump

Most centrifugal pumps are not designed to operate on a mixture of liquid and gases. To do so is an invitation to serious mechanical trouble, shortened life and unsatisfactory operation. The presence of relatively small quantities of air can result in considerable reduction in capacity, since only 2% free air will cause a 10% reduction in capacity, and 4% free air will reduce the capacity by 43.5%.

In addition to a serious loss in efficiency and wasted power, the pump may be noisy with destructive vibration. Entrained air is one of the most frequent causes of shaft breakage. It also may cause the pump to lose its prime and greatly accelerate corrosion.

Air may be present in the liquid being pumped due to leaky suction lines, stuffing boxes improperly packed, or inadequately sealed on suction lift or from other sources.

Refer also to Section TECH-D-7, Pumping Liquids with Entrained Gas.

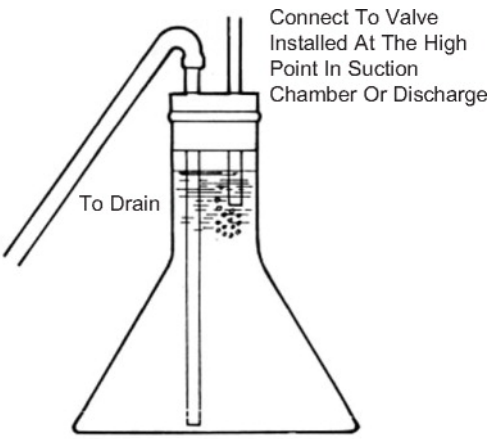
On the other hand, very small amounts of entrained air (less than 1%) can actually quiet noisy pumps by cushioning the collapse of cavitation bubbles.

TESTING FOR AIR IN CENTRIFUGAL PUMPS

The amount of air which can be handled with reasonable pump life varies from pump to pump. The elimination of air has greatly improved the operation and life of many troublesome pumps. When trouble occurs, it is common to suspect everything but air, and to consider air last, if at all.

In many cases a great deal of time, inconvenience, and expense can be saved by making a simple test for the presence of air. We will assume that calculations have already been made to determine that there is sufficient NPSH Margin (2 - 5 times the NPSHR) to insure that the noise is not due to cavitation. The next step should be to check for the presence of entrained air in the pumpage.

When the source of suction supply is above the centerline of the pump, a check for air leaks can be made by collecting a sample in a "bubble bottle" as illustrated. Since the pressure at the suction chamber of the pump is above atmospheric pressure, a valve can be installed in one of the tapped openings at the high point in the chamber and liquid can be fed into the "bubble bottle." The presence of air or vapor will show itself in the "bubble bottle."



This test can also be made from a high point in the discharge side.

Obviously, the next step is to eliminate the source of air since quantities present insufficient amount to be audible are almost certain to cause premature mechanical failure.

Note: The absence of bubbles is not proof that the pumpage doesn't contain air.

TECH-J-2 PS20 Pump Load Monitors

The PS20 Pump Load Monitors measure the motor input power in combination with a proprietary algorithm to accurately determine the pump's load.

During dry-run conditions, pump power is reduced and recognized by the PumpSmart ® Pump Load Monitor. During run-out conditions, power increases, which is also a recognizable condition. Power increase is also experienced when internal wear results from upset conditions. Customers may configure the devices to automatically shut down the pump or warn the operator via integrated relay output(s).

The PS20 offers two underload and two overload condition protection functions (four total) as well as the ability to output pump load through an integrated 4-20 mA output. A six button keypad and LCD readout enables greater configuration and operation options. The PS20 can be applied on motors up to 999 F.L. Amps.

Refer to the PumpSmart ® Section for additional details.

TECH-J-3 Raised Face and Flat Face Flanges (Mating Combinations)

Pumps of cast iron construction are furnished with 125 or 250 lb. flat face (F.F.) flanges. Since industry normally uses fabricated steel piping, the pumps are often connected to 150 or 300 lb. $^{1}/_{16}$" raised face (R.F.) steel flanges.

Difficulty can occur with this flange mating combination. The pump flange tends to pivot around the edge of the raised face as the flange bolts are tightened. This can cause the pump flange to break allowing leakage at the joint (Fig. 1).

A similar problem can be encountered when a bronze pump with F.F. flanges is connected to R.F. steel flanges (Fig. 2). Since the materials are not of equal strength, the bronze flange may distort, resulting in leakage.

To avoid problems when attaching bronze or cast iron F.F. pump flanges to R.F. steel pipe flanges, the following steps should be taken (refer to Fig. 3).

1 Machine off the raised face on the steel pipe flange.

2 Use a full face gasket.

If the pump is steel or stainless steel with F.F. flanges, no problem arises since materials of equal strength are being connected. Many customers, however, specify R.F. flanges on steel pumps for mating to R.F. companion flanges. This arrangement is technically and practically not required.

The purpose of a R.F. flange is to concentrate more pressure on a smaller gasket area and thereby increase the pressure containment capability of the joint. To create this higher gasket load, it is only necessary to have one-half of the flanged joint supplied with a raised face - not both. The following illustrations show 4" steel R.F. and F.F. mating flange combinations and the gasket loading incurred in each instance.

Assuming the force (F) from the flange bolts to be 10,000 lbs. and constant in each combination, the gasket stress is:

$$P\ (Stress) = \frac{Bolt\ Force\ (F)}{Gasket\ Area}$$

$$P_1\ (Fig.\ 4) = \frac{10{,}000\ lbs.}{49.4\ sq.\ in.} = 203\ psi$$

$$P_2\ (Fig.\ 5) = \frac{10{,}000\ lbs}{15.9\ sq.\ in.} = 630\ psi$$

P_3 (Fig. 6) = 15.9 sq. in.

It can be readily seen that the smaller gasket, used with a raised face flange, increases the pressure containment capability of a flanged joint. However, it can also be noted that there is no difference in pressure capability between R.F.-to-R.F. and R.F.-to-F.F. flange combinations.

In addition to being technically unnecessary to have a R.F.-to-R.F. mating combination, the advantages are:

1 The elimination of the extra for R.F. flanges.

2 The elimination of the extra delivery time required for a non-standard casing.

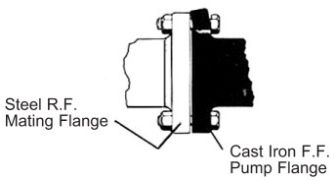


Fig. 1

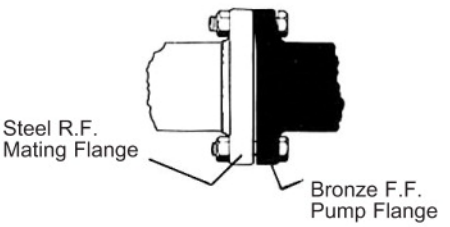


Fig. 2

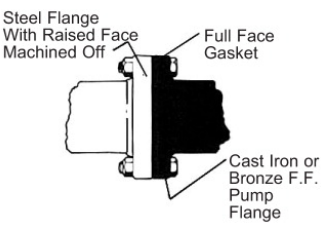


Fig. 3

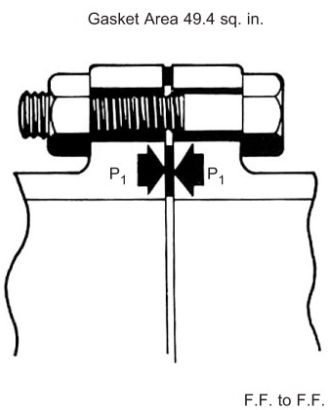


Fig. 4

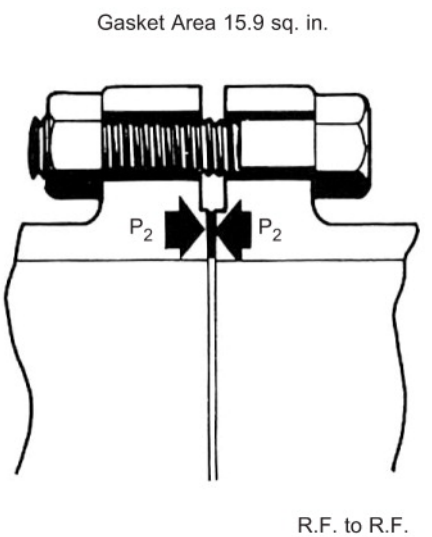


Fig. 5

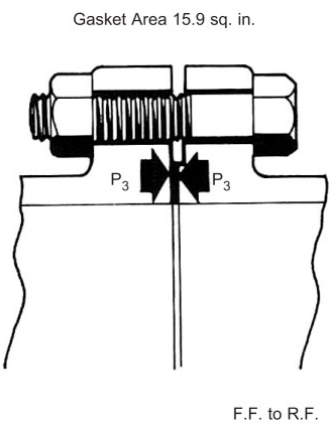


Fig. 6

TECH-J-4 Predictive and Preventive Maintenance Program

This overview of Predictive and Preventive Maintenance (PPM) is intended to assist the pump users who are starting a PPM program or have an interest in the continuous improvement of their current programs.

There are four areas that should be incorporated in a PPM program. Individually each one will provide information that gives an indication of the condition of the pump; collectively they will provide a complete picture as to the actual condition of the pump.

PUMP PERFORMANCE MONITORING

There are six parameters that should be monitored to understand how a pump is performing. They are *suction pressure (P_s), discharge pressure (P_d), flow (Q), pump speed (N_r), pumpage properties,* and *power* . Power is easiest measured with a clip on amp meter but some facilities have continuous monitoring systems that can be utilized. In any event, the intent is to determine the BHP of the pump. When using a clip on amp meter, the degree of accuracy is limited. It should not be used to determine the efficiency of the pump. Clip on amp meters are best used for troubleshooting where the engineer is trying to determine the operating point of the pump.

The most basic method of determining the TDH of the pump is by utilizing suction and discharge gauges to determine P_S and P_d . The installation of the taps for the gauges is very important. Ideally, they should be located normal to the pipe wall and on the horizontal centerline of the pipe. They should also be in a straight section of pipe. Avoid locating the taps in elbows or reducers because the readings will not indicate the true static pressure due to the velocity head component. Avoid locating taps in the top or bottom of the pipe because the gauges can become air bound or clogged with solids.

Flow measurements can be difficult to obtain but every effort should be made to do so, especially when troubleshooting. In some new installations permanent flow meters are installed which make the job easier. When this is the case, make sure the flow meters are working properly and have been calibrated on a regular schedule. When flow meters are not installed, pitot tubes can be used. Pitot tubes provide a very accurate measure of flow, but this in an obtrusive device and provisions must be made to insert the tube into the piping. The other method of determining flow is with either a doppler or transitime device. Again, provisions must be made on the piping for these instruments, but these are non-obtrusive devices and are easier to use than the pitot tube. Caution must be exercised because each device must be calibrated, and independent testing has shown these devices are sensitive to the pumpage and are not 100% accurate.

An accurate power measurement reading can also be difficult to obtain. Clip on map meters are the most common tool available to the Field Engineer who is troubleshooting a pump problem. In most cases this has proven to be accurate. However, as previously mentioned, this tool must be used and applied properly. Clip on map meters are not accurate enough to determine the actual efficiency of a pump. If accurate horsepower readings are necessary, a torque shaft must be installed but is not very practical in an actual field installation and lends itself to use in a laboratory environment much better. In some critical installations where the user has provided a permanent power monitor, these have varying degrees of accuracy and they must be understood up front.

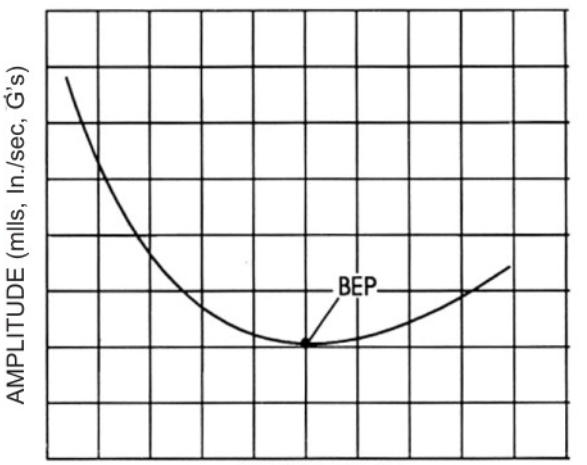
Finally, the properties of the pumpage must be known to accurately determine the actual pump performance. Pumpage temperature (T_p), viscosity, and specific gravity (S.G.), must be known.

When all of the above parameters are known, it becomes a simple matter of calculating the pump performance. There are instances when it proves to be a very difficult if not an impossible task to determine all of the above parameters in the field, therefore, the Field Engineer must rely on his or her ability to understand where a compromise must be made to get the job done. The basic document the Field Engineer must have is the pump performance curve. With this it can be determined where the pump is performing in some cases without all of the information.

PUMP VIBRATION AND BEARING ANALYSIS

Vibration analysis is the cornerstone of all PPM programs. Perhaps the question asked most often is "What is the vibration level that indicates the pump is in distress?". The answer is that there is no absolute vibration amplitude level that is indicative of a pump in distress. However, there are several guidelines that have been developed as target values that enable the analyst to set alarm levels. Also many users have developed their own site criteria that is used as a guideline. Institutions such as the Hydraulic Institute and API have developed independent vibration criteria. Caution should be exercised when applying the published values...each installation is unique and should be handled accordingly. When a machine is initially started, a baseline vibration reading should be taken and trended over time.

Typically, readings are taken on the motor outboard and inboard bearing housings in the vertical and horizontal directions and on the pump outboard and inboard bearing housings in the vertical and horizontal directions. Additionally, an axial vibration measurement is taken on the pump. The inboard location is defined as the coupling end of the machine. It is critical that when the baseline vibration measurement is taken that the operating point of the pump is also recorded. The vibration level of a pump is directly related to where it is operating and in relation to its Best Efficiency Point (BEP). The further away from the BEP, the higher the vibrations will be. See the following chart for a graphical representation of vibration amplitude- vs- flow.



Typical Vibration Level Characteristic vs. Capacity

The engineer must also look at the frequency where the amplitude is occurring. Frequency identifies what the defect is that is causing the problem, and the amplitude is an indication of the severity of the problem. These are general guidelines and do not cover every situation. The spectrum in the chart is a typical spectrum for a pump that has an unbalance condition.

Bearing defect analysis is another useful tool that can be used in many condition monitoring programs. Each component of a roller bearing has its own unique defect frequency. Vibration equipment available today enables the engineer to isolate the unique bearing defects and determine if the bearing is in distress. This allows the user to shut the machine down prior to a catastrophic failure. There are several methods utilized but the most practical from a Field Engineering perspective is called bearing enveloping. In this method, special filters built into the analyzer are used to amplify the repetitive high frequency signals in the high frequency range and amplify them in the low frequency part of the vibration spectrum. Bearing manufacturers publish the bearing defect frequency as a function of running speed which allows the engineer to identify and monitor the defect frequency. Similar to conventional vibration analysis, a baseline must be established and then trended. There are other methods available such as High Frequency Detection (HFD), and Spike Energy but the enveloping technology is the latest development.

It is a common practice to monitor bearing temperature. The most accurate method to monitor the actual bearing temperature is to use a device that will contact the outer race of the bearing. This requires holes to be drilled into the bearing housings which is not always practical. The other method is the use of an infrared 'gun' where the analyst aims the gun at a point on the bearing housing where the temperature reading is going to be taken. Obviously, this method is the most convenient but there is a downside. The temperature being measured is the outside surface of the bearing housing, not the actual

bearing temperature. This must be considered when using this method.

To complete the condition monitoring portion of a PPM program, many users have begun an oil analysis program. There are several tests that can be performed on the lubricant to determine the condition of the bearing or determine why a bearing failed so appropriate corrective action can be taken. These tests include Spectrographic Analysis, Viscosity Analysis, Infrared Analysis, Total Acid Number, Wear Particle Analysis and Wear Particle Count. Most of these tests have to be performed under laboratory conditions. Portable instruments are now available that enable the user to perform the test on site.

PUMP SYSTEM ANALYSIS

Pump system analysis is often overlooked because it is assumed the system was constructed and operation of the pumps are in accordance with the design specifications. This is often not the case. A proper system analysis begins with a system head curve. System head curves are very difficult to obtain from the end user and, more often than not, are not available. On simple systems, they can be generated in the field but on more complicated systems this can't be done. As has been stated previously, it is imperative to know where the pumps are being operated to perform a correct analysis and this is dependent on the system.

A typical system analysis will include the following information; $NPSH_A$, $NPSH_R$, static head, friction loss through the system, and a complete review of the piping configuration and valving. The process must also be understood because it ultimately dictates how the pumps are being operated. All indicators may show the pump is in distress when the real problem is it is being run at low or high flows which will generate high hydraulic forces inside the pump.

CONCLUSION

A PPM program that incorporates all of the topics discussed will greatly enhance the effectiveness of the program. The more complete understanding the engineer has of the pumping system, the more effective the PPM program becomes.