4. APPENDIX D - BIOSOLIDS COMPOSTING FACILITY OPERATION AND MAINTENANCE MANUAL SPECIFICATION SECTION 11260 AND 11270 - IRRIGATION PUMPS

RAIN BIRD

PGA Series

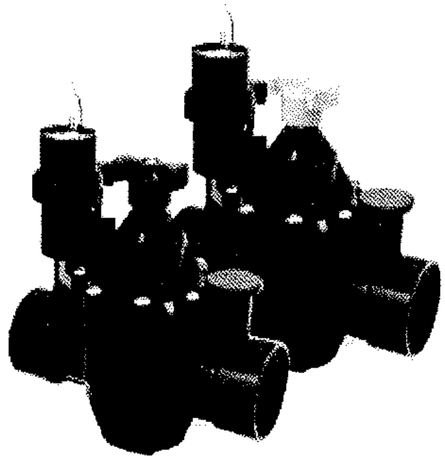
| More

Plastic Irrigation Valves

Click to Enlarge Photos

Rain Bird manufactures only the highest quality valves. PGA series plastic globe/angle valves may be used for residential and light commercial irrigation applications. The PGA Series offers versatility at an affordable price.

All Rain Bird valves work with any standard sprinkler timer.



Recommended Product

Rain Bird VB Series Valve Boxes

Features

Models

Specifications

FAQs

Manuals & Literature

- Globe and angle configuration for flexibility in design and installation.
- Rugged PVC and glass-filled nylon construction for reliable operation.
- Normally closed, forward flow design.
- Filtered pilot flow to resist debris and clogging of solenoid ports.
- Slow closing to prevent water hammer and subsequent system damage.
- Manual internal bleed operates the valve without allowing water into the valve box. Allows pressure regulator to be adjusted without turning the valve on at the controller.
- One-piece solenoid design with captured plunger and spring for easy servicing. Prevents loss of parts during field service.
- Non-rising flow control handle adjusts water flow as needed.
- Accommodates optional, field-installed PRS-D pressure regulating module to ensure optimum sprinkler performance.

Dimensions

Model	Height	Length	Width
• 100-PGA	7 ¼" (18.4 cm)	5 ½" (14.0 cm)	3 ¼" (8.3 cm)
• 150-PGA	8" (20.3 cm)	6 ¾" (17.2 cm)	3 ½" (8.9 cm)
• 200-PGA:	10" (25.4 cm)	7 ¾" (19.7 cm)	5" (12.7 cm)

Note: *PRS-Dial adds 2" (5.1 cm) to valve height*

Models

- 100-PGA: 1" (26/34)
- 150-PGA: 1 ½" (40/49)
- 200-PGA: 2" (50/60)

BSP threads available; specify when ordering

Recommendations

1. Rain Bird recommends flow rates in the supply line not to exceed 7.5 ft/sec (2.29 m/s) in order to reduce the effects of water hammer

2. For flows below 5 gpm (1.14 m³/h; 19.2 l/m), Rain Bird recommends use of upstream filtration to prevent debris from collecting below the diaphragm

3. For flows below 10 gpm (2.27 m³/h; 37.8 l/m) Rain Bird recommends the flow control stem be turned down two full turns from the fully open position

PGA Series Temperature Rating

Water Temperature	Continuous Pressure
73° F	150 psi
80° F	132 psi
90° F	112 psi
100° F	93 psi
110° F	75 psi

PGA Series Temperature Rating METRIC

Water Temperature	Continuous Pressure
23° C	10.4 bar
27° C	9.1 bar
32° C	7.7 bar
38° C	6.4 bar
43° C	5.2 bar

PGA Series Valve Pressure Loss (psi)

Flow gpm	100-PGA Globe 1"	100-PGA Angle 1"	150-PGA Globe 1½"	150-PGA Angle 1½"	200-PGA Globe 2"	200-PGA Angle 2"
1	5.1	4.3	-	-	-	-
5	5.5	5.0	-	-	-	-
10	5.9	5.5	-	-	-	-
20	6.0	5.6	-	-	-	-
30	6.4	5.5	1.9	1.3	-	-
40	7.0	7.5	3.2	2.0	1.2	1.0
50	-	-	4.8	3.0	1.5	0.9
75	-	-	11.1	6.5	3.0	1.7
100	-	-	19.2	11.7	5.5	3.0
125	-	-	-	-	8.6	4.8
150	-	-	-	-	12.0	6.5

PGA Series Valve Pressure Loss (bar) METRIC

Flow m³/h	Flow l/m	100-PGA Globe 2.5 cm	100-PGA Angle 2.5 cm	150-PGA Globe 3.8 cm	150-PGA Angle 3.8 cm	200-PGA Globe 5.1 cm	200-PGA Angle 5.1 cm
0.23	3.8	0.35	0.30	-	-	-	-
0.6	10	0.36	0.32	-	-	-	-
1.2	20	0.38	0.35	-	-	-	-
3	50	0.41	0.38	-	-	-	-
6	100	0.43	0.38	0.10	0.07	-	-
9	150	0.48	0.51	0.22	0.14	0.08	0.07
12	200	-	-	0.38	0.23	0.12	0.07
15	250	-	-	0.61	0.36	0.17	0.10
18	300	-	-	0.86	0.51	0.24	0.13
21	350	-	-	1.16	0.70	0.33	0.18
24	400	-	-	-	-	0.43	0.23
27	450	-	-	-	-	0.54	0.30
30	500	-	-	-	-	0.66	0.36
34	568	-	-	-	-	0.83	0.45

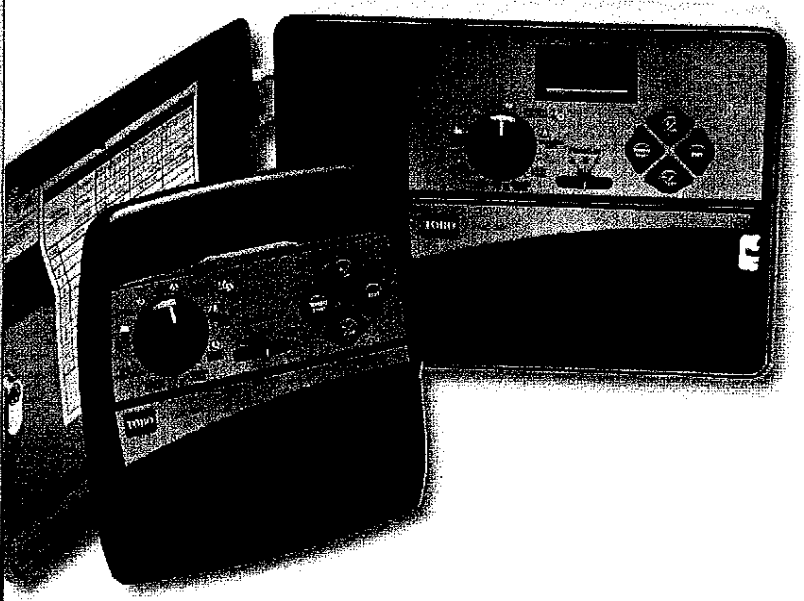
Notes

1. Loss values are with flow control fully open

2. PRS-Dial recommended for use in shaded area only

- 2- to 12-Stations
- Indoor and Outdoor
- Modular

Designed for flexibility, the Toro® TMC-212 is the ideal controller choice for residential applications. With station count modularity from 2 -12 stations and indoor or outdoor models, it's also one of the only controllers needed in a contractor's inventory.




Rain Sensor Compatible


TMR-1 Compatible


PSS-KIT Compatible

EPA WaterSense® approved when used with Irritrol® Climate Logic®

Features & Benefits

Station Count Modularity
For flexibility and reduced inventory— modular from 2 to 12 stations in 2-station increments.

Automatic Short Detection
For circuit protection and faster troubleshooting.

Non-Volatile Memory
Requires no batteries and holds programming for up to five years.

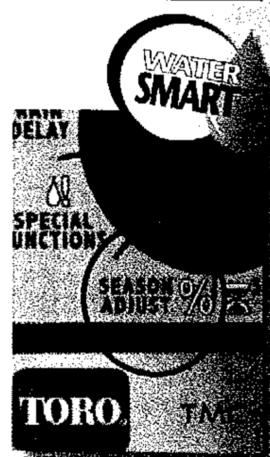
Scheduling Flexibility
Three independent programs and four start times per program.

Pump Start Compatibility
Pump Delay and Well Recovery/Station Delay with Pump-enabled Option.

Water Management Highlight

Auto-split on Season Adjust > 100%

The TMC-212 is designed to help minimize the potential for runoff. When Season Adjust is set > 100%, the TMC-212 will automatically split station run-times in half and run two cycles of the program to minimize the effects of extended runtimes and allow for absorption.



Two-station Modules

Two-station modules provide station count flexibility and cost-effectiveness.

TSM-02 Standard

Specifications

Dimensions

- Indoor: 8" W x 8 ½" H x 2" D (203 x 216 x 51mm)
- Outdoor: 13" W x 9 ½" H x 3 ½" D (330 x 241 x 89mm)
- Weight:
  - Indoor – 3 lbs. 4 oz. (1,5 kg)
  - Outdoor – 5 lbs. 6 oz. (2,4 kg)

Electrical Specifications

- Electrical input power:
  - 120 VAC
  - 18 VA maximum (indoor models)
  - 20 VA maximum (outdoor models)
  - UL, CUL Listed
- Station output power:
  - 24 VAC
  - 0.50 amps per station maximum
  - 0.50 amps pump/master valve
  - 0.70 amps total load
- Surge Protection:
  - 6.0 KV common mode; 600 V normal mode

Operating Specifications

- Three programs, four start times per program
- Station run times from one minute to four hours
- Three Scheduling choices
  - Seven-day calendar
  - 1- to 7-day interval with day exclusion
  - Odd/even days with day exclusion
- Programmable well recovery/station delay from 1 to 60 seconds or 1 to 60 minutes
- Pump start delay from 1 to 60 seconds
- Master valve on/off by program
- Automatic split cycle when season adjust is greater than 100%
- Program stacking
- Rain delay from one to seven days
- Hot-swappable station modules
- Compatible with normally open or normally closed rain sensors
- Operation of two solenoids per station (up to 0.50 amps per station max)
- Indoor and key-lock outdoor models

Optional Accessories

- PSS-KIT - Precision™ Soil Sensor Kit
- TRS – Wired RainSensor
- 53853 – Wired Rain/Freeze Sensor
- TWRS/TWRFS – Wireless RainSensor or Wireless Rain/Freeze Sensor
- TMR-1 – Maintenance Remote

Warranty

- Three years

Advanced Features

Pump Start Delay provides settable time delay between activation of MV/PS and first valve to allow for main pressurization. Well Recovery/Station Delay provides settable time delay between stations to allow for slow-closing valves or well refill with selectable MV/PS Energized during delay.

TMC-212 Series Model List

Model	Description
• TMC-212-ID • TMC-212-OD	4-station, Indoor 4-station, Outdoor
Station Modules - *Base model includes 4 stations (2 modules)*	
Model	**Description**
• TSM-02	2-station Expansion Module

Specifying Information—TMC-212

TMC-212-XX

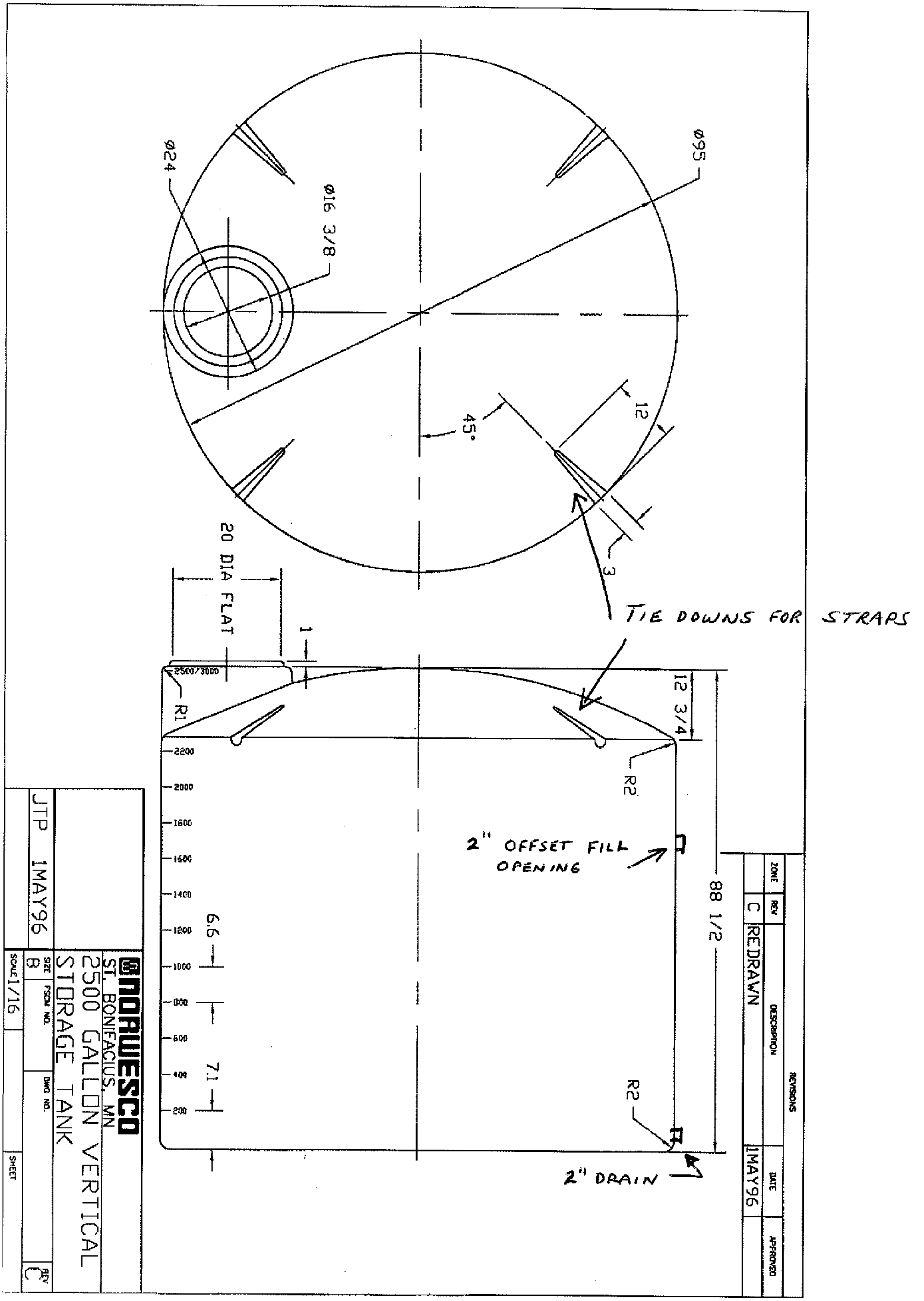
Model	Cabinet Type
TMC-212	**XX**
TMC-212—Toro Controller	ID—Indoor OD—Outdoor

Specifying Information—TSM Module

TSM-02

Model	Module Description
TSM	**02**
TSM—Toro Station Module	02—2-station Expansion Module
Example: A 6-station indoor TMC-212 Controller, would be specified as: TMC-212-ID and TSM-02	

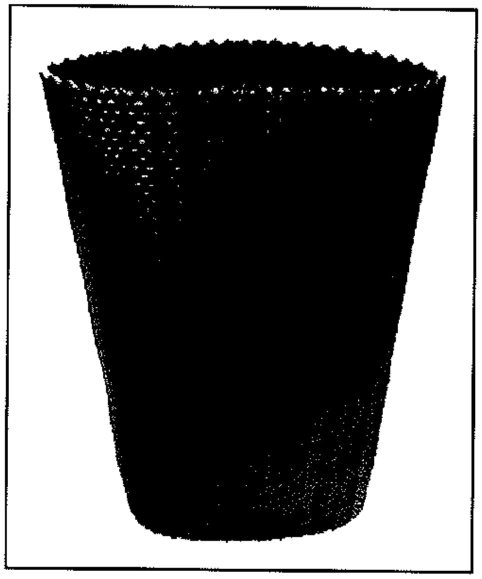
Note: Base model includes four stations (two modules)



Ø95
Ø24
Ø16 3/8
45°
12
3
TIE DOWNS FOR STRAPS
20 DIA FLAT
1
2500/3000
R1
12 3/4
R2
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
6.6
7.1
88 1/2
2" OFFSET FILL OPENING
2" DRAIN
NORWESCO
ST. BONIFACIUS, MN
2500 GALLON VERTICAL
STORAGE TANK
JTP
1MAY96
SIZE B
FSCM NO.
DWG NO.
REV C
SCALE 1/16
SHEET
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
C
REDRAWN
1MAY96

Water Discharge Hose

WA20 BLACK IRON RIVER (OROFLEX 10 STYLE)



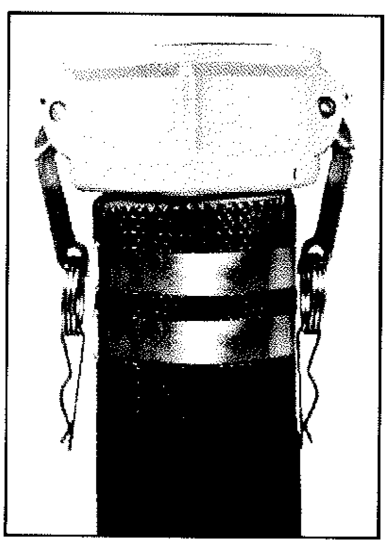
Application:
A premium high pressure rubber layflat hose, suited ideally for mining, construction, agriculture, water jetting, dewatering, industrial wash down, submersible pump discharge applications. This hose has excellent abrasion and weathering resistance and limited oil resistance.

Construction:
Tube - Black ribbed abrasion and oil resistant nitrile rubber.
Reinforcement - Circular woven polyester yarns.
Cover - Black abrasion, weather and oil resistant nitrile rubber.
Branding - FLEXTRAL WA20-200 2" IRON RIVER DISCHARGE HOSE 200 PSI MAX WP

Temperature Range:
-20°C to +82°C (-4°F to +180°F)

Part No.	I.D. Inches	O.D. Inches	Max W.P. PSI	Weight (lbs./ft.)	Stand. Lengths
WA20-150	1½	1.70	200	0.21	300'
WA20-200	2	2.24	200	0.30	300'
WA20-250	2½	2.75	175	0.42	300'
WA20-300	3	3.28	175	0.46	300'
WA20-400	4	4.28	150	0.64	300'
WA20-600	6	6.34	150	1.11	300'
WA20-800	8	8.34	150	1.51	300'
WA20-1000	10	10.36	150	2.50	50/100'
WA20-1200	12	12.42	150	3.92	50/100'

WA20 BLACK IRON RIVER ASSEMBLIES

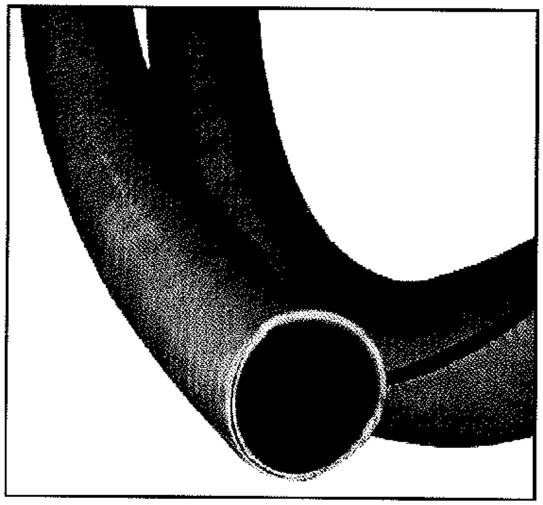


Part No.	Hose Size	Fitting A	Fitting B	Length (ft)	Attaching Method
WA20-150CE50	1½	C	E	50	Preform Clamp
WA20-200CE50	2	C	E	50	Preform Clamp
WA20-300CE50	3	C	E	50	Preform Clamp
WA20-400CE50	4	C	E	50	Preform Clamp
WA20-600CE50	6	C	E	50	Preform Clamp
WA20-800CE50	8	C	E	50	Perform Clamp

* Call for other lengths, fitting and crimping/clamping combinations.

Water Suction Hose

WA50 HD RUBBER SUCTION & DISCHARGE



Application:
A heavy duty rubber suction hose for construction, quarries, mining, dewatering and heavy duty applications, and general use. Suitable for full vacuum.

Construction:
Tube - Black smooth rubber.
Reinforcement - Synthetic yarn with a wire helix.
Cover - Black smooth abrasion resistant rubber.
Branding - FLEXTRAL WA50-200 2" RUBBER WATER SUCTION HOSE 150 PSI MAX WP

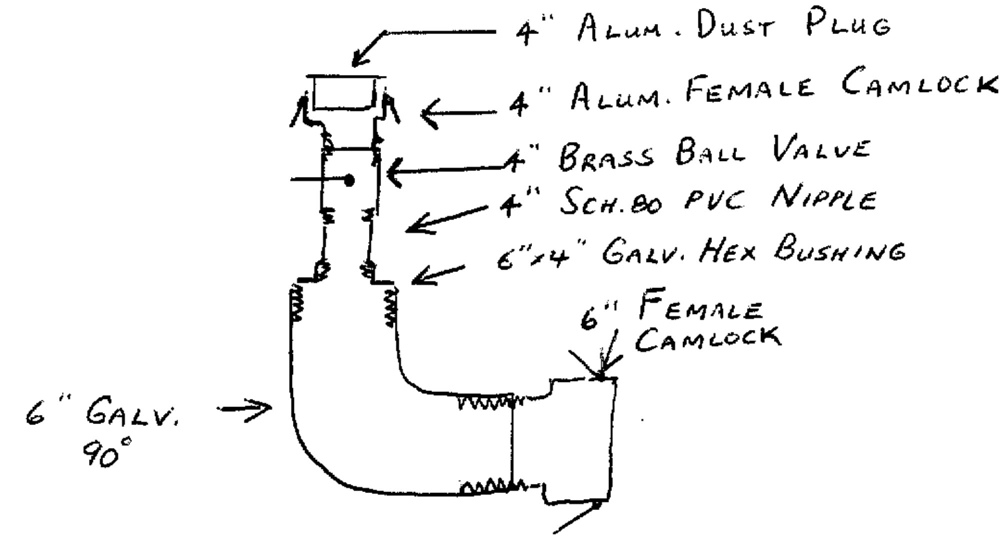
Temperature Range:
-32°C to +85°C (-25°F to +185°F)

Part No.	I.D. Inches	O.D. Inches	Max W.P. PSI@70°F	Radius Inches	Vacuum (Hg.)	Weight (lbs./ft.)	Stand. Lengths
WA50-075	¾	1.22	100	3	29	0.48	100'
WA50-100	1	1.38	150	6	29	0.49	100'
WA50-125	1¼	1.72	150	6	29	0.75	100'
WA50-150	1½	1.96	150	6.5	29	0.80	100'
WA50-200	2	2.49	150	8	29	1.10	100'
WA50-250	2½	2.99	150	10	29	1.75	100'
WA50-300	3	3.50	150	12	29	2.24	100'
WA50-400	4	4.53	150	18	29	2.79	100'
WA50-500	5	5.68	150	26	29	3.25	100'
WA50-600	6	6.54	150	31	29	5.75	20/100'
WA50-800	8	8.79	100	42	29	6.59	20'
WA50-1000	10	10.91	75	50	29	10.25	20'
WA50-1200	12	12.91	75	60	29	13.50	20'

WA50 RUBBER SUCTION & DISCHARGE ASSEMBLIES

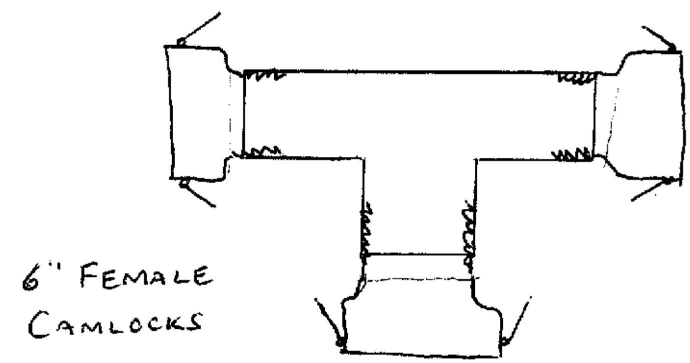
Part No.	Hose Size	Fitting A	Fitting B	Length (ft)	Attaching Method
WA50-150CM20	1½	C	CNT	20	Preform Clamp
WA50-200CM20	2	C	CNT	20	Preform Clamp
WA50-300CM20	3	C	CNT	20	Preform Clamp
WA50-400CM20	4	C	CNT	20	Preform Clamp
WA50-600CM20	6	C	CNT	20	Preform Clamp

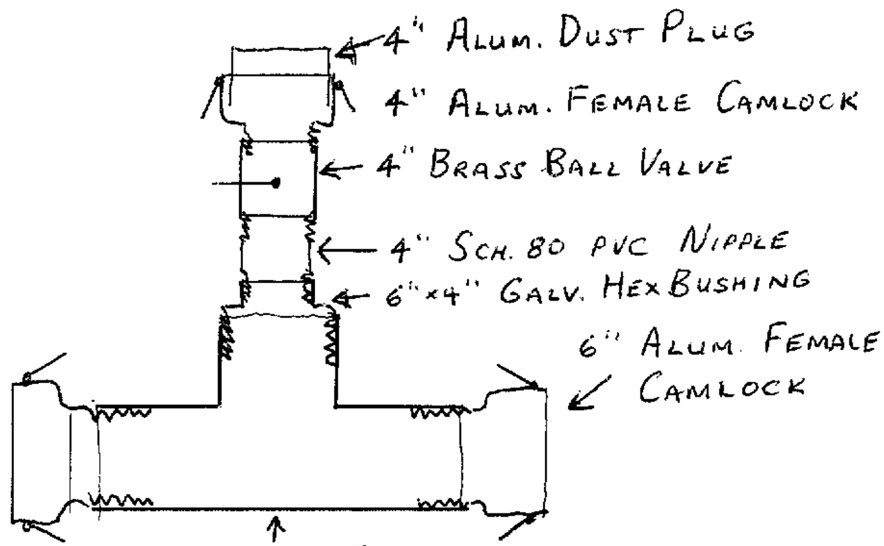
* Call for other lengths and fitting combinations.



6" End of Line (2)

6" Galv. Mainline Tee (1)

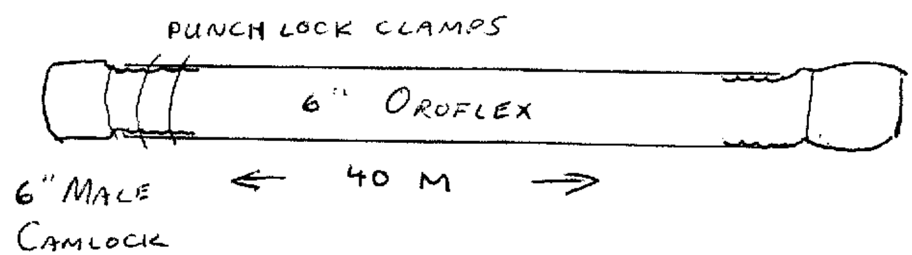




6" Galv. Tee
(20)

All 6" Oroflex Irrigation Hose will be male camlock × male camlock.

Typical (22) Pieces;



BOSHART INDUSTRIES

Telephone: 1-519-595-4444 - Toll Free: 1-800-561-3164
Fax: 1-519-595-4380 - www.boshart.com

NO LEAD FULL PORT BALL VALVES

2 PIECE

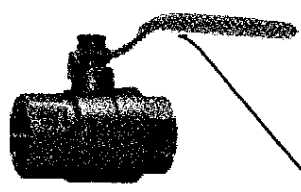
NO LEAD <0.25% Pb by weighted avg. | Third Party Certified to NSF / ANSI 372

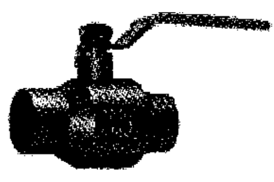
- Rated 600 W.O.G. • Full Port • Blow out proof stem • Blue plastic sleeve
- Temp rating: 32°F to 392°F (0°C to 200°C)
- Packing & seat material: PTFE (polytetrafluoroethylene)

PART NO. THREADED	LIST	PART NO.	LIST	SIZE	PORT DIA.INS.	QUANTITY CTN	CASE
0820-02NL				1/4"	0.354	12	120
0820-03NL				3/8"	0.393	12	120
0820-05NL				1/2"	0.500	10	100
0820-07NL				3/4"	0.748	8	64
0820-10NL				1"	0.984	6	30
0820-12NL				1 1/4"	1.259	6	24
0820-15NL				1 1/2"	1.496	4	16
0820-20NL				2"	1.969	2	8
0820-25NL				2 1/2"	2.480	2	4
0820-30NL				3"	2.952	2	4
0820-40NL				4"		1	2

"BII" FORGED BRASS FULL PORT BALL VALVES - SERIES 0825

BII SERIES 0825





- 1/4" thru 2" rated 600 W.O.G., 2-1/2" thru 4" rated 400 W.O.G.
- 150 PSI saturated steam
- Forged brass
- Blow-out proof stem
- Chrome plated ball
- Yellow plastic sleeve
- Packing & seat material: PTFE (polytetrafluoroethylene)

◇ **The following gas approvals apply to 1/2" - 2" threaded valves only:**
- Meets CSA approval
- Temp Rating: -22°F to +302°F (-30°C to +150°C)

5G STANDARD 3.88 (USA) STANDARD CR91-002 (CAN) 5 PSIG RATED GAS VALVE

PART NO. THREADED	LIST PRICE-F	PART NO. CxC	LIST PRICE-F	SIZE	PORT DIA.INS.	QUANTITY CTN	CASE
0825-02	**5.92**			1/4"	0.393	15	120
0825-03	**5.92**			3/8"	0.393	15	120
0825-05 ◇	**9.06**	0825C-05	**7.99**	1/2"	0.590	15	120
0825-07 ◇	**13.43**	0825C-07	**13.13**	3/4"	0.787	10	60
0825-10 ◇	**19.25**	0825C-10	**18.22**	1"	0.984	8	48
0825-12 ◇	**30.88**	0825C-12	**32.54**	1 1/4"	1.259	4	24
0825-15 ◇	**43.75**	0825C-15	**46.49**	1 1/2"	1.575	2	24
0825-20 ◇	**65.48**	0825C-20	**67.02**	2"	1.969	2	12
0825-25	**134.70**	0825C-25	**125.20**	2 1/2"	2.559	2	6
0825-30	**188.50**	0825C-30	**201.96**	3"	2.952	2	4
0825-40	**320.73**	0825C-40	**320.73**	4"	3.937	1	2

"BII" FORGED BRASS FULL PORT BALL VALVES - SERIES 0827

BII SERIES 0827

- 1/4" thru 2" rated 600 CWP, 2-1/2" thru 4" rated 400 CWP
- CWP (Cold Working Pressure) Rating: -20°F to +100°F (-28°C to +37°C)
- Max Temp Rating: 400°F (204°C)
- PTFE (polytetrafluoroethylene) Packing
- WSP (Working Steam Pressure) Rating: 150 PSI Saturated Steam
- Chrome Plated Ball
- Blow-out Proof Stem
- Yellow plastic sleeve
- UL Listed, FM Certified: 1/4" thru 2" threaded and CxC
- cUPC Certified by IAPMO according to IGC157: 1/4" thru 2" threaded and CxC
- NSF/ANSI 61-8 Certified by IAPMO: 1/4" thru 4" threaded and CxC

◇ **The following CSA gas approvals apply to 1/4" - 2" threaded valves only:**

BRS125G 125 PSIG RATING (USA) ASME B16.33 STANDARD

CAN 3.16 CAN / CGA - 3.16 STANDARD 125 PSIG RATING (CAN) FOR OUTDOOR USE

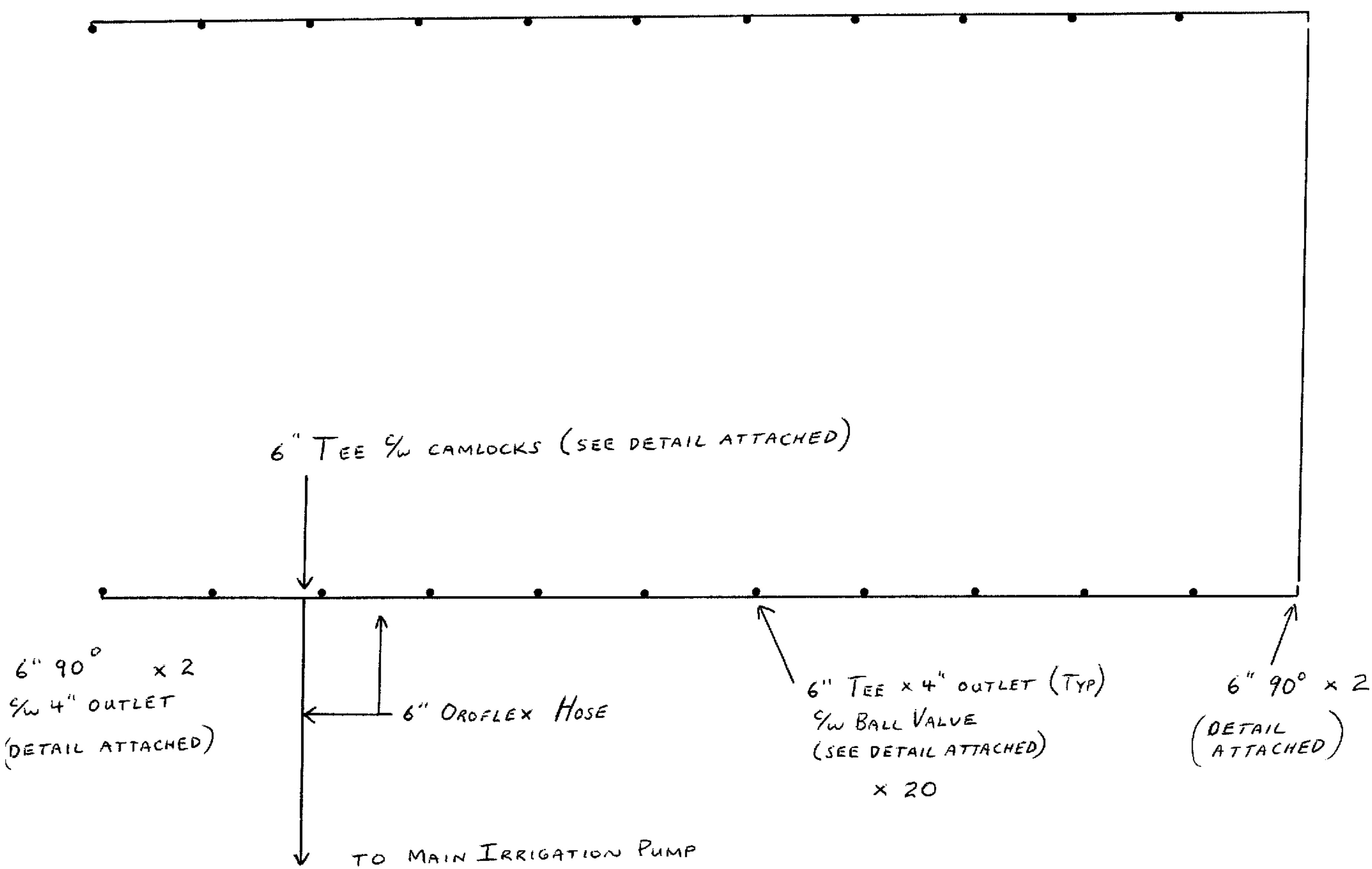
1/2PSI ANSI Z21.15 (USA) CGA 9.1 (CAN) 1/2 PSIG APPLIANCE VALVE

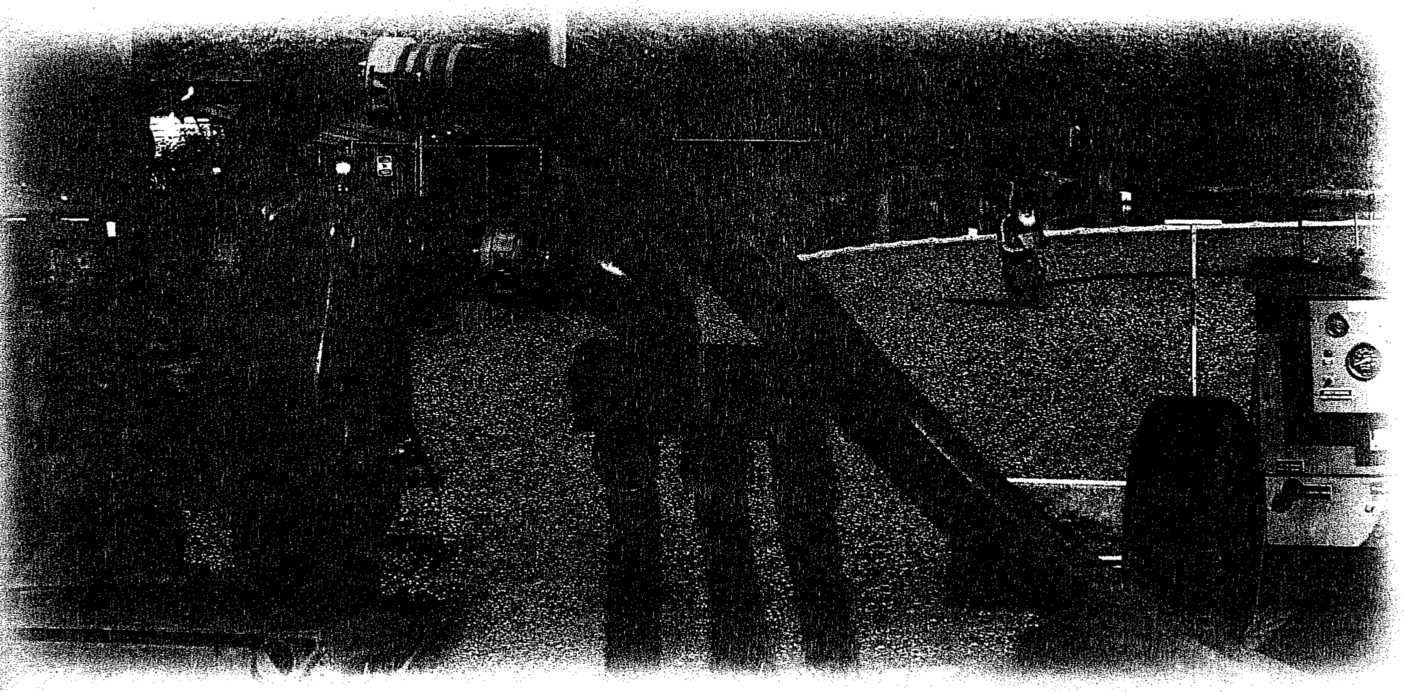
5G STANDARD 3.88 (USA) STANDARD CR91-002 (CAN) 5 PSIG RATED GAS VALVE

PART NO. THREADED	LIST PRICE-F	PART NO. CxC	LIST PRICE-F	SIZE	PORT DIA.INS.	QUANTITY CTN	CASE
0827-02 ◇	**5.81**			1/4"	0.39	12	120
0827-03 ◇	**5.27**			3/8"	0.39	12	120
0827-05 ◇	**7.44**	0827C-05	**6.51**	1/2"	0.59	10	100
0827-07 ◇	**11.35**	0827C-07	**10.46**	3/4"	0.75	8	64
0827-10 ◇	**18.25**	0827C-10	**16.27**	1"	0.98	6	30
0827-12 ◇	**26.49**	0827C-12	**24.52**	1 1/4"	1.25	6	24
0827-15 ◇	**41.03**	0827C-15	**38.97**	1 1/2"	1.57	4	16
0827-20 ◇	**58.12**	0827C-20	**53.55**	2"	1.97	2	8
0827-25	**140.41**	0827C-25	**118.27**	2 1/2"	2.52	2	4
0827-30	**171.93**	0827C-30	**155.43**	3"	2.95	2	4
0827-40	**277.10**	0827C-40	**280.03**	4"	3.90	1	2

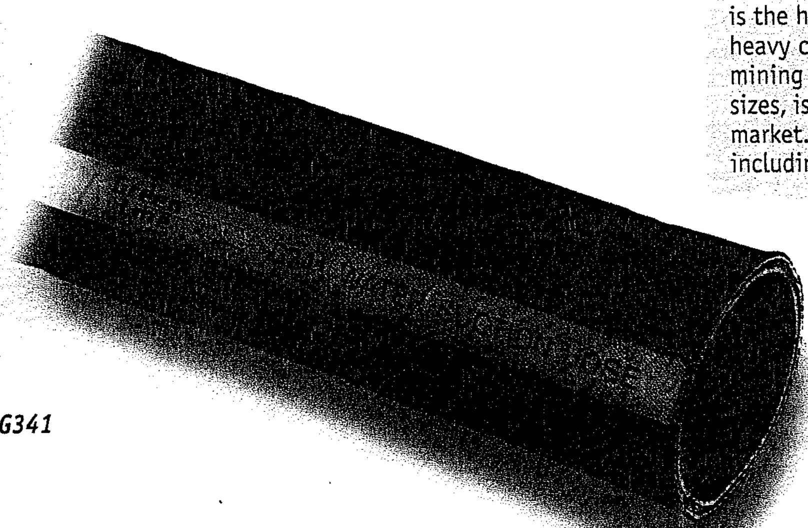
NOTE: Handles are available. Please contact your Sales Rep.

Leaf + Yard Waste Pad





Rubber Water Suction is the "traditional" suction hose. It is the heavy-duty product still preferred by many users for heavy construction, dewatering, municipal, irrigation and mining applications. Our hose, particularly in the larger sizes, is more robust than many other products found in the market. It is ideal for rugged and demanding applications, including vacuum truck service.



G341

G341... RUBBER WATER SUCTION

Tube: Smooth, black rubber.

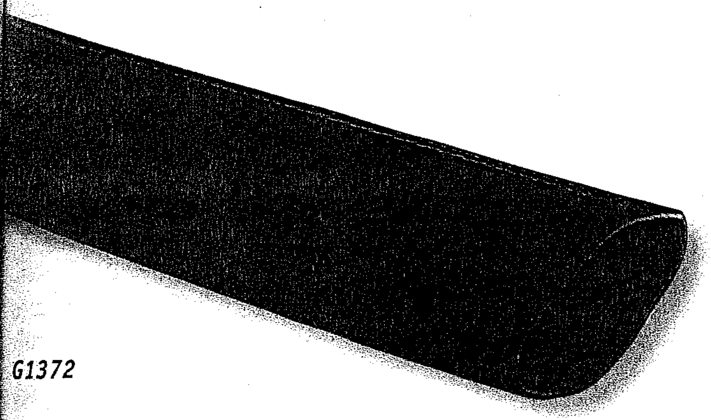
Reinforcement: Heavy wire helix embedded between layers of synthetic textile cords.

Cover: Black, wrapped finish, weather and abrasion resistant rubber with green stripe.

Temperature Range: -40°C (-40°F) to 70°C (158°F)

I.D.	Part Number	O.D.	Working Pressure	Vacuum Rating	Bend Radius	Weight per foot	PRICE PER FOOT Cut	PRICE PER FOOT Std Length	Standard Length
1"	G341-100	1.38"	150 psi	Full	7"	0.50 lb	$ 6.10	$ 5.10	100 ft
11/4	G341-125	1.65	150	Full	8	0.61	6.80	5.50	100
11/2	G341-150	1.93	150	Full	9	0.80	6.90	5.60	100
2	G341-200	2.48	150	Full	12	1.06	7.70	6.60	20 or 100
21/2	G341-250	2.95	150	Full	15	1.51	10.70	8.90	100
3	G341-300	3.46	150	Full	21	1.81	12.10	10.00	20 or 100
4	G341-400	4.57	150	Full	30	2.42	17.60	14.50	20 or 100
5	G341-500	5.60	75	Full	40	4.20	29.00	24.20	100
6	G341-600	6.77	75	Full	48	5.78	33.60	27.90	20 or 60
8	G341-800	8.82	75	Full	64	7.56	65.60	48.90	20 or 40
10	G341-1000	10.94	75	Full	80	10.20		73.10	20
12	G341-1200	12.88	60	Full	96	13.37		126.10	20

For popular suction and discharge assemblies see pages 48-49.



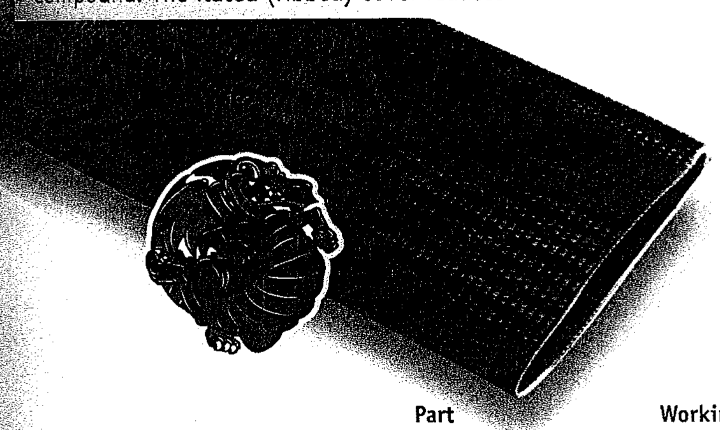
G1372

Where conventional fabric covered fire hoses are used in wash-down or mill discharge applications, they quickly become frayed on the cover. Adding a nitrile/PVC blend rubber cover gives a long lasting hose suitable for many applications such as plant wash-down and general water discharge for construction and rental companies.

Tube: Nitrile/PVC blend rubber.
Reinforcement: Woven synthetic fabric.
Cover: Rib finish nitrile/PVC blend rubber.
Temperature Range: -20°C (4°F) to 70°C (158°F)

I.D.	Part Number	O.D.	Working Pressure	Weight per ft	LIST PRICE PER FOOT Cut	Std Length	Standard Length
$1^1/_2$"	G1372-150	1.66"	200 psi	0.21 lb	$ 3.90	$ 2.80	50 or 200 ft
2	G1372-200	2.16	200	0.30	4.90	3.50	50 or 200
3	G1372-300	3.20	175	0.48	7.60	5.50	50 or 200
4	G1372-400	4.24	150	0.67	9.90	7.20	50 or 200
6	G1372-600	6.28	150	1.36	18.00	12.30	50 or 200

Black Dragon is a unique product which combines the "single wall" features of the PVC discharge hoses (light-weight, easy to coil, compact construction) with the abrasion resistance and temperature range of rubber. In addition, it incorporates an oil and chemical resistant nitrile rubber compound. The fluted (ribbed) cover reduces dragging friction to make handling easier and further reduce wear. Black Dragon is fast overtaking conventional discharge hoses in popularity. It is an excellent value when both durability and easy handling are considered. Black Dragon is even suitable for some oil products and is ideal for use with pollution control equipment.



G1373

G1373... BLACK DRAGON

Construction: G1373 Black Dragon is manufactured using a unique process which incorporates the inner tube, reinforcement, and outer cover into a single "solid wall" hose. The reinforcement, a seamless, woven, high-tenacity polyester, is embedded in black nitrile/PVC blend rubber. This gives the hose the same tough, abrasion, oil and weather resistant properties inside and out.

Temperature Range: -30°C (-22°F) to 70°C (158°F).

I.D.	Part Number	O.D.	Working Pressure	Weight per ft	PRICE PER FOOT Cut	Std Length	Standard Length
$1^1/_2$"	G1373-150	1.66"	200 psi	0.21 lb	$ 4.60	$ 3.30	50 or 100 ft*
2	G1373-200	2.16	200	0.30	5.90	4.30	50 or 100
$2^1/_2$	G1373-250	2.66	175	0.37	8.20	5.90	50 or 100
3	G1373-300	3.20	175	0.48	8.80	6.40	50 or 100
4	G1373-400	4.25	150	0.67	11.40	8.30	50 or 100
6	G1373-600	6.25	150	1.36	20.50	14.00	50 or 100
8	G1373-800	8.28	150	1.75	41.60	27.50	50
10	G1373-1000	10.32	150	2.02	84.50	49.90	50

For popular discharge hose assemblies see page 50.

ALUMINUM CAM-LOCKS

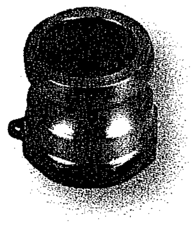
Our aluminum cam-locks are manufactured from aluminum alloy 384 (JIS grade ADS12) and feature type 316 stainless pins, forged brass handles, and plated steel finger rings. G65 couplings fit Commercial Item Description (CID) #A-A-59326B for sizes 3/4" to 6" and will interchange with other couplings that meet this specification. No government standard has been established for 1/2", 8" and 10" so different manufacturers' couplings may not interchange in this size. Female couplers are supplied with locking clips.

Aluminum working pressures:

1/2" to 2"	250 psi
2 1/2" to 4"	150
5" & 6"	75
8"	50

Standard gaskets are rated to 105°C (221°F)

G65A... PART A FEMALE NPT ADAPTER

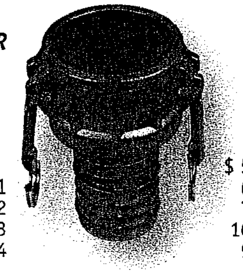


Part No.	Size	IMPA Code	PRICE EACH
G65A-050	1/2"	35-17-01	$ 3.30
G65A-075	3/4"	35-17-02	3.30
G65A-100	1"	35-17-03	3.50
G65A-125	1 1/4"	35-17-04	4.50
G65A-150	1 1/2"	35-17-05	4.30
G65A-200	2"	35-17-06	4.90
G65A-250	2 1/2"	35-17-07	8.90
G65A-300	3"	35-17-08	8.70
G65A-400	4"	35-17-09	14.60
G65A-500	5"	35-17-10	34.90
G65A-600	6"	35-17-11	33.20
G65A-800	8"	35-17-12	158.60
G65A-1000	10"		337.10

G65B... PART B MALE NPT COUPLER

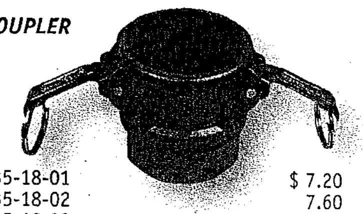
Part No.	Size	IMPA Code	PRICE EACH
G65B-050	1/2"	35-18-51	$ 6.70
G65B-075	3/4"	35-18-52	7.50
G65B-100	1"	35-18-53	8.50
G65B-125	1 1/4"	35-18-54	10.60
G65B-150	1 1/2"	35-18-55	10.60
G65B-200	2"	35-18-56	11.20
G65B-250	2 1/2"	35-18-57	16.80
G65B-300	3"	35-18-58	18.80
G65B-400	4"	35-18-59	27.20
G65B-500	5"	35-18-60	62.80
G65B-600	6"	35-18-61	60.40
G65B-800	8"	35-18-62	307.70
G65B-1000	10"		546.10

G65C... PART C HOSE SHANK COUPLER



Part No.	Size	IMPA Code	PRICE EACH
G65C-050	1/2"		$ 5.90
G65C-075	3/4"	35-20-01	6.10
G65C-100	1"	35-20-02	7.00
G65C-125	1 1/4"	35-20-03	10.00
G65C-150	1 1/2"	35-20-04	9.90
G65C-200	2"	35-20-05	11.60
G65C-250	2 1/2"	35-20-06	17.20
G65C-300	3"	35-20-07	19.60
G65C-400	4"	35-20-08	26.00
G65C-500	5"	35-20-09	65.60
G65C-600	6"	35-20-10	60.40
G65C-800	8"	35-20-11	296.10
G65C-1000	10"		719.50

G65D... PART D FEMALE NPT COUPLER



Part No.	Size	IMPA Code	PRICE EACH
G65D-050	1/2"	35-18-01	$ 7.20
G65D-075	3/4"	35-18-02	7.60
G65D-100	1"	35-18-03	8.20
G65D-125	1 1/4"	35-18-04	10.90
G65D-150	1 1/2"	35-18-05	10.20
G65D-200	2"	35-18-06	11.10
G65D-250	2 1/2"	35-18-07	18.00
G65D-300	3"	35-18-08	18.90
G65D-400	4"	35-18-09	28.20
G65D-500	5"	35-18-10	54.30
G65D-600	6"	35-18-11	59.30
G65D-800	8"	35-18-12	282.50
G65D-1000	10"		546.10

G65E... PART E HOSE SHANK ADAPTER

Part No.	Size	IMPA Code	PRICE EACH
G65E-050	1/2"		$ 3.70
G65E-075	3/4"	35-19-01	3.50
G65E-100	1"	35-19-02	4.00
G65E-125	1 1/4"	35-19-03	5.30
G65E-150	1 1/2"	35-19-04	5.00
G65E-200	2"	35-19-05	6.30
G65E-250	2 1/2"	35-19-06	10.80
G65E-300	3"	35-19-07	12.60
G65E-400	4"	35-19-08	20.90
G65E-500	5"	35-19-09	48.50
G65E-600	6"	35-19-10	51.20
G65E-800	8"	35-19-11	189.50
G65E-1000	10"		447.30

G65F... PART F MALE NPT ADAPTER

Part No.	Size	IMPA Code	PRICE EACH
G65F-050	1/2"	35-17-51	$ 4.20
G65F-075	3/4"	35-17-52	4.20
G65F-100	1"	35-17-53	4.60
G65F-125	1 1/4"	35-17-54	6.20
G65F-150	1 1/2"	35-17-55	5.40
G65F-200	2"	35-17-56	6.50
G65F-250	2 1/2"	35-17-57	11.80
G65F-300	3"	35-17-58	12.50
G65F-400	4"	35-17-59	20.40
G65F-500	5"	35-17-60	48.80
G65F-600	6"	35-17-61	46.70
G65F-800	8"	35-17-62	200.00
G65F-1000	10"		367.60

Safety Note: ***Cam-locks should not be used with compressed air or other compressed gases.***

OROFLEX 10	Nominal Diameter	Minimum DIAM	Maximum DIAM	Min.Thickness	Max.Thickness	
	[mm]	[mm]	[mm]	[mm]	[mm]	
	25	24,0	26,0	2,1	2,3	
	30	29,0	31,0	2,1	2,3	
	38	37,5	39,5	2,0	2,2	
	45	44,0	47,0	1,7	1,9	
	52	52,0	55,0	1,8	2,0	
	60	59,5	62,0	2,5	2,8	
	65	64,5	67,0	1,8	2,1	
	70	69,0	72,0	1,8	2,1	
	75	74,5	77,0	2,1	2,4	**Metric**
	76	76,0	79,0	2,1	2,4	**Kamlock**
	80	79,5	82,0	2,1	2,4	
	90	89,5	92,0	2,2	2,5	
	102	101,5	105,0	2,2	2,5	
	110	110,0	112,0	2,3	2,6	
	127	124,5	127,0	2,7	3,2	
	152	151,0	155,0	2,7	3,2	
	204	203,0	206,0	3,5	4,0	
	254	251,0	257,0	3,7	4,2	
	305	302,0	308,0	5,0	5,5	

TECNICAS E INGENIERIA DE PROTECCIÓN S.A.
Pol. Ind. Can Manou, s/nº
08736 - GUARDIOLA DE FONT-RUBI (BCN)
TEL. +34 93 897 89 50
FAX + 34 93 897 85 79

CERTIFICATE OF ORIGIN

Hereby we certify that the hoses **OROFLEX** are manufactured by **TÉCNICAS E INGENIERÍA DE PROTECCIÓN S.A.** in Guardiola de Font Rubí (Barcelona), and are manufactured according to the **ISO 9001 : 2008** standard.

TECNICAS E INGENIERIA DE PROTECCIÓN S.A.
Eva Martín
Plant Engineer

Date: 10th, June 2013

tipsa

FROM THE MANUFACTURER

Nº:	020513/3

Técnicas e Ingeniería de Protección S.A.
P.O. Box 293
08720 Vilafranca del Penedés
Barcelona - Spain

CERTIFICATE OF CONFORMANCE

To Whom It May Concern:

Tipsa, manufacturer of the OROFLEX 20 4", 6" & 8" certifies that the results for those articles,

are according to our internal quality control and and ISO 9001:2008 requirements.

Signed on 2nd May 2013 in Guardiola de Font-Rubí by :

Eva Martin
Process & Quality Manager

OROFLEX 10

Applications: Suitable for use and recommended for INDUSTRIAL an AGRICULTURE applications in:

Cleaning of Industrial Plants
Bilge water operations
Fire protection in mining (MSHA)
Refineries and Petro-Chemical
Applications for water discharge
Water operations "Bypass"
Cable Shealth
Relining

Not recommended or approved for fire fighting.
However, " **ARMTEX & ARMTEX HD "** hoses with similar characteristics are recommended

Construction: Hose shall be made from 100% high tenacity synthetic yarn circular woven and completely, protected and locked-in by tough highly resistant synthetic nitrile rubber, forming a single homogenous construction without the use of glues or adhesiv

Lining Properties:

a. Ultimate Tensile Strength:
Tensile strength of the lining and cover shall not be less than 1500 psi (10,500 kpa).
b. Ultimate Elongation:
400% minimum.
c. Accelerated Aging Test:

The tensile strength and ultimate elongation of the vulcanized rubber compound which has been subjected to the action of oxygen at a pressure of 300 psi +/- 10 psi , (2100kpa +/- 70kpa) and temperature of 70 degrees centigrade +/-1 degree cent.

Physical Values:

Diameter		Working Pressure		Burst Pressure		End Pull		Weight		Wall Thickness		Bend radius at W.P.	
Inch	mm	psi	K Pa	psi	K Pa	lb	Kg.	lb/ft	gr /m.	inch	mm.	ft.	mm.
1 1/4	30	300	2100	1300	9000	1543	700	0,192	285	0,09	2,3	1,64	500
1 1/2	38	200	1400	600	4200	1984	900	0,209	310	0,08	2,0	2,30	700
1 3/4	45	200	1400	600	4200	2646	1200	0,249	370	0,07	1,8	2,95	900
2	52	200	1400	600	4200	2866	1300	0,269	400	0,08	2,0	3,61	1100
2 1/4	60	200	1400	600	4200	3086	1400	0,390	580	0,11	2,86	3,94	1200
2 1/2	63,5	145	1000	435	3000	3086	1400	0,320	475	0,08	2,0	4,27	1300
2 3/4	70	145	1000	435	3000	3748	1700	0,384	570	0,08	2,15	4,43	1350
3	76	145	1000	435	3000	3968	1800	0,444	660	0,10	2,5	4,76	1450
3 1/2	90	145	1000	435	3000	4630	2100	0,579	860	0,10	2,5	4,86	1480
4	102	145	1000	435	3000	5291	2400	0,639	950	0,10	2,5	5,58	1700
4 1/4	110	145	1000	435	3000	8818	4000	0,734	1092	0,09	2,34	5,91	1800
5	127	145	1000	435	3000	9259	4200	0,976	1450	0,12	3,0	6,89	2100
6	152	145	1000	435	3000	11023	5000	1,110	1650	0,12	3,0	7,38	2250
8	203	110	800	350	2400	14550	6600	1,918	2850	0,12	3,0	9,84	3000
10	254	110	800	350	2400	15873	7200	2,490	3700	0,14	3,5	10,50	3200

Abrasion Resistance:
In very extreme conditions where abrasion is the most serious concern OROFLEX 10 would extend hose life. Abrasion resistance> 2000 cycles. DIN Class 5

Cold Resistance:
Hose shall have a capability of use down to **-** 22 ºF. Hose shall have no apparent damage to cover, reinforcement or lining when subject to -36 ºF

Ozone Resistance:
Hose shall show no visible signs of cracking of the lining or cover when tested in accordance with ASTM D1149-64 (R1970), ASTM D518 Procedure B, 100pphm/118 F/70 hours.

Chemical Resistance:
Exposure to seawater and contamination by most chemical substances, hydrocarbons, oils, alkalis, acids and greases must have no effect on the short or long term performance of the hose. A chemical resistance chart is available and TIPSA will supply specific chemical resistance data on request of purchaser for unique applications.

Heat Resistance:
The hose when subjected to a static pressure of 100 psi (700 kpa) shall be capable of withstanding a surface temperature of 1200 F for a minimum of two minutes without rupture or damage to the synthetic reinforcement.

Repairability:
Cover damage, small holes and punctures are repairable with use of ***REPOKIT*** and Vulcanizer. Full instructions for use supplied on request.

Color:
Black and Ocre(Yellow), special orders in other colors, all with ribbed cover

Couplings:
As required by purchaser, Kamlock , Combination , Short shank , Victaulic ETC..

Lengths:
Standard 50' (15m), 100' (30m), 200' (60m). special lengths up to 660' (200m)

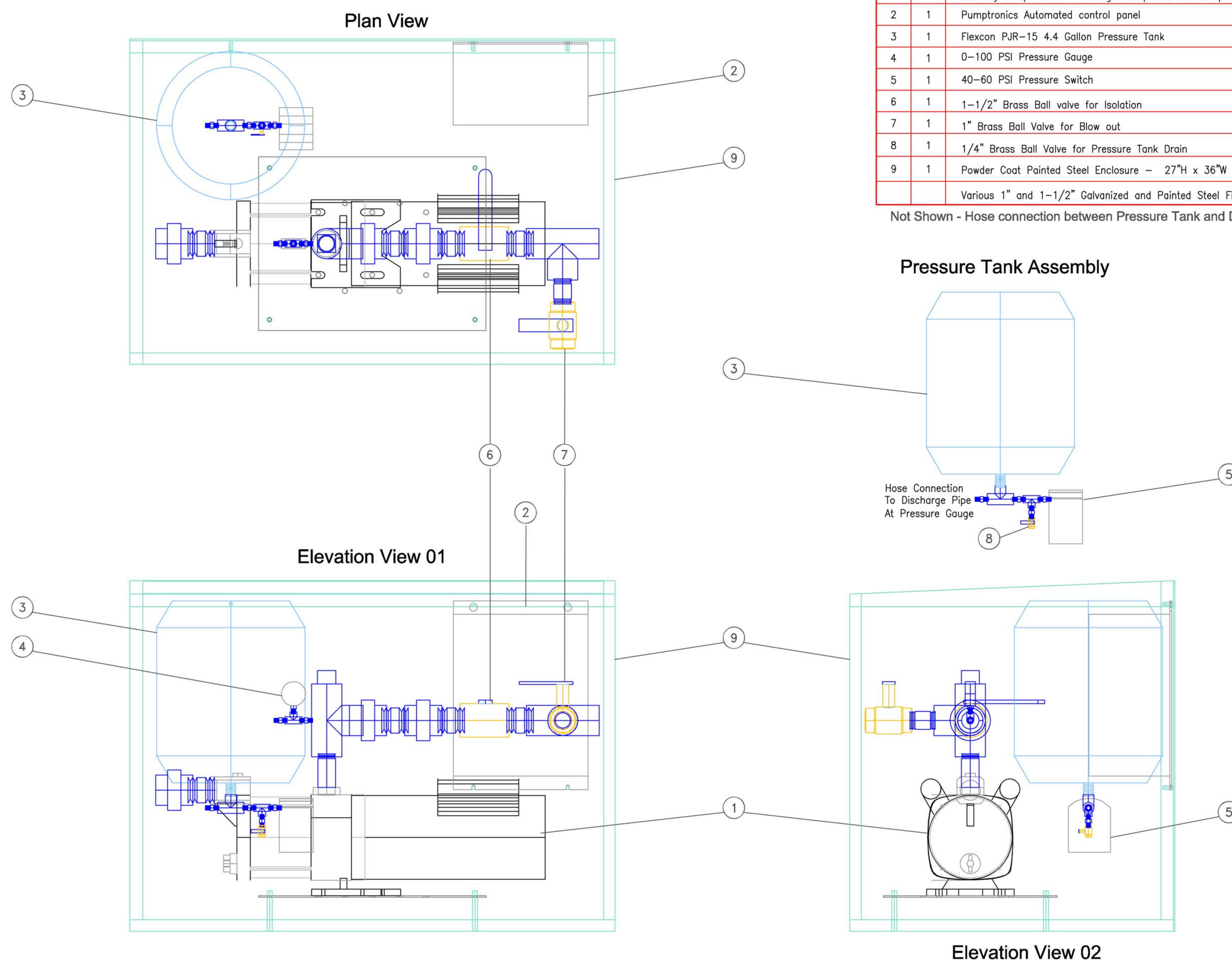
TIPSA reserves the right to modify any specification without prior notice to meet or exceed changing standards. Customers are advised that special diameters or construction characteristics can be produced on special request and you are requested to contact your local dealer or TIPSA at our email address.

tipsaex@tipsa.com

EQUIPMENT SCHEDULE

ITEM	Q'TY	DESCRIPTION
1	1	Berkeley 2 Hp SSHM – 4 stage Pump end and 2 Hp Motor 230/1/60
2	1	Pumptronics Automated control panel
3	1	Flexcon PJR-15 4.4 Gallon Pressure Tank
4	1	0–100 PSI Pressure Gauge
5	1	40–60 PSI Pressure Switch
6	1	1-1/2" Brass Ball valve for Isolation
7	1	1" Brass Ball Valve for Blow out
8	1	1/4" Brass Ball Valve for Pressure Tank Drain
9	1	Powder Coat Painted Steel Enclosure – 27"H x 36"W x 25"D
		Various 1" and 1-1/2" Galvanized and Painted Steel Fittings

Not Shown - Hose connection between Pressure Tank and Discharge pipe



PUMPTRONICS PUMPING SYSTEMS	Pump Model #: MB-1CSC-30/75-2-3450-230/1/60	
230/1/60	PUMPTRONICS	30 USGPM @ 75 PSI
June 3 2013	2 Hp Mini-Universal	Revision 1

POWER & MINE

PUMPS • VALVES & ACTUATORS
MECHANICAL SEALS • PROCESS EQUIPMENT

POWER & MINE SUPPLY CO. LTD

May 16, 2013

BRRMF L&YW Irrigation Pump Submittal

Owner:	Brady Landfill
Project:	BRRMF L&YW Biosolids Composting
Engineer:	CH2M Hill
Contractor:	Ful-Flo Industries Ltd.
Contractor's PO Number:	2061
Equipment Tags:	P-101
Serial Numbers:	TBD
Specifications Section:	11270

PUMPS • VALVES & ACTUATORS
MECHANICAL SEALS • PROCESS EQUIPMENT

POWER & MINE SUPPLY CO. LTD

□□de□

Winnipeg: 4 – 75 Meridian Drive, Winnipeg MB R2R 2V9 • **Phone** (204) 694-9300 • **Fax** (204) 694-7876
Saskatoon: 901 First Avenue, Saskatoon SK S7K 1Y4 •**Phone** (306) 244-7274 • **Fax** (306) 244-9911
Regina: 306 – 845 Broad Street, Regina SK S4R 8G9 • **Phone** (306) 791-0417 • **Fax** (306) 791-0418
Thunder Bay: 675 Harold Crescent, Thunder Bay ON P7C 5H6 • **Phone** (807) 622-4044 •**Fax** (807) 622-3235

PUMPS • VALVES & ACTUATORS
MECHANICAL SEALS • PROCESS EQUIPMENT

POWER & MINE SUPPLY CO. LTD

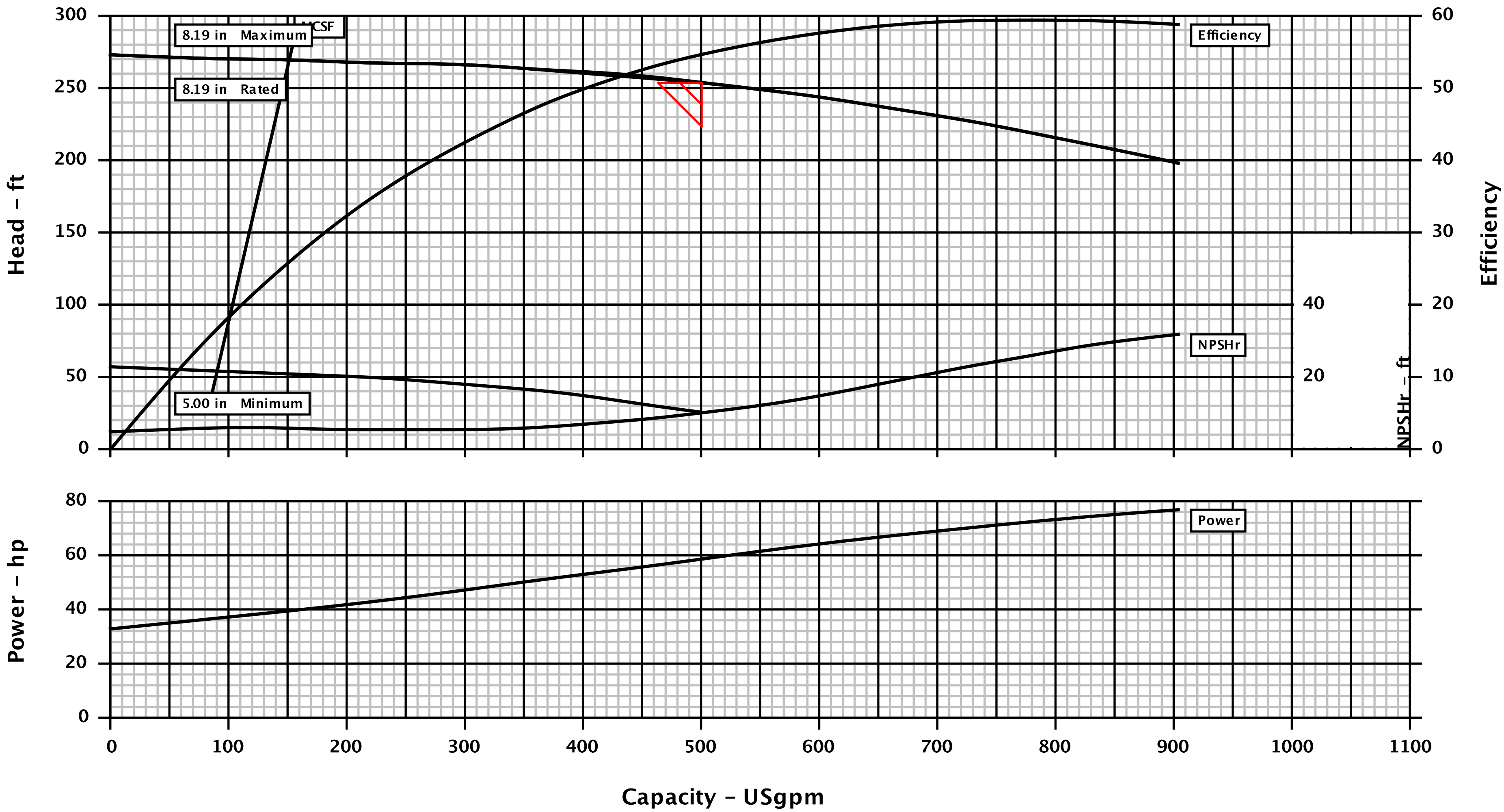
Section 1
Pump & Motor Datasheets

Winnipeg: 4 – 75 Meridian Drive, Winnipeg MB R2R 2V9 • **Phone** (204) 694-9300 • **Fax** (204) 694-7876
Saskatoon: 901 First Avenue, Saskatoon SK S7K 1Y4 •**Phone** (306) 244-7274 • **Fax** (306) 244-9911
Regina: 306 – 845 Broad Street, Regina SK S4R 8G9 • **Phone** (306) 791-0417 • **Fax** (306) 791-0418
Thunder Bay: 675 Harold Crescent, Thunder Bay ON P7C 5H6 • **Phone** (807) 622-4044 •**Fax** (807) 622-3235

Customer	: Ful-Flo Industries	Pump size & type	: 2K4x3US-82RV M3US
Item number	: P-101	Based on curve no.	: MIII8075
Service	: Irrigation Pump	Number of stages	: 1
Flowserve reference	: 127808 Version 1	Test tolerance	: Hydraulic Institute Level A
Date	: May 16, 2013		

Capacity	: 500.0 USgpm	Specific gravity	: 1.000
Head	: 254.00 ft	Pump speed	: 3550 rpm

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS; CAPACITY, HEAD, AND EFFICIENCY.



FLOWSERVE

Hydraulic Datasheet

Customer	: Ful-Flo Industries	Pump / Stages	: 2K4x3US-82RV M3US / 1
Customer reference	:	Based on curve no.	: MIII8075
Item number	: P-101	Flowserve reference	: 127808 Version 1
Service	: Irrigation Pump	Date	: May 16, 2013

Operating Conditions

Capacity	: 500.0 USgpm
Water capacity (CQ=1.00)	: -
Normal capacity	: -
Total Developed Head	: 254.00 ft
Water head (CH=1.00)	: -
NPSH available (NPSHa)	: 33.4 ft
NPSHa less NPSH margin	: -
Maximum suction pressure	: 0.0 psig

Liquid

Liquid type	: Fresh water
Temperature / Spec. Gravity	: 60 F / 1.000
Solid Size - Actual / Limit	: - / -
Viscosity / Vapor pressure	: 1.0 cSt / 0.26 psia

Materials / Specification

Material column code	: S/D
Pump specification	: ANSI B73.1

Other Requirements

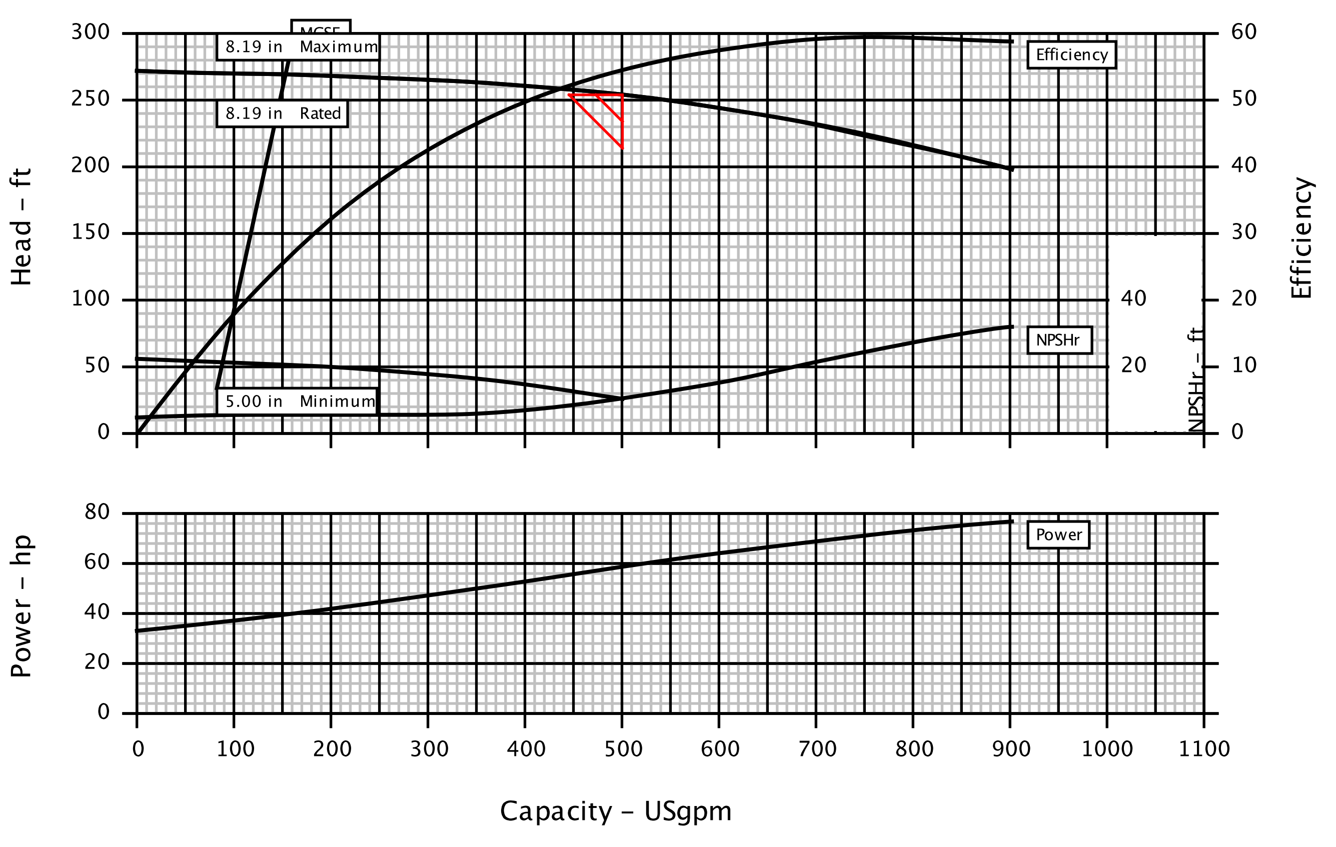
Hydraulic selection : No specification
Construction : No specification
Test tolerance : Hydraulic Institute Level A
Driver Sizing : Max Power(MCSF to EOC)with SF
Seal configuration : Single Seal

Performance

Hydraulic power	: 32.1 hp
Pump speed	: 3550 rpm
Efficiency (CE=1.00)	: 54.7 %
NPSH required (NPSHr)	: 9.5 ft
Rated power	: 58.6 hp
Maximum power	: 76.6 hp
Driver power	: 100.0 hp / 74.6 kW
Casing working pressure	: 117.9 psig
(based on shut off and Rated specific gravity @ Cut dia)	
Maximum allowable	: 285.0 psig
Hydrostatic test pressure	: 428.0 psig
Est. rated seal chamb. press.	: -

Impeller diameter	
Rated	: 8.19 in
Maximum	: 8.19 in
Minimum	: 5.00 in
Suction specific speed	: 8910 US units
Minimum continuous flow	: 150.0 USgpm
Maximum head @ rated dia	: 272.33 ft
Flow at BEP	: 785.4 USgpm
Flow as % of BEP	: 63.7 %
Efficiency at normal flow	: -
Impeller dia ratio (rated/max)	: 100.0 %
Head rise to shut off	: 7.2 %
Total head ratio (rated/max)	: 100.0 %

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS; CAPACITY, HEAD, AND EFFICIENCY.



FLOWSERVE

Construction Datasheet

Customer	: Ful-Flo Industries	Pump / Stages	: 2K4x3US-82RV M3US / 1
Customer reference	:	Based on curve no.	: MIII8075
Item number	: P-101	Flowserve reference	: 127808 Version 1
Service	: Irrigation Pump	Date	: May 16, 2013

Construction

Nozzles	Size	Rating	Face	Pos'n
Suction	4.00	150#	FF	End
Discharge	3.00	150#	FF	Top

Casing mounting	: Foot
Casing split	: Radial
Impeller type	: Reverse Vane
Bearing type (radial)	: Single row
Bearing number (radial)	: 6310-C3
Bearing type (thrust)	: Double row
Bearing number (thrust)	: 5310-AHC3
Bearing lubrication	: Flood
Rotation (view from cplg)	: CW per Hyd. Institute

Materials

Casing	: DS/WCB
Impeller	: DUCTILE IRON (DCI)
Seal chamber	: FML Box / (DCI)
Shaft	: BB 1144 Steel
Sleeve	: NO SLEEVE

Baseplate, Coupling and Guard

Baseplate type	: Fabricated Steel
Baseplate material	:
Baseplate size	:
Coupling manufacturer	: Woods SC8/10H
Coupling size	:
Coupling / Shaft guard	: Steel
Shaft / seal guard	: None Provided

Weights (Approx.)

Bareshaft pump(nett)	: 400.0 lb
Baseplate(nett)	: -
Driver(nett)	: -
Shipping gross weight/vol.	: 460.0 lb / 0.00 cu.ft

Testing

Hydrostatic test	: Non witnessed
Performance test	: Non witnessed
NPSH test	: None

Paint and Package

Pump paint	: Std.Polyurethane
Base grout surface prep	: N/A
Shipment type	: Domestic

Driver Information

Manufacturer	: By Others
Power	: 100.0 hp / 74.6 kW

See motor datasheets for details

Sound Pressure (dBA @ 1.0 m)

Driver, expected	: -
Pump & driver, estimated	: N/A

Seal Information

Arrangement	: Sgl Int O-Ring
Size	: 1.875 Inch
Manufacturer / Type	: Flowserve / ISC Pusher
Material code (Man'f/API)	: CSCPX----ECXV- / SBTFN
Internal neck bushing	: Not Available

Gland

Gland material	: 316SS
Flush	: .375" NPT
Vent	: .375" NPT
Drain	: .375" NPT
Auxiliary seal device	: -

Piping

Seal flush plan	: -
Seal flush construction	: Hose
Seal flush material	: -
Aux seal flush plan	: -
Aux seal flush construction	: -
Aux seal flush material	: -

Notes

-

Mark IIIA Power End

-

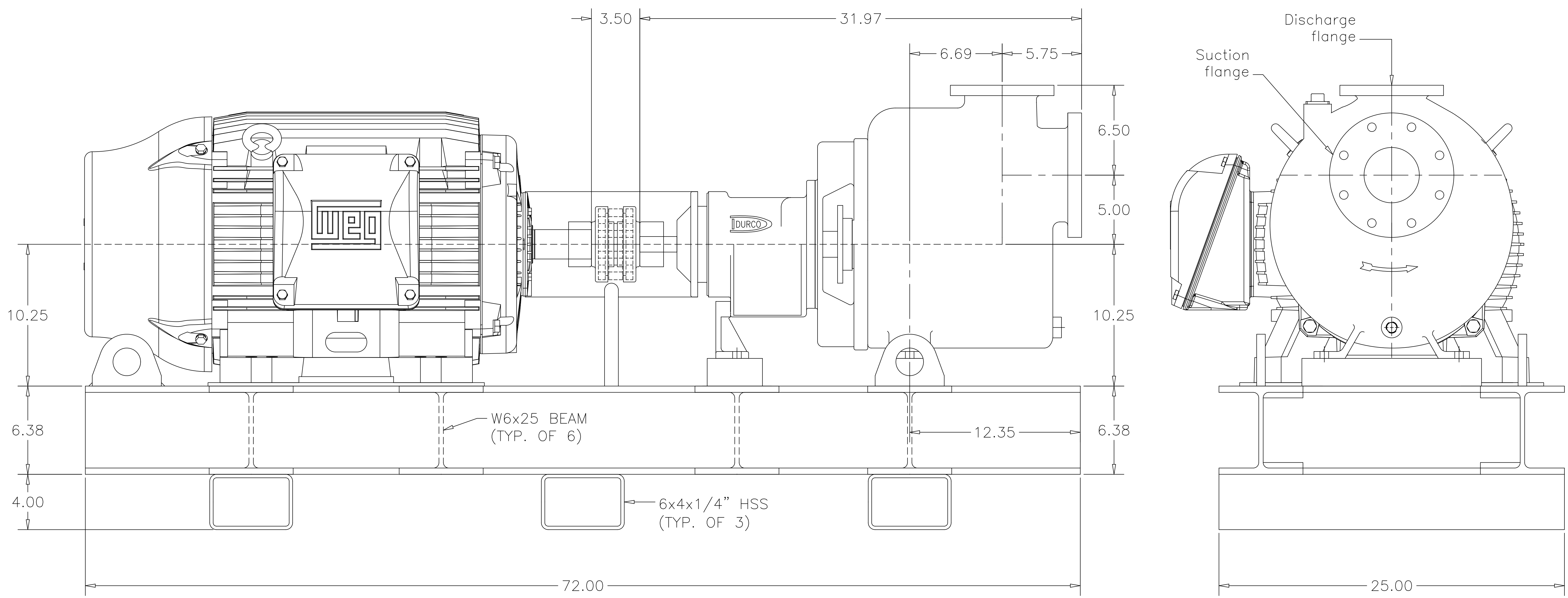
-

-

No cust. insp. or documents required

MOTOR DATA				PUMP DATA		MECHANICAL SEAL DATA		CUSTOMER INFO	
MFR.	WEG	PHASE	3	MODEL	2K4X3US-82RV	MANUFACTURER	Flowserve	CUSTOMER	Ful-Flo Industries
TYPE	TEFC	CYCLE	60	SUCT. FLANGE	4" 150# ANSI FF	TYPE	ISC2	PROJECT	BRRMF L&YW Biosolids Facilty
HP	100	VOLTS	575	DISCH. FLANGE	3" 150# ANSI FF	MATERIAL CODE	SilCar/Carbon	ENGINEER	CH2M Hill
RPM	3600	FRAME	405TS	COUPLING	WOODS 8SC	PIPING PLAN	n/a	PURCHASE ORDER	2061
MOUNTING BY:	POWER & MINE			DBSE	3.5"	NOTES	Viton / 316SS	TAG(S)	P-101

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



3rd Angle Projection

DO NOT SCALE DRAWING. WRITTEN DIMENSIONS GOVERN.

Power & Mine

POWER & MINE SUPPLY CO. LTD.
4 – 75 MERIDIAN DRIVE
WINNIPEG, MB R2R2V9
PH (204) 694-9300, FAX: (204) 694-7876
EMAIL: sales@powerandmine.ca
WEB: www.powerandmine.ca

Durco 2K4x3US-82RV pump with 405TS motor and non-grouted baseplate

POWER & MINE REF: TBA		DWG FILE: 2K4x3US-82-405TS.dwg	REV: 0
DRAWN BY: AT	APPROVED: MG	SCALE: NTS UNITS: INCHES	DATE: May 15, 2013

	No.:
	Date: 14-MAY-2013

DATA SHEET

Three-phase induction motor - Squirrel cage rotor

Customer	:
Product line	: TEFC - W22 NEMA Premium Efficiency

Frame	: 404/5TS
Output	: 100 HP
Frequency	: 60 Hz
Poles	: 2
Full load speed	: 3555
Slip	: 1.25 %
Voltage	: 575 V
Rated current	: 88.0 A
Locked rotor current	: 572 A
Locked rotor current (Il/In)	: 6.5
No-load current	: 20.8 A
Full load torque	: 146 lb.ft
Locked rotor torque	: 200 %
Breakdown torque	: 240 %
Design	: B
Insulation class	: F
Temperature rise	: 80 K
Locked rotor time	: 14 s (hot)
Service factor	: 1.25
Duty cycle	: S1
Ambient temperature	: -20°C - +40°C
Altitude	: 1000
Degree of Protection	: IP55
Approximate weight	: 1045 lb
Moment of inertia	: 13.196 sq.ft.lb
Noise level	: 79 dB(A)

	D.E.	N.D.E.
Bearings	6314 C3	6314 C3
Regreasing interval	4000 h	4000 h
Grease amount	27 g	27 g

Load	Power factor	Efficiency (%)
100%	0.91	94.1
75%	0.90	94.1
50%	0.85	93.0

Notes:

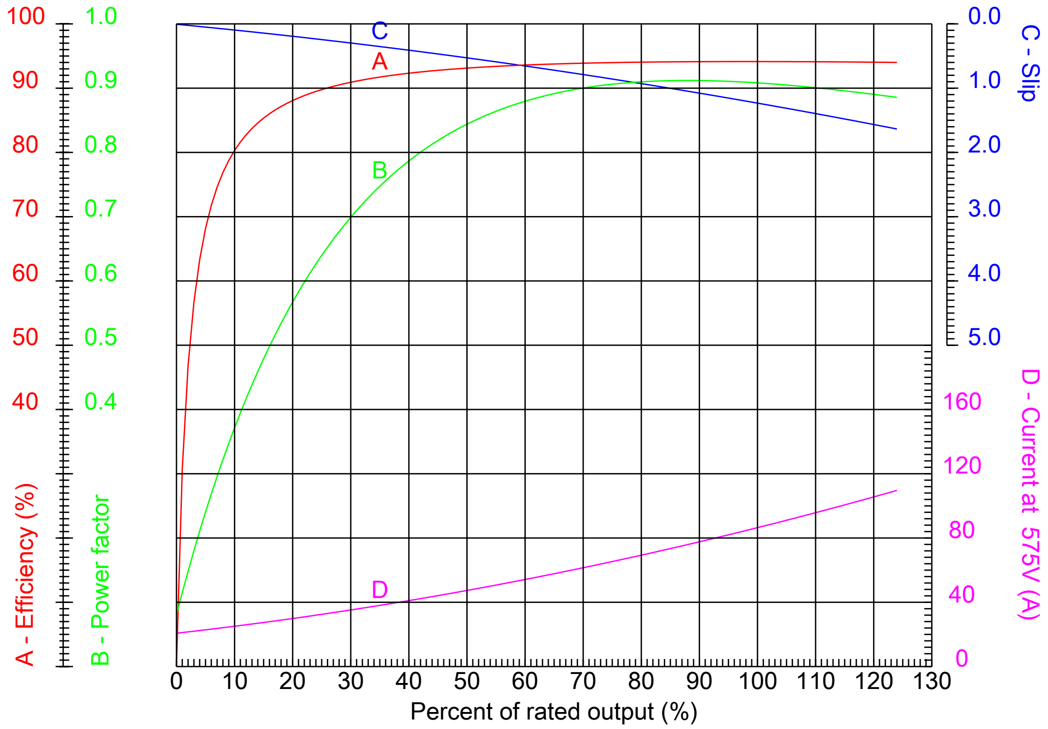
-120V Space heaters included

Performed by Blair Darragh	Checked

No.:	
Date: 14-MAY-2013	

PERFORMANCE CURVES RELATED TO RATED OUTPUT

Three-phase induction motor - Squirrel cage rotor



Customer	:	
Product line	:	TEFC - W22 NEMA Premium Efficiency

Frame	:	404/5TS	Locked rotor current (Il/In)	:	6.5
Output	:	100 HP	Duty cycle	:	S1
Frequency	:	60 Hz	Service factor	:	1.25
Full load speed	:	3555	Design	:	B
Voltage	:	575 V	Locked rotor torque	:	200 %
Rated current	:	88.0 A	Breakdown torque	:	240 %
Insulation class	:	F			

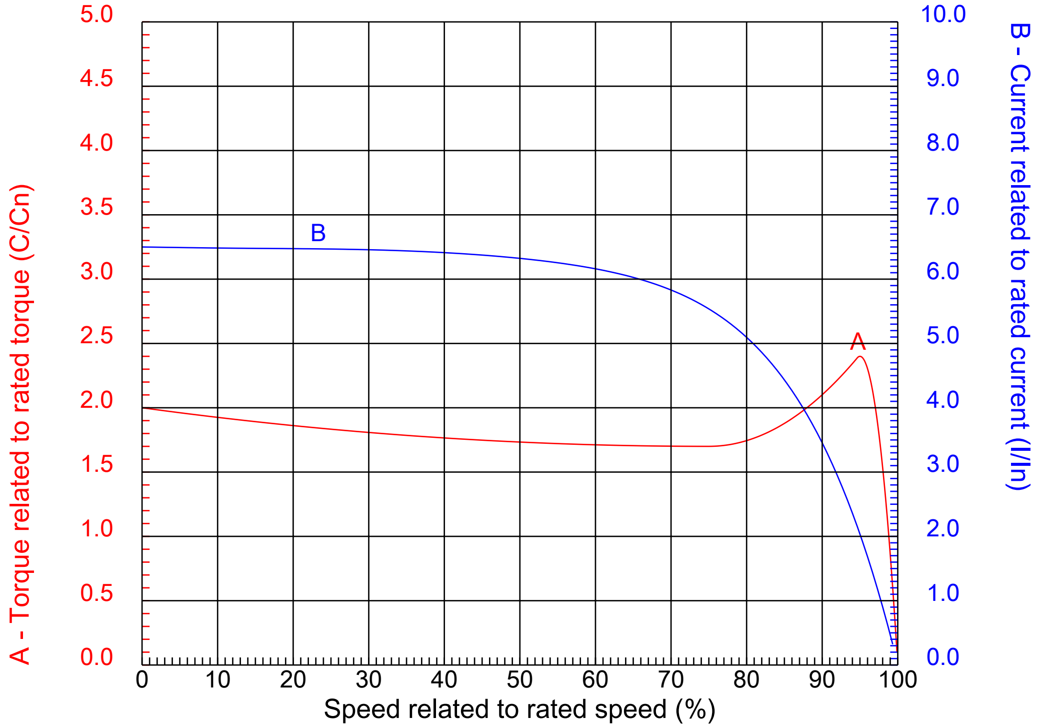
Notes:
HT100502NPBW22

Performed by	Checked
Blair Darragh	

WEG		No.:
		Date: 14-MAY-2013

CHARACTERISTIC CURVES RELATED TO SPEED

Three-phase induction motor - Squirrel cage rotor

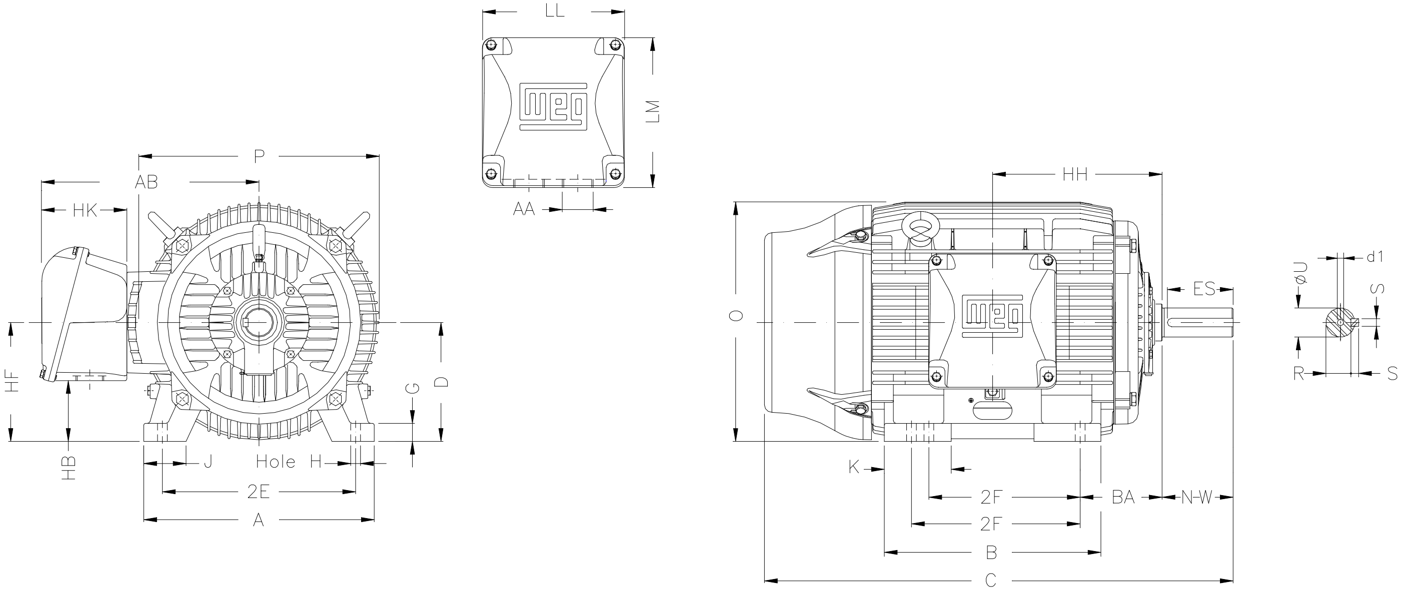


Customer	:		
Product line	:	TEFC - W22 NEMA Premium Efficiency	

Frame	: 404/5TS	Locked rotor current (Il/In)	: 6.5
Output	: 100 HP	Duty cycle	: S1
Frequency	: 60 Hz	Service factor	: 1.25
Full load speed	: 3555	Design	: B
Voltage	: 575 V	Locked rotor torque	: 200 %
Rated current	: 88.0 A	Breakdown torque	: 240 %
Insulation class	: F		

Notes:
HT100502NPBW22

Performed by	Checked
Blair Darragh	



2E 15.984	J 3.937	A 19.921	P 19.134	AB 16.023
2F 12.244/13.740	K 5.669	B 18.386	BA 6.625	U 2.125
N-W 4.250	ES 2.756	S 0.500	R 1.842	depth 0.500
D 10.000	G 1.811	HB 3.977	O 19.566	HH 14.213
HK 6.023	H 0.810	C 36.732	LL 10.590	LM 11.181
AA NPT 3"	d1 DUNC 3/4"-10			

Notes: HT100502NPBW22

Performed by: Blair Darragh

Checked:

Customer:

TEFC - W22 NEMA Premium Efficiency

Three-phase induction motor
Frame 404/5TS - IP55

14-MAY-2013

PUMPS • VALVES & ACTUATORS
MECHANICAL SEALS • PROCESS EQUIPMENT

POWER & MINE SUPPLY CO. LTD

Section 2
Pump IO&M

Winnipeg: 4 – 75 Meridian Drive, Winnipeg MB R2R 2V9 • **Phone** (204) 694-9300 • **Fax** (204) 694-7876
Saskatoon: 901 First Avenue, Saskatoon SK S7K 1Y4 •**Phone** (306) 244-7274 • **Fax** (306) 244-9911
Regina: 306 – 845 Broad Street, Regina SK S4R 8G9 • **Phone** (306) 791-0417 • **Fax** (306) 791-0418
Thunder Bay: 675 Harold Crescent, Thunder Bay ON P7C 5H6 • **Phone** (807) 622-4044 •**Fax** (807) 622-3235

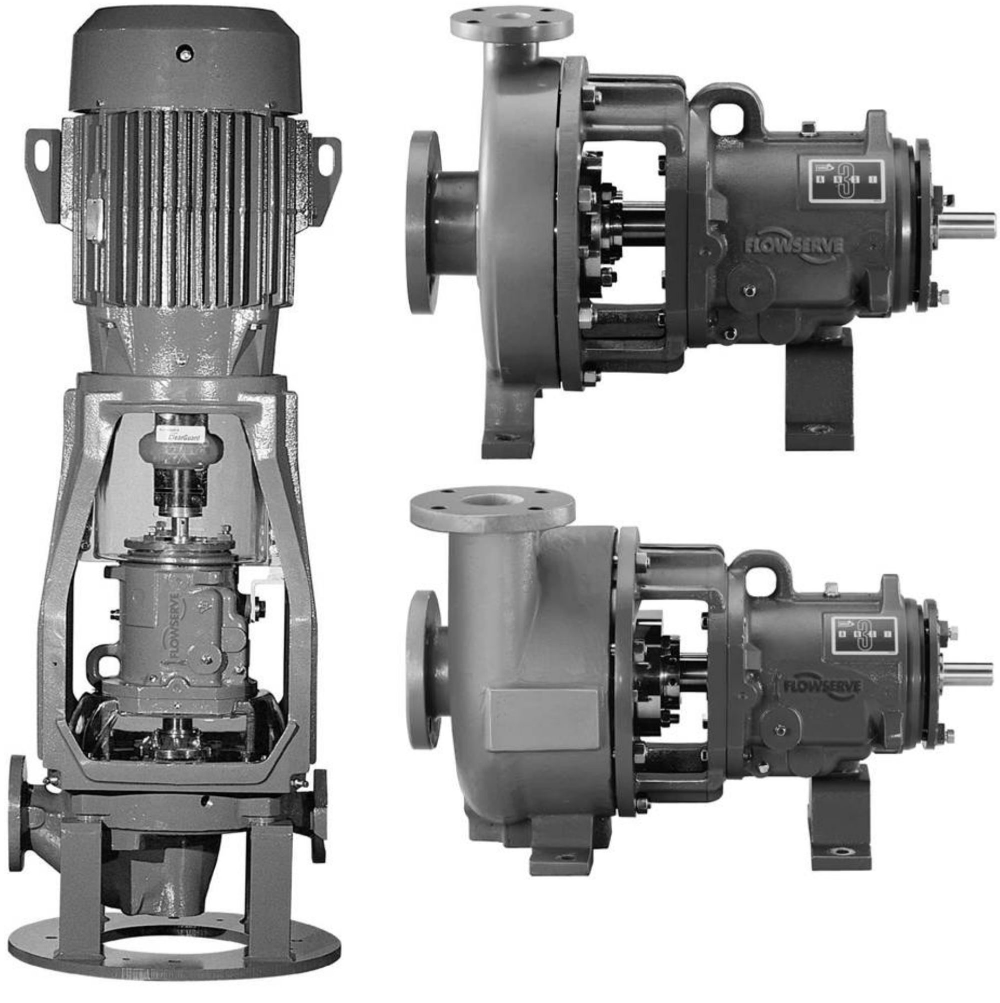
USER INSTRUCTIONS

Durco Mark 3 sealed metallic pumps

Mark 3 Standard, In-Line, Lo-Flo, Recessed Impeller,
Unitized Self-Priming and Sealmatic pumps

PCN=71569102 08-06 (E) (incorporating P-10-502-E)

Installation
Operation
Maintenance



These instructions must be read prior to installing, operating, using and maintaining this equipment.

Experience In Motion

CONTENTS

1 INTRODUCTION AND SAFETY

1.1 General

These instructions must always be kept close to the product's operating location or directly with the product.

Flowserve products are designed, developed and manufactured with state-of-the-art technologies in modern facilities. The unit is produced with great care and commitment to continuous quality control, utilizing sophisticated quality techniques, and safety requirements.

Flowserve is committed to continuous quality improvement and being at your service for any further information about the product in its installation and operation or about its support products, repair and diagnostic services.

These instructions are intended to facilitate familiarization with the product and its permitted use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. The instructions may not take into account local regulations; ensure such regulations are observed by all, including those installing the product. Always coordinate repair activity with operations personnel, and follow all plant safety requirements and applicable safety and health laws/regulations.

These instructions must be read prior to installing, operating, using and maintaining the equipment in any region worldwide. The equipment must not be put into service until all the conditions relating to safety noted in the instructions, have been met.

1.2 CE marking and approvals

It is a legal requirement that machinery and equipment put into service within certain regions of the world shall conform with the applicable CE Marking Directives covering Machinery and, where applicable, Low Voltage Equipment, Electromagnetic Compatibility (EMC), Pressure Equipment Directive (PED) and Equipment for Potentially Explosive Atmospheres (ATEX).

Where applicable, the Directives and any additional Approvals, cover important safety aspects relating to machinery and equipment and the satisfactory provision of technical documents and safety instructions. Where applicable this document incorporates information relevant to these Directives and Approvals.

To confirm the Approvals applying and if the product is CE marked, check the serial number plate markings and the Certification. (See section 9, *Certification*.)

1.3 Disclaimer

Information in these User Instructions is believed to be reliable. In spite of all the efforts of Flowserve Pump Division to provide sound and all necessary information the content of this manual may appear insufficient and is not guaranteed by Flowserve as to its completeness or accuracy.

Flowserve manufactures products to exacting International Quality Management System Standards as certified and audited by external Quality Assurance organizations. Genuine parts and accessories have been designed, tested and incorporated into the products to help ensure their continued product quality and performance in use. As Flowserve cannot test parts and accessories sourced from other vendors the incorrect incorporation of such parts and accessories may adversely affect the performance and safety features of the products. The failure to properly select, install or use authorized Flowserve parts and accessories is considered to be misuse. Damage or failure caused by misuse is not covered by the Flowserve warranty. In addition, any modification of Flowserve products or removal of original components may impair the safety of these products in their use.

1.4 Copyright

1.5 Duty conditions

This product has been selected to meet the specifications of your purchaser order. The acknowledgement of these conditions has been sent separately to the Purchaser. A copy should be kept with these instructions.

The product must not be operated beyond the parameters specified for the application. If there is any doubt as to the suitability of the product for the application intended, contact Flowserve for advice, quoting the serial number.

If the conditions of service on your purchase order are going to be changed (for example liquid pumped, temperature or duty) it is requested that the user seeks the written agreement of Flowserve before start up.

1.6 Safety

1.6.1 Summary of safety markings

These User Instructions contain specific safety markings where non-observance of an instruction would cause hazards. The specific safety markings are:

DANGER This symbol indicates electrical safety instructions where non-compliance will involve a high risk to personal safety or the loss of life.

This symbol indicates safety instructions where non-compliance would affect personal safety and could result in loss of life.

This symbol indicates "hazardous and toxic fluid" safety instructions where non-compliance would affect personal safety and could result in loss of life.

CAUTION This symbol indicates safety instructions where non-compliance will involve some risk to safe operation and personal safety and would damage the equipment or property.

This symbol indicates explosive atmosphere zone marking according to ATEX. It is used in safety instructions where non-compliance in the hazardous area would cause the risk of an explosion.

Note: This sign is not a safety symbol but indicates an important instruction in the assembly process.

1.6.2 Personnel qualification and training

All personnel involved in the operation, installation, inspection and maintenance of the unit must be qualified to carry out the work involved. If the personnel in question do not already possess the necessary knowledge and skill, appropriate training and instruction must be provided. If required the operator may commission the manufacturer/supplier to provide applicable training.

Always coordinate repair activity with operations and health and safety personnel, and follow all plant safety requirements and applicable safety and health laws and regulations.

1.6.3 Safety action

This is a summary of conditions and actions to help prevent injury to personnel and damage to the environment and to equipment. For products used in potentially explosive atmospheres section 1.6.4 also applies.

DANGER NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER (Lock out.)

DRAIN THE PUMP AND ISOLATE PIPEWORK BEFORE DISMANTLING THE PUMP
The appropriate safety precautions should be taken where the pumped liquids are hazardous.

FLUOROELASTOMERS (When fitted.)
When a pump has experienced temperatures over 250 ºC (482 ºF), partial decomposition of fluoroelastomers (example: Viton) will occur. In this condition these are extremely dangerous and skin contact must be avoided.

HANDLING COMPONENTS
Many precision parts have sharp corners and the wearing of appropriate safety gloves and equipment is required when handling these components. To lift heavy pieces above 25 kg (55 lb) use a crane appropriate for the mass and in accordance with current local regulations.

NEVER OPERATE THE PUMP WITHOUT THE COUPLING GUARD AND ALL OTHER SAFETY DEVICES CORRECTLY INSTALLED

GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL

THERMAL SHOCK
Rapid changes in the temperature of the liquid within the pump can cause thermal shock, which can result in damage or breakage of components and should be avoided.

NEVER APPLY HEAT TO REMOVE IMPELLER
Trapped lubricant or vapor could cause an explosion.

HOT (and cold) PARTS
If hot or freezing components or auxiliary heating equipment can present a danger to operators and persons entering the immediate area, action must be taken to avoid accidental contact (such as shielding). If complete protection is not possible, the machine access must be limited to maintenance staff only with clear visual warnings and indicators to those entering the immediate area. Note: bearing housings must not be insulated and drive motors and bearings may be hot.

If the temperature is greater than 68 °C (175 °F) or below 5 °C (20 °F) in a restricted zone, or exceeds local regulations, action as above shall be taken.

HAZARDOUS LIQUIDS
When the pump is handling hazardous liquids care must be taken to avoid exposure to the liquid by appropriate pump placement, limiting personnel access and by operator training. If the liquid is flammable and/or explosive, strict safety procedures must be applied.

Gland packing must not be used when pumping hazardous liquids.

CAUTION PREVENT EXCESSIVE EXTERNAL PIPE LOAD
Do not use pump as a support for piping. Do not mount expansion joints, unless allowed by Flowserve in writing, so that their force, due to internal pressure, acts on the pump flange.

CAUTION ENSURE CORRECT LUBRICATION
(See section 5, *Commissioning, startup, operation and shutdown*.)

CAUTION NEVER EXCEED THE MAXIMUM DESIGN PRESSURE (MDP) AT THE TEMPERATURE SHOWN ON THE PUMP NAMEPLATE
See section 3 for pressure versus temperature ratings based on the material of construction.

CAUTION NEVER OPERATE THE PUMP WITH THE DISCHARGE VALVE CLOSED
(Unless otherwise instructed at a specific point in the User Instructions.)
(See section 5, *Commissioning start-up, operation and shutdown*.)

CAUTION NEVER RUN THE PUMP DRY OR WITHOUT PROPER PRIME (Casing flooded)

CAUTION NEVER OPERATE THE PUMP WITH THE SUCTION VALVE CLOSED
It should be fully opened when the pump is running.

CAUTION NEVER OPERATE THE PUMP AT ZERO FLOW OR FOR EXTENDED PERIODS BELOW THE MINIMUM CONTINUOUS FLOW

CAUTION THE PUMP SHAFT MUST TURN CLOCKWISE WHEN VIEWED FROM THE MOTOR END
It is absolutely essential that the rotation of the motor be checked before installation of the coupling spacer and starting the pump. Incorrect rotation of the pump for even a short period can unscrew the impeller, which can cause significant damage.

1.6.4 Products used in potentially explosive atmospheres

Measures are required to:
- Avoid excess temperature
- Prevent build up of explosive mixtures
- Prevent the generation of sparks
- Prevent leakages
- Maintain the pump to avoid hazard

The following instructions for pumps and pump units when installed in potentially explosive atmospheres must be followed to help ensure explosion protection. Both electrical and non-electrical equipment must meet the requirements of European Directive 94/9/EC.

1.6.4.1 Scope of compliance

Use equipment only in the zone for which it is appropriate. Always check that the driver, drive coupling assembly, seal and pump equipment are suitably rated and/or certified for the classification of the specific atmosphere in which they are to be installed.

Where Flowserve has supplied only the bare shaft pump, the Ex rating applies only to the pump. The party responsible for assembling the pump set shall select the coupling, driver, seal and any additional equipment, with the necessary CE Certificate/ Declaration of Conformity establishing it is suitable for the area in which it is to be installed.

The output from a variable frequency drive (VFD) can cause additional heating affects in the motor. On pump installations controlled by a VFD, the ATEX Certification for the motor must state that it covers the situation where electrical supply is from the VFD. This particular requirement still applies even if the VFD is in a safe area.

1.6.4.2 Marking

An example of ATEX equipment marking is shown below. The actual classification of the pump will be engraved on the nameplate.

II 2 GD c IIC 135 ºC (T4)

Equipment Group
I = Mining
II = Non-mining

Category
2 or M2 = high level protection
3 = normal level of protection

Gas and/or dust
G = Gas
D = Dust

c = Constructional safety
(in accordance with EN13463-5)

Gas Group (*Equipment Category 2 only*)
IIA – Propane (typical)
IIB – Ethylene (typical)
IIC – Hydrogen (typical)

Maximum surface temperature (Temperature Class) (see section 1.6.4.3.)

1.6.4.3 Avoiding excessive surface temperatures

ENSURE THE EQUIPMENT TEMPERATURE CLASS IS SUITABLE FOR THE HAZARD ZONE

Pump liquid temperature

Pumps have a temperature class as stated in the ATEX Ex rating on the nameplate. These are based on a maximum ambient temperature of 40 ºC (104 ºF); refer to Flowserve for higher ambient temperatures.

The surface temperature on the pump is influenced by the temperature of the liquid handled. The maximum permissible liquid temperature depends on the temperature class and must not exceed the values in the table applicable below. The temperature rise at the seals and bearings and due to the minimum permitted flow rate is taken into account in the temperatures stated.

Maximum permitted liquid temperature for pumps

Temperature class to EN 13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled (* depending on material and construction variant – check which is lower)
T6	85 °C (185 °F)	Consult Flowserve
T5	100 °C (212 °F)	Consult Flowserve
T4	135 °C (275 °F)	115 °C (239 °F) *
T3	200 °C (392 °F)	180 °C (356 °F) *
T2	300 °C (572 °F)	275 °C (527 °F) *
T1	450 °C (842 °F)	400 °C (752 °F) *

Maximum permitted liquid temperature for pumps with self priming casing

Temperature class to EN 13463-1	Maximum surface temperature permitted	Temperature limit of liquid handled (* depending on material and construction variant - check which is lower)
T6	85 °C (185 °F)	Consult Flowserve
T5	100 °C (212 °F)	Consult Flowserve
T4	135 °C (275 °F)	110 °C (230 °F) *
T3	200 °C (392 °F)	175 °C (347 °F) *
T2	300 °C (572 °F)	270 °C (518 °F) *
T1	450 °C (842 °F)	350 °C (662 °F) *

The responsibility for compliance with the specified maximum liquid temperature is with the plant operator.

Temperature classification “Tx” is used when the liquid temperature varies and the pump could be installed in different hazardous atmospheres. In this case the user is responsible for ensuring that the pump surface temperature does not exceed that permitted in the particular hazardous atmosphere.

Do not attempt to check the direction of rotation with the coupling element/pins fitted due to the risk of severe contact between rotating and stationary components.

Where there is any risk of the pump being run against a closed valve generating high liquid and casing external surface temperature, it is recommended that users fit an external surface temperature protection device.

Avoid mechanical, hydraulic or electrical overload by using motor overload trips, temperature monitor or a power monitor and perform routine vibration monitoring.

In dirty or dusty environments, regular checks must be made and dirt removed from areas around close clearances, bearing housings and motors.

Additional requirements for self-priming casing pumps

Where the system operation does not ensure control of priming, as defined in the User Instructions, and the maximum permitted surface temperature of the T Class could be exceeded, it is recommended that user install an external surface temperature protection device.

1.6.4.4 Preventing the build up of explosive mixtures

ENSURE PUMP IS PROPERLY FILLED AND VENTED AND DOES NOT RUN DRY

Ensure that the pump and relevant suction and discharge piping is totally filled with liquid at all times during the pumps operation so that an explosive atmosphere is prevented.

In addition, it is essential to make sure that seal chambers, auxiliary shaft seal systems and any heating and cooling systems are properly filled.

If the operation of the system can not avoid this condition it is recommended that you fit an appropriate dry run protection device (for example liquid detection or a power monitor).

To avoid potential hazards from fugitive emissions of vapor or gas to atmosphere, the surrounding area must be well ventilated.

1.6.4.5 Preventing sparks

To prevent a potential hazard from mechanical contact, the coupling guard must be non-sparking.

To avoid the potential hazard from random induced current generating a spark, the earth contact on the baseplate must be used.

Avoid electrostatic charge: do not rub non-metallic surfaces with a dry cloth; ensure cloth is damp.

The coupling must be selected to comply with 94/9/EC and correct alignment must be maintained.

Additional requirements for pumps on non-metallic baseplates
When metallic components are fitted on a non-metallic baseplate they must be individually earthed.

1.6.4.6 Preventing leakage

Pumps with mechanical seal. The pump must only be used to handle liquids for which it has been approved to have the correct corrosion resistance.

Avoid entrapment of liquid in the pump and associated piping due to closing of suction and discharge valves, which could cause dangerous excessive pressures to occur if there is heat input to the liquid. This can occur if the pump is stationary or running.

Bursting of liquid containing parts due to freezing must be avoided by draining or protecting the pump and auxiliary systems.

Where there is the potential hazard of a loss of a seal barrier fluid or external flush, the fluid must be monitored.

If leakage of liquid to atmosphere can result in a hazard, the installation of a liquid detection device is recommended.

1.6.4.7 Maintenance of the centrifugal pump to avoid a hazard

CORRECT MAINTENANCE IS REQUIRED TO AVOID POTENTIAL HAZARDS WHICH GIVE A RISK OF EXPLOSION

The responsibility for compliance with maintenance instructions is with the plant operator.

To avoid potential explosion hazards during maintenance, the tools, cleaning and painting materials used must not give rise to sparking or adversely affect the ambient conditions. Where there is a risk from such tools or materials, maintenance must be conducted in a safe area.

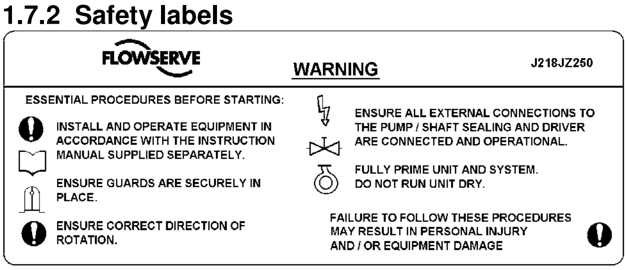
It is recommended that a maintenance plan and schedule is adopted. (See section 6, *Maintenance.)*

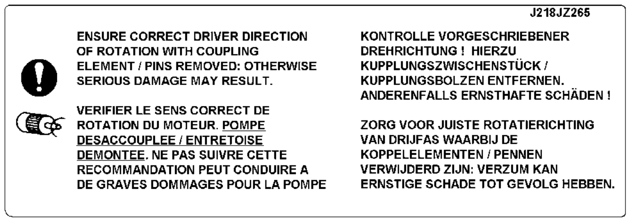
1.7 Name plate and safety labels

1.7.1 Nameplate

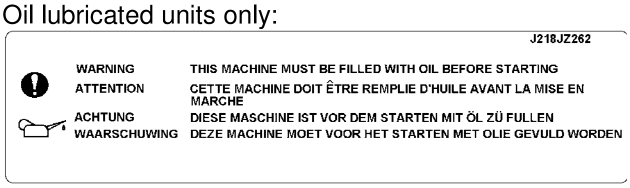
For details of nameplate, see the *Declaration of Conformity* and section 3.

1.7.2 Safety labels

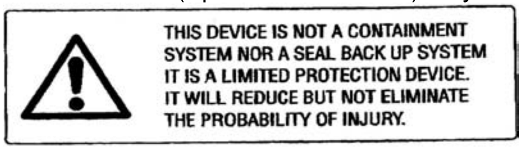




Oil lubricated units only:



DurcoShield™ (Splash/Shaft Guard) only:



1.8 Noise level

Attention must be given to the exposure of personnel to the noise, and local legislation will define when guidance to personnel on noise limitation is required, and when noise exposure reduction is mandatory. This is typically 80 to 85 dBA.

The usual approach is to control the exposure time to the noise or to enclose the machine to reduce emitted sound. You may have already specified a limiting noise level when the equipment was ordered, however if no noise requirements were defined, then attention is drawn to the following table to give an indication of equipment noise level so that you can take the appropriate action in your plant.

Pump noise level is dependent on a number of operational factors, flow rate, pipework design and acoustic characteristics of the building, and so the values given are subject to a 3 dBA tolerance and cannot be guaranteed.

Similarly the motor noise assumed in the "pump and motor" noise is that typically expected from standard and high efficiency motors when on load directly driving the pump. Note that a motor driven by an inverter may show an increased noise at some speeds.

If a pump unit only has been purchased for fitting with your own driver then the "pump only" noise levels in the table should be combined with the level for the driver obtained from the supplier. Consult Flowserve or a noise specialist if assistance is required in combining the values.

It is recommended that where exposure approaches the prescribed limit, then site noise measurements should be made.

The values are in sound pressure level L_{pA} at 1 m (3.3 ft) from the machine, for "free field conditions over a reflecting plane".

For estimating sound power level L_{WA} (re 1pW) then add 14 dBA to the sound pressure value.

Motor size and speed kW (hp)	Typical sound pressure level L_{pA} at 1 m reference 20 µPa, dBA							
	3 550 r/min		2 900 r/min		1 750 r/min		1 450 r/min	
	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor	Pump only	Pump and motor
<0.55(<0.75)	72	72	64	65	62	64	62	64
0.75 (1)	72	72	64	66	62	64	62	64
1.1 (1.5)	74	74	66	67	64	64	62	63
1.5 (2)	74	74	66	71	64	64	62	63
2.2 (3)	75	76	68	72	65	66	63	64
3 (4)	75	76	70	73	65	66	63	64
4 (5)	75	76	71	73	65	66	63	64
5.5 (7.5)	76	77	72	75	66	67	64	65
7.5 (10)	76	77	72	75	66	67	64	65
11(15)	80	81	76	78	70	71	68	69
15 (20)	80	81	76	78	70	71	68	69
18.5 (25)	81	81	77	78	71	71	69	71
22 (30)	81	81	77	79	71	71	69	71
30 (40)	83	83	79	81	73	73	71	73
37 (50)	83	83	79	81	73	73	71	73
45 (60)	86	86	82	84	76	76	74	76
55 (75)	86	86	82	84	76	76	74	76
75 (100)	87	87	83	85	77	77	75	77
90 (120)	87	88	83	85	77	78	75	78
110 (150)	89	90	85	87	79	80	77	80
150 (200)	89	90	85	87	79	80	77	80
200 (270)	①	①	①	①	85	87	83	85
300 (400)	–				87	90	85	86

① The noise level of machines in this range will most likely be of values which require noise exposure control, but typical values are inappropriate.
Note: for 1 180 and 960 r/min reduce 1 450 r/min values by 2 dBA. For 880 and 720 r/min reduce 1 450 r/min values by 3 dBA.

2 TRANSPORT AND STORAGE

2.1 Consignment receipt and unpacking

Immediately after receipt of the equipment it must be checked against the delivery/shipping documents for its completeness and that there has been no damage in transportation. Any shortage and/or damage must be reported immediately to Flowserve Pump Division and must be received in writing within ten days of receipt of the equipment. Later claims cannot be accepted.

Check any crate, boxes or wrappings for any accessories or spare parts that may be packed separately with the equipment or attached to side walls of the box or equipment.

Each product has a unique serial number. Check that this number corresponds with that advised and always quote this number in correspondence as well as when ordering spare parts or further accessories.

2.2 Handling

Boxes, crates, pallets or cartons may be unloaded using fork lift vehicles or slings dependent on their size and construction.

2.3 Lifting

⚠ CAUTION Pumps and motors often have integral lifting lugs or eye bolts. These are intended for use in only lifting the individual piece of equipment.

⚠ CAUTION Do not use eye bolts or cast-in lifting lugs to lift pump, motor and baseplate assemblies.

⚠ CAUTION To avoid distortion, the pump unit should be lifted as shown.

⚠ CAUTION Care must be taken to lift components or assemblies above the center of gravity to prevent the unit from flipping. This is especially true with In-Line pumps.

2.3.1 Lifting pump components

2.3.1.1 Casing [1100]

Use a choker hitch pulled tight around the discharge nozzle.

2.3.1.2 Rear cover [1220]

Insert an eye hook in the drilled and tapped hole at the top of the cover. Use either a sling or hook through the eye bolt.

2.3.1.3 Bearing housing [3200]

Group 1: insert a sling between the upper and lower support ribs between the housing barrel and the casing attachment flange. Use a choker hitch when slinging. (Make sure there are no sharp edges on the bottom side of the ribs that could cut the sling.)

Group 2 and 3: insert either a sling or hook through the lifting lug located on the top of the housing.

2.3.1.4 Power end

Same as bearing housing.

2.3.1.5 Bare pump

Horizontal pumps: sling around the pump discharge nozzle and around the outboard end of the bearing housing with separate slings. Choker hitches must be used at both attachment points and pulled tight. Make sure the completion of the choker hitch on the discharge nozzle is toward the coupling end of the pump shaft as shown in figure 2-1. The sling lengths should be adjusted to balance the load before attaching the lifting hook.

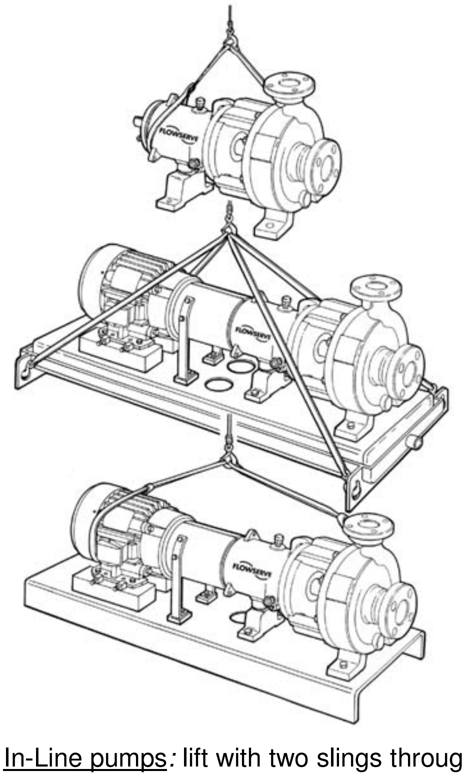


Figure 2-1

In-Line pumps: lift with two slings through the pump adapter on opposite sides of the shaft. (Figure 2-2.)

Bare pump with motor adapter (In-Line only): lift with two slings through the motor adapter shaft holes. This method is also used to lift the bare motor adapter. (Figure 2-2.)

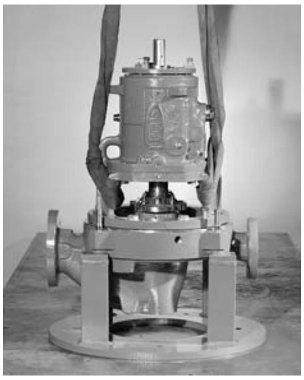
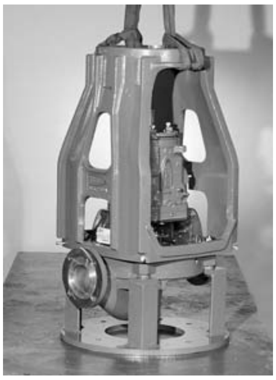




Figure 2-2

2.3.2 Lifting pump, motor and baseplate assembly

2.3.2.1 Horizontal assemblies

If the baseplate has lifting holes cut in the sides at the end (Type A Group 3, Type D and Type E bases) insert lifting S hooks at the four corners and use slings or chains to connect to the lifting eye. (Figure 2-1.) Do not use slings through the lifting holes.

For other baseplates, sling around the pump discharge nozzle, and around the outboard end of the motor frame using choker hitches pulled tight. (Figure 2-1.)

The sling should be positioned so the weight is not carried through the motor fan housing. Make sure the completion of the choker hitch on the discharge nozzle is toward the coupling end of the pump shaft as shown in figure 2-1.

2.3.2.2 In-Line assemblies

If the pump is to be lifted as a complete assembly, the motor lifting lugs must be used to ensure that the assembly does not flip over. Check with motor supplier for lifting lug capacities. If there is any uncertainty, the motor should be removed prior to moving the pump. (Figure 2-2.)

2.4 Storage

CAUTION Store the pump in a clean, dry location away from vibration. Leave flange covers in place to keep dirt and other foreign material out of pump casing. Turn the pump shaft at regular intervals to prevent brinelling of the bearings and the seal faces, if fitted, from sticking.

The pump may be stored as above for up to 6 months. Consult Flowserve for preservative actions when a longer storage period is needed.

2.4.1 Short term storage and packaging

Normal packaging is designed to protect the pump and parts during shipment and for dry, indoor storage for up to six months or less. The following is an overview of our normal packaging:

- All loose unmounted items are packaged in a water proof plastic bag and placed under the coupling guard
- Inner surfaces of the bearing housing, shaft (area through bearing housing) and bearings are coated with Cortec VCI-329 rust inhibitor, or equal.
  Note: Bearing housings are not filled with oil prior to shipment
- Regreasable bearings are packed with grease (EXXON POLYREX EM for horizontal pumps and EXXON UNIREX N3 for In-Line pumps)
- The internal surfaces of ferrous casings, covers, flange faces, and the impeller surface are sprayed with Cortec VCI-389, or equal
- Exposed shafts are taped with Polywrap
- Flange covers are secured to both the suction and discharge flanges
- In some cases with assemblies ordered with external piping, components may be disassembled for shipment
- The pump must be stored in a covered, dry location

2.4.2 Long term storage and packaging

Long term storage is defined as more than six months, but less than 12 months. The procedure Flowserve follows for long term storage of pumps is given below. These procedures are in addition to the short term procedure.

- Each assembly is hermetically (heat) sealed from the atmosphere by means of tack wrap sheeting and rubber bushings (mounting holes)
- Desiccant bags are placed inside the tack wrapped packaging
- A solid wood box is used to cover the assembly

This packaging will provide protection for up to twelve months from humidity, salt laden air, dust etc.

After unpacking, protection will be the responsibility of the user. Addition of oil to the bearing housing will remove the inhibitor. If units are to be idle for extended periods after addition of lubricants, inhibitor oils and greases should be used. Every three months, the pump shaft should be rotated approximately 10 revolutions.

2.5 Recycling and end of product life

At the end of the service life of the product or its parts, the relevant materials and parts should be recycled or disposed of using an environmentally acceptable method and in accordance with local regulations. If the product contains substances that are harmful to the environment, these should be removed and disposed of in accordance with current local regulations. This also includes the liquids and/or gases that may be used in the "seal system" or other utilities.

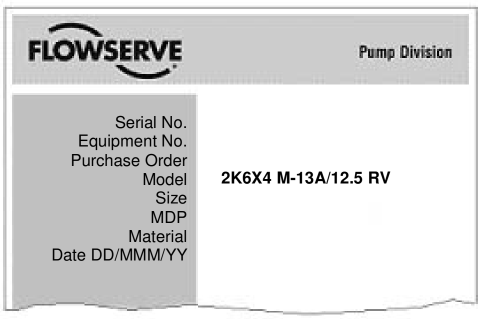
Make sure that hazardous substances are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current local regulations at all times.

3 DESCRIPTION

3.1 Configurations

The Durco Mark 3 chemical process pumps are metallic , single stage, sealed, centrifugal pumps. The horizontal family conforms to ASME B73.1M, which has a centerline discharge and is represented by our Standard, Sealmatic, Unitized self-priming, Recessed impeller and Lo-Flo pump models. The vertical pump or In-Line conforms to ASME B73.2M.

Figure 3-1: Nameplate mounted to housing



The Prima^{3} ™ is an ANSI 3A power end adapted to other pump models from Flowserve as well as from other pump manufacturers. Only the information in this manual involving the ANSI 3A power end may be used when Installing, Operating or Maintaining a pump that has been upgraded to a Prima^{3} ™. All other information regarding the pump type must be obtained from the original pump manufacturer's User Instructions.

3.2 Nomenclature

The pump size will be engraved on the nameplate typically as below:

2 K 6 X 4 M - 13 A /12.5 RV

- *Frame size*
  "2" indicates a medium size pump frame (in this example, a Group 2)
  1 = Group 1 (small frame)
  2 = Group 2 (medium frame)
  3 = Group 3 (large frame)
- *Power end*
  K = Mark 3 style power end
  Mark 3A – Standard
  ANSI 3A – Optional (3 year guarantee)
  J = Mark 3 style PE arranged for Mark 2 wet end
  (No letter and no preceding number indicates a Mark 2 power end)
- "6" = *nominal suction port size* (in.)
- "4" = *Nominal discharge port size* (in.)
- *Modifier for "specialty pumps"*
  Blank or no letter = standard pump
  M = Sealmatic
  R = recessed impeller
  US = unitized self-priming
  V = vertical In-Line
  LF = Lo-Flo
- *Nominal maximum impeller diameter.* "13" = 13 in.
- *Pump design variation*
  A = This pump has been redesigned from an earlier version. The impeller and casing are no longer interchangeable with the earlier version.
  H = This pump is designed for a higher flow capacity than another pump with the same basic designation. (Examples: 4X3-10 and 4X3-10H; 6X4-10 and 6X4-10H; 10X8-16 and 10X8-16H.
  HH = This pump is designed for a higher head than another pump with the same basic designation. (Example: 4X3-13 and 4X3-13HH.)
- *Actual impeller size*
  "12.5" = 12 ½ in. diameter; 8.13 = 8 ⅛ in;
  10.75 = 10 ¾ in
  (Previous annotation: 124 = 12 $^{4}/_{8}$ or 12 ½ in. diameter; 83 = 8 ⅜ in.)
- *Impeller style*
  RV = reverse vane impeller; OP = Open impeller

3.3 Design of major parts

3.3.1 Pump casing
Removal of the casing is not required when performing maintenance of the rotating element. The pump is designed with a gasket perpendicular to the shaft allowing the rotating element to be easily removed (back pull out).

3.3.2 Impeller
Depending on the product, the impeller is either reverse vane or open.

3.3.3 Shaft/sleeve
Solid and sleeved shafts are available, supported on bearings, threaded impeller end and keyed drive end.

3.3.4 Pump bearings and lubrication
Ball bearings are fitted as standard and may be either oil or grease lubricated.

3.3.5 Bearing housing
Large oil bath reservoir.

3.3.6 Seal chamber (cover plate)
The seal chamber has a spigot (rabbet) fit between the pump casing and bearing housing (adapter) for optimum concentricity. The design enables a number of sealing options to be fitted.

3.3.7 Shaft seal
The mechanical seal(s), attached to the pump shaft, seals the pumped liquid from the environment. Gland packing may be fitted as an option.

3.3.8 Driver
The driver is normally an electric motor. Different drive configurations may be fitted such as internal combustion engines, turbines, hydraulic motors etc driving via couplings, belts, gearboxes, drive shafts etc.

3.3.9 Accessories
Accessories may be fitted when specified by the customer.

3.4 Performance and operation limits
This product has been selected to meet the specification of your purchase order. See section 1.5.

The following data is included as additional information to help with your installation. It is typical, and factors such as liquid being pumped, temperature, material of construction, and seal type may influence this data. If required, a definitive statement for your application can be obtained from Flowserve.

3.4.1 Alloy cross reference chart
Figure 3-2 is the Alloy cross-reference chart for all Mark 3 pumps.

3.4.2 Pressure-temperature ratings
The pressure-temperature (P-T) ratings for Mark 3 pumps are shown in figures 3-3 and 3-4. Determine the appropriate casing “Material Group No.” in Figure 3-2. Interpolation may be used to find the pressure rating for a specific temperature.

Example:
The pressure temperature rating for an ANSI standard GP2-10 in. pump with Class 300 flanges and CF8M construction at an operating temperature of 149 ˚C is found as follows:

a) The correct pressure-temperature chart is Figure 3-4C.
b) From Figure 3-2, the correct material group for CF8M is 2.2.
c) From Figure 3-4C, the pressure-temperature rating is 21.5 bar.

⚠ The maximum discharge pressure must be less than or equal to the P-T rating. Discharge pressure may be approximated by adding the suction pressure and the differential head developed by the pump.

3.4.3 Suction pressure limits
The suction pressure limits for Mark 3 pumps with reverse vane impellers is limited by the values given in figure 3-5 and by the P-T ratings.

Suction pressure for pump sizes 10x8-14, 8x6-16A, 10x8-16 and 10x8-16H (up to a maximum liquid specific gravity of 2.0) is limited only by the P-T ratings. Suction pressure for pumps with open impellers is also limited only by the P-T ratings.

The suction pressure limits for Sealmatic pumps are determined by the repeller head capability found in Bulletin P-18-102e.

3.4.4 Minimum continuous flow
The minimum continuous flow (MCF) is based on a percentage of the *best efficiency point* (BEP). Figure 3-7 identifies the MCF for all Mark 3 pump models with the exception of the Lo-Flo pump line; there is no MCF associated with this product line.

3.4.5 Minimum suction pipe submergence
The minimum submergence is shown in figure 3-8 and 3-9 for Unitized self-priming pumps.

Figure 3-2: Alloy cross-reference chart

Flowserve material code	Designation	Durco legacy codes	ACI designation	Equivalent wrought designation	ASTM specifications	Material Group No.
E3020	Ductile iron	DCI	None	None	A395, Gr. 60-40-18	1.0
E3033	High chrome iron	CR28	None	None	A532 class 3	Cr
E4027	High chrome iron	CR29	None	None	None	Cr
E4028	High chrome iron	CR35	None	None	None	Cr
C3009	Carbon steel	DS	None	Carbon steel	A216 Gr. WCB	1.1
C3062	Durco CF8	D2	CF8	304	A744, Gr. CF8	2.1
C3069	Durco CF3	D2L	CF3	304L	A744, Gr. CF3	2.1
C3063	Durco CF8M	D4	CF8M	316	A744, Gr. CF8M	2.2
C3067	Durco CF3M	D4L	CF3M	316L	A744, Gr. CF3M	2.2
C3107	Durcomet 100	CD4M	CD4MCuN	Ferralium®	A995, Gr. CD4MCuN	2.8
C4028	Durimet 20	D20	CN7M	Alloy 20	A744, Gr. CN7M	3.17
C4029	Durcomet 5	DV	None	None	None	2.2
K3005	Durco CY40	DINC	CY40	Inconel® 600	A494, Gr. CY40	3.5
K3007	Durco M35	DMM	M351	Monel® 400	A494, Gr. M35-1	3.4
K3008	Nickel	DNI	CZ100	Nickel 200	A494, Gr. CZ100	3.2
K4007	Chlorimet 2	DC2	N7M	Hastelloy® B	A494, Gr. N7M	3.7
K4008	Chlorimet 3	DC3	CW6M	Hastelloy® C	A494, Gr. CW6M	3.8
E3041	Duriron®	D	None	None	A518, Gr. 1	No load
E3042	Durichlor 51®	D51	None	None	A518, Gr. 2	No load
E4035	Superchlor®	SD51	None	None	A518, Gr. 2	No load
D4036	Durco DC8	DC8	None	None	None	-
H3004	Titanium	Ti	None	Titanium	B367, Gr. C3	Ti
H3005	Titanium-Pd	TiP	None	Titanium-Pd	B367, Gr. C8A	Ti
H3007	Zirconium	Zr	None	Zirconium	B752, Gr. 702C	Ti

® Duriron, Durichlor 51 and Superchlor are registered trademarks of Flowserve Corporation.
® Ferralium is a registered trademark of Langley Alloys.
® Hastelloy is a registered trademark of Haynes International, Inc.
® Inconel and Monel are registered trademarks of International Nickel Co. Inc.

Notes:

Figure 3-3: Class 150 flanges

Temp ºC (ºF)	Material Group No.												
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti	Cr
	bar (psi)												
-73 (-100)	–	–	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	–
-29 (-20)	17.2 (250)	19.7 (285)	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	–
-18 (0)	17.2 (250)	19.7 (285)	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	12.6 (183)
38 (100)	17.2 (250)	19.7 (285)	19.0 (275)	19.0 (275)	19.7 (285)	9.7 (140)	15.9 (230)	15.2 (220)	20.0 (290)	20.0 (290)	15.9 (230)	20.0 (290)	12.6 (183)
93 (200)	16.2 (235)	17.9 (260)	15.9 (230)	16.2 (235)	17.9 (260)	9.7 (140)	13.8 (200)	13.8 (200)	17.9 (260)	17.9 (260)	13.8 (200)	17.9 (260)	12.6 (183)
149 (300)	14.8 (215)	15.9 (230)	14.1 (205)	14.8 (215)	15.9 (230)	9.7 (140)	13.1 (190)	12.4 (180)	15.9 (230)	15.9 (230)	12.4 (180)	15.9 (230)	12.6 (183)
171 (340)	14.4 (209)	15.0 (218)	13.7 (199)	14.3 (207)	15.0 (218)	9.7 (140)	13.0 (188)	12.1 (176)	15.0 (218)	15.0 (218)	11.9 (172)	15.0 (218)	12.6 (183)
204 (400)	13.8 (200)	13.8 (200)	13.1 (190)	13.4 (195)	13.8 (200)	9.7 (140)	12.8 (185)	11.7 (170)	13.8 (200)	13.8 (200)	11.0 (160)	13.8 (200)	–
260 (500)	11.7 (170)	11.7 (170)	11.7 (170)	11.7 (170)	11.7 (170)	9.7 (140)	11.7 (170)	11.0 (160)	11.7 (170)	11.7 (170)	10.3 (150)	11.7 (170)	–
316 (600)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	9.7 (140)	–
343 (650)	8.6 (125)	8.6 (125)	8.6 (125)	8.6 (125)	–	–	8.6 (125)	8.6 (125)	8.6 (125)	8.6 (125)	–	8.6 (125)	–
371 (700)	–	7.6 (110)	7.6 (110)	7.6 (110)	–	–	7.6 (110)	7.6 (110)	7.6 (110)	7.6 (110)	–	7.6 (110)	–

Figure 3-4A: Group 2 – 13 in. In-Lines and Group 3 pumps with Class 300 flanges

Temp ºC (ºF)	Material Group No.										
	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	bar (psi)										
-73 (-100)	–	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
-29 (-20)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
-18 (0)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
38 (100)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	17.4 (252)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)	24.1 (350)
93 (200)	22.0 (319)	20.1 (292)	20.8 (301)	23.2 (336)	17.4 (252)	21.3 (309)	22.9 (332)	24.1 (350)	24.1 (350)	20.9 (303)	21.4 (310)
149 (300)	21.4 (310)	18.1 (263)	18.8 (272)	21.4 (310)	17.4 (252)	19.9 (289)	21.4 (310)	23.5 (341)	23.5 (341)	18.7 (271)	18.7 (271)
204 (400)	20.7 (300)	16.6 (241)	17.3 (250)	19.8 (287)	17.4 (252)	19.3 (280)	19.9 (288)	22.7 (329)	22.7 (329)	16.9 (245)	15.9 (231)
260 (500)	19.6 (284)	15.3 (222)	16.1 (233)	18.5 (268)	17.4 (252)	19.1 (277)	19.3 (280)	21.4 (310)	21.4 (310)	15.7 (228)	13.2 (191)
316 (600)	17.9 (260)	14.6 (211)	15.1 (219)	17.9 (259)	17.4 (252)	19.1 (277)	19.2 (278)	19.5 (282)	19.5 (282)	14.5 (210)	10.5 (152)
343 (650)	17.4 (253)	14.4 (209)	14.9 (216)	–	–	19.1 (277)	19.0 (276)	19.0 (275)	19.0 (275)	–	9.1 (132)
371 (700)	17.4 (253)	14.2 (207)	14.4 (209)	–	–	19.1 (277)	18.9 (274)	18.3 (266)	18.3 (266)	–	7.7 (112)

Figure 3-4B: Group 2 - 13 in. Lo-Flo pumps with Class 300 flanges

Temp ºC (ºF)	Material Group No.											
	1.0	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	bar (psi)											
-73 (-100)	–	–	31.0 (450)	31.0 (450)	31.0 (450)	17.4 (252)	24.1 (350)	27.6 (400)	31.0 (450)	31.0 (450)	24.1 (350)	31.0 (450)
-29 (-20)	31.0 (450)	31.0 (450)	31.0 (450)	31.0 (450)	31.0 (450)	17.4 (252)	24.1 (350)	27.6 (400)	31.0 (450)	31.0 (450)	24.1 (350)	31.0 (450)
-18 (0)	31.0 (450)	31.0 (450)	31.0 (450)	31.0 (450)	31.0 (450)	17.4 (252)	24.1 (350)	27.6 (400)	31.0 (450)	31.0 (450)	24.1 (350)	31.0 (450)
38 (100)	31.0 (450)	31.0 (450)	31.0 (450)	31.0 (450)	31.0 (450)	17.4 (252)	24.1 (350)	27.6 (400)	31.0 (450)	31.0 (450)	24.1 (350)	31.0 (450)
93 (200)	29.1 (422)	28.3 (410)	25.9 (375)	26.7 (388)	29.8 (432)	17.4 (252)	21.3 (309)	26.1 (379)	31.0 (450)	31.0 (450)	20.9 (303)	27.5 (399)
149 (300)	27.4 (397)	27.5 (398)	23.3 (338)	24.1 (350)	27.5 (399)	17.4 (252)	19.9 (289)	24.4 (354)	30.2 (438)	30.2 (438)	18.7 (271)	24.0 (348)
204 (400)	25.5 (369)	26.6 (386)	21.3 (309)	22.2 (322)	25.4 (369)	17.4 (252)	19.3 (280)	22.7 (330)	29.2 (423)	29.2 (423)	16.9 (245)	20.5 (297)
260 (500)	24.0 (348)	25.2 (365)	19.7 (285)	20.7 (300)	23.8 (345)	17.4 (252)	19.1 (277)	22.1 (320)	27.5 (399)	27.5 (399)	15.7 (228)	17.0 (246)
316 (600)	22.5 (327)	23.1 (334)	18.7 (272)	19.4 (281)	23.0 (333)	17.4 (252)	19.1 (277)	21.9 (318)	25.0 (363)	25.0 (363)	14.5 (210)	13.4 (195)
343 (650)	21.8 (316)	22.4 (325)	18.5 (269)	19.2 (2780	–	–	19.1 (277)	21.8 (316)	24.4 (354)	24.4 (354)	–	11.7 (170)
371 (700)	–	22.4 (325)	18.3 (266)	18.5 (269)	–	–	19.1 (277)	21.6 (313)	23.6 (342)	23.6 (342)	–	9.9 (144)

Figure 3-4C: All other Class 300 flanges

Temp ºC (ºF)	Material Group No.										
	1.1	2.1	2.2	2.8	3.2	3.4	3.5	3.7	3.8	3.17	Ti
	bar (psi)										
-73 (-100)	–	27.6 (400)	27.6 (400)	27.6 (400)	17.4 (252)	24.1 (350)	24.1 (350)	27.6 (400)	27.6 (400)	24.1 (350)	27.6 (400)
-29 (-20)	27.6 (400)	27.6 (400)	27.6 (400)	27.6 (400)	17.4 (252)	24.1 (350)	24.1 (350)	27.6 (400)	27.6 (400)	24.1 (350)	27.6 (400)
-18 (0)	27.6 (400)	27.6 (400)	27.6 (400)	27.6 (400)	17.4 (252)	24.1 (350)	24.1 (350)	27.6 (400)	27.6 (400)	24.1 (350)	27.6 (400)
38 (100)	27.6 (400)	27.6 (400)	27.6 (400)	27.6 (400)	17.4 (252)	24.1 (350)	24.1 (350)	27.6 (400)	27.6 (400)	24.1 (350)	27.6 (400)
93 (200)	25.2 (365)	23.0 (333)	23.7 (344)	26.5 (384)	17.4 (252)	21.3 (309)	22.9 (332)	27.6 (400)	27.6 (400)	20.9 (303)	24.5 (355)
149 (300)	24.4 (354)	20.7 (300)	21.5 (311)	24.5 (355)	17.4 (252)	19.9 (289)	21.4 (310)	26.8 (389)	26.8 (389)	18.7 (271)	21.3 (309)
204 (400)	23.7 (343)	19.0 (275)	19.7 (286)	22.6 (328)	17.4 (252)	19.3 (280)	19.9 (288)	25.9 (376)	25.9 (376)	16.9 (245)	18.2 (264)
260 (500)	22.4 (324)	17.5 (253)	18.4 (267)	21.1 (307)	17.4 (252)	19.1 (277)	19.3 (280)	24.5 (355)	24.5 (355)	15.7 (228)	15.1 (219)
316 (600)	20.5 (297)	16.7 (242)	17.2 (250)	20.4 (296)	17.4 (252)	19.1 (277)	19.2 (278)	22.2 (323)	22.2 (323)	14.5 (210)	12.0 (173)
343 (650)	19.9 (289)	16.5 (239)	17.0 (247)	–	–	19.1 (277)	19.0 (276)	21.7 (315)	21.7 (315)	–	10.4 (151)
371 (700)	19.9 (289)	16.3 (236)	16.5 (239)	–	–	19.1 (277)	18.9 (274)	21.0 (304)	21.0 (304)	–	8.8 (128)

Figure 3-5a: Suction pressure limits 1 750 r/min

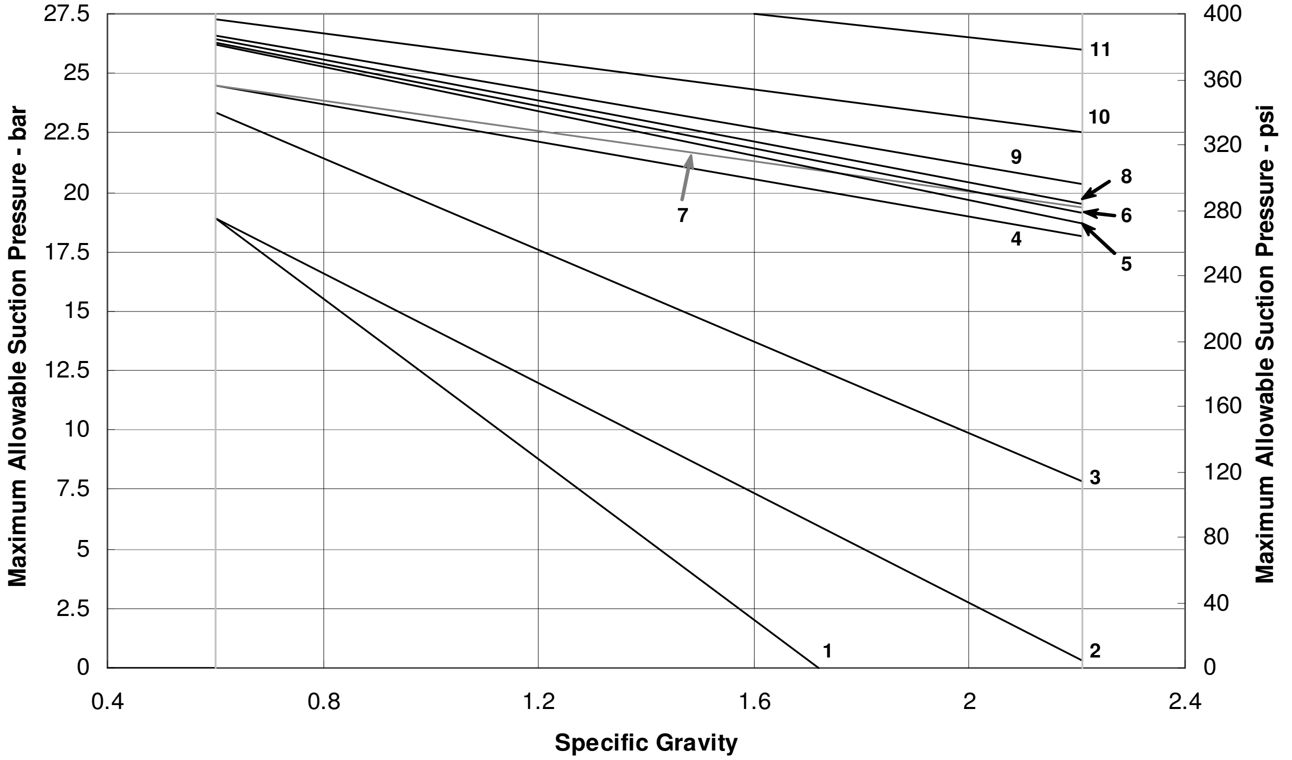


Figure 3-5b: Suction pressure limits 3 500 r/min

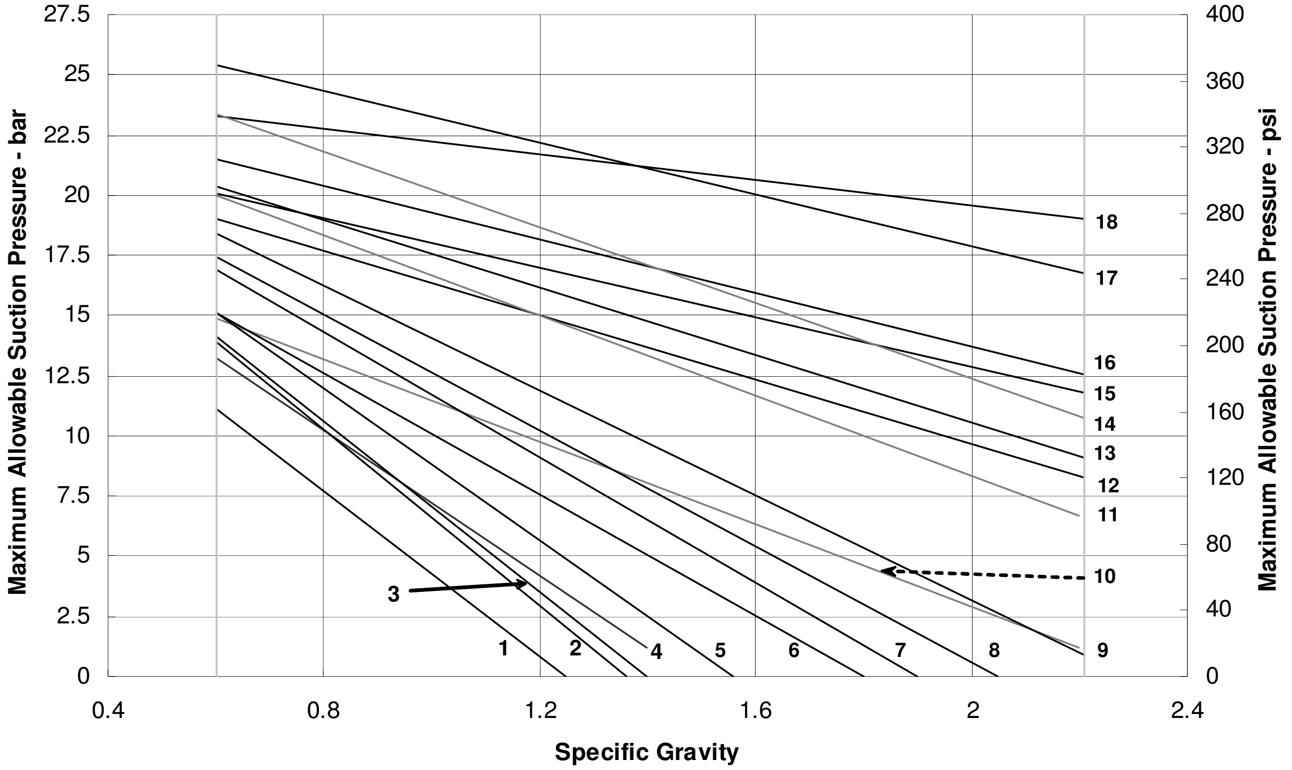


Figure 3-6: Suction pressure reference numbers

Pump size	1 750	3 500
1K 1.5x1-6	7	10
1K 3x1.5-6	10	15
1K 3x2-6	10	12
1K 2 x1.5V-6	PT	18
1K 1.5x1-8 1K 1.5x1.5US-8	7	6
1K 2x1.5V-8	PT	16
1K 3x1.5-8	4	4
1K 3x2V-7	PT	11
2K 3x2-8	10	7
2K 4x3-8	10	13
2K 2x1-10A	8	3
2K 2x1.5V-10A 2K 2x1.5US-10A	8	3
2K 3x1.5-10A	10	17
2K 3x2-10A 2K 3x2V-10 In-Line	10 11	14 9
2K 4x3-10	6	2
2K 4x3-10H	3	na
2K 6x4-10	5	8
2K 6x4-10H	10	na
2K 3x1.5-13	9	5
2K 3x2-13	5	1
2K 4x3-13/13	1	na
2K 4x3-13/12	1	na
2K 4x3-13/11 max	1	2
2K 4x3-13HH	10	na
2K 6x4-13A	1	na
2K 6x4-13A/10.25	1	?
3K 8x6-14A	2	na
3K 10x8-14	PT	na
3K 6x4-16	PT	na
3K 8x6-16A	PT	na
3K 10x8-16 & 16H	PT	na
3K 10x8-17	3	na
Recessed impellers	PT	PT
Lo-Flo pumps	PT	PT
Open impellers	PT	PT

Notes:
1. Self-Primer and In-Line pumps not specifically listed above are to use the standard pump ratings given.
   For example: 2K 3x2V-13 and 2K 3x2US-13 pumps utilize the standard 2K 3x2-13 ratings.
2. P-T: Only limited by Pressure-Temperature ratings.
3. Open impeller pumps including the Lo-Flo and Recessed Impeller products are limited in suction pressure only by the Pressure-Temperature ratings.
4. Sealmatic pump suction pressure is limited by the repeller.

Figure 3-7: Minimum continuous flow

Pump size	MCF % of BEP		
	3 500/2 900 r/min	1 750/1 450 r/min	1 180/960 r/min
1K3x2-6	20%	10%	10%
1K3x2-7	25%	10%	10%
2K3x2-8	20%	10%	10%
2K4x3-8	20%	10%	10%
2K3x2-10	30%	10%	10%
2K4x3-10	30%	10%	10%
2K6x4-10	40%	10%	10%
2K6x4-10H	n.a.	20%	10%
2K3x1.5-13	30%	10%	10%
2K3x2-13	40%	10%	10%
2K4x3-13	40%	20%	10%
2K4x3-13HH	n.a.	50%	30%
2K6x4-13	60%	40%	10%
3K8x6-14	n.a.	40%	15%
3K10x8-14	n.a.	40%	10%
3K6x4-16	n.a.	50%	10%
3K8x6-16	n.a.	50%	10%
3K10x8-16	n.a.	50%	10%
3K10x8-17	n.a.	50%	10%
All other sizes	10%	10%	10%

Figure 3-8: Minimum submergence

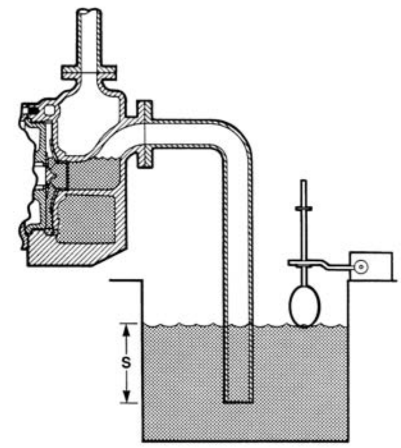
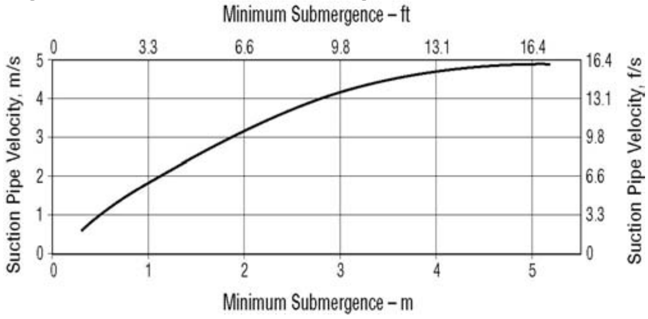


Figure 3-9: Minimum submergence



4 INSTALLATION

Zirconium 702 or high chrome iron components

CAUTION If any of the components of the pump have been made of zirconium or high chrome iron, the following precautionary measures should be followed:

- Use hand wrenches rather than impact wrenches
- This equipment should not be subjected to sudden changes in temperature or pressure
- Avoid striking this equipment with any sharp blows

Zirconium 705 and high chrome iron components

CAUTION Avoid any repair or fabrication welds on Zirconium 705 and high chrome iron components.

4.1 Location

The pump should be located to allow room for access, ventilation, maintenance, and inspection with ample headroom for lifting and should be as close as practicable to the supply of liquid to be pumped. Refer to the general arrangement drawing for the pump set.

4.2 Part assemblies

The supply of motors and baseplates are optional. As a result, it is the responsibility of the installer to ensure that the motor is assembled to the pump and aligned as detailed in section 4.5 and 4.8.

4.3 Foundation

4.3.1 Protection of openings and threads

When the pump is shipped, all threads and all openings are covered. This protection/covering should not be removed until installation. If, for any reason, the pump is removed from service, this protection should be reinstalled.

4.3.2 In-Line pump mounting

The Mark 3 In-Line can be supported in several ways:

- The pump may be supported by the piping; in which case it is recommended that the suction and discharge pipes be supported adjacent to the pump nozzles
- The pump may be supported under the casing foot or on the optional "pump stand"

The "pump stand" will allow the pump to free stand without the aid of piping. The pump stand may be bolted (and grouted) into place. In this case, the piping loads must be within the limits of the casing and of the "pump stand" as found in section 4.6.

The most advantageous method is the one that permits the pump to move with the piping. This eliminates problems due to thermal expansion, as the pump is designed to withstand forces that the piping is normally capable of transmitting.

4.3.3 Rigid baseplates - overview

The function of a baseplate is to provide a rigid foundation under a pump and its driver that maintains alignment between the two. Baseplates may be generally classified into two types:

- Foundation-mounted, grouted design. (Figure 4-1.)
- Stilt mounted, or free standing. (Figure 4-2.)

Figure 4-1

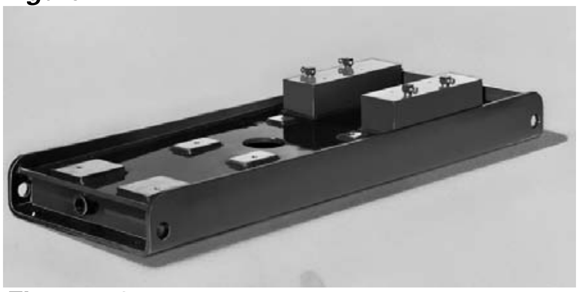


Figure 4-2

Baseplates intended for grouted installation are designed to use the grout as a stiffening member. Stilt mounted baseplates, on the other hand, are designed to provide their own rigidity. Therefore the designs of the two baseplates are usually different.

Regardless of the type of baseplate used, it must provide certain functions that ensure a reliable installation. Three of these requirements are:

1. The baseplate must provide sufficient rigidity to assure the assembly can be transported and installed, given reasonable care in handling, without damage. It must also be rigid enough when properly installed to resist operating loads.
2. The baseplate must provide a reasonably flat mounting surface for the pump and driver. Uneven surfaces will result in a soft-foot condition that may make alignment difficult or impossible. Experience indicates that a baseplate with a top surface flatness of 1.25 mm/m (0.015 in./ft) across the diagonal corners of the baseplate provides such a mounting surface. Therefore, this is the tolerance to which we supply our standard baseplate.

Some users may desire an even flatter surface, which can facilitate installation and alignment. Flowserve will supply flatter baseplates upon request at extra cost. For example, mounting surface flatness of 0.17 mm/m (0.002 in./ft) is offered on the Flowserve Type E "Ten Point" baseplate shown in figure 4-1.

3. The baseplate must be designed to allow the user to final field align the pump and driver to within their own particular standards and to compensate for any pump or driver movement that occurred during handling. Normal industry practice is to achieve final alignment by moving the motor to match the pump. Flowserve practice is to confirm in our shop that the pump assembly can be accurately aligned. Before shipment, the factory verifies that there is enough horizontal movement capability at the motor to obtain a "perfect" final alignment when the installer puts the baseplate assembly into its original, top leveled, unstressed condition.

4.3.4 Stilt and spring mounted baseplates

Flowserve offers stilt and spring mounted baseplates. (See figure 4-2 for stilt mounted option.) The low vibration levels of Mark 3 pumps allow the use of these baseplates - provided they are of a rigid design. The baseplate is set on a flat surface with no tie down bolts or other means of anchoring it to the floor.

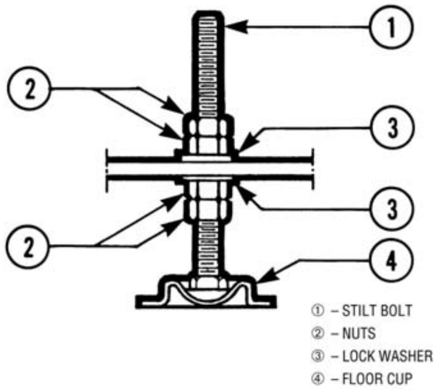
General instructions for assembling these baseplates are given below. For dimensional information, please refer to the appropriate Flowserve "Sales print."

4.3.4.1 Stilt mounted baseplate assembly instructions

Refer to figure 4-3.

a) Raise or block up baseplate/pump above the floor to allow for the assembly of the stilts.
b) Predetermine or measure the approximate desired height for the baseplate above the floor.
c) Set the bottom nuts [2] above the stilt bolt head [1] to the desired height.
d) Assemble lock washer [3] down over the stilt bolt.
e) Assemble the stilt bolt up through hole in the bottom plate and hold in place.
f) Assemble the lock washer [3] and nut [2] on the stilt bolt. Tighten the nut down on the lock washer.
g) After all four stilts have been assembled, position the baseplate in place, over the floor cups [4] under each stilt location, and lower the baseplate to the floor.
h) Level and make final height adjustments to the suction and discharge pipe by first loosening the top nuts and turning the bottom nuts to raise or lower the baseplate.
i) Tighten the top and bottom nuts at the lock washer [3] first then tighten the other nuts.
j) It should be noted that the connecting pipelines must be individually supported, and that the stilt mounted baseplate is not intended to support total static pipe load.

Figure 4-3



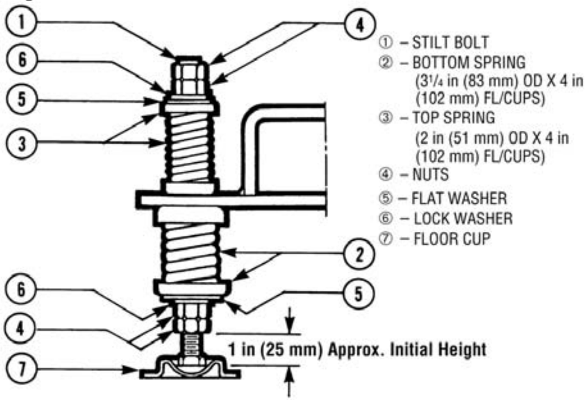
4.3.4.2 Stilt/spring mounted baseplate assembly instructions

Refer to figure 4-4.

a) Raise or block up baseplate/pump above the floor to allow for the assembly of the stilts.
b) Set the bottom nuts [4] above the stilt bolt head [1]. This allows for 51 mm (2 in.) upward movement for the final height adjustment of the suction/discharge flange.
c) Assemble the lock washer [6] flat washer [5] and bottom spring/cup assembly [2] down over the stilt bolt [1].
d) Assemble the stilt bolt/bottom spring up through hole in the bottom plate and hold in place.
e) Assemble top spring/cup assembly [3] down over stilt bolt.
f) Assemble flat washer [5], lock washer [6] and nuts [4] on the stilt bolt.
g) Tighten down top nuts, compressing the top spring approximately 13 mm (0.5 in.). Additional compression may be required to stabilize the baseplate.
h) After all four stilts have been assembled, position the baseplate in place, over the floor cups [7] under each stilt location, and lower the baseplate down to the floor.
i) Level and make final height adjustments to the suction and discharge pipe by first loosening the top nuts, and turning the bottom nuts to raise or lower the baseplate.
j) Recompress the top spring to the compression established in step g) and lock the nuts.

k) It should be noted that the connecting pipelines must be individually supported, and that the spring mounted baseplate is not intended to support total static pipe loads.

Figure 4-4



4.3.4.3 Stilt/spring mounted baseplates - motor alignment

The procedure for motor alignment on stilt or spring mounted baseplates is similar to grouted baseplates. The difference is primarily in the way the baseplate is leveled.

a) Level the baseplate by using the stilt adjusters. (Shims are not needed as with grouted baseplates.)
b) After the base is level, it is locked in place by locking the stilt adjusters.
c) Next the initial pump alignment must be checked. The vertical height adjustment provided by the stilts allows the possibility of slightly twisting the baseplate. If there has been no transit damage or twisting of the baseplate during stilt height adjustment, the pump and driver should be within 0.38 mm (0.015 in.) parallel, and 0.0025 mm/mm (0.0025 in./in.) angular alignment. If this is not the case, check to see if the driver mounting fasteners are centered in the driver feet holes.
d) If the fasteners are not centered there was likely shipping damage. Re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.
e) If the fasteners are centered, then the baseplate may be twisted. Slightly adjust (one turn of the adjusting nut) the stilts at the driver end of the baseplate and check for alignment to the above tolerances. Repeat as necessary while maintaining a level condition as measured from the pump discharge flange.
f) Lock the stilt adjusters.

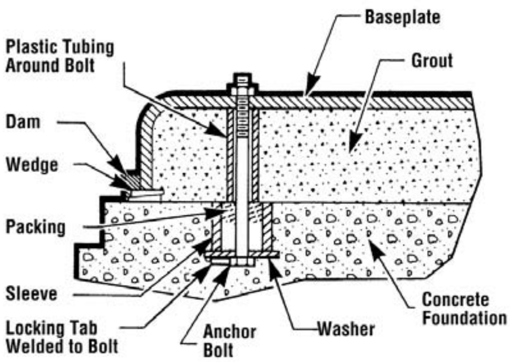
The remaining steps are as listed for new grouted baseplates.

4.4 Grouting

a) The pump foundation should be located as close to the source of the fluid to be pumped as practical.
b) There should be adequate space for workers to install, operate, and maintain the pump. The foundation should be sufficient to absorb any vibration and should provide a rigid support for the pump and motor.
c) Recommended mass of a concrete foundation should be three times that of the pump, motor and base. Refer to figure 4-5.

Note: Foundation bolts are imbedded in the concrete inside a sleeve to allow some movement of the bolt.

Figure 4-5



d) Level the pump baseplate assembly. If the baseplate has machined coplanar mounting surfaces, these machined surfaces are to be referenced when leveling the baseplate. This may require that the pump and motor be removed from the baseplate in order to reference the machined faces. If the baseplate is without machined coplanar mounting surfaces, the pump and motor are to be left on the baseplate. The proper surfaces to reference when leveling the pump baseplate assembly are the pump suction and discharge flanges. DO NOT stress the baseplate.
e) Do not bolt the suction or discharge flanges of the pump to the piping until the baseplate foundation is completely installed. If equipped, use leveling jackscrews to level the baseplate. If jackscrews are not provided, shims and wedges should be used. (See Figure 4-5.) Check for levelness in both the longitudinal and lateral directions. Shims should be placed at all base anchor bolt locations, and in the middle edge of the base if the base is more than 1.5 m (5 ft.) long. Do not rely on the bottom of the baseplate to be flat. Standard baseplate bottoms are not machined, and it is not likely that the field mounting surface is flat.

f) After leveling the baseplate, tighten the anchor bolts. If shims were used, make sure that the baseplate was shimmed near each anchor bolt before tightening. Failure to do this may result in a twist of the baseplate, which could make it impossible to obtain final alignment.
g) Check the level of the baseplate to make sure that tightening the anchor bolts did not disturb the level of the baseplate. If the anchor bolts did change the level, adjust the jackscrews or shims as needed to level the baseplate.
h) Continue adjusting the jackscrews or shims and tightening the anchor bolts until the baseplate is level.
i) Check initial alignment. If the pump and motor were removed from the baseplate proceed with step j) first, then the pump and motor should be reinstalled onto the baseplate using Flowserve's factory preliminary alignment procedure as described in section 4.5, and then continue with the following. As described above, pumps are given a preliminary alignment at the factory. This preliminary alignment is done in a way that ensures that, if the installer duplicates the factory conditions, there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. If the pump and motor were properly reinstalled to the baseplate or if they were not removed from the baseplate and there has been no transit damage, and also if the above steps where done properly, the pump and driver should be within 0.38 mm (0.015 in.) FIM (Full Indicator Movement) parallel, and 0.0025 mm/mm (0.0025 in./in.) FIM angular. If this is not the case, first check to see if the driver mounting fasteners are centered in the driver feet holes. If not, re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.
j) Grout the baseplate. A non-shrinking grout should be used. Make sure that the grout fills the area under the baseplate. After the grout has cured, check for voids and repair them. Jackscrews, shims and wedges should be removed from under the baseplate at this time. If they were to be left in place, they could rust, swell, and cause distortion in the baseplate.
k) Run piping to the suction and discharge of the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant loads.

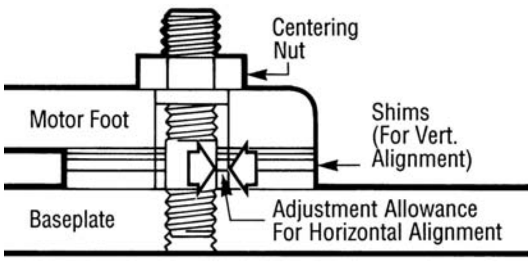
4.5 Initial alignment

4.5.1 Horizontal initial alignment procedure

The purpose of factory alignment is to ensure that the user will have full utilization of the clearance in the motor holes for final job-site alignment. To achieve this, the factory alignment procedure specifies that the pump be aligned in the horizontal plane to the motor, with the motor foot bolts centered in the motor holes. This procedure ensures that there is sufficient clearance in the motor holes for the customer to field align the motor to the pump, to zero tolerance. This philosophy requires that the customer be able to place the base in the same condition as the factory. Thus the factory alignment will be done with the base sitting in an unrestrained condition on a flat and level surface. This standard also emphasizes the need to ensure the shaft spacing is adequate to accept the specified coupling spacer.

The factory alignment procedure is summarized below:
a) The baseplate is placed on a flat and level workbench in a free and unstressed position.
b) The baseplate is leveled as necessary. Leveling is accomplished by placing shims under the rails of the base at the appropriate anchor bolt hole locations. Levelness is checked in both the longitudinal and lateral directions.
c) The motor and appropriate motor mounting hardware is placed on the baseplate and the motor is checked for any planar soft-foot condition. If any is present it is eliminated by shimming.
d) The motor feet holes are centered on the motor mounting fasteners. This is done by using a centering nut as shown in figure 4-6.

Figure 4-6



e) The motor is fastened in place by tightening the nuts on two diagonal motor mounting studs.
f) The pump is put onto the baseplate and leveled. The foot piece under the bearing housing is adjustable. It is used to level the pump, if necessary.
Mark 3A and ANSI 3A design
If an adjustment is necessary, add or remove shims [3126.1] between the foot piece and the bearing housing.

Mark 3 design (old)
If an adjustment is necessary, the adjuster nut [6576] is used to move the footpiece up or down.

g) The spacer coupling gap is verified.
h) The parallel and angular vertical alignment is made by shimming under the motor.
i) The motor feet holes are again centered on the motor mounting studs using the centering nut. At this point the centering nut is removed and replaced with a standard nut. This gives maximum potential mobility for the motor to be horizontally moved during final, field alignment. All four motor feet are tightened down.
j) The pump and motor shafts are then aligned horizontally, both parallel and angular, by moving the pump to the fixed motor. The pump feet are tightened down.
k) Both horizontal and vertical alignment is again final checked as is the coupling spacer gap.

See section 4.8, *Final shaft alignment*.

4.5.2 In-Line initial alignment procedure

The factory alignment proceed procedure ensures that the unit may be aligned in the field. The initial alignment is no more than 0.38 mm (0.015 in.) parallel, and 0.0025 mm/mm (0.0025 in./in.) angular misalignment.

The Mark 3 In-Line incorporates motor alignment capabilities. Parallel alignment is achieved by moving the motor adapter and motor as an assembly relative to the power end. Four adjustment screws (as shown in figures 4-7 and 4-8) allow for precise changes in parallel alignment. Angular alignment is controlled by machining tolerances, but cannot prevent uneven cover gasket compression.

a) Check angular alignment. Additional torque may be applied to the appropriate casing bolts to correct angularity.
b) Check parallel alignment within a plane defined by the adjusters at opposite corners of the motor adapter. To make corrections, the motor adapter nuts [6580.3] must be slightly loosened to allow the motor adapter to move. All adjusters except for the one in the desired direction of motor movement should be loosened during adjustment. Tighten the adjuster slowly against the stud until desired alignment numbers are reached.
c) Check parallel alignment within a plane 90 degrees from the first. Corrections are made as described in the previous step.
d) Several iterations between planes may be necessary. Tighten all fasteners and recheck alignment.

Figure 4-7

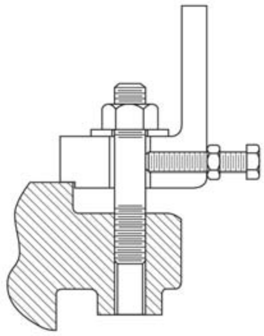
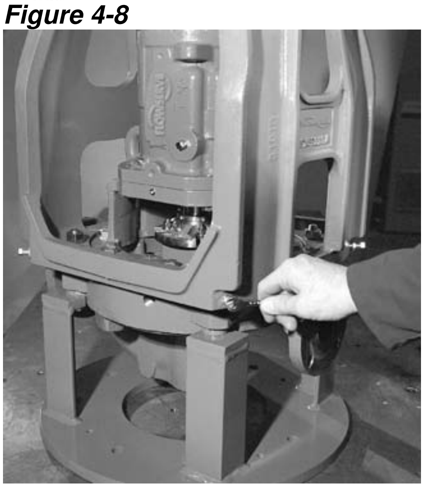


Figure 4-8



4.6 Piping

CAUTION Protective covers are fitted to both the suction and discharge flanges of the casing and must be removed prior to connecting the pump to any pipes.

4.6.1 Suction and discharge piping

All piping must be independently supported, accurately aligned and preferably connected to the pump by a short length of flexible piping. The pump should not have to support the weight of the pipe or compensate for misalignment. It should be possible to install suction and discharge bolts through mating flanges without pulling or prying either of the flanges. All piping must be tight. Pumps may air-bind if air is allowed to leak into the piping. If the pump flange(s) have tapped holes, select flange fasteners with thread engagement at least equal to the fastener diameter but that do not bottom out in the tapped holes before the joint is tight.

4.6.2 Suction piping

To avoid NPSH and suction problems, suction piping must be at least as large as the pump suction connection. Never use pipe or fittings on the suction that are smaller in diameter than the pump suction size.

Figure 4-9 illustrates the ideal piping configuration with a minimum of 10 pipe diameters between the source and the pump suction. In most cases, horizontal reducers should be eccentric and mounted with the flat side up as shown in figure 4-10 with a maximum of one pipe size reduction. Never mount eccentric reducers with the flat side down. Horizontally mounted concentric reducers should not be used if there is any possibility of entrained air in the process fluid. Vertically mounted concentric reducers are acceptable. In applications where the fluid is completely de-aerated and free of any vapor or suspended solids, concentric reducers are preferable to eccentric reducers.

Figure 4-9

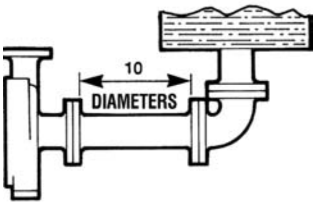
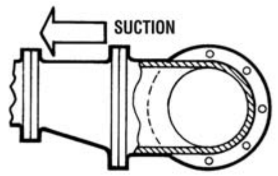


Figure 4-10



Avoid the use of throttling valves and strainers in the suction line. Start up strainers must be removed shortly before start up. When the pump is installed below the source of supply, a valve should be installed in the suction line to isolate the pump and permit pump inspection and maintenance. However, never place a valve directly on the suction nozzle of the pump.

Refer to the Durco Pump Engineering Manual and the Centrifugal Pump IOM Section of the Hydraulic Institute Standards for additional recommendations on suction piping. (See section 10.)

Refer to section 3.4 for performance and operating limits.

4.6.2.1 Mark 3 Self-Priming Pumps

The suction piping must be as short as possible and be as close to the diameter of the suction nozzle as is practical. The pump works by removing the air contained in the suction piping. Once removed, it operates exactly the same as a flooded suction standard pump. Longer and larger the suction pipe have a greater volume of air that has to be removed, resulting in longer priming time. The suction piping and seal chamber must be airtight to allow priming to occur. When possible, it is recommended that suction piping be sloped slightly towards the casing to limit priming fluid loss down the suction line during priming and shutdown.

4.6.3 Discharge piping

Install a valve in the discharge line. This valve is required for regulating flow and/or to isolate the pump for inspection and maintenance.

CAUTION When fluid velocity in the pipe is high, for example, 3 m/s (10 ft/sec) or higher, a rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

4.6.3.1 Mark 3 Self-Priming Pumps

During the priming cycle, air from the suction piping is evacuated into the discharge piping. There must be a way for this air to vent. If air is not able to freely vent out the discharge pipe, it is typically recommended to install an air bleed line. The air bleed line is typically connected from the discharge pipe to the sump. Car must be taken to prevent air from re-entering suction pipe.

4.6.4 Allowable nozzle loads

Flowserve chemical process pumps meet or exceed the allowable nozzle loads given by ANSI/HI 9.6.2. The following paragraphs describe how to calculate the allowable loads for each pump type and how to determine if the applied loads are acceptable. The first configuration covered is ASME B73.1M pumps, including the Mark 3 Standard, Sealmatic, Lo-Flo, Recessed Impeller, and Unitized Self-Priming pumps. The second configuration covered is the ASME B73.2M vertical, Mark 3 In-Line pump.

4.6.4.1 Mark 3 horizontal pumps (ASME B73.1M)

The following steps are based upon ANSI/HI 9.6.2. All information necessary to complete the evaluation is given below. For complete details please review the standard.

a) Determine the appropriate casing “Material Group No.” from figure 3-2.
b) Find the “Casing material correction factor” in Figure 4-11 based upon the “Material Group No.” and operating temperature. Interpolation may be used to determine the correction factor for a specific temperature.
c) Find the “Baseplate correction factor” in Figure 4-12. The correction factor depends upon how the baseplate is to be installed.
d) Locate the pump model being evaluated in Figure 4-16 and multiply each load rating by the casing correction factor. Record the ”adjusted Figure 4-16 loads”.
e) Locate the pump model being evaluated in Figures 4-17 and 4-18 and multiply each load rating by the baseplate correction factor. Record the adjusted Figure 4-17 and 4-18 loads.

f) Compare the "adjusted Figure 4-16 loads" to the values shown in figure 4-15. The lower of these two values should be used as the adjusted figure 4-15 values. *(The HI standard also asks that figure 4-15 loads be reduced if figure 4-17 or 4-18 values are lower. Flowserve does not follow this step.)*
g) Calculate the applied loads at the casing flanges according to the coordinate system found in figure 4-13. The 12 forces and moments possible are Fxs, Fys, Fzs, Mxs, Mys, Mzs, Fxd, Fyd, Fzd, Mxd, Myd and Mzd. For example, Fxd designates Force in the "x" direction on the discharge flange. Mys designates the Moment about the "y"-axis on the suction flange.
h) Figure 4-14 gives the acceptance criteria equations. For long coupled pumps, equation sets 1 through 5 must be satisfied. For close coupled and C-face pumps, only equation sets 1 and 2 must be satisfied.
i) Equation set 1. Each applied load is divided by the corresponding adjusted figure 4-15 value. The absolute value of each ratio must be less than or equal to one.
j) Equation set 2. The summation of the absolute values of each ratio must be less than or equal to two. The ratios are the applied load divided by the adjusted figure 4-16 values.
k) Equation sets 3 and 4. These equations are checking for coupling misalignment due to nozzle loading in each axis. Each applied load is divided by the corresponding adjusted load from figure 4-17 and 4-18. The result of each equation must be between one and negative one.
l) Equation set 5. This equation calculates the total shaft movement from the results of equations 3 and 4. The result must be less than or equal to one.

Figure 4-11: Casing material correction factors

		Material Group No.													
		1.0	**1.1**	**2.1**	**2.2**	**2.4**	**2.8**	**3.2**	**3.4**	**3.5**	**3.7**	**3.8**	**3.17**	**Ti**	**Cr**
				Austenitic steels				Nickel and nickel alloys							
Temp ˚C	Temp ˚F	DCI	Carbon Steel	Type 304 and 304L	Type 316 and 316L	Type 321	CD-4MCu	Nickel	Monel	Inconel	Hast B	Hast C	Alloy 20	Ti, Ti-Pd, Zr	High Chrome -18 to 171 ˚C 340 ˚F)
-129	-200	–	–	1.00	1.00	1.00	–	0.50	–	–	–	–	0.83	–	–
-73	-100	–	–	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	–
-29	-20	0.89	1.00	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	0.65
38	100	0.89	1.00	1.00	1.00	1.00	1.00	0.50	0.83	0.93	1.00	1.00	0.83	0.89	0.65
93	200	0.83	0.94	0.83	0.86	0.93	1.00	0.50	0.74	0.88	1.00	1.00	0.72	0.86	0.65
150	300	0.78	0.91	0.75	0.78	0.83	0.92	0.50	0.69	0.82	1.01	1.01	0.65	0.81	0.65
205	400	0.73	0.88	0.69	0.72	0.69	0.85	0.50	0.67	0.77	0.98	0.98	0.58	0.69	0.65
260	500	0.69	0.83	0.63	0.67	0.64	0.80	0.50	0.66	0.74	0.92	0.92	0.54	0.57	–
315	600	0.65	0.76	0.60	0.63	0.60	0.77	0.50	0.66	0.74	0.84	0.84	0.50	0.45	–
344	650	0.63	0.74	0.60	0.62	0.60	–	–	0.66	0.73	0.82	0.82	–	0.39	–
370	700	–	0.74	0.59	0.60	0.58	–	–	0.66	0.73	0.79	0.79	–	0.33	–

Figure 4-12: Baseplate correction factors

Base type	Grouted	Bolted	Stilt mounted
Type A	1.0	0.7	0.65
Type B - Polybase	1.0	n/a	0.95
Type C	n/a	1.0	1.0
Type D	1.0	0.8	0.75
Type E - PIP	1.0	0.95	n/a
Polyshield - baseplate/ foundation	1.0	n/a	n/a

Figure 4-13: Coordinate system

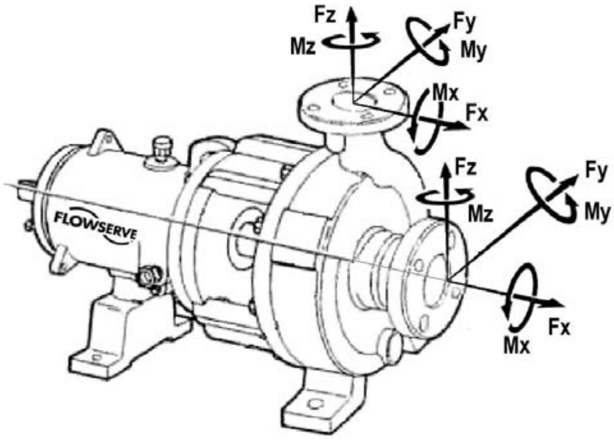


Figure 4-14: Acceptance criteria equations

Set	Equations	Figure	Remarks
1	$\left\|\frac{F_{xs}}{F_{xs\_adj}}\right\| \leq 1.0,\ \left\|\frac{F_{ys}}{F_{ys\_adj}}\right\| \leq 1.0,\ \left\|\frac{F_{zs}}{F_{zs\_adj}}\right\| \leq 1.0,\ \left\|\frac{M_{xs}}{M_{xs\_adj}}\right\| \leq 1.0,\ \left\|\frac{M_{ys}}{M_{ys\_adj}}\right\| \leq 1.0,\ \left\|\frac{M_{zs}}{M_{zs\_adj}}\right\| \leq 1.0,$ $\left\|\frac{F_{xd}}{F_{xd\_adj}}\right\| \leq 1.0,\ \left\|\frac{F_{yd}}{F_{yd\_adj}}\right\| \leq 1.0,\ \left\|\frac{F_{zd}}{F_{zd\_adj}}\right\| \leq 1.0,\ \left\|\frac{M_{xd}}{M_{xd\_adj}}\right\| \leq 1.0,\ \left\|\frac{M_{yd}}{M_{yd\_adj}}\right\| \leq 1.0,\ \left\|\frac{M_{zd}}{M_{zd\_adj}}\right\| \leq 1.0$	Adjusted 4-15	Maximum individual loading
2	$\left\|\frac{F_{xs}}{F_{xs\_adj}}\right\| + \left\|\frac{F_{ys}}{F_{ys\_adj}}\right\| + \left\|\frac{F_{zs}}{F_{zs\_adj}}\right\| + \left\|\frac{M_{xs}}{M_{xs\_adj}}\right\| + \left\|\frac{M_{ys}}{M_{ys\_adj}}\right\| + \left\|\frac{M_{zs}}{M_{zs\_adj}}\right\| +$ $\left\|\frac{F_{xd}}{F_{xd\_adj}}\right\| + \left\|\frac{F_{yd}}{F_{yd\_adj}}\right\| + \left\|\frac{F_{zd}}{F_{zd\_adj}}\right\| + \left\|\frac{M_{xd}}{M_{xd\_adj}}\right\| + \left\|\frac{M_{yd}}{M_{yd\_adj}}\right\| + \left\|\frac{M_{zd}}{M_{zd\_adj}}\right\| \leq 2.0$	Adjusted 4-16	Nozzle stress, bolt stress, pump slippage
3	$A = \frac{F_{ys}}{F_{ys\_adj}} + \frac{M_{xs}}{M_{xs\_adj}} + \frac{M_{ys}}{M_{ys\_adj}} + \frac{M_{zs}}{M_{zs\_adj}} +$ $\frac{F_{yd}}{F_{yd\_adj}} + \frac{M_{xd}}{M_{xd\_adj}} + \frac{M_{yd}}{M_{yd\_adj}} + \frac{M_{zd}}{M_{zd\_adj}}$ $-1.0 \leq A \leq 1.0$	Adjusted 4-17	y-axis movement
4	$B = \frac{F_{xs}}{F_{xs\_adj}} + \frac{F_{zs}}{F_{zs\_adj}} + \frac{M_{xs}}{M_{xs\_adj}} + \frac{M_{ys}}{M_{ys\_adj}} + \frac{M_{zs}}{M_{zs\_adj}} +$ $\frac{F_{xd}}{F_{xd\_adj}} + \frac{F_{yd}}{F_{yd\_adj}} + \frac{F_{zd}}{F_{zd\_adj}} + \frac{M_{xd}}{M_{xd\_adj}} + \frac{M_{yd}}{M_{yd\_adj}} + \frac{M_{zd}}{M_{zd\_adj}}$ $-1.0 \leq B \leq 1.0$	Adjusted 4-18	z-axis movement
5	$\sqrt{A^2 + B^2} \leq 1.0$	-	Combined axis movement

Note: All of the above equations are found by dividing the applied piping loads by the **adjusted** figure values**.**

Figure 4-15: Maximum individual loading

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
1K 1.5x1-LF4	4 670 (1 050)	3 336 (750)	3 336 (750)	976 (720)	231 (170)	231 (170)	3 558 (800)	6 005 (1350)	13 344 (3 000)	556 (410)	556 (410)	556 (410)
1K 1.5x1-6	4 670 (1 050)	3 336 (750)	3 336 (750)	976 (720)	231 (170)	231 (170)	3 558 (800)	6 005 (1350)	13 344 (3 000)	556 (410)	556 (410)	556 (410)
1K 3x1.5-6	4 670 (1 050)	5 516 (1 240)	5 560 (1 250)	1 220 (900)	664 (490)	664 (490)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	678 (500)	746 (550)	692 (510)
1K 3x2-6	4 670 (1 050)	4 670 (1 050)	4 670 (1 050)	1 220 (900)	298 (220)	298 (220)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	678 (500)	1 356 (1 000)	692 (510)
1K 1.5x1-8 and LF8	4 670 (1 050)	5 382 (1 210)	5 382 (1 210)	976 (720)	258 (190)	258 (190)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	488 (360)	488 (360)	488 (360)
1K 1.5x1.5US-8	4 670 (1 050)	5 382 (1 210)	5 382 (1 210)	976 (720)	258 (190)	258 (190)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	488 (360)	488 (360)	488 (360)
1K 3x1.5-8	4 670 (1 050)	5 516 (1 240)	5 560 (1 250)	1 220 (900)	664 (490)	664 (490)	3 558 (800)	6 005 (1 350)	13 344 (3 000)	597 (440)	597 (440)	597 (440)
2K 3x2-8	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	814 (600)	814 (600)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 4x3-8	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	475 (350)	475 (350)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 980 (1 460)	936 (690)
2K 2x1-10A and LF10	10 408 (2 340)	4 270 (960)	4 270 (960)	1 722 (1 270)	298 (220)	298 (220)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 2x1.5US-10A	10 408 (2 340)	4 270 (960)	4 270 (960)	1 722 (1 270)	298 (220)	298 (220)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 2x2R-10	10 408 (2 340)	4 270 (960)	4 270 (960)	1 722 (1 270)	298 (220)	298 (220)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	895 (660)	895 (660)	895 (660)
2K 3x1.5-10A	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	570 (420)	570 (420)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	502 (370)	502 (370)	502 (370)
2K 3x2-10A	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	759 (560)	759 (560)	759 (560)
2K 3x2US-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	759 (560)	759 (560)	759 (560)
2K 3x3R-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	759 (560)	759 (560)	759 (560)
2K 4x3-10 and 10H	10 230 (2 300)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 980 (1 460)	936 (690)
2K 4x3US-10H	10 230 (2 300)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	420 (310)	420 (310)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 980 (1 460)	936 (690)
2K 6x4-10 and 10H	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 492 (1 100)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 3x1.5-13 and LF13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	909 (670)	909 (670)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	719 (530)	719 (530)	719 (530)
2K 3x2-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	1 763 (1 300)	475 (350)	475 (350)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 722 (1 270)	936 (690)
2K 3x2US-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	1 763 (1 300)	475 (350)	475 (350)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	1 722 (1 270)	936 (690)
2K 4x3-13 and 13HH	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	542 (400)	542 (400)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 4x3US-13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	542 (400)	542 (400)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 4x3R-13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	542 (400)	542 (400)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 6x4-13A	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 763 (1 300)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 6x4US-13A	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 763 (1 300)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
2K 6x4R-13	12 010 (2 700)	6 005 (1 350)	6 672 (1 500)	1 763 (1 300)	1 763 (1 300)	1 492 (1 100)	6 227 (1 400)	6 005 (1 350)	14 456 (3 250)	1 627 (1 200)	2 034 (1 500)	936 (690)
3K 8x6-14A	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	1 587 (1 170)	1 587 (1 170)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 10x8-14	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	2 712 (2 000)	2 915 (2 150)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 6x4-16	15 568 (3 500)	12 721 (2 860)	8 006 (1 800)	1 831 (1 350)	1 431 (1 055)	1 431 (1 055)	6 005 (1 350)	12 010 (2 700)	14 011 (3 150)	1 526 (1 125)	3 465 (2 555)	3 465 (2 555)
3K 8x6-16A	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	2 007 (1 480)	2 007 (1 480)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 10x8-16 and 16H	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	1 532 (1 130)	1 532 (1 130)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)
3K 10x8-17	15 568 (3 500)	14 145 (3 180)	8 896 (2 000)	2 034 (1 500)	1 532 (1 130)	1 532 (1 130)	6 672 (1 500)	13 344 (3 000)	15 568 (3 500)	1 695 (1 250)	3 851 (2 840)	3 851 (2 840)

Figure 4-16: Maximum combined loading

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
1K 1.5x1-LF4	8 985 (2 020)	3 336 (750)	3 336 (750)	2 481 (1 830)	231 (170)	231 (170)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	556 (410)	556 (410)	556 (410)
1K 1.5x1-6	8 985 (2 020)	3 336 (750)	3 336 (750)	2 481 (1 830)	231 (170)	231 (170)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	556 (410)	556 (410)	556 (410)
1K 3x1.5-6	8 985 (2 020)	5 516 (1 240)	9 385 (2 110)	3 105 (2 290)	664 (490)	664 (490)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	746 (550)	746 (550)	692 (510)
1K 3x2-6	8 985 (2 020)	4 670 (1 050)	4 670 (1 050)	3 105 (2 290)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 397 (1 030)	1 397 (1 030)	692 (510)
1K 1.5x1-8 and LF-8	8 985 (2 020)	5 382 (1 210)	5 382 (1 210)	2 481 (1 830)	258 (190)	258 (190)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	488 (360)	488 (360)	488 (360)
1K 1.5x1.5US-8	8 985 (2 020)	5 382 (1 210)	5 382 (1 210)	2 481 (1 830)	258 (190)	258 (190)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	488 (360)	488 (360)	488 (360)
1K 3x1.5-8	8 985 (2 020)	5 516 (1 240)	7 295 (1 640)	3 105 (2 290)	664 (490)	664 (490)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	597 (440)	597 (440)	597 (440)
2K 3x2-8	12 010 (2 700)	6 005 (1 350)	11 076 (2 490)	5 058 (3 730)	814 (600)	814 (600)	8 763 (1 970)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 4x3-8	12 010 (2 700)	6 005 (1 350)	8 184 (1 840)	5 058 (3 730)	475 (350)	475 (350)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 2x1-10A and LF10	10 408 (2 340)	4 270 (960)	4 270 (960)	4 936 (3 640)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 2x1.5US-10A	10 408 (2 340)	4 270 (960)	4 270 (960)	4 936 (3 640)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 2x2R-10	10 408 (2 340)	4 270 (960)	4 270 (960)	4 936 (3 640)	298 (220)	298 (220)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	895 (660)	895 (660)	895 (660)
2K 3x1.5-10A	12 010 (2 700)	6 005 (1 350)	8 496 (1 910)	5 058 (3 730)	570 (420)	570 (420)	8 629 (1 940)	6 005 (1 350)	27 756 (6 240)	502 (370)	502 (370)	502 (370)
2K 3x2-10A	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	759 (560)	759 (560)	759 (560)
2K 3x2US-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	759 (560)	759 (560)	759 (560)
2K 3x3R-10	12 010 (2 700)	6 005 (1 350)	6 583 (1 480)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	759 (560)	759 (560)	759 (560)
2K 4x3-10 and 10H	10 230 (2 300)	6 005 (1 350)	7 295 (1 640)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 4x3US-10H	10 230 (2 300)	6 005 (1 350)	7 295 (1 640)	5 058 (3 730)	420 (310)	420 (310)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 6x4-10 and 10H	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	1 492 (1 100)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	4 204 (3 100)	4 204 (3 100)	936 (690)
2K 3x1.5-13 and LF13	12 010 (2 700)	6 005 (1 350)	13 611 (3 060)	5 058 (3 730)	909 (670)	909 (670)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	719 (530)	719 (530)	719 (530)
2K 3x2-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	5 058 (3 730)	475 (350)	475 (350)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 3x2US-13	8 540 (1 920)	5 471 (1 230)	5 471 (1 230)	5 058 (3 730)	475 (350)	475 (350)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	1 980 (1 460)	1 980 (1 460)	936 (690)
2K 4x3-13 and 13HH	12 010 (2 700)	6 005 (1 350)	10 631 (2 390)	5 058 (3 730)	542 (400)	542 (400)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 346 (1 730)	2 346 (1 730)	936 (690)
2K 4x3US-13	12 010 (2 700)	6 005 (1 350)	10 631 (2 390)	5 058 (3 730)	542 (400)	542 (400)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 346 (1 730)	2 346 (1 730)	936 (690)
2K 4x3R-13	12 010 (2 700)	6 005 (1 350)	10 631 (2 390)	5 058 (3 730)	542 (400)	542 (400)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 346 (1 730)	2 346 (1 730)	936 (690)
2K 6x4-13A	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	6 753 (4 980)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 915 (2 150)	2 915 (2 150)	936 (690)
2K 6x4US-13A	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	6 753 (4 980)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 915 (2 150)	2 915 (2 150)	936 (690)
2K 6x4R-13	12 010 (2 700)	6 005 (1 350)	27 756 (6 240)	5 058 (3 730)	6 753 (4 980)	1 492 (1 100)	8 985 (2 020)	6 005 (1 350)	27 756 (6 240)	2 915 (2 150)	2 915 (2 150)	936 (690)
3K 8x6-14A	28 289 (6 360)	14 145 (3 180)	22 596 (5 080)	12 163 (8 970)	1 587 (1 170)	1 587 (1 170)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	9 194 (6 780)	5 221 (3 850)	3 851 (2 840)
3K 10x8-14	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	3 322 (2 450)	2 915 (2 150)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	9 790 (7 220)	3 851 (2 840)
3K 6x4-16	28 289 (6 360)	14 145 (3 180)	20 327 (4 570)	12 163 (8 970)	1 431 (1 055)	1 431 (1 055)	25 465 (5 725)	12 720 (2 860)	53 888 (12 115)	8 272 (6 100)	4 699 (3 465)	3 465 (2 555)
3K 8x6-16A	28 289 (6 360)	14 145 (3 180)	29 713 (6 680)	12 163 (8 970)	2 007 (1 480)	2 007 (1 480)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	8 895 (6 560)	5 044 (3 720)	3 851 (2 840)
3K 10x8-16 & 16HH	28 289 (6 360)	14 145 (3 180)	22 818 (5 130)	12 163 (8 970)	1 532 (1 130)	1 532 (1 130)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	12 285 (9 060)	3 851 (2 840)
3K 10x8-17	28 289 (6 360)	14 145 (3 180)	22 818 (5 130)	12 163 (8 970)	1 532 (1 130)	1 532 (1 130)	28 289 (6 360)	14 145 (3 180)	59 870 (13 460)	12 163 (8 970)	12 285 (9 060)	3 851 (2 840)

Figure 4-17: Maximum Y-axis loading for shaft deflection

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
Group 1	–	-8 896 (-2 000)	–	1 220.4 (900)	1 627.2 (1 200)	1 695 (1 250)	–	6 672 (1 500)	–	-678 (-500)	2 034 (1 500)	1 695 (1 250)
Group 2	–	-15 568 (-3 500)	–	1 762.8 (1 300)	1 762.8 (1 300)	4 068 (3 000)	–	11 120 (2 500)	–	-1 627 (-1 200)	2 034 (1 500)	4 068 (3 000)
Group 3	–	-22 240 (-5 000)	–	2 034 (1 500)	2 712 (2 000)	5 424 (4 000)	–	13 344 (3 000)	–	-1 695 (-1 250)	6 780 (5 000)	5 424 (4 000)

Figure 4-18: Maximum Z-axis loading for shaft deflection

Pump size	Suction flange						Discharge flange					
	Forces N (lbf)			Moments Nm (lbf•ft)			Forces N (lbf)			Moments Nm (lbf•ft)		
	Fxs	Fys	Fzs	Mxs	Mys	Mzs	Fxd	Fyd	Fzd	Mxd	Myd	Mzd
Group 1	4 670 (1 050)	–	-5 560 (-1 250)	2 034 (1 500)	1 627 (1 200)	-3 390 (-2 500)	3 558 (800)	8 896 (2 000)	-13 344 (-3 000)	-2 034 (-1 500)	1 356 (1 000)	-3 390 (-2 500)
Group 2	15 568 (3 500)	–	-6 672 (-1 500)	2 034 (1 500)	1 763 (1 300)	-4 746 (-3 500)	6 227 (1 400)	11 120 (2 500)	-14 456 (-3 250)	-2 034 (-1 500)	2 915 (2 150)	-4 746 (-3 500)
Group 3	15 568 (3 500)	–	-8 896 (-2 000)	2 034 (1 500)	5 560 (4 100)	-5 424 (-4 000)	6 672 (1 500)	17 792 (4 000)	-15 568 (-3 500)	-2 034 (-1 500)	6 780 (5 000)	-5 424 (-4 000)

4.6.4.2 Mark 3 In-Line pumps (ASME B73.2M)

4.6.4.2a Pump mounting
Review *Pump mounting*, section 4.3.

The pump may be mounted such that it is free to move with the piping. The pump may be supported by the piping, so that it is free to move in all directions. The pump may also be supported underneath the casing or by the optional pump stand which is not bolted to the foundation. In these cases, the pump is free to move with the piping in all directions except for vertically downward.

The above mounting methods are recommended as they reduce the piping loads applied to the pump. In these cases, nozzle loads are limited only by the casing limitations.

The pump may also be rigidly mounted, with the optional pump stand bolted to the foundation. In this case pump movement is restricted and piping loads are applied to both the pump and stand. In this case, nozzle loads are limited by both the casing and pump stand limitations.

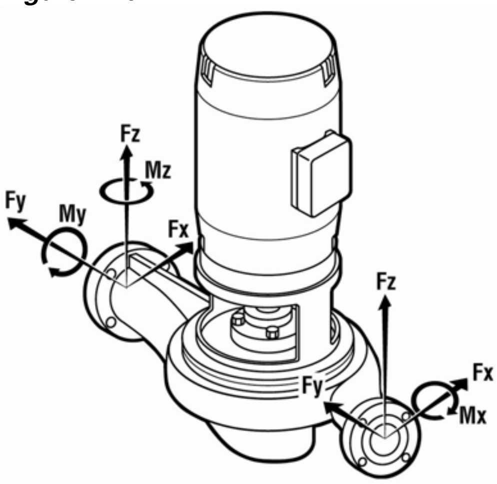
4.6.4.2b Casing limitations
To simplify or eliminate additional calculations, the In-Line casing may be treated as a spool of schedule 40 pipe with a diameter equal to the discharge, length equal to the face to face dimension (SD) and material equal to that of the casing. In cases where pump movement is limited, the constraint may be placed at the center of the spool. Stress in the pump flanges and bolting should not be ignored. This method allows for the use of automated piping programs to determine the acceptability of loads.

The casing limitations can also be determined by ANSI/HI 9.6.2. All information necessary to complete the evaluation is given below. For complete details please review the standard.

a) Determine the appropriate casing "Nozzle load material group" from figure 3-2.
b) Find the "Casing material correction factor" in figure 4-11 based upon the "Nozzle load material group" and operating temperature. Interpolation may be used to determine the correction factor for a specific temperature.
c) Multiply the allowable loads found in figure 4-20 by the material correction factor. Record the adjusted loads.
d) Calculate the applied piping loads at the center of the casing flanges according to the coordinate system found in figure 4-19. The 12 forces and moments possible are Fxs, Fys, Fzs, Mxs, Mys, Mzs, Fxd, Fyd, Fzd, Mxd, Myd and Mzd. For example, Fxd designates force in the "x" direction on the discharge flange. Mys designates the moment about the "y"-axis on the suction flange.
e) The absolute value of the applied suction load divided by the corresponding adjusted load must be less than or equal to one. Also, the absolute value of the applied discharge load divided by the corresponding adjusted load must be less than or equal to one.
   For example:

$$\left|\frac{F_{xs}}{F_{x\_adj}}\right| \le 1.0,\ \left|\frac{F_{yd}}{F_{y\_adj}}\right| \le 1.0 \ldots\ldots\ldots\ldots \left|\frac{M_{zd}}{M_{z\_adj}}\right| \le 1.0$$

Figure 4-19



4.6.4.2c Pump stand limitations

In cases where the pump is rigidly mounted by the pump stand, both the casing limitations and the pump stand limitations must be satisfied. Due to the limited load capacity of the pump stands, it may be necessary to restrain the piping to prevent loads.

a) Ensure all applied loads are within the allowable limits of the casing.
b) Translate the flange loads using the formulae found in figure 4-21. Dimensional variables S_{RS}, S_{RD} and R_S can be found in figure 4-20.
c) Calculate F_T and F_N using the formulae found in figure 4-21.
d) F_T and F_N must be less than F_{TMAX} and F_{NMAX} found in figure 4-22.
e) F_T and F_N must meet the combination formulae found in figure 4-22.

Figure 4-20: Dimensional data and casing limitations

	Dimensions m (ft)				Allowable casing loads (suction or discharge)					
					Forces N (lbf)			Moments Nm (lbf•ft)		
	SD	SRd	SRs	Rs	Fx	Fy	Fz	Mx	My	Mz
2x1.5V-6	0.381 (1.25)	0.191 (0.625)	0.191 (0.625)	0.163 (0.53)	1 824 (410)	17 685 (3 976)	1 824 (410)	692 (510)	976 (720)	692 (510)
2x1.5V-8	0.432 (1.42)	0.229 (0.75)	0.203 (0.67)	0.163 (0.53)	1 601 (360)	17 685 (3 976)	1 601 (360)	692 (510)	976 (720)	692 (510)
3x2V-7	0.432 (1.42)	0.203 (0.67)	0.229 (0.75)	0.163 (0.53)	2 824 (635)	28 147 (6 328)	2 824 (635)	1 120 (900)	1 722 (1 270)	1 120 (900)
3x1.5V-8	0.483 (1.58)	0.226 (0.74)	0.254 (0.83)	0.163 (0.53)	1 601 (360)	17 685 (3 976)	1 601 (360)	692 (510)	976 (720)	692 (510)
2x1.5V-10A	0.483 (1.58)	0.229 (0.75)	0.254 (0.83)	0.197 (0.65)	1 423 (320)	17 685 (3 976)	1 423 (320)	692 (510)	976 (720)	692 (510)
3x2V-10	0.508 (1.67)	0.241 (0.79)	0.267 (0.88)	0.197 (0.65)	2 402 (540)	28 147 (6 328)	2 402 (540)	1 120 (900)	1 722 (1 270)	1 120 (900)
4x3V-10	0.635 (2.08)	0.292 (0.96)	0.343 (1.13)	0.197 (0.65)	2 823 (638)	28 147 (6 328)	2 823 (638)	1 803 (1 330)	2 549 (1 880)	1 803 (1 330)
3x1.5V-13	0.61 (2.00)	0.292 (0.96)	0.318 (1.04)	0.248 (0.81)	1 134 (255)	17 685 (3 976)	1 134 (255)	692 (510)	976 (720)	692 (510)
3x2V-13	0.61 (2.00)	0.292 (0.96)	0.318 (1.04)	0.248 (0.81)	2 002 (450)	28 147 (6 328)	2 002 (450)	1 120 (900)	1 722 (1 270)	1 120 (900)
4x3V-13	0.711 (2.33)	0.33 (1.08)	0.381 (1.25)	0.248 (0.81)	2 535 (570)	28 147 (6 328)	2 535 (570)	1 803 (1 330)	2 549 (1 880)	1 803 (1 330)
6x4V-13	0.762 (2.50)	0.356 (1.17)	0.406 (1.33)	0.248 (0.81)	2 891 (650)	83 195 (18 704)	2 891 (650)	2 210 (1 630)	3 119 (2 300)	2 210 (1 630)

Figure 4-21: Pump stand load translation formulae

Forces	Moments
$F_{XC} = F_{XS} + F_{XD}$	$M_{XC} = M_{XS} + M_{XD} + (F_{ZS} \times SR_S) - (F_{ZD} \times SR_D)$
$F_{YC} = F_{YS} + F_{YD}$	$M_{YC} = M_{YS} + M_{YD}$
$F_{ZC} = F_{ZS} + F_{ZD}$	$M_{ZC} = M_{ZS} + M_{ZD} - (F_{XS} \times SR_S) + (F_{XD} \times SR_D)$

$$F_T = \sqrt{\left[\left|F_{xc}\right| + \left(0.707 \times \frac{M_{zc}}{R_s}\right)\right]^2 + \left[\left|F_{yc}\right| + \left(0.707 \times \frac{M_{zc}}{R_s}\right)\right]^2} \le F_{TMax}$$

$$F_N = \left|F_{zc}\right| + \frac{\left|M_{xc}\right| + \left|M_{yc}\right|}{0.707 R_s} \le F_{N\_MAX}$$

Figure 4-22: Allowable stand loads

	$F_{T\ MAX}$ in N (lbf)	$F_{N\ MAX}$ in N (lbf)	Combination loading in N (lbf)
GP1 pumps	8 020 (1 800)	108 531 (24 400)	F_N + (13.556) F_T ≤ 108 531 F_N + (13.556) F_T ≤ 24 400
GP2 V-10 pumps	8 129 (1 827)	120 115 (27 004)	F_N + (0.0019) F_T^2 - (0.941) F_T ≤ 120 115 F_N + (0.0086) F_T^2 - (0.941) F_T ≤ 27 004
GP2 V-13 pumps	6 792 (1 535)	140 461 (31 579)	F_N + (0.0018) F_T^2 + (8.453) F_T ≤ 140 461 F_N + (0.0079) F_T^2 + (8.453) F_T ≤ 31 579

4.6.5 Pump and shaft alignment check

After connecting the piping, rotate the pump drive shaft clockwise (viewed from motor end) by hand several complete revolutions to be sure there is no binding and that all parts are free. Recheck shaft alignment (see section 4.5). If piping caused unit to be out of alignment, correct piping to relieve strain on the pump.

4.6.6 Auxiliary piping

4.6.6.1 Mechanical seal

When the pump is intended to be equipped with a mechanical seal, it is Flowserve standard practice to install the mechanical seal in the pump prior to shipment. Specific order requirements may specify that the seal be shipped separately, or none be supplied. It is the pump installer's responsibility to determine if a seal was installed. If a seal was supplied but not installed, the seal and installation instructions will be shipped with the pump.

CAUTION Failure to ensure that a seal is installed may result in serious leakage of the pumped fluid.

Seal and seal support system must be installed and operational as specified by the seal manufacturer.

The stuffing box/seal chamber/gland may have ports that have been temporarily plugged at the factory to keep out foreign matter. It is the installer's responsibility to determine if these plugs should be removed and external piping connected. Refer to the seal drawings and or the local Flowserve representative for the proper connections.

4.6.6.2 Packing

When the pump is intended to be equipped with shaft packing, it is not Flowserve standard practice to install the packing in the stuffing box prior to shipment. The packing is shipped with the pump. It is the pump installer's responsibility to install the packing in the stuffing box.

CAUTION Failure to ensure that the packing is installed may result in serious leakage of the pumped fluid.

4.6.6.3 Piping connection – seal/packing support system

CAUTION If the pump has a seal support system it is mandatory that this system be fully installed and operational before the pump is started.

If packing is used:

4.6.6.3a Packing lubrication

Water, when compatible with the pumpage, should be introduced into tap V (figure 4-23) at pressure 69 to 103 kPa (10 to 15 lbf/in.^{2}) above the stuffing box pressure. The gland should be adjusted to give a flow rate of 20 to 30 drops per minute for clean fluid. For abrasive applications, the regulated flow rate should be 0.06 to 0.13 l/s (1 to 2 US gpm).

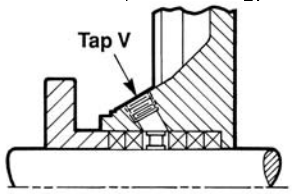


Figure 4-23

Grease lubrication, when compatible with the liquid being pumped, may be used. Again, introduced into tap V.

In non-abrasive applications the liquid being pumped may be sufficient to lubricate the packing without need for external lines. Tap V should be plugged.

4.6.6.3b Abrasive packing arrangement

The installation procedures are the same as the standard packing with some exceptions. A special lip seal is installed first, followed by two seal cage assemblies, then two of the packing rings provided (figure 4-24). A flush line from a clean external source should be connected via tap V, in the top of the stuffing box.

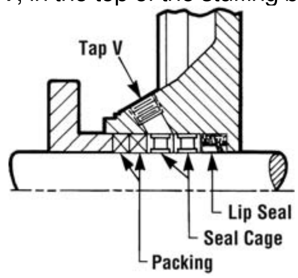


Figure 4-24

4.6.6.4 Piping connection - bearing housing cooling system

Make connections as shown below. Liquid at less than 32 °C (90 °F) should be supplied at a regulated flow rate of at least 0.06 l/s (1 US gpm).

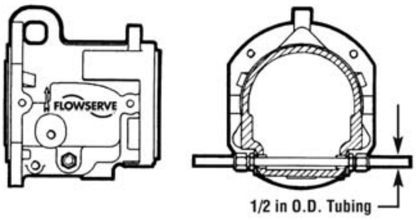


Figure 4-25

4.6.6.5 Piping connection - support leg cooling for centerline mounting option

If the casing is centerline mounted, and the process temperature is over 178 °C (350 °F), then the casing support legs may need to be cooled. Cool water - less than 32 °C (90 °F) - should be run through the legs at a flow rate of at least 0.06 l/s (1 US gpm) as shown below.

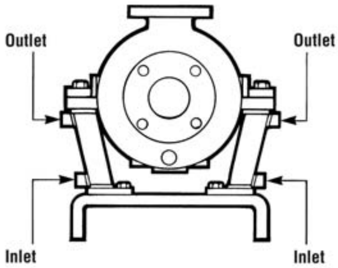


Figure 4-26

4.6.6.6 Piping connection - heating/cooling fluid for jacketed cover/casing

The piping connections for jacketed covers and casings are shown below. The flow rate of the cooling water - less than 32 °C (90 °F) - should be at least 0.13 l/s (2 US gpm).

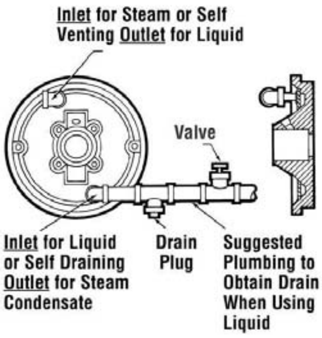


Figure 4-27

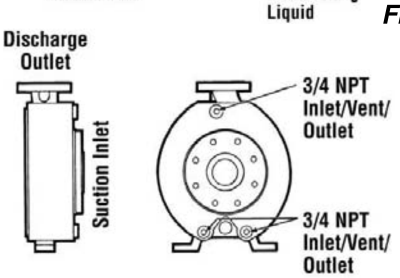


Figure 4-28

Notes:

1. When circulating steam, use top hole for inlet. Both bottom holes must be plumbed together for outlet, to ensure draining both sides of jacket.
2. When circulating liquid use both bottom holes as inlets. Use top hole as outlet.

4.6.6.7 Piping connection - Oil mist lubrication system

The piping connections for an oil mist lubrication system are shown below.

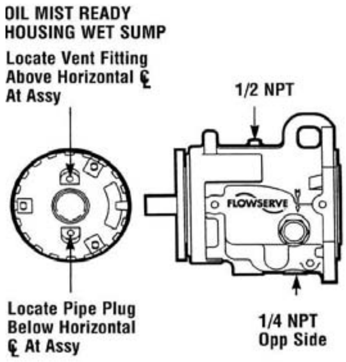


Figure 4-29

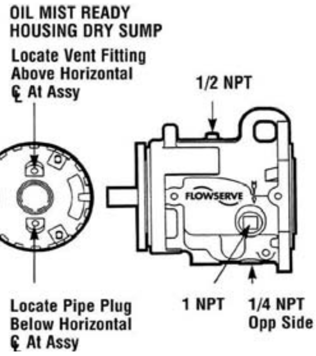


Figure 4-30

4.7 Electrical connections

DANGER Electrical connections must be made by a qualified Electrician in accordance with relevant local national and international regulations.

It is important to be aware of the EUROPEAN DIRECTIVE on potentially explosive areas where compliance with IEC60079-14 is an additional requirement for making electrical connections.

It is important to be aware of the EUROPEAN DIRECTIVE on electromagnetic compatibility when wiring up and installing equipment on site.

Attention must be paid to ensure that the techniques used during wiring/installation do not increase electromagnetic emissions or decrease the electromagnetic immunity of the equipment, wiring or any connected devices. If in any doubt contact Flowserve for advice.

DANGER The motor must be wired up in accordance with the motor manufacturer's instructions (normally supplied within the terminal box) including any temperature, earth leakage, current and other protective devices as appropriate. The identification nameplate should be checked to ensure the power supply is appropriate.

CAUTION See section 5.4, *Direction of rotation,* before connecting the motor to the electrical supply.

For close coupled pumps it is necessary to wire the motor with flexible conduit of sufficient length to allow the motor/power end assembly to be moved back from the casing for maintenance.

4.8 Final shaft alignment check

4.8.1 Horizontal pumps

a) Level baseplate if appropriate.
b) Mount and level pump if appropriate. Level the pump by putting a level on the discharge flange. If not level, adjust the footpiece as follows:
   <u>Mark 3A and ANSI 3 design</u>
   Add or delete shims [3126.1] between the footpiece and the bearing housing.
   <u>Mark 3 design</u>
   Use the adjuster nut [6576] to adjust the footpiece up or down.
c) Check initial alignment. If pump and driver have been remounted or the specifications given below are not met, perform an initial alignment as described in section 4.5. This ensures there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. The pump and driver should be within 0.38 mm (0.015 in.) FIM (full indicator movement) parallel, and 0.0025 mm/mm (0.0025 in./in.) FIM angular.
   <u>Stilt mounted baseplates</u>
   If initial alignment cannot be achieved with the motor fasteners centered, the baseplate may be twisted. Slightly adjust (one turn of the adjusting nut) the stilts at the driver end of the baseplate and check for alignment to the above tolerances. Repeat as necessary while maintaining a level condition as measured from the pump discharge flange.
d) Run piping to the suction and discharge to the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant changes.
e) Perform final alignment. Check for soft-foot under the driver. An indicator placed on the coupling, reading in the vertical direction, should not indicate more than 0.05 mm (0.002 in.) movement when any driver fastener is loosened. Align the driver first in the vertical direction by shimming underneath its feet.
f) When satisfactory alignment is obtained the number of shims in the pack should be minimized. It is recommended that no more than five shims be used under any foot. Final horizontal alignment is made by moving the driver. Maximum pump reliability is obtained by having near perfect alignment. Flowserve recommends no more than 0.05 mm (0.002 in.) parallel, and 0.0005 mm/mm (0.0005 in./in.) angular misalignment. (See section 6.8.4.7.)
g) Operate the pump for at least an hour or until it reaches final operating temperature. Shut the pump down and recheck alignment while the pump is hot. Piping thermal expansion may change the alignment. Realign pump as necessary.

4.8.2 Close coupled pumps

Alignment between the pump shaft and motor shaft is built in by precise machining of the parts that position these shafts. Parallel alignment of 0.018 mm (0.007 in.) and angular alignment of 0.002 mm/mm (0.002 in/in) can be expected. If a more refined alignment is desired, it can be accomplished with the "C-Plus" optional alignment feature.

The C-Plus option requires that a spacer as shown in section 8.9 be installed. Four adjusting screws are used to push on the motor mounting studs to achieve parallel alignment. The motor mounting fasteners must be snug, but not tight during alignment. It may be necessary to check the motor alignment with motor fasteners tight. Corrections may be made until the desired alignment is achieved. The motor fasteners, adjusters and jam nuts should be tight.

4.8.3 In-Line pumps

The final field alignment follows the same procedure as the initial alignment as described in section 4.5.2. Maximum pump reliability is obtained by having near perfect alignment. Flowserve recommends no more than 0.05 mm (0.002 in.) parallel, and 0.0005 mm/mm (0.0005 in./in.) angular misalignment.

4.9 Protection systems

Ex The following protection systems are recommended particularly if the pump is installed in a potentially explosive area or is handling a hazardous liquid. If in doubt consult Flowserve.

If there is any possibility of the system allowing the pump to run against a closed valve or below minimum continuous safe flow a protection device should be installed to ensure the temperature of the liquid does not rise to an unsafe level.

If there are any circumstances in which the system can allow the pump to run dry, or start up empty, a power monitor should be fitted to stop the pump or prevent it from being started. This is particularly relevant if the pump is handling a flammable liquid.

If leakage of product from the pump or its associated sealing system can cause a hazard it is recommended that an appropriate leakage detection system is installed.

To prevent excessive surface temperatures at bearings it is recommended that temperature or vibration monitoring is carried out.

5 COMMISSIONING, STARTUP, OPERATION AND SHUTDOWN

CAUTION ***These operations must be carried out by fully qualified personnel.***

5.1 Pre-commissioning procedure

5.1.1 Pre start-up checks

Prior to starting the pump it is essential that the following checks be made. These checks are all described in detail in the *Maintenance* section of this manual.

- Pump and motor properly secured to the baseplate
- Remove the temporary motor supports installed for shipping close coupled pumps
- All fasteners tightened to the correct torque
- Coupling guard in place and not rubbing
- Rotation check, see section 5.4.
  This is absolutely essential
- Impeller clearance setting
- Shaft seal properly installed
- Seal support system operational
- Bearing lubrication
- Bearing housing cooling system operational
- Support leg cooling for centerline mounting option operational
- Heating/cooling for jacketed casing/cover operational
- Pump instrumentation is operational
- Pump is primed
- Rotation of shaft by hand

As a final step in preparation for operation, it is important to rotate the shaft by hand to be certain that all rotating parts move freely, and that there are no foreign objects in the pump casing.

5.2 Pump lubricants

5.2.1 Oil bath

Oil bath is available on all product lines with the exception of the In-Line pump. The standard bearing housing bearings are oil bath lubricated and are not lubricated by Flowserve. Before operating the pump, fill the bearing housing to the center of the oil sight glass with the proper type oil. (See figure 5-2 for approximate amount of oil required - do not overfill.)

On the Mark 3A design, an optional oil slinger is available. The oil slinger is not necessary; however, if used, it provides an advantage by allowing a larger tolerance in acceptable oil level. Without an oil slinger, the oil level in the bearing housing must be maintained at ±3 mm (±$^{1}/_{8}$ in.) from the center of the sight glass. The sight glass has a 6 mm (¼ in.) hole in the center of its reflector. The bearing housing oil level must be within the circumference of the center hole to ensure adequate lubrication of the bearings.

See figure 5-3 for recommended lubricants. ***DO NOT USE DETERGENT OILS.*** The oil must be free of water, sediment, resin, soaps, acid and fillers of any kind. It should contain rust and oxidation inhibitors. The proper oil viscosity is determined by the bearing housing operating temperature as given in figure 5-4.

To add oil to the housing, clean and then remove the vent plug [6521] at the top of the bearing housing, pour in oil until it is visually half way up in the sight glass [3856]. Fill the constant level oiler bottle, if used, and return it to its position. The correct oil level is obtained with the constant level oiler in its lowest position, which results in the oil level being at the top of the oil inlet pipe nipple, or half way up in the sight glass window. Oil must be visible in the bottle at all times.

Note that on ANSI 3A™ power ends there is no constant level oiler. As stated above, proper oil level is the center of the "bull's eye" sight glass [3856]. (See figure 5-1.)

Figure 5-1

In many pumping applications lubricating oil becomes contaminated before it loses its lubricating qualities or breaks down. For this reason it is recommended that the first oil change take place after approximately 160 hours of operation, at which time, the used oil should be examined carefully for contaminants. During the initial operating period monitor the bearing housing operating temperature. Record the external bearing housing temperature. See figure 5-5 for maximum acceptable temperatures. The normal oil change interval is based on temperature and is shown in figure 5-6.

Figure 5-2: Amount of oil required

Pump	Mark 3	Mark 3A
Group 1	148 ml (5 fl. oz.)	251 ml (8.5 fl. oz.)
Group 2	560 ml (19 fl. oz.)	946 ml (32 fl. oz.)
Group 3	1419 ml (48 fl. oz.)	1419 ml (48 fl. oz.)

CAUTION The maximum temperature that the bearing can be exposed to is 105 °C (220 °F).

Figure 5-3a: Recommended oil lubricants

	Oil	Splash / force feed / oil mist lubrication		
Centrifugal pump lubrication	Viscosity cSt at 40 ºC	32	46	68
	Oil temp. range * ºC (ºF)	-5 to 65 (-23 to 149)	-5 to 78 (-23 to 172)	-5 to 80 (-23 to 176)
	Designation according to DIN51502 ISO VG	HL/HLP 32	HL/HLP 46	HL/HLP 68
Oil companies and lubricants	**BP**	BP Energol HL32 BP Energol HLP32	BP Energol HL46 BP Energol HLP46	BP Energol HL68 BP Energol HLP68
	DEA	Anstron HL32 Anstron HLP32	Anstron HL46 Anstron HLP46	Anstron HL68 Anstron HLP68
	Elf	OLNA 32 HYDRELEF 32 TURBELF 32 ELFOLNA DS32	TURBELF SA46 ELFOLNA DS46	TURBELF SA68 ELFOLNA DS68
	Esso	TERESSO 32 NUTO H32	TERESSO 46 NUTO H46	TERESSO 68 NUTO H68
	Mobil	Mobil DTE oil light Mobil DTE13M MobilDTE24	Mobil DTE oil medium Mobil DTE15M Mobil DTE25	Mobil DTE oil heavy medium Mobil DTE26
	Q8	Q8 Verdi 32 Q8 Haydn 32	Q8 Verdi 46 Q8 Haydn 46	Q8 Verdi 68 Q8 Haydn 68
	Shell	Shell Tellus 32 Shell Tellus 37	Shell Tellus 01 C 46 Shell Tellus 01 46	Shell Tellus 01 C 68 Shell Tellus 01 68
	Texaco	Rando Oil HD 32 Rando Oil HD-AZ-32	Rando Oil 46 Rando Oil HD B-46	Rando Oil 68 Rando Oil HD C-68
	Wintershall (BASF Group)	Wiolan HN32 Wiolan HS32	Wiolan HN46 Wiolan HS46	Wiolan HN68 Wiolan HS68

* Note that some oils have a greater Viscosity Index than the minimum acceptable of 95 (eg Mobil DTE13M) which may extend the minimum temperature capability of the oil. Always check the grade capability where the ambient is less than -5 ºC (-23 ºF).

Figure 5-3b: Recommended lubricants

Mineral oil	Quality mineral oil with rust and oxidation inhibitors. Mobil DTE heavy/medium (or equivalent)
Synthetic	Royal Purple or Conoco SYNCON (or equivalent). Some synthetic lubricants require Viton O-rings.
Grease	EXXON POLYREX EM (or compatible) – horizontal Polyurea with mineral oil EXXON Unirex N3 (or compatible) – In-Line Lithium Complex with mineral oil

Figure 5-4: Oil viscosity grades

Maximum oil temperature	ISO viscosity grade	Minimum viscosity index
Up to 71 °C (160 °F)	46	95
71-80 °C (160-175 °F)	68	95
80-94 °C (175-200 °F)	100	95

Figure 5-5: Maximum external housing temperatures

Lubrication	Temperature
Oil bath	82 °C (180 °F)
Oil mist	82 °C (180 °F)
Grease	94 °C (200 °F)

Figure 5-6: Lubrication intervals *

Lubricant	Under 71 °C (160 °F)	71-80 °C (160-175 °F)	80-94 °C (175-200 °F)
Grease	6 months	3 months	1.5 months
Mineral oil	6 months	3 months	1.5 months
Synthetic oil**	18 months	18 months	18 months

* Assuming good maintenance and operation practices, and no contamination.
** May be increased to 36 months with ANSI 3A™ power end.
*** Bearing temperatures up to 16 °C (30 °F) higher than housing.

5.2.2 Grease

5.2.2.1 Regreasable

<u>*Single shielded regreasable bearings*</u>
When the grease lubrication option is specified, single shielded bearings, grease fittings and vent pipe plugs are installed inboard and outboard.

CAUTION The orientation of the bearing shields is different for horizontal pumps (Standard, Sealmatic, Unitized, Recessed, and Lo-Flo - see figure 5-7) and In-Line pumps (see figure 5-8).

Figure 5-7: Horizontal pump shield orientation

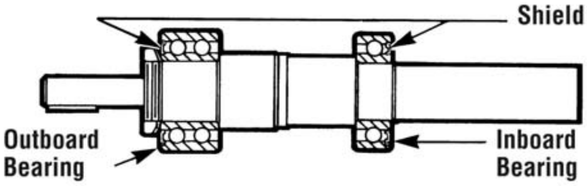
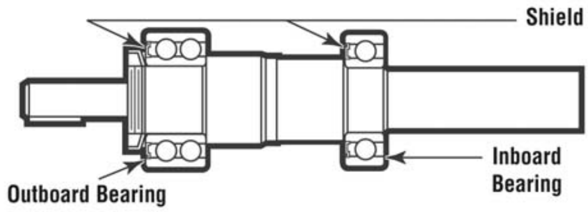


Figure 5-8: In-Line pump shield orientation



Horizontal pump bearings are packed with Exxon POLYREX EM grease prior to assembly. For relubrication, a grease with the same type base (polyurea) and oil (mineral) should be used. In the case of the In-Line pump the bearings are packed with Exxon Unirex N3 grease. For relubrication, a grease with the same type base (lithium) and oil (mineral) should be used. To regrease, remove the pipe plug from both the inboard and outboard bearing location. (See figure 5-9.) After relubricating the bearings three times, it is typically recommended that the bearing housing is cleaned out.

CAUTION To regrease bearings under coupling guard, stop pump, lock the motor, remove coupling guard, and then regrease the bearings.

The amount of grease required for horizontal pumps is shown in figure 5-10 and for In-Line pumps in figure 5-11.

Figure 5-9: Regreasable configuration

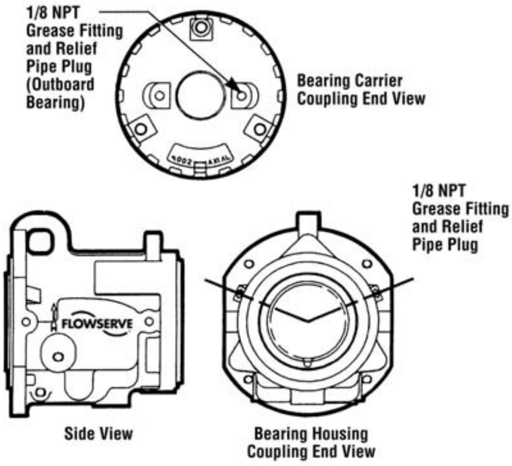


Figure 5-10: Horizontal lubrication amounts

Housing	Initial lube	Relubrication
Group 1 inboard	Until grease comes out of plug	7.5 cm^3 (0.46 in.^{3})
Group 1 outboard	Until grease comes out of plug	14 cm^3 (0.85 in.^{3})
Group 1 duplex	34 cm^3 (2.1 in.^{3})	17 cm^3 (1.0 in.^{3})
Group 2 inboard	Until grease comes out of plug	17 cm^3 (1.0 in.^{3})
Group 2 outboard	Until grease comes out of plug	28 cm^3 (1.7 in.^{3})
Group 2 duplex	68 cm^3 (4.1 in.^{3})	34 cm^3 (2.1 in.^{3})
Group 3 inboard	Until grease comes out of plug	30 cm^3 (1.8 in.^{3})
Group 3 outboard	Until grease comes out of plug	54 cm^3 (3.3 in.^{3})
Group 3 duplex	115 cm^3 (7.0 in.^{3})	60 cm^3 (3.7 in.^{3})

Figure 5-11: In-Line lubrication amounts

Housing location	New bearing	Relubrication
Group 1 inboard	10 cm^3 (0.6 in.^{3})	7.5 cm^3 (0.46 in.^{3})
Group 1 outboard	20.5 cm^3 (1.3 in.^{3})	14 cm^3 (0.85 in.^{3})
Group 2 inboard	16.4 cm^3 (1.0 in.^{3})	17 cm^3 (1.0 in.^{3})
Group 2 outboard	47.4 cm^3 (2.9 in.^{3})	28 cm^3 (1.7 in.^{3})

*If new bearings are not lubricated, they should be packed prior to installation and the housing lubricated as described above.

CAUTION Do not fill the housing with oil when greased bearings are used. The oil will leach the grease out of the bearings and the life of the bearings may be drastically reduced.

5.2.2.1 Grease for life

<u>*Double shielded or double sealed bearings*</u>
These bearings are packed with grease by the bearing manufacturer and should not be relubricated. The replacement interval for these bearings is greatly affected by their operating temperature and speed. Shielded bearings typically operate cooler.

5.2.3 Oil mist
The inlet port for all horizontal pumps is the plugged ½ in. NPT located at the top of the bearing housing. A vent fitting has been supplied on the bearing carrier as well as a plugged ¼ in. NPT bottom drain on the bearing housing. See section 4.6.6.7, *Oil mist lubrication system*. Do not allow oil level to remain above the center of the bearing housing sight glass window with purge mist (wet sump) systems.

The optional oil slinger must not be used with an oil mist system.

There are two inlet ports for In-Line pumps. In addition to the connection described above a second inlet is made at the ⅛ in. NPT plugged port on the bearing carrier [3240]. A vent fitting has been supplied on the bearing carrier as well as a plugged ⅛ in. NPT bottom drain on the bearing housing for Group 1 pumps and on the adapter [1340] for Group 2 pumps.

5.3 Impeller clearance
The impeller clearance was set at the factory based on the application temperature at the time the pump was purchased. (See figure 5-12.) For a reverse vane impeller the clearance is set to the cover while the open impeller clearance is set to the casing. If the process temperature changes the impeller clearance must be reset. (See section 6.6.)

Figure 5-12: Impeller clearance settings

Temperature °C (°F)	Clearance mm (in.)
< 93 (200)	0.46 ± 0.08 (0.018 ± 0.003)
93 to 121 (200 to 250)	0.53 (0.021)
122 to 149 (251 to 300)	0.61 (0.024)
150 to 176 (301 to 350)	0.69 (0.027)
177 to 204 (351 to 400)	0.76 (0.030)
205 to 232 (401 to 450)	0.84 (0.033)
>232 (450)	0.91 (0.036)

Notes:
1. For 3x1.5-13 and 3x2-13 at 3500 rpm add 0.08 mm (0.003 in.).
2. Rotation of bearing carrier from center of one lug to center of next results in axial shaft movement of 0.1 mm (0.004 in.).
3. Reverse vane impeller set to cover, open impeller to casing.

5.4 Direction of rotation

5.4.1 Rotation check
CAUTION It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge and damage the impeller, casing, shaft and shaft seal. All Mark 3 pumps turn clockwise as viewed from the motor end.

A direction arrow is cast on the front of the casing as shown in figure 5-13. Make sure the motor rotates in the same direction.

Figure 5-13

5.4.2 Coupling installation
CAUTION The coupling (figure 5-14) should be installed as advised by the coupling manufacturer. Pumps are shipped without the spacer installed. If the spacer has been installed to facilitate alignment, then it must be removed prior to checking rotation. Remove all protective material from the coupling and shaft before installing the coupling.

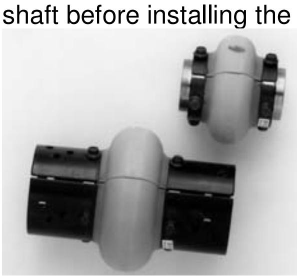


Figure 5-14

5.5 Guarding
CAUTION Power must never be applied to the driver when the coupling guard is not installed.

Flowserve coupling guards are safety devices intended to protect workers from inherent dangers of the rotating pump shaft, motor shaft and coupling. It is intended to prevent entry of hands, fingers or other body parts into a point of hazard by reaching through, over, under or around the guard. No standard coupling guard provides complete protection from a disintegrating coupling. Flowserve cannot guarantee their guards will completely contain an exploding coupling.

5.5.1 Clam shell guard - standard
The standard coupling guard for all Mark 3 pumps is the "clam shell" design and is shown in figure 5-15. It is hinged at the top and it can be removed by loosening one of the foot bolts and sliding the support leg out from under the cap screw. Note that the foot is slotted. The leg can then be rotated upward and half of the guard can be disengaged (unhinged) from the other.

Only one side of the guard needs to be removed. To reassemble simply reverse the above procedure.

Figure 5-15

The coupling guard shown in figure 5-15 conforms to the USA standard ASME B15.1, *"Safety standard for mechanical power transmission apparatus."* Flowserve manufacturing facilities worldwide conform to local coupling guard regulations.

5.5.2 ClearGuard™ - optional

Flowserve offers as an option a ClearGuard™, which allows you to see the condition of the coupling (see figure 5-16). This guard can be used in place of the existing clamshell guard described above. Disassembly of the ClearGuard™ is accomplished by removing the fasteners that hold the two guard halves together followed by removing the foot bolts and rotating the support leg out of the slot on the guard.

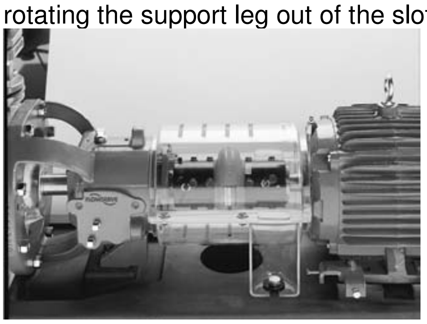


Figure 5-16

5.5.3 Trimming instructions

In order to correctly fit the pump/motor configuration, each guard must be trimmed to a specific length. This trimming is done on the motor end of the guard.

a) Measure minimum distance from the center of mounting hole in the baseplate to the motor. (If clam shell guard proceed to step c.)
b) Locate a reference center in the slot of the ClearGuard™ coupling guard flange, see figure 5-17. Transfer the length measurement to the guard using this reference center.
c) Trim the motor end of the guard according to the above measurement. Trimming is best done with a band saw, but most other types of manual or power saws give acceptable results. Care must be taken to ensure that there is no gap larger than 6 mm (0.24 in.) between the motor and the coupling guard.
d) **Note:** If motor diameter is smaller than guard diameter, trim guard so that it extends over the end of the motor as far as possible.
e) Deburr the trimmed end with a file or a sharp knife if ClearGuard™. Care must be taken to eliminate all sharp edges.

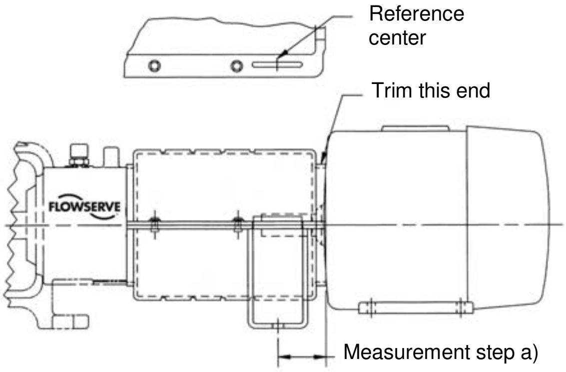


Figure 5-17

5.5.4 Assembly instructions

Clam shell guard

a) Mount support leg to each clam shell, figure 5-15.
b) Attach one half of the guard to the baseplate.
c) Engage the tabs of guard halves together.
d) Attach the second support leg to the baseplate.

ClearGuard™

a) Place the bottom and top halves of the guard around the coupling.
b) Install the support legs by inserting and then rotating the tab on the leg through the slot in the guard until it comes through and locks the top and bottom halves of the guard together.
c) Attach the support legs to the baseplate using the fasteners and washers provided.
d) Install fasteners in the holes provided to secure the guard flanges together.

5.6 Priming and auxiliary supplies

The Mark 3 standard, Sealmatic, Recessed Impeller, Lo-Flo, and In-Line centrifugal pump will not move liquid unless the pump is primed. A pump is said to be "primed" when the casing and the suction piping are completely filled with liquid. Open discharge valves a slight amount. This will allow any entrapped air to escape and will normally allow the pump to prime, if the suction source is above the pump. When a condition exists where the suction pressure may drop below the pump's capability, it is advisable to add a low-pressure control device to shut the pump down when the pressure drops below a predetermined minimum.

The Mark 3 Unitized self-priming centrifugal pumps have a slightly different requirement regarding priming. The initial priming liquid must be added to the pump casing until the liquid has reached the bottom of the suction nozzle. Once the initial prime is in place, the pump will automatically replenish itself and additional priming liquids are not normally needed. If liquid is lost, additional priming liquid may be needed.

5.7 Starting the pump

a) Open the suction valve to full open position. It is very important to leave the suction valve open while the pump is operating. Any throttling or adjusting of flow must be done through the discharge valve. Partially closing the suction valve can create serious NPSH and pump performance problems.
b) CAUTION Never operate pump with both the suction and discharge valves closed. This could cause an explosion.
c) Ensure the pump is primed. (See section 5.6.)
d) All cooling, heating, and flush lines must be started and regulated.
e) Start the driver (typically, the electric motor).
f) Slowly open the discharge valve until the desired flow is reached, keeping in mind the minimum continuous flow listed in section 3.4.
g) CAUTION It is important that the discharge valve be opened within a short interval after starting the driver. Failure to do this could cause a dangerous build up of heat, and possibly an explosion.

5.8 Running or operation

5.8.1 Minimum continuous flow

Minimum continuous stable flow is the lowest flow at which the pump can operate and still meet the bearing life, shaft deflection and bearing housing vibration limits documented in the latest version of ASME B73.1M. Pumps may be operated at lower flows, but it must be recognized that the pump may exceed one or more of these limits. For example, vibration may exceed the limit set by the ASME standard. The size of the pump, the energy absorbed, and the liquid pumped are some of the considerations in determining the minimum continuous flow (MCF).

The minimum continuous flow (capacity) is established as a percentage of the *best efficiency point* (BEP). (See section 3.4.4.)

5.8.2 Minimum thermal flow

All Mark 3 pumps also have a *minimum thermal flow*. This is defined as the minimum flow that will not cause an excessive temperature rise. Minimum thermal flow is application dependent.

CAUTION Do not operate the pump below minimum thermal flow, as this could cause an excessive temperature rise. Contact a Flowserve sales engineer for determination of minimum thermal flow.

Avoid running a centrifugal pump at drastically reduced capacities or with discharge valve closed for extended periods of time. This can cause severe temperature rise and the liquid in the pump may reach its boiling point. If this occurs, the mechanical seal will be exposed to vapor, with no lubrication, and may score or seize to the stationary parts. Continued running under these conditions when the suction valve is also closed can create an explosive condition due to the confined vapor at high pressure and temperature.

Thermostats may be used to safeguard against over heating by shutting down the pump at a predetermined temperature.

Safeguards should also be taken against possible operation with a closed discharge valve, such as installing a bypass back to the suction source. The size of the bypass line and the required bypass flow rate is a function of the input horsepower and the allowable temperature rise.

5.8.3 Reduced head

Note that when discharge head drops, the pump's flow rate usually increases rapidly. Check motor for temperature rise as this may cause overload. If overloading occurs, throttle the discharge.

5.8.4 Surging condition

A rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

5.8.5 Operation in sub-freezing conditions

When using the pump in sub-freezing conditions where the pump is periodically idle, the pump should be properly drained or protected with thermal devices which will keep the liquid in the pump from freezing. High chrome iron pumps are not recommended for applications below -18 °C (0 °F).

5.9 Stopping and shutdown

5.9.1 Shutdown considerations

When the pump is being shutdown, the procedure should be the reverse of the start-up procedure. First, slowly close the discharge valve, shut down the driver, and then close the suction valve. Remember that closing the suction valve while the pump is running is a safety hazard and could seriously damage the pump and other equipment.

5.9.2 Shutdown - Mark 3 Self-Priming

At shutdown, the liquid in the discharge piping falls back into the priming chamber and washes through the impeller into the suction. The backflow creates a siphon effect in the casing until the liquid level falls below the bottom of the suction nozzle. The inertia of the flow pulls fluid from the priming chamber to a level lower than the initial priming fill. Though the level is lower, there is still sufficient fluid in the priming chamber to allow the pump to reprime itself.

5.10 Hydraulic, mechanical and electrical duty

5.10.1 Net positive suction head (NPSH)

Net positive suction head - available ($NPSH_A$) is the measure of the energy in a liquid above the vapor pressure. It is used to determine the likelihood that a fluid will vaporize in the pump. It is critical because a centrifugal pump is designed to pump a liquid, not a vapor. Vaporization in a pump will result in damage to the pump, deterioration of the *Total differential head* (TDH), and possibly a complete stopping of pumping.

Net positive suction head - required ($NPSH_R$) is the decrease of fluid energy between the inlet of the pump, and the point of lowest pressure in the pump. This decrease occurs because of friction losses and fluid accelerations in the inlet region of the pump and particularly accelerations as the fluid enters the impeller vanes. The value for $NPSH_R$ for the specific pump purchased is given in the pump data sheet, and on the pump performance curve.

For a pump to operate properly the $NPSH_A$ must be greater than the $NPSH_R$. Good practice dictates that this margin should be at least 1.5 m (5 ft) or 20%, whichever is greater.

CAUTION Ensuring that $NPSH_A$ is larger than $NPSH_R$ by the suggested margin will greatly enhance pump performance and reliability. It will also reduce the likelihood of cavitation, which can severely damage the pump.

5.10.2 Specific gravity (SG)

Pump capacity and total head in meters (feet) of liquid do not change with SG, however pressure displayed on a pressure gauge is directly proportional to SG. Power absorbed is also directly proportional to SG. It is therefore important to check that any change in SG will not overload the pump driver or overpressurize the pump.

5.10.3 Viscosity

For a given flow rate the total head reduces with increased viscosity and increases with reduced viscosity. Also for a given flow rate the power absorbed increases with the increased viscosity, and reduces with reduced viscosity. It is important that checks are made with your nearest Flowserve office if changes in viscosity are planned.

5.10.4 Pump speed

Changing the pump speed affects flow, total head, power absorbed, $NPSH_R$, noise and vibration levels. Flow varies in direct proportion to pump speed. Head varies as speed ratio squared. Power varies as speed ratio cubed. If increasing speed it is important to ensure the maximum pump working pressure is not exceeded, the driver is not overloaded, $NPSH_A > NPSH_R$ and that noise and vibration are within local requirements and regulations.

6 MAINTENANCE

⚠ It is the plant operator's responsibility to ensure that all maintenance, inspection and assembly work is carried out by authorized and qualified personnel who have adequately familiarized themselves with the subject matter by studying this manual in detail. (See also section 1.6.2.)

Any work on the machine must be performed when it is at a standstill. It is imperative that the procedure for shutting down the machine is followed, as described in section 5.9.

On completion of work all guards and safety devices must be re-installed and made operative again. Before restarting the machine, the relevant instructions listed in section 5, *Commissioning, start up, operation and shut down* must be observed.

Oil and grease leaks may make the ground slippery. Machine maintenance must always begin and finish by cleaning the ground and the exterior of the machine.

If platforms, stairs and guard rails are required for maintenance, they must be placed for easy access to areas where maintenance and inspection are to be carried out. The positioning of these accessories must not limit access or hinder the lifting of the part to be serviced.

When air or compressed inert gas is used in the maintenance process, the operator and anyone in the vicinity must be careful and have the appropriate protection.

Do not spray air or compressed inert gas on skin.

Do not direct an air or gas jet towards other people.

Never use air or compressed inert gas to clean clothes.

Before working on the pump, take measures to prevent the pump from being accidentally started. Place a warning sign on the starting device:
"Machine under repair: do not start."

With electric drive equipment, lock the main switch open and withdraw any fuses. Put a warning sign on the fuse box or main switch:
"Machine under repair: do not connect."

Never clean equipment with flammable solvents or carbon tetrachloride. Protect yourself against toxic fumes when using cleaning agents.

Refer to the parts list shown in section 8 for item number references used throughout this section.

6.1 Maintenance schedule

It is recommended that a maintenance plan and schedule be implemented, in accordance with these User Instructions, to include the following:

a) Any auxiliary systems installed must be monitored, if necessary, to ensure they function correctly.
b) Gland packing must be adjusted correctly to give visible leakage and concentric alignment of the gland follower to prevent excessive temperature of the packing or follower.
c) Check for any leaks from gaskets and seals. The correct functioning of the shaft seal must be checked regularly.
d) Check bearing lubricant level, and the remaining hours before a lubricant change is required.
e) Check that the duty condition is in the safe operating range for the pump.
f) Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation.
g) Check dirt and dust is removed from areas around close clearances, bearing housings and motors.
h) Check coupling alignment and re-align if necessary

6.1.1 Preventive maintenance

The following sections of this manual give instructions on how to perform a complete maintenance overhaul. However, it is also important to periodically repeat the *Pre start-up checks* listed in section 5.1. These checks will help extend pump life as well as the length of time between major overhauls.

6.1.2 Need for maintenance records

A procedure for keeping accurate maintenance records is a critical part of any program to improve pump reliability. There are many variables that can contribute to pump failures. Often long term and repetitive problems can only be solved by analyzing these variables through pump maintenance records.

6.1.3 Cleanliness

One of the major causes of pump failure is the presence of contaminants in the bearing housing. This contamination can be in the form of moisture, dust, dirt and other solid particles such as metal chips. Contamination can also be harmful to the mechanical seal (especially the seal faces) as well as other parts of the pump. For example, dirt in the impeller threads could cause the impeller to not be seated properly against the shaft. This, in turn, could cause a series of other problems. For these reasons, it is very important that proper cleanliness be maintained. Some guidelines are listed below.

- After draining the oil from the bearing housing, periodically send it out for analysis. If it is contaminated, determine the cause and correct
- The work area should be clean and free from dust, dirt, oil, grease etc
- Hands and gloves should be clean
- Only clean towels, rags and tools should be used

6.2 Spare parts

The decision on what spare parts to stock varies greatly depending on many factors such as the criticality of the application, the time required to buy and receive new spares, the erosive/corrosive nature of the application, and the cost of the spare part. Section 8 identifies all of the components that make up each pump addressed in this manual. Please refer to the *Flowserve Mark 3 Pump Parts Catalog* for more information. A copy of this book can be obtained from your local Flowserve sales engineer or distributor/representative.

CAUTION Prior to resizing impellers in high chrome iron and nickel, please consult your local Flowserve sales representative.

6.2.1 Ordering of spare parts

Flowserve keeps records of all pumps that have been supplied. Spare parts can be ordered from your local Flowserve sales engineer or from a Flowserve distributor or representative. When ordering spare parts the following information should be supplied:

1) Pump serial number
2) Pump size and type
3) Part name – see section 8
4) Part item number – see section 8
5) Material of construction (alloy)
6) Number of parts required

The pump size and serial number can be found on the nameplate located on the bearing housing. (See figure 3-1.)

6.3 Recommended spares and consumable items

Mechanical process fluid seals, bearing housing lip seals, bearings, shafting, impeller, and gaskets.

6.4 Tools required

A typical range of tools that will be required to maintain these pumps is listed below.

Standard hand tools SAE

- Hand wrenches
- Socket wrenches
- Allen wrenches
- Soft mallet
- Screwdrivers

Specialized equipment

- Bearing pullers
- Bearing induction heaters
- Dial indicators
- Spanner wrench
- Flowserve Mark 3 tool kit (see below)

To simplify maintenance, it is recommended that the Flowserve Mark 3 tool kit (shown in figure 6-1) is used. This tool kit includes a handy impeller wrench, which simplifies installation and removal of the impeller. It also contains “nose cones” which protect shaft threads and O-rings during maintenance. This tool kit can be ordered from your local Flowserve sales engineer or from a Flowserve distributor or representative.

Figure 6-1

6.5 Fastener torques

Figure 6-2: Recommended bolt torques

Item	Description	Group 1 non-lubricated	Group 2 non-lubricated	Group 3 non-lubricated
[6570.12]	Bearing retainer cap screws - standard bearings	n/a	n/a	5/16 in. – 16 Nm (12 lbf•ft)
[6570.12]	Bearing retainer cap screws - duplex bearings	3/16 in. – 6 Nm (4 lbf•ft)	3/16 in. – 6 Nm (4 lbf•ft)	5/16 in. –16 Nm (12 lbf•ft)
[6570.5]	Bearing housing/adapter cap screws and nuts	n/a	½ in. – 54 Nm (40 lbf•ft)	⅝ in. – 122 Nm (90 lbf•ft)
[6580.2]	Mechanical seal gland studs/nuts, with gasket	⅜ in. – 16 Nm (12 lbf•ft)	⅜ in. – 16 Nm (12 lbf•ft)	½ in. – 41 Nm (30 lbf•ft)
[6580.2]	Mechanical seal gland studs/nuts, with O-ring	⅜ in. – 27 Nm (20 lbf•ft)	⅜ in. – 27 Nm (20 lbf•ft)	½ in. – 54 Nm (40 lbf•ft)
[6580.1]	Casing studs/nuts	½ in. – 41 Nm (30 lbf•ft)	½ in. – 41 Nm (30 lbf•ft) ⅝ in. – 81 Nm (60 lbf•ft)	¾ in. – 136 Nm (100 lbf•ft) ⅞ in. – 217 Nm (160 lbf•ft)
[6570.2]	Cap screw cover/adapter (token bolts)	⅜ in. – 27 Nm (20 lbf•ft)	⅜ in. – 27 Nm (20 lbf•ft)	½ in. – 54 Nm (40 lbf•ft)
[6570.3]	Bearing carrier set screws	⅜ in. – 16 Nm (12 lbf•ft)	½ in. – 41 Nm (30 lbf•ft)	½ in. – 41 Nm (30 lbf•ft)
[6570.4]	Cap screw foot	½ in. – 54 Nm (40 lbf•ft)	¾ in. – 217 Nm (160 lbf•ft)	1 in. – 300 Nm (228 lbf•ft)
[6570.13]	Cap screws - repeller cover to cover	n/a	⅜ in. – 16 Nm (12 lbf•ft)	½ in. – 41 Nm (30 lbf•ft)
[6570.15]	Cap screw – bearing housing	½ in. – 54 Nm (40 lbf•ft)	½ in. – 54 Nm (40 lbf•ft)	n/a
[3712]	Bearing Locknut	27 +4/-0 Nm (20 +5/-0 lbf•ft)	54 +7 / -0 Nm (40 +5 / -0 lbf•ft)	95 +7 / -0 Nm (70 +5 / -0 lbf•ft)

Notes: 1. For lubricated or PTFE-coated threads, use 75% of the values given.
2. Gasket joint torque values are for unfilled PTFE gaskets. Other gasket materials may require additional torque to seal. Exceeding metal joint torque values is not recommended.

6.6 Setting impeller clearance and impeller replacement

A new impeller gasket [4590.2] must be installed whenever the impeller has been removed from the shaft. Impeller clearance settings may be found in section 5.3. Impeller balancing instruction may be found in section 6.8.

Note: Mark 3 Unitized Self-Priming pumps require that the outside diameter of the impeller be 3 mm (0.125 in.) from the casing cutwater. If this close clearance is not maintained the pump may not prime.

CAUTION Do not adjust the impeller clearance with the seal set. Doing so may result in seal leakage and/or damage.

CAUTION The impeller could have sharp edges, which could cause an injury. It is very important to wear heavy gloves.

CAUTION It is recommended that two people install a Group 3 impeller. The weight of a Group 3 impeller greatly increases the chance of thread damage and subsequent lock-up concerns.

CAUTION Do not attempt to tighten the impeller on the shaft by hitting the impeller with a hammer or any other object or by inserting a pry bar between the impeller vanes. Serious damage to the impeller may result from such actions.

CAUTION Care should be taken in the handling of high chrome iron impellers

Install the impeller [2200] by screwing it onto the shaft (use heavy gloves) until it firmly seats against the shaft shoulder.

Tighten the impeller with the impeller wrench from the Flowserve Mark 3 tool kit. To do this, grasp the impeller in both hands and, with the impeller wrench handle to the left (viewed from the impeller end of the shaft - figure 6-3) spin the impeller forcefully in a clockwise direction to impact the impeller wrench handle on the work surface to the right (figure 6-4).

Figure 6-3

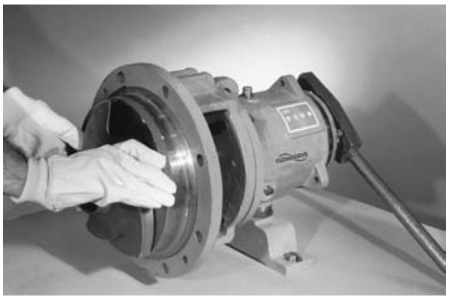


Figure 6-4

6.6.1 Installation and clearance setting for reverse vane impellers on Mark 3 Standard, Unitized self-priming, In-Line and open vane impeller on the recessed impeller pump

Flowserve reverse vane impellers and recessed open impellers are set off the cover. This allows the impeller to be set without the casing.

Set the impeller clearance by loosening the set screws [6570.3] and rotating the bearing carrier [3240] to obtain the proper clearance. Turn the bearing carrier counter-clockwise until the impeller comes into light rubbing contact with the rear cover. Rotating the shaft at the same time will accurately determine this zero setting. Now, rotate the bearing carrier clockwise to get the proper clearance. Refer to figure 5-12 for the proper impeller clearance based on the operating temperature for the application.

Rotating the bearing carrier the width of one of the indicator patterns cast into the bearing carrier moves the impeller axially 0.1 mm (0.004 in.). (See figure 6-5.)

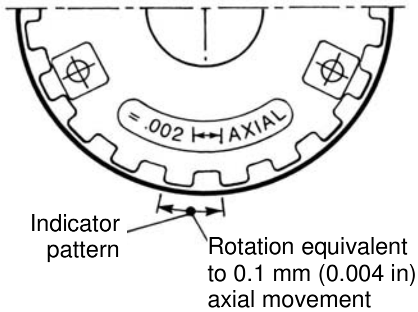


Figure 6-5

Determine how far to rotate the bearing carrier by dividing the desired impeller clearance by 0.1 mm (0.004 in) (one indicator pattern). Tightening the set screws [6570.3] will cause the impeller to move 0.05 mm (0.002 in.) closer to the rear cover because of the internal looseness in the bearing carrier threads. This must be considered when setting the impeller clearance. Rotate the bearing carrier clockwise the required amount to get the desired clearance to the cover.

Note: Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place.

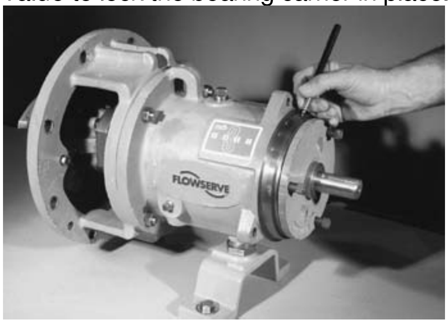


Figure 6.6

Example: If a pump was to be placed in a service with an operating temperature of 100 °C (212 °F) the impeller setting would be 0.53 mm (0.021 in.) off the rear cover plate. Since it is necessary to add 0.05 mm (0.002 in.) for the movement caused by tightening the set screws an adjustment of 0.58 mm (0.023 in.) is needed. First turn the bearing carrier counter-clockwise until the impeller comes into light rubbing contact with the rear cover. To determine the number of indicator patterns that you will need to rotate the carrier, divide 0.10 into the desired setting;
0.58 / 0.10 = 5.8 (0.023 / 0.004 = 5.8). Rotate the bearing carrier clockwise 6 indicator patterns which will give a clearance of 0.60 mm (0.024 in.).

Flowserve suggests that a felt tip pen be used to mark an initial reference point on the bearing housing and the bearing carrier as shown in figure 6-6. Then make a second mark on the bearing carrier 6 indicator patterns counter-clockwise from the initial reference point. Rotate the bearing carrier clockwise until the second mark on the bearing carrier lines up with the initial reference point mark on the bearing housing. Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place.

6.6.2 Installation and clearance setting for front vane open style impeller on Mark 3 Standard, Unitized self-priming, Lo-Flo, and In-Line pumps

Like all front vane open style impellers, the Flowserve open impeller clearance must be set off the casing. The casing must be installed to accurately set the impeller clearance. (Realizing that this can be very difficult, Flowserve strongly promotes the use of reverse vane impellers, which do not require the presence of the casing to be properly set.)

Attach the power end/rear cover plate assembly to the casing. Now set the impeller clearance by loosening the set screws [6570.3] and rotating the bearing carrier [3240] to obtain the proper clearance. Turn the bearing carrier clockwise until the impeller comes into light rubbing contact with the casing. Rotating the shaft at the same time will accurately determine this zero setting. Now, rotate the bearing carrier counter-clockwise to get the proper clearance. Refer to figure 5-12 for the proper impeller clearance.

Rotating the bearing carrier the width of one of the indicator patterns cast into the bearing carrier moves the impeller axially 0.1 mm (0.004 in.). (See figure 6-5.)

Determine how far to rotate the bearing carrier by dividing the desired impeller clearance by 0.1 mm (0.004 in.) (one indicator pattern). Tightening the set screws [6570.3] will cause the impeller to move 0.05 mm (0.002 in.) away from the casing because of the internal looseness in the bearing carrier threads. This must be considered when setting the impeller clearance. Rotate the bearing carrier counter-clockwise the required amount to get the desired clearance to the casing.

Note: Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place.

See section 5.3 for impeller clearance settings.

Example: If a pump was to be placed in a service with an operating temperature of 150 °C (302 °F) the impeller setting would be 0.69 mm (0.027 in.) off the casing. Since it is necessary to subtract 0.05 mm (0.002 in.) for the movement caused by tightening the set screws an adjustment of 0.64 mm (0.025 in.) is needed. First, turn the bearing carrier clockwise until the impeller comes into light rubbing contact with the casing. To determine the number of indicator patterns that you will need to rotate the carrier, divide 0.10 into the desired setting;
0.64 / 0.10 = 6.4 (.025 / 0.004 = 6.3). Rotate the bearing carrier counter-clockwise 6.5 indicator patterns which will give a clearance of 0.65 mm (0.026 in.). Flowserve suggests that a felt tip pen be used to mark an initial reference point on the bearing housing and the bearing carrier as shown in figure 6-6. Then make a second mark on the bearing carrier 6.5 indicator patterns clockwise from the initial reference point. Rotate the bearing carrier counter-clockwise until the second mark on the bearing carrier lines up with the initial reference point mark on the bearing housing. Lastly, uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place. The impeller is now set for an impeller setting of 0.7 mm (0.028 in.) off the casing.

The above procedure is fairly straightforward when doing the final setting of the impeller. However it can be quite laborious when doing the preliminary setting in order to establish the location of the mechanical seal. For this reason, the following practice is recommended. Before the pump is taken out of service, adjust the impeller until it touches the casing and then rotate the bearing carrier until the desired impeller clearance is obtained. Identify this location on the bearing carrier and then rotate the bearing carrier until the impeller contacts the rear cover. Record the distance from the desired impeller clearance setting to when the impeller contacts the rear cover. The pump is now removed from the casing and taken to the shop for maintenance. When it is time to set the seal, the impeller is simply set off the rear cover by the same distance recorded earlier.

Note: The above technique is only applicable if all of the original pump components are reinstalled. If the casing, cover, impeller or shaft is replaced this method must not be used.

6.6.3 Installation and clearance setting for Sealmatic pumps

Install the repeller [2000.1] and covers [1220 and 1220.1] as described in section 6.9.3. Install a seal guide from the Mark 3 tool kit to hold the repeller in place. Set the repeller 0.38 to 0.51 mm (0.015 to 0.020 in.) off the cover following the instruction above in section 6.6.1. Uniformly tighten the set screws [6570.3] in incremental steps up to the final torque value to lock the bearing carrier in place. Remove the seal guide and install the impeller. Check the impeller setting with a feeler gage. The gap should be 0.38 to 0.51 mm (0.015 to 0.020 in.). If the gap is outside of the correct setting, it may be readjusted to get the beat gap at the repeller and impeller.

6.7 Disassembly

6.7.1 Power end removal

a) Before performing any maintenance, disconnect the driver from its power supply and lock it off line.

   CAUTION Lock out power to driver to prevent personal injury.
b) Close the discharge and suction valves, and drain all liquid from the pump.
c) Close all valves on auxiliary equipment and piping, then disconnect all auxiliary piping.
d) Decontaminate the pump as necessary.

   CAUTION If Flowserve Mark 3 pumps contain dangerous chemicals, it is important to follow plant safety guidelines to avoid personal injury or death.
e) Remove the coupling guard. (See section 5.5.)
f) Remove the spacer from the coupling. Close coupled pumps required that the motor be removed from the pump assembly. The motor must be fully supported and the jackscrews [6575] loose before removal.
g) Remove casing fasteners [6580.1]. On Group 1 In-Line pumps the studs [6572.1] must be removed.
h) Remove the fasteners holding the bearing housing foot to the baseplate. (Not applicable on In-Line pumps).
i) Move the power end, rear cover, and seal chamber assembly away from the casing. On In-Line pumps the simplest method of power end removal is to first remove the motor and motor adapter with a crane. However this is often not practical and the power end must be removed by hand. This operation is illustrated in figures 6-7, 6-8 and 6-9. Discard the casing/cover gasket [4590.1].

   CAUTION The power end and rear cover assembly is heavy. It is important to follow plant safety guidelines when lifting it.
j) Transport the assembly to the maintenance shop.

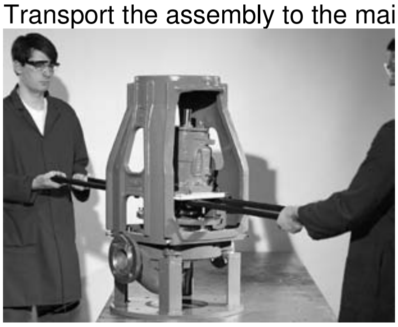


Figure 6-7

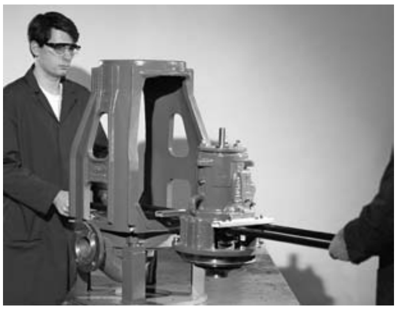


Figure 6-8

Figure 6-9

6.7.2 Pump disassembly

k) Remove the coupling hub from the pump shaft [2100]. Close coupled pumps require the motor adapter [3160] be removed.

l) Using the shaft key [6700], mount the impeller wrench from the Flowserve Mark 3 tool kit (figure 6-1) to the end of the shaft. With the wrench handle pointing to the left when viewed from the impeller end, grasp the impeller [2200] firmly with both hands (wear heavy gloves). By turning the impeller in the clockwise direction move the wrench handle to the 11 o'clock position and then spin the impeller quickly in a counter-clockwise direction so that the wrench makes a sudden impact with a hard surface on the bench. After several sharp raps, the impeller should be free. Unscrew the impeller and remove from the shaft. Discard the impeller gasket [4590.2].

CAUTION ***Do not apply heat to the impeller. If liquid is entrapped in the hub, an explosion could occur.***

m) If a cartridge type mechanical seal [4200] is used (figure 6-10), the spacing clips or tabs should be installed prior to loosening the set screws which attaches the seal to the shaft or removing it from the cover. This will ensure that the proper seal compression is maintained.

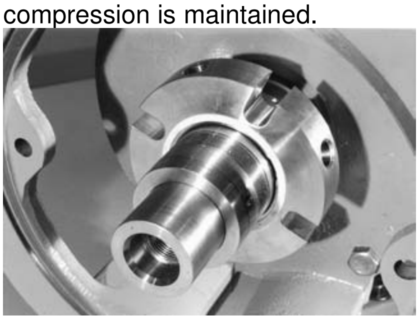


Figure 6-10

n) Remove the seal or packing gland nuts [6580.2] if so equipped.

o) Remove the cover.
<u>All pumps except Sealmatic</u>
Remove the two cap screws [6570.2] which attach the rear cover [1220] to the adapter. Carefully remove this part.
<u>Sealmatic pump only</u>
Remove the cap screws that hold the rear cover [1220] to the repeller cover [1220.1]. For Group 3 pumps remove the capscrews [6570.2] that hold the rear cover [1220] to the adapter [1340]. Remove the cover. The repeller is now exposed [2200.1] and should be free to slip from the shaft. In the event it is stuck, the repeller can be pried off by the use of 2 screwdrivers wedged between the repeller [2200.1] and the repeller cover [1220.1].

p) If a component type inside mechanical seal [4200] is used, loosen the set screws on the rotating unit and remove it from the shaft (see figure 6-11). Then pull the gland [4120] and stationary seat off the shaft. Remove the stationary seat from the gland. Discard all O-rings and gaskets.

Figure 6-11

q) If a component type outside mechanical seal is used, remove the gland and the stationary seat. Remove the stationary seat from the gland. Loosen the set screws in the rotating unit and remove it from the shaft. Discard all O-rings and gaskets.

r) If packing [4130] is used, remove it and the seal cage [lantern ring, 4134]. Remove the gland [4120].

s) If the pump has a hook type sleeve [2400] it can now be removed. Unit now appears as shown in figure 6-12.

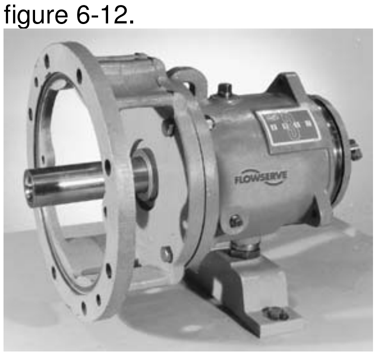


Figure 6-12

t) If the power end is oil lubricated, remove the drain plug [6569.1] and drain the oil from the bearing housing [3200].

u) If the pump has lip seals, a deflector [2540] will be present. Remove it.

v) Loosen the three set screws [6570.3] on the bearing carrier [3240]. The bearing carrier must be completely unscrewed from the bearing housing.

Note: Do not pry against the shaft.

<u>Mark 3A and ANSI 3A design</u>
The face of the bearing carrier has three square lugs that protrude from the surface. The bearing carrier is turned by using an open end wrench on one of the square lugs as shown in figure 6-13.

Mark 3 design
On Group 1 and 2 pumps the bearing carrier is turned by using a strap wrench, with the strap located around the outside diameter of the carrier face. On Group 3 pumps, the bearing carrier is turned by using a spanner wrench to engage the cogs on the outside diameter of the bearing carrier.

Figure 6-13

w) Because the O-rings [4610.2] will cause some resistance in removing the bearing carrier assembly from the housing, hold the bearing carrier flange firmly and with slight rotation, pull it out of the bearing housing. The bearing carrier assembly with the shaft and bearings should come free. This unit will appear as shown in figure 6-14. Further disassembly is not required unless the bearings are to be replaced.

Figure 6-14

x) Remove the snap ring [2530] (see figure 6-15) on Group 1 and 2 pumps, or the bearing retainer [2530.1] on Group 3 pumps.

Figure 6-15

Note: Group 1 and 2 pumps equipped with duplex angular contact bearings use a bearing retainer [2530.1] instead of the snap ring. Remove the carrier from the bearing.

y) The bearing locknut [3712] and lockwasher [6541.1] may now be removed from the shaft [2100]. Discard the lockwasher.

z) An arbor or hydraulic press may be used to remove the bearings [3011 and 3013] from the shaft. It is extremely important to apply even pressure to the inner bearing race only. Never apply pressure to the outer race as this exerts excess load on the balls and causes damage.

⚠ CAUTION Applying pressure to the outer race could permanently damage the bearings.

aa) The Mark 3A design has an optional oil slinger [2541] located between the bearings. If present, inspect it for damage or looseness. Remove if it needs to be replaced.

bb) On Group 2 and 3 pumps, the bearing housing [3200] must be separated from the bearing housing adapter [1340]. The adapter O-ring [4610.1] should be discarded.
Mark 3A and ANSI 3A design
This is accomplished by removing the cap screws [6570.5], which thread into the bearing housing.
Mark 3 In-Line design
There is no adapter o-ring [4610.1] when an oil drain tap is supplied in the adapter.
Mark 3 design
This is accomplished by removing the hex nuts [6580.8] and the cap screws [6570.5].

cc) If lip seals [4310.1 and 4310.2] (see figure 6-16) are used, they should be removed from the bearing carrier and adapter and discarded.

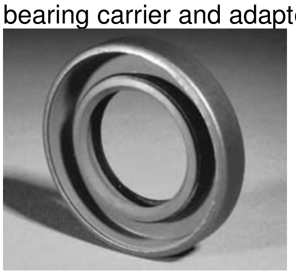


Figure 6-16

dd) If the bearing isolators are removed from either the bearing carrier or adapter they must not be reused, discard appropriately.

ee) If magnetic seals are used, maintain the seals as specified by the manufacturer.
Mark 3 and Mark 3A design
Remove the Trico oiler/site gage [3855] (figure 6-17) and oil level tag (figure 6-18) from the bearing housing.
ANSI 3A design
Remove the site gage [3856] (figure 5-1) and oil level tag (figure 6-18) from the bearing housing. Save these parts for reuse.

Figure 6-17

Figure 6-18

6.8 Examination of parts

6.8.1 Cleaning/inspection

All parts should now be thoroughly cleaned and inspected. New bearings, O-rings, gaskets, and lip seals should be used. Any parts that show wear or corrosion should be replaced with new genuine Flowserve parts.

CAUTION It is important that only non-flammable, non-contaminated cleaning fluids are used. These fluids must comply with plant safety and environmental guidelines.

6.8.2 Critical measurements and tolerances

To maximize reliability of pumps, it is important that certain parameters and dimensions are measured and maintained within specified tolerances. It is important that all parts be checked. Any parts that do not conform to the specifications should be replaced with new Flowserve parts.

6.8.3 Parameters that should be checked by users

Flowserve recommends that the user check the measurements and tolerances in figure 6-19 whenever pump maintenance is performed. Each of these measurements is described in more detail on the following pages.

6.8.4 Additional parameters checked by Flowserve

The parameters listed below are somewhat more difficult to measure and/or may require specialized equipment. For this reason, they are not typically checked by our customers, although they are monitored by Flowserve during the manufacturing and/or design process.

6.8.4.1 Shaft and sleeve (if fitted)

Replace if grooved, pitted or worn. Prior to mounting bearings or installing the shaft into the bearing housing, check the following parameters:

Diameter/tolerance, under bearings

In order to ensure proper fit between the shaft and bearings, verify that both the inboard (IB) and outboard (OB) shaft diameter is consistently within the minimum/maximum values shown in figure 6-20. A micrometer should be used to check these outside diameter (OD) dimensions on the shaft.

6.8.4.2 Bearings

It is recommended that bearings not be re-used after removal from the shaft. Prior to mounting bearings, check the following parameters:

Diameter/tolerance, inside diameter

In order to ensure proper fit between bearings and the shaft, verify that the inside diameter (ID) of both the IB and OB bearing are consistently within the minimum/maximum values shown in figure 6-20. An inside caliper should be used to check these ID diameters on the bearings.

Diameter/tolerance, outside diameter

In order to ensure proper fit between bearings and the bearing housing, verify that the OD on both the IB and OB bearings are consistently within the minimum/maximum values shown in figure 6-21. A micrometer should be used to check these outside diameter (OD) dimensions on the bearings.

6.8.4.3 Impeller balancing

Shaft whip is deflection where the centerline of the impeller is moving around the true axis of the pump. It is not caused by hydraulic force but rather by an imbalance with the rotating element. Shaft whip is very hard on the mechanical seal because the faces must flex with each revolution in order to maintain contact. To minimize shaft whip it is imperative that the impeller is balanced. All impellers manufactured by Flowserve are balanced after they are trimmed. If for any reason, a customer trims an impeller, it must be re-balanced. See note 1 under figure 6-19 regarding acceptance criteria.

6.8.4.4 Bearing housing/carrier

Prior to installing the shaft into the bearing housing, check the following parameters:

Diameter/tolerance, at bearing surface

In order to ensure proper fit between the bearing housing/carrier and the bearings, verify that the ID of both the IB and OB bearing surfaces are consistently within the minimum/maximum values shown in figure 6-21. An inside caliper should be used to check these ID dimensions in the bearing housing.

Figure 6-19

Topic	ASME B73.1M standard mm (in.)	Suggested by major seal vendors mm (in.)	Suggested and/or provided by Flowserve mm (in.)
Shaft			
Diameter tolerance, under bearings	n/s		0.005 (0.0002)
Impeller			
Balance		See note 1	
Bearing housing			
Diameter (ID) tolerance at bearings	n/s		0.013 (0.0005)
Power end assembly			
Shaft runout	0.05 (0.002)	0.03 (0.001)	
Shaft sleeve runout	0.05 (0.002)	0.05 (0.002)	0.05 (0.002)
Radial deflection - static	n/s	0.076 (0.003)	0.05 (0.002)
Shaft endplay	n/s	0.05 (0.002)	0.05 (0.002)
Seal chamber			
Face squareness to shaft	0.08 (0.003)	0.03 (0.001)	0.08 (0.003)
Register concentricity		0.13 (0.005)	0.13 (0.005)
Complete pump			
Shaft movement caused by pipe strain	n/s	0.05 (0.002)	0.05 (0.002)
Alignment	n/s		See note 2
Vibration at bearing housing	See note 3		See note 3

n/s = not specified.

1. The maximum values of acceptable unbalance are:
   1 500 r/min: 40 g·mm/kg (1 800 r/min: 0.021 oz-in/lb) of mass.
   2 900 rpm: 20 g·mm/kg (3 600 rpm: 0.011 oz-in/lb) of mass.
   Flowserve performs a single plane spin balance on most impellers. The following impellers are exceptions: 10X8-14, 10X8-16 and 10X8-16H. On these Flowserve performs a two plane dynamic balance, as required by the ASME B73.1M standard. All balancing, whether single or two plane, is performed to the ISO 1940 Grade 6.3 tolerance criteria.
2. The ASME B73.1M standard does not specify a recommended level of alignment. Flowserve recommends that the pump and motor shafts be aligned to within 0.05 mm (0.002 in.) parallel FIM (full indicator movement) and 0.0005 mm/mm (0.0005 in./in.) angular FIM. Closer alignment will extend MTBPM. For a detailed discussion of this subject see the *Alignment* section of this manual.
3. The ASME B73.1M, paragraph 5.1.4.

Figure 6-20

		Group 1	Group 2	Group 3
OB bearing/ shaft mm (in.)	Bearing	30.000/29.990 (1.1811/1.1807)	50.000/49.987 (1.9685/1.9680)	70.000/69.985 (2.7559/2.7553)
	Shaft	30.013/30.003 (1.1816/1.1812)	50.013/50.003 (1.9690/1.9686)	70.015/70.002 (2.7565/2.7560)
	Fit	0.023T/0.003T (0.0009T/0.0001T)	0.026T/0.003T (0.0010T/0.0001T)	0.030T/0.002T (0.0012T/0.0001T)
IB bearing/ shaft mm (in.)	Bearing	35.000/34.989 (1.3780/1.3775)	50.000/49.987 (1.9685/1.9680)	70.000/69.985 (2.7559/2.7553)
	Shaft	35.014/35.004 (1.3785/1.3781)	50.013/50.003 (1.9690/1.9686)	70.015/70.002 (2.7565/2.7560)
	Fit	0.025T/0.004T (0.0010T/0.0001T)	0.026T/0.003T (0.0010T/0.0001T)	0.030T/0.002T (0.0012T/0.0001T)

Figure 6-21

		Group 1	Group 2	Group 3
OB bearing/ carrier mm (in.)	Bearing	71.999/71.986 (2.8346/2.8341)	110.000/109.985 (4.3307/4.3301)	150.000/149.979 (5.9055/5.9047)
	Carrier	71.999/72.017 (2.8346/2.8353)	110.007/110.022 (4.3310/4.3316)	150.002/150.030 (5.9056/5.9067)
	Fit	0.031L/0.000L (0.0012L/0.0000L)	0.037L/0.007L (0.0015/0.0003L)	0.051L/0.002L (0.0020L/0.0001L)
IB bearing/ housing mm (in.)	Bearing	71.999/71.986 (2.8346/2.8341)	110.000/109.985 (4.3307/4.3301)	150.000/149.979 (5.9055/5.9047)
	Housing	71.999/72.017 (2.8346/2.8353)	110.007/110.022 (4.3310/4.3316)	150.007/150.025 (5.9058/5.9065)
	Fit	0.031L/0.000L (0.0012L/0.0000L)	0.037L/0.007L (0.0015L/0.0003L)	0.046L/0.007L (0.0018L/0.0003L)

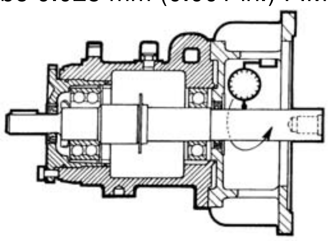
6.8.4.5 *Power end*

Assembled bearing housing, carrier, bearings, and shaft.

<u>*Shaft/shaft sleeve run-out*</u>

Shaft run-out is the amount the shaft is "out of true" when rotated in the pump. It is measured by attaching a dial indicator to a stationary part of the pump so that its contact point indicates the radial movement of the shaft surface as the shaft is rotated slowly. If a shaft sleeve is used then shaft sleeve run-out must be checked. It is analogous to shaft run-out. Measurement of shaft run-out/shaft sleeve run-out will disclose any out of roundness of the shaft, any eccentricity between the shaft and the sleeve, any permanent bend in the shaft, and/or any eccentricity in the way the shaft or bearings are mounted in the bearing housing.

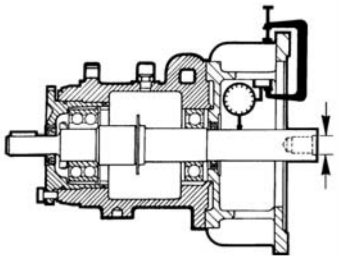
Shaft run-out can shorten the life of the bearings and the mechanical seal. The following diagram shows how to measure shaft/shaft sleeve run-out. Note that both ends need to be checked. The run-out should be 0.025 mm (0.001 in.) FIM or less.



Runout

Radial deflection - static

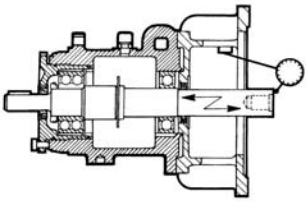
Radial movement of the shaft can be caused by a loose fit between the shaft and the bearing and/or the bearing and the housing. This movement is measured by attempting to displace the shaft vertically by applying an upward force of approximately 4.5 kg (10 lb) to the impeller end of the shaft. While applying this force, the movement of an indicator is observed as shown in the following diagram. The movement should be checked at a point as near as possible to the location of the seal faces. A movement of more than 0.05 mm (0.002 in.) is not acceptable.



Deflection

Shaft endplay

The maximum amount of axial shaft movement, or endplay, on a Durco pump should be 0.03 mm (0.001 in.) and is measured as shown below. Observe indicator movement while tapping the shaft from each end in turn with a soft mallet. Shaft endplay can cause several problems. It can cause fretting or wear at the point of contact between the shaft and the secondary sealing element. It can also cause seal overloading or underloading and possibly chipping of the seal faces. It can also cause the faces to separate if significant axial vibration occurs.



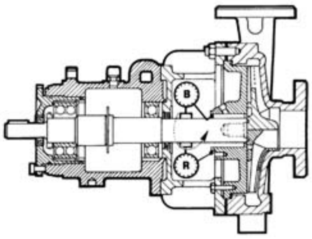
Endplay

6.8.4.6 Seal chamber

Assembled power end and rear cover.

Face squareness to shaft

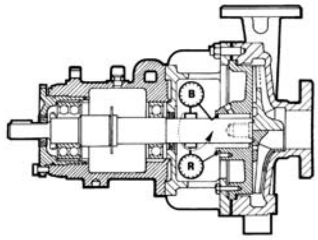
Also referred to as "Seal chamber face run-out." This run-out occurs when the seal chamber face is not perpendicular to the shaft axis. This will cause the gland to cock, which causes the stationary seat to be cocked, which causes the seal to wobble. This run-out should be less than 0.08 mm (0.003 in) and should be measured as shown below:



Face squareness

Register concentricity

An eccentric seal chamber bore or gland register can interfere with the piloting and centering of the seal components and alter the hydraulic loading of the seal faces, resulting in reduction of seal life and performance. The seal chamber register concentricity should be less than 0.13 mm (0.005 in.). The diagram below shows how to measure this concentricity.



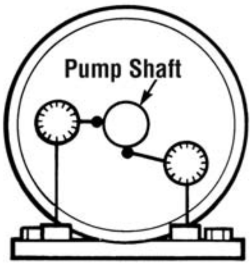
Concentricity

6.8.4.7 Installed pump

Complete pump installed.

Shaft movement caused by pipe strain

Pipe strain is any force put on the pump casing by the piping. Pipe strain should be measured as shown below. Install the indicators as shown before attaching the piping to the pump. The suction and discharge flanges should now be bolted to the piping separately while continuously observing the indicators. Indicator movement should not exceed 0.05 mm (0.002 in.).



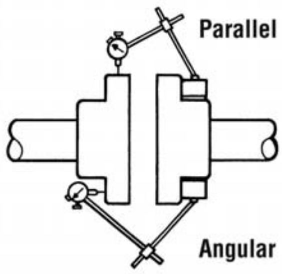
Pipe strain movement

Alignment

Misalignment of the pump and motor shafts can cause the following problems:

- Failure of the mechanical seal
- Failure of the motor and/or pump bearings
- Failure of the coupling
- Excessive vibration/noise

The schematics below show the technique for a typical rim and face alignment using a dial indicator. It is important that this alignment be done after the flanges are loaded, and at typical operating temperatures. If proper alignment cannot be maintained a C-flange motor adapter and/or stilt/spring mounting should be considered.



Alignment

Many companies today are using laser alignment which is a more sophisticated and accurate technique. With this method a laser and sensor measure misalignment. This is fed to a computer with a graphic display that shows the required adjustment for each of the motor feet.

See section 4.8 for recommended final shaft alignment limits.

Vibration analysis
Vibration analysis is a type of condition monitoring where a pump's vibration "signature" is monitored on a regular, periodic basis. The primary goal of vibration analysis is extension on MTBPM. By using this tool Flowserve can often determine not only the existence of a problem before it becomes serious, but also the root cause and possible solution.

Modern vibration analysis equipment not only detects if a vibration problem exists, but can also suggest the cause of the problem. On a centrifugal pump, these causes can include the following: unbalance, misalignment, defective bearings, resonance, hydraulic forces, cavitation and recirculation. Once identified, the problem can be corrected, leading to increased MTBPM for the pump.

Flowserve does not make vibration analysis equipment, however Flowserve strongly urges customers to work with an equipment supplier or consultant to establish an on-going vibration analysis program. See note 3 under figure 6-19 regarding acceptance criteria.

6.9 Assembly of pump and seal

CAUTION It is important that all pipe threads be sealed properly. PTFE tape provides a very reliable seal over a wide range of fluids, but it has a serious shortcoming if not installed properly. If, during application to the threads, the tape is wrapped over the end of the male thread, strings of the tape will be formed when threaded into the female fitting. These strings can then tear away and lodge in the piping system.
If this occurs in the seal flush system, small orifices can become blocked effectively shutting off flow. For this reason, Flowserve does not recommend the use of PTFE tape as a thread sealant.

Flowserve has investigated and tested alternate sealants and has identified two that provide an effective seal, have the same chemical resistance as the tape, and will not plug flush systems. These are La-co Slic-Tite and Bakerseal. Both products contain finely ground PTFE particles in an oil based carrier. They are supplied in a paste form which is brushed onto the male pipe threads. Flowserve recommends using one of these paste sealants.

Full thread length engagement is required for all fasteners.

Note: Refer to figure 6-2 for recommended bolt torques.

6.9.1 Power end assembly

The Mark 3A design has an optional oil slinger. If the slinger was removed during disassembly, install a new slinger [2541]. (See figure 6-22.)

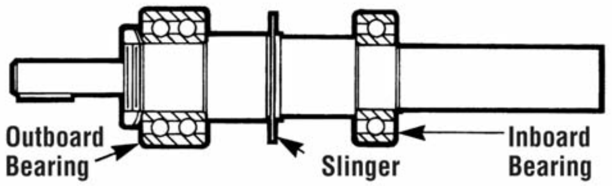


Figure 6-22

6.9.1.1 Bearing installation

Mounting of bearings on shafts must be done in a clean environment. Bearing and power end life can be drastically reduced if even very small foreign particles work their way into the bearings. Wear clean gloves.

Bearings should be removed from their protective packaging only immediately before assembly to limit exposure to possible contamination. After removing the packaging they should only come in contact with clean hands, fixtures, tools and work surfaces.

The chart shown in figure 6-23 gives the SKF part numbers for bearings in Flowserve Mark 3 pumps. Note that the term "inboard bearing" refers to the bearing nearest to the casing. "Outboard bearing" refers to the bearing nearest to the motor. (See figure 6-22.)

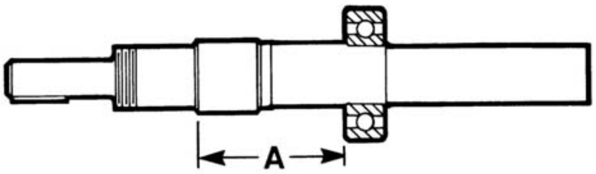
CAUTION Both bearings have a slight interference fit which requires that they be pressed on the shaft with an arbor or hydraulic press. Figure 6-20 identifies the bearing fits. Even force should be applied to only the inner race. Never press on the outer race, as the force will damage the balls and races.

An alternate method of installing bearings is to heat the bearings to 93 °C (200 °F) by means of an oven or induction heater. With this approach the bearing must be quickly positioned on the shaft.

Never heat the bearings above 110 °C (230 °F). To do so will likely cause the bearing fits to permanently change, leading to early failure.

a) Install the inboard bearing [3011] on the shaft [2100].
   Mark 3A and ANSI 3A design
   The inboard bearing must be positioned against the shoulder as shown in figure 6-22.
   Mark 3 design
   On Group 1 and Group 2 shafts, the inboard bearing must be located as shown in figure 6-24. On Group 3 shafts position the inboard bearing against the shoulder.

Figure 6-24: Bearing position - Mark 3 design



Mark 3 standard shaft		Mark 3 duplex bearing shaft	
Group	**A**	**Group**	**A**
1	68 mm ($2\frac{11}{16}$ in.)	**1**	61 mm ($2\frac{3}{8}$ in.)
2	139 mm ($5\frac{15}{32}$ in.)	**2**	129 mm ($5\frac{3}{32}$ in.)
3	*	**3**	*

* Inboard bearing located against shoulder.

If the power end is equipped with single shielded regreasable bearings, see figures 5-7 and 5-8 for proper orientation of the shields

CAUTION The orientation of the bearing shields is different for horizontal pumps (figure 5-7) and In-Line pumps (figure 5-8).

b) Install the outboard bearing retaining device onto the shaft.
   Double row bearings
   Place the snap ring [2530] onto the outboard end of the shaft and slide down to the inboard bearing.
   Note: The proper orientation of the snap ring must be assured in this step. The flat side of the snap ring must face away from the inboard bearing.
   Duplex angular contact bearings
   Place the bearing retainer [2530.1] onto the outboard end of the shaft and slide down to the inboard bearing.
   Note: The proper orientation of the bearing retainer must be assured in this step. The small side of the retainer must face away from the inboard bearing.

Figure 6-23: Flowserve Mark 3 bearings

Group	Type of bearing	Inboard single row, deep groove [5]	Outboard double row, angular contact, deep groove [5 & 9]	Optional outboard duplex angular contact [5]
1	Oil bath/mist - open [1]	6207-C3	5306-AC3 or 3306-AC3	7306-BECBY
	Regreasable - single shielded [2]	6207-ZC3	5306-AZC3 or 3306-AZC3	NA [6]
	Greased for life - double shielded [3]	6207-2ZC3	5306-A2ZC3 or 3306-A2ZC3	NA [7]
	Sealed for life - double sealed [4]	6207-2RS1C3	5306-A2RSC3 or 3306-A2RS1C3	NA [7]
2	Oil bath/mist - open [1]	6310-C3	5310-AC3 (AHC3) or 3310-AC3	7310-BECBY
	Regreasable – single shielded [2]	6310-ZC3	5310-AZC3 or 3310-AZC3	NA [6]
	Greased for life - double shielded [3]	6310-2ZC3	5310-A2ZC3 or 3310-A2ZC3	NA [7]
	Sealed for life - double sealed [4]	6310-2RS1C3	5310-A2RSC3 or 3310-A2RS1C3	NA [7]
3	Oil bath/mist - open [1]	6314-C3	5314-AC3 or 3314-AC3	7314-BECBY
	Regreasable - single shielded [2]	6314-ZC3	5314-AZC3 or 3314-AZC3	NA [6]
	Greased for life - double shielded [3]	6314-2ZC3	5314-A2ZC3 or 3314-A2ZC3	NA [7]
	Sealed for life - double sealed [4]	6314-2RS1C3	5314-A2RSC3 or 3314-A2RS1C3	NA [7]

Notes:
1. These bearings are open on both sides. They are lubricated by oil bath or oil mist.
2. These bearings are pre-greased by Flowserve. Replacement bearings will generally not be pre-greased, so grease must be applied by the user. They have a single shield, which is located on the side next to the grease buffer, or reservoir. The bearings draw grease from the reservoir as it is needed. The shield protects the bearing from getting too much grease, which would generate heat. The grease reservoir is initially filled with grease by Flowserve. Lubrication fittings are provided, to allow the customer to periodically replenish the grease, as recommended by the bearing and/or grease manufacturer.
3. These bearings are shielded on both sides. They come pre-greased by the bearing manufacturer. The user does not need to regrease these bearings. The shields do not actually contact the bearing race, so no heat is generated.
4. These bearings are sealed on both sides. They come pre-greased by the bearing manufacturer. The user does not need to regrease these bearings. The seals physically contact and rub against the bearing race, which generates heat. These bearings are not recommended at speeds above 1750 r/min.
5. The codes shown are SKF codes. Inboard and outboard bearings have the C3, greater than “normal” clearance. These clearances are recommended by SKF to maximize bearing life.
6. Regreasable - single shielded bearings are not available in the duplex configuration; however, open oil bath-type bearings can be used for the regreasable configuration. These bearings must be pre-greased during assembly. Lubrication fittings are provided, to allow the user to periodically replenish the grease, as recommended by the bearing and/or grease manufacturer.
7. Not available.
8. All bearing configurations are supplied only with steel cages
9. SKF - the 5300 and 3300 bearing series are identical and therefore can be used interchangeably.

c) Install the outboard bearing.
Double row bearings
Install the outboard bearing [3013] firmly against the shoulder as shown in figure 6-22. If hot bearing mounting techniques are used, steps must be taken to ensure the outboard bearing is firmly positioned against the shaft shoulder. The outboard bearing, while still hot, is to be positioned against the shaft shoulder.
Duplex angular contact bearings
Duplex angular contact bearings must be mounted back-to-back with the wider thrust sides of the outer races in contact with each other as shown in figure 6-25. Only bearings designed for universal mounting should be used. The SKF designation is “BECB”. NTN’s designation is “G”.
Note: A special shaft is required when using duplex angular contact bearings.)

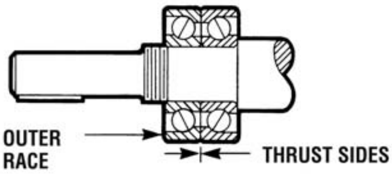


Figure 25

CAUTION The orientation of the bearing shields is different for horizontal pumps (figure 5-7) and In-Line pumps (figure 5-8).

CAUTION It must be understood that fixtures and equipment used to press the bearing must be designed so no load is ever transmitted through the bearing balls. This would damage the bearing.

d) After the bearing has cooled below 38 °C (100 °F) the bearing should be pressed against the shaft shoulder. Figure 6-26 identifies the approximate force needed to seat the bearing against the shaft shoulder. If a press is not available the locknut [3712] should be installed immediately after the bearing is placed on the shaft and tightened to ensure the bearing remains in contact with the shaft shoulder. The locknut should then be retightened repeatedly during the time the bearing is cooling. Once cool the locknut should be removed.

Figure 6-26

Pump	Press force N (lbf)	Locknut torque Nm (lbf·ft)
Group 1	5 780 (1 300)	27 +4/-0 (20 +5/-0)
Group 2	11 100 (2 500)	54 +7/-0 (40 +5/-0)
Group 3	20 000 (4 500)	95 +7/-0 (70 +5/-0)

e) Install lockwasher [6541.1] and locknut [3712]. The locknut should be torqued to the value shown in figure 6-26. One tang on the lockwasher must be bent into a corresponding groove on the locknut.

6.9.1.2 Bearing housing seals

Lip seals
If lip seals were used (see figure 6-16), install new lip seals in the bearing carrier [3240] and the housing [3200 - Group 1] or the adapter [1340 - Group 2 and 3]. The lip seals [4310.1 and 4310.2] are double lip style, the cavity between these two lips should be $^1/_2$ to $^2/_3$ filled with grease. When installing this part, the large metal face on the lip seal must face away from the bearings.

Labyrinth seals
The following are general installation instructions regarding the VBXX Inpro seal. Follow the instructions provided with the seal by the manufacturer.

The elastomer O-ring located on the OD of the seal has been sized to overfill the groove in which it is located. When installing the seal into its corresponding housing, in addition to compressing the O-ring a certain amount of material may shear off. This sheared material should be removed. An arbor press should be used to install the seal.

Install the inboard seal in the bore of the bearing housing (Group 1) or adapter (Group 2 and Group 3) with the single expulsion port positioned at the 6 o’clock position.

Install the outboard seal in the bore of the bearing carrier. There are no orientation issues since this is a multiport design seal.

Magnetic seals
Follow the installation instructions provided by the manufacturer.

6.9.1.3 Bearing carrier/power end assembly

a) Install new O-rings [4610.2] onto the bearing carrier. Be sure to use the correct size O-rings. (The Mark 3 and Mark 3A bearing carriers use different O-rings.)
b) Slide the bearing carrier [3240] over the outboard bearing [3013].
c) Install the outboard bearing retaining device.
Double row bearings on Group 1 and 2 pumps
Slide the snap ring [2530] in place with its flat side against the outboard bearing and snap it into its groove in the bearing carrier.
Duplex angular contact bearings on Group 1 and 2 pumps; all bearings on Group 3 pumps
Slide the bearing retainer [2530.1] against the outboard bearing and install and tighten the socket head capscrews [6570.12]. See figure 6-2 for correct torque values.

CAUTION Never compress the snap ring unless it is positioned around the shaft and between the bearings. In this configuration, it is contained therefore if it should slip off the compression tool it is unlikely to cause serious injury.

d) The shaft, bearings, and bearing carrier assembly (figure 6-14) can now be installed into the bearing housing [3200]. The bearing carrier [3240] should be lubricated with oil on the O-rings and threads before installing the assembly into the bearing housing. Thread the bearing carrier into the bearing housing by turning it clockwise to engage the threads. Thread the carrier onto the housing until the carrier flange is approximately 3 mm ($^1/_8$ in.) from the housing. Install the set screws [6570.3] loosely.

e) Reinstall any tags, plugs, site gages and oiler.
Mark 3 and Mark 3A design
Install the following items onto the bearing housing; oil level tag (figure 6-18) and combination Trico oiler/site gage [3855], vent/breather [6521] and drain plug [6569.1].
ANSI 3A design
Install the following items onto the bearing housing; oil level tag (figure 6-18) and site gage [3855], plug [6521] and magnetic drain plug [6569.4].

f) On Group 2 and 3 pumps, assemble the bearing housing adapter [1340] to the bearing housing [3200]. Be sure to install a new O-ring [4610.1].
Mark 3 In-Line design
The adapter O-ring [4610.1] should not be installed if there is a drain tap in the adapter [1340]. This tap is present on pumps with regreasable bearings and most oil mist applications.
Mark 3A and ANSI 3A design
Thread the capscrews [6570.5] through the adapter and into the tapped holes in the bearing housing.
Mark 3 design
Use the capscrews [6570.5] and hexnuts [6580.8]. Orient the bearing housing adapter with the two holes for capscrews [6570.5] on a horizontal line.

g) If the pump has lip seals, install the deflector [2540].

h) If the pump is equipped with a hook type sleeve [2400], slip it into place over the impeller end of the shaft [2100].

6.9.2 Wet end assembly

6.9.2.1 Cartridge mechanical seals

Review the seal assembly instructions and drawings provided by the seal manufacturer.

a) Install a nose cone on the end of the shaft and then slide the cartridge seal [4200] onto the shaft until it lightly touches the bearing housing [3200] or adapter [1340]. (See figure 6-10.)

b) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2]. Now install the cartridge seal gland to the rear cover plate [1220] using studs [6572.2] and nuts [6580.2].

c) Install the impeller [2200] as instructed in section 6.6. Care should be taken in the handling of high chrome iron impellers.

d) Tighten set screws on the seal to lock the rotating unit to the shaft. Finally, remove centering clips from the seal.

6.9.2.2 Component type mechanical seal

Review the seal assembly instructions and drawings (seal set dimension) provided by the seal manufacturer.

In order to properly set a component seal it is necessary to first locate the shaft in its final axial position. This is accomplished in the following manner.

a) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].

b) Install and set the impeller [2200] clearance as outlined in section 6.6. Put blueing on the shaft/ sleeve in the area near the face of the seal chamber (rear cover 1220]. Scribe a mark on the shaft at the face of the seal chamber (figure 6-27).

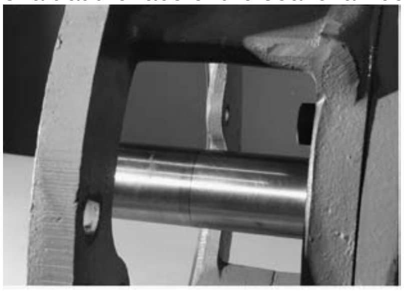


Figure 6-27

c) Remove the impeller and seal chamber (rear cover) following the instructions given in section 6.7 and install a nose cone onto the end of the shaft.

Single internal seal installation

d) Place the gland [4120] and stationary seat onto the shaft until it lightly touches the bearing housing (Group 1) or adapter (Group 2 and 3).

e) Install a gland gasket [4590.3] into the gland. (See figure 6-28.)

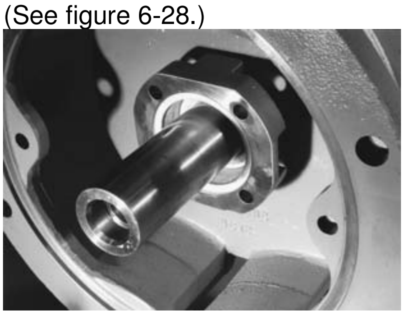


Figure 6-28

f) Locate the rotary seal unit onto the shaft (or sleeve) according to the set dimension provided by the seal manufacture. Tighten set screws on the seal to lock the rotating unit to the shaft/sleeve.
g) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
h) Attach the gland/seat to the rear cover plate [1220] using studs [6572.2] and nuts [6580.2].

Single external seal installation

Carry out steps a) to c), above.

d) Locate the rotary seal unit onto the shaft/sleeve according to the set dimension provided by the seal manufacturer. Tighten set screws on the seal to lock the rotating unit to the shaft/sleeve.
e) Attach the gland [4120] and stationary seat onto rear cover plate [1220] using studs [6572.2] and nuts [6580.2]
f) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].

Double seal installation

Carry out steps a) to c), above.

d) Place the gland [4120] and stationary seat onto the shaft until it lightly touches the bearing housing (Group 1) or adapter (Group 2 and 3). Install a gland gasket [4590.3] into the gland. (See figure 6-28.)
e) Locate the rotary seal unit onto the shaft/sleeve according to the set dimension provided by the seal manufacturer. Tighten set screws on the seal to lock the rotating unit to the shaft/sleeve. Install a stationary seat into the rear cover plate [1220].
f) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
g) Attach the gland/seat to the rear cover plate [1220] using studs [6572.2] and nuts [6580.2].
h) Install the impeller [2200] as instructed in section 6.6. Remember that the impeller clearance is already set. It cannot be changed at this point without resetting the seal.

6.9.2.3 Packing

Split gland installation

a) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
b) Install and set the impeller [2200] clearance as outlined in section 6.6.
c) Install the packing rings [4130] and seal cage halves [4134] into the stuffing box as shown in figures 4-23 and 4-24. Always stagger the end gaps 90 degrees to ensure a better seal. To speed installation of each ring, have an assistant turn the pump shaft in one direction. This movement of the shaft will tend to draw the rings into the stuffing box.
d) A split gland [4120] is an assembly of two matched gland halves that are bolted together. Unbolt the gland halves and install the gland halves around the shaft. Bolt the halves together to form a gland assembly.
e) Now install the gland assembly [4120] using studs [6572.2] and nuts [6580.2].
f) Lightly snug up the gland. Final adjustments must be made after the pump has begun operation.

One piece gland installation

a) Install the gland [4120] over shaft until it lightly touches the bearing housing (Group 1) or adapter (Group 2 and 3).
b) Install the rear cover plate [1220] to the bearing housing (Group 1) or the bearing housing adapter (Group 2 and 3) by using the capscrews [6570.2].
c) Install and set the impeller [2200] clearance as outlined in section 6.6.
d) Install the packing rings [4130] and seal cage halves [4134] into the stuffing box as shown in figure 4-24. Always stagger the end gaps 90 degrees to ensure a better seal. To speed installation of each ring, have an assistant turn the pump shaft in one direction. This movement of the shaft will tend to draw the rings into the stuffing box.
e) Now attach the gland [4120] to the cover using studs [6572.2] and nuts [6580.2].
f) Lightly snug up the gland. Final adjustments must be made after the pump has begun operation.

6.9.2.4 Reassembly - Sealmatic with Checkmatic seal

a) Remove any sharpness of edge at wet end of shaft with #400 emery cloth.
b) Clean all exposed surfaces of the wet end of the shaft.
c) Install a shaft guide tool from the Flowserve tool kit (see figure 6-1). Do not lubricate surfaces.
d) Slide one lip seal onto the shaft with a lip facing away from the bearing housing.
e) Position the O-ring [4610.10] over the tail of the lip seal (see section 8-3). Slide it all the way to the bearing housing.
f) Clean all surfaces of the gland, and install the ceramic into the gland.
g) Slide gland/ceramic seat assembly onto the shaft and move it back to the lip seal.
h) Slide a second lip seal onto the shaft, with the lip facing the bearing housing, all the way to the ceramic seat. Position the O-ring [4610.10] over the tail of the lip seal. (See section 8-3.)

i) Reinstall the repeller cover, repeller, rear cover, and impeller as instructed in section 6.9.3.
j) The Checkmatic gland must now be moved forward toward the impeller, pushing the forward lip ahead of it. It is important that the forward lip be firmly loaded against the seat when the gland is seated. Care must be taken to maintain even pressure on both sides of the gland, keeping the lip seal/ceramic seal faces perpendicular to the shaft.
k) Tighten the gland nuts evenly.
l) Finally, the rear lip must be slipped forward and tight against the seat. Care should be taken so as not to damage the seal face.

6.9.2.5 Reassembly - Sealmatic with dry running seal

Component seals will generally require that the wet end is assembled as described in 6.9.3 so that the impeller may be set prior to seal installation. Review the seal assembly instructions and drawings provided by the seal manufacturer. Section 6.9.2.2 contains the general assembly sequences for component seals.

6.9.2.6 Reassembly - Sealmatic with FXP seal

a) Remove any sharpness of edge at wet end of shaft with #400 emery cloth.
b) Clean all exposed surfaces of the wet end of the shaft.
c) Install a shaft guide tool from the Flowserve tool kit. (See figure 6-1.)
d) Insert the O-rings into the grooves on the inside diameter of the seal rotor.
e) Slide the drive collar onto the shaft until it contacts the bearing housing (pins facing away from bearing housing).
f) Lubricate the O-rings and shaft with non-abrasive liquid hand soap and slide the seal rotor onto the shaft until it contacts the rotor drive collar. The notches on the back side of the rotor should face toward the bearing housing.
g) Place repeller cover face down on workbench and set the Teflon disk against the gland surface (i.e. end of stuffing box). Attach gland to repeller cover and screw on gland nuts finger-tight.
h) Reinstall the repeller cover, repeller, rear cover, and impeller as instructed in section 6.9.3.
i) Tighten gland nuts fully. Slide the seal rotor forward until it contacts the Teflon disk. Slide the drive collar forward until its pins are fully engaged in the slots on the back side of the seal rotor.
j) Preload the seal by applying even pressure on the back of the drive collar in order to push it and the seal rotor into the Teflon disk. The rotor and drive collar should be moved approximately 3mm (⅛ in.) into the Teflon disk. Tighten the drive collar setscrews while maintaining pressure on the back of the drive collar.
k) Once the pump is flooded, check the seal to ensure it is not leaking. If the seal leaks, repeat step j) above, applying only enough pressure to the drive collar to stop the leak. Do not over tighten the seal.

6.9.3 Sealmatic pump: installation of repeller cover, repeller, cover, and impeller

Group 2 pumps - see figure in section 8-3.
Group 3 pumps - see figure 6-29.

a) For Group 2 pumps, install the repeller cover to the adapter using capscrews [6570.2].
For Group 3 pumps install the repeller cover [1220.1] over the shaft and push it all the way back until it touches the bearing housing.
b) Install a new repeller O-ring [4610.11] into the repeller groove. Lubricate the O-ring with liquid soap.
c) Install the slip-on repeller [2200.1] onto the shaft.
d) Install the repeller cover/cover gasket [4590.9].
e) For Group 2 pumps, install the cover [1220] to the repeller cover using capscrews [6570.13].
For Group 3 pumps, install the cover [1220] to the adapter. Attach to the adapter using capscrews [6570.2]. Attach the repeller cover to the cover using the capscrews [6570.13].
f) The repeller and impeller may now be set following the instructions given in section 6.6.3.

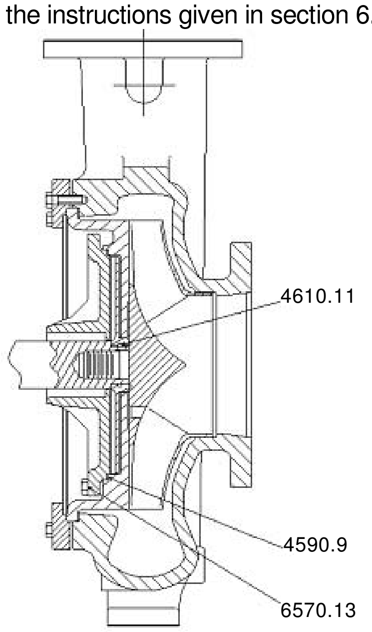


Figure 6-29 - Group 3 Sealmatic

Item	Part name
4610.11	Repeller O-ring
4590.9	Gasket – repeller cover
6570.13	Capscrew

6.9.4 Close coupled final assembly

a) Install the motor adapter [3160] onto the bearing housing using three screws [6570.15].
b) Install unit into casing as described in section 6.9.5.
c) Level the unit with the adjustable support feet [3134]. Eliminate soft foot with by adjusting the support feet and or rotating the motor adapter slightly. Bolt the unit to the baseplate and tighten the support feet set screws [6570.17].
d) Reinstall the motor, coupling and coupling guard.

6.9.5 Reassemble to casing

a) Install a new rear cover gasket [4590.1] between the rear cover plate [1220] and the casing [1100].
b) Use studs [6572.1] and nuts [6580.1] to complete the rebuild of your Flowserve Mark 3 pump.

7 FAULTS; CAUSES AND REMEDIES

The following is a guide to troubleshooting problems with Flowserve Mark 3 pumps. Common problems are analyzed and solutions offered. Obviously, it is impossible to cover every possible scenario. If a problem exists that is not covered by one of the examples, then refer to one of the books listed in section 10, *Additional sources of information,* or contact a Flowserve sales engineer or distributor/representative for assistance.

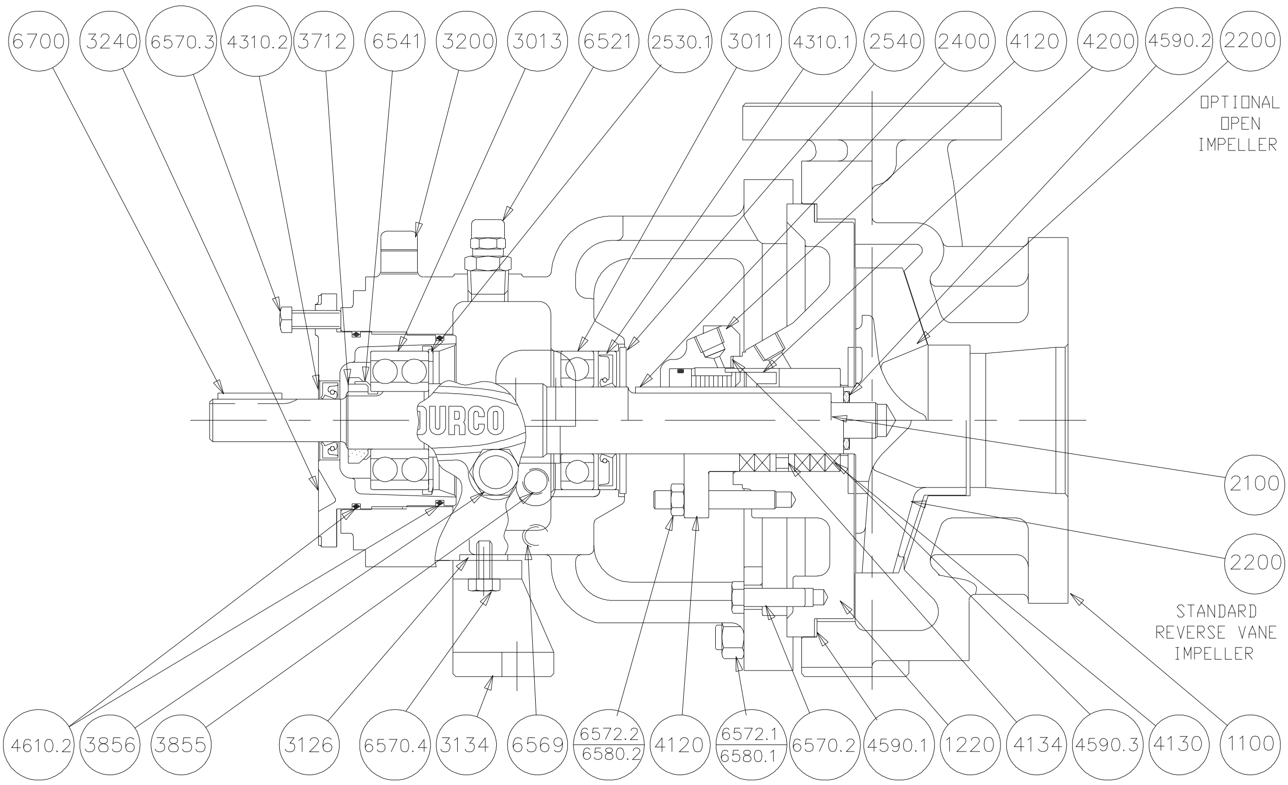
FAULT SYMPTOM

Pump not reaching design flow rate	Pump not reaching design head (TDH)	No discharge or flow with pump running	Pump operates for short period, then loses prime	Excessive noise from wet end	Excessive noise from power end					PROBABLE CAUSES	POSSIBLE REMEDIES
●	●		●	●						Insufficient NPSH. (Noise may not be present.)	Recalculate NPSH available. It must be greater than the NPSH required by pump at desired flow. If not, redesign suction piping, holding number of elbows and number of planes to a minimum to avoid adverse flow rotation as it approaches the impeller.
●	●	●								System head greater than anticipated.	Reduce system head by increasing pipe size and/or reducing number of fittings. Increase impeller diameter. (note: Increasing impeller diameter may require use of a larger motor.)
●	●		●							Entrained air. Air leak from atmosphere on suction side.	1. Check suction line gaskets and threads for tightness. 2. If vortex formation is observed in suction tank, install vortex breaker. 3. Check for minimum submergence
●	●									Entrained gas from process.	Process generated gases may require larger pumps.
●	●									Speed too low.	Check motor speed against design speed.
●	●	●								Direction of rotation wrong.	After confirming wrong rotation, reverse any two of three leads on a three phase motor. The pump should be disassembled and inspected before it is restarted.
●	●									Impeller too small.	Replace with proper diameter impeller. (NOTE: Increasing impeller diameter may require use of a larger motor.)
●	●									Impeller clearance too large.	Reset impeller clearance.
●	●	●								Plugged impeller, suction line or casing which may be due to a product or large solids.	1. Reduce length of fiber when possible. 2. Reduce solids in the process fluid when possible. 3. Consider larger pump.
●	●									Wet end parts (casing cover, impeller) worn, corroded or missing.	Replace part or parts.
	●	●								Not properly primed.	Repeat priming operation, recheck instructions. If pump has run dry, disassemble and inspect the pump before operation.
				●						Impeller rubbing.	1. Check and reset impeller clearance. 2. Check outboard bearing assembly for axial end play.
	●	●								Damaged pump shaft, impeller.	Replace damaged parts.
				●						Abnormal fluid rotation due to complex suction piping.	Redesign suction piping, holding the number of elbows and planes to a minimum to avoid adverse fluid rotation as it approaches the impeller.
					●					Bearing contamination appearing on the raceways as scoring, pitting, scratching or rusting caused by adverse environment and entrance of abrasive contaminants from atmosphere.	1. Work with clean tools in clean surroundings. 2. Remove all outside dirt from housing before exposing bearings. 3. Handle with clean dry hands. 4. Treat a used bearing as carefully as a new one. 5. Use clean solvent and flushing oil. 6. Protect disassembled bearing from dirt and moisture. 7. Keep bearings wrapped in paper or clean cloth while not in use. 8. Clean inside of housing before replacing bearings. 9. Check oil seals and replace as required. 10. Check all plugs and tapped openings to make sure that they are tight.

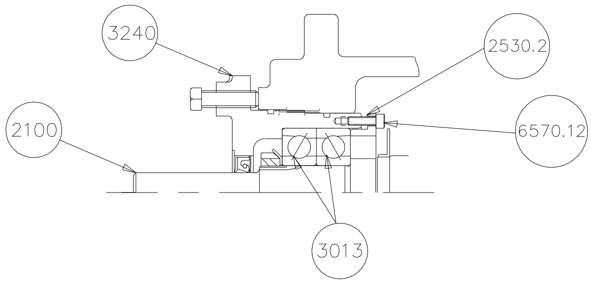
Pump not reaching design flow rate	Pump not reaching design head (TDH)	No discharge or flow with pump running	Pump operates for short period, then loses prime	Excessive noise from wet end	Excessive noise from power end					PROBABLE CAUSES	POSSIBLE REMEDIES
					●					Brinelling of bearing identified by indentation on the ball races, usually caused by incorrectly applied forces in assembling the bearing or by shock loading such as hitting the bearing or drive shaft with a hammer.	When mounting the bearing on the drive shaft use a proper size ring and apply the pressure against the inner ring only. Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.
					●					False brinelling of bearing identified again by either axial or circumferential indentations usually caused by vibration of the balls between the races in a stationary bearing.	1. Correct the source of vibration. 2. Where bearings are oil lubricated and employed in units that may be out of service for extended periods, the drive shaft should be turned over periodically to relubricate all bearing surfaces at intervals of one to three months.
					●					Thrust overload on bearing identified by flaking ball path on one side of the outer race or in the case of maximum capacity bearings, may appear as a spalling of the races in the vicinity of the loading slot. (Please note: maximum capacity bearings are not recommended in Mark 3 pumps.) These thrust failures are caused by improper mounting of the bearing or excessive thrust loads.	Follow correct mounting procedures for bearings.
					●					Misalignment identified by fracture of ball retainer or a wide ball path on the inner race and a narrower cocked ball path on the outer race. Misalignment is caused by poor mounting practices or defective drive shaft. For example, bearing not square with the centerline or possibly a bent shaft due to improper handling.	Handle parts carefully and follow recommended mounting procedures. Check all parts for proper fit and alignment.
					●					Bearing damaged by electric arcing identified as electro- etching of both inner and outer ring as a pitting or cratering. Electrical arcing is caused by a static electrical charge emanating from belt drives, electrical leakage or short circuiting.	1. Where current shunting through the bearing cannot be corrected, a shunt in the form of a slip ring assembly should be incorporated. 2. Check all wiring, insulation and rotor windings to be sure that they are sound and all connections are properly made. 3. Where pumps are belt driven, consider the elimination of static charges by proper grounding or consider belt material that is less generative.
					●					Bearing damage due to improper lubrication, identified by one or more of the following: 1. Abnormal bearing temperature rise. 2. A stiff cracked grease appearance. 3. A brown or bluish discoloration of the bearing races.	1. Be sure the lubricant is clean. 2. Be sure proper amount of lubricant is used. The constant level oiler supplied with Durco pumps will maintain the proper oil level if it is installed and operating properly. In the case of greased lubricated bearings, be sure that there is space adjacent to the bearing into which it can rid itself of excessive lubricant, otherwise the bearing may overheat and fail prematurely. 3. Be sure the proper grade of lubricant is used.

8 PARTS LIST AND DRAWINGS

8.1 Standard Mark 3 pump, Group 1

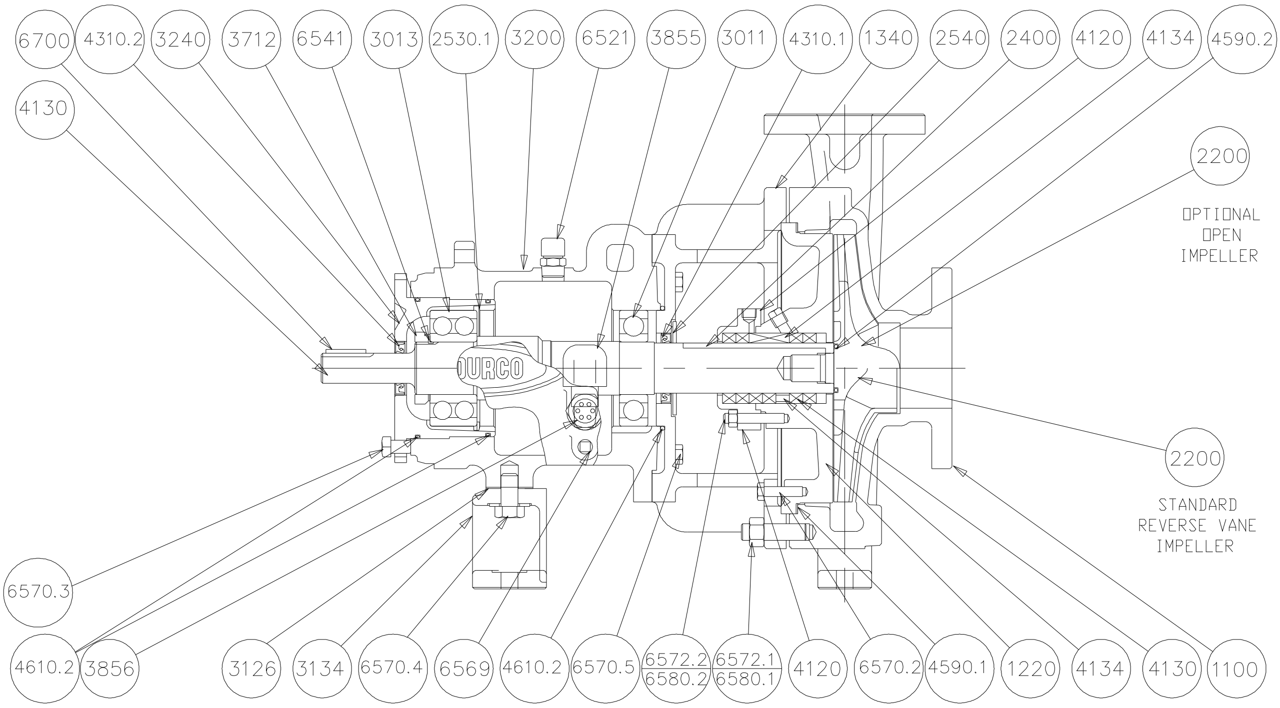


Optional duplex arrangement

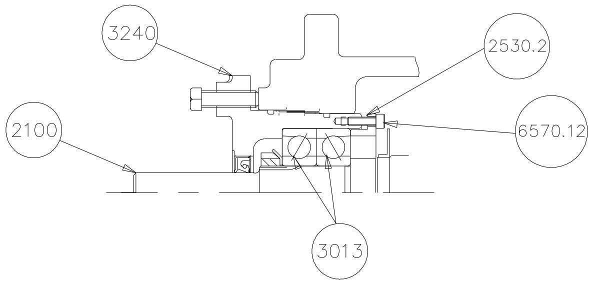


Item	Description				
1100	Casing	3200	Bearing housing	4610.2	O-ring - bearing carrier
1220	Cover	3240	Bearing carrier	6521	Plug - bearing housing vent
1340	Adapter - bearing housing	3712	Bearing locknut	6541.1	Lockwasher - bearing
2100	Shaft	3855	Constant level oiler (not shown)	6569.1	Plug - bearing housing drain
2200	Impeller	3856	Sight gage - bearing housing	6570.12	Screw - clamp
2400	Sleeve, optional	4120	Gland	6570.2	Screw - cover/adapter
2530.1	Retaining ring - bearing	4130	Packing - optional	6570.3	Screw - bearing carrier set
2530.2	Retaining ring - clamp type	4134	Seal cage – packing optional,	6570.4	Screw - foot
2540	Deflector - inboard optional	4200	Mechanical seal	6570.5	Screw - bearing housing
2541	Oil flinger - optional	4310.1	Oil seal inboard	6572.1	Stud - casing
3011	Ball bearing - inboard	4310.2	Oil seal outboard	6572.2	Stud - gland
3013	Ball bearing - outboard	4590.1	Gasket - cover	6580.1	Nut - casing
3126.1	Shim	4590.2	Gasket - impeller	6580.2	Nut - gland
3134	Support foot	4590.3	Gasket - Gland	6700	Key - shaft/coupling
		4610.1	O-ring - adapter		

8.2 Standard Mark 3 pump, Group 2 and Group 3

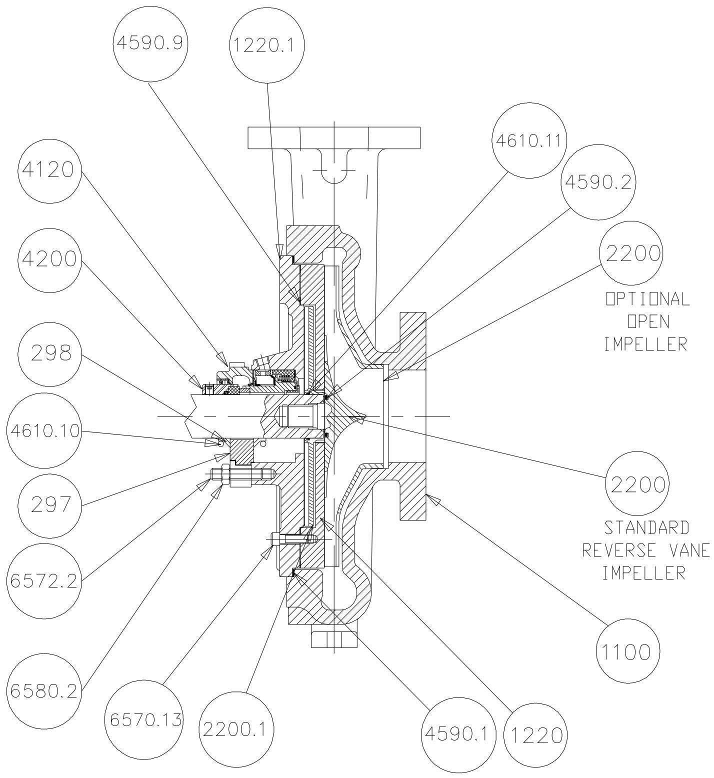


Group 2 Optional duplex bearing arrangement
Group 3 Standard bearing clamp arrangement



Item	Description	3200	Bearing housing	4610.2	O-ring - bearing carrier
1100	Casing	3240	Bearing carrier	6521	Plug - bearing housing vent
1220	Cover	3712	Bearing locknut	6541.1	Lockwasher - bearing
1340	Adapter - bearing housing	3855	Constant level oiler (not shown)	6569.1	Plug - bearing housing drain
2100	Shaft	3856	Sight gage - bearing housing	6570.12	Screw - clamp
2200	Impeller	4120	Gland	6570.2	Screw - cover/adapter
2400	Sleeve, optional	4130	Packing - optional	6570.3	Screw - bearing carrier set
2530.1	Retaining ring - bearing	4134	Seal cage – packing optional,	6570.4	Screw - foot
2530.2	Retaining ring - clamp type	4200	Mechanical seal	6570.5	Screw - bearing housing
2540	Deflector - inboard optional	4310.1	Oil seal inboard	6572.1	Stud - casing
2541	Oil flinger - optional	4310.2	Oil seal outboard	6572.2	Stud - gland
3011	Ball bearing - inboard	4590.1	Gasket - cover	6580.1	Nut - casing
3013	Ball bearing - outboard	4590.2	Gasket - impeller	6580.2	Nut - gland
3126.1	Shim	4590.3	Gasket - gland	6700	Key - shaft/coupling
3134	Support foot	4610.1	O-ring - adapter		

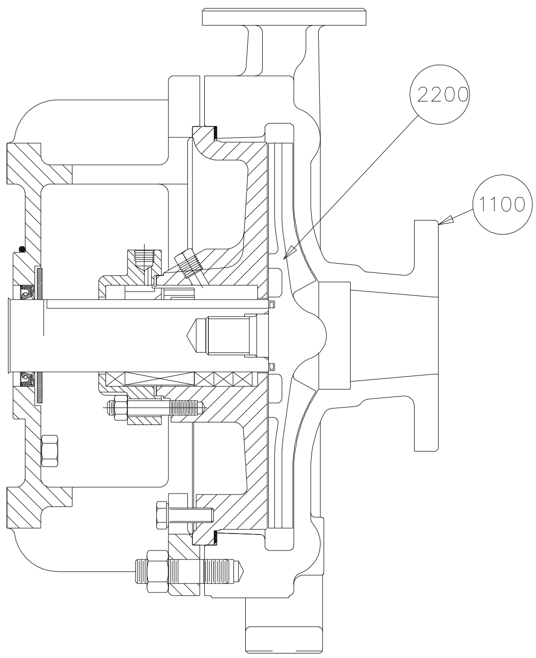
8.3 Mark 3 Sealmatic pump, Group 2



Item	Description
297	Seat
298	Lipseal
1100	Casing
1220	Cover
1220.1	Cover - repeller
2200	Impeller
2200.1	Repeller
4120	Gland
4200	Mechanical seal
4590.1	Gasket – cover
4590.2	Gasket – impeller
4590.9	Gasket – repeller cover
4610.10	O-ring - lipseal
4610.11	O-ring - repeller
6570.13	Screw – repeller cover
6572.2	Stud - gland
6580.2	Nut - gland

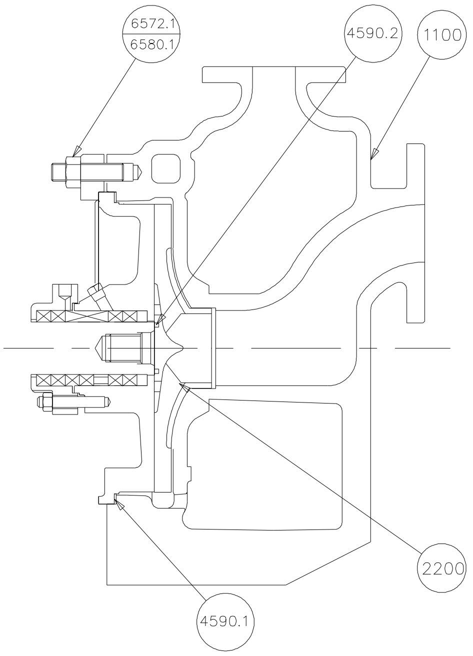
Notes:
See figure 6-30, GP3 Sealmatic wet end.

8.4 Mark 3 Lo-Flo, Group 2

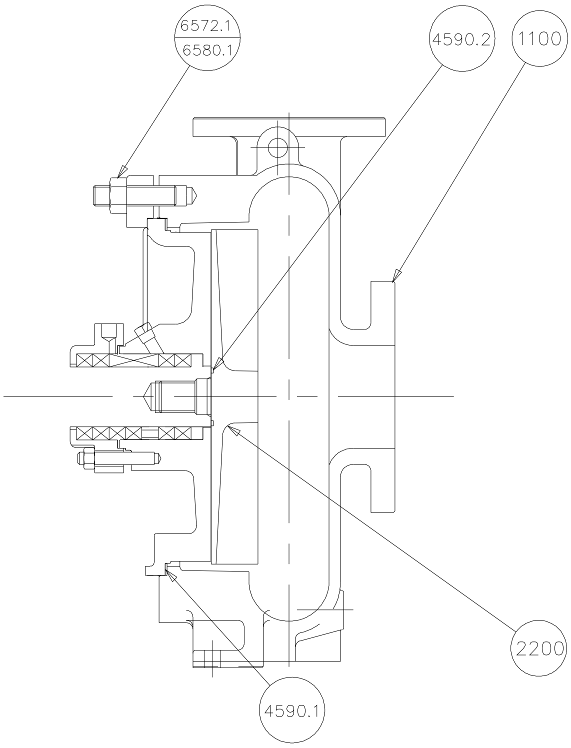


Item	Description
1100	Casing
1220	Cover

8.5 Mark 3 Unitized Self Priming pump, Group 2

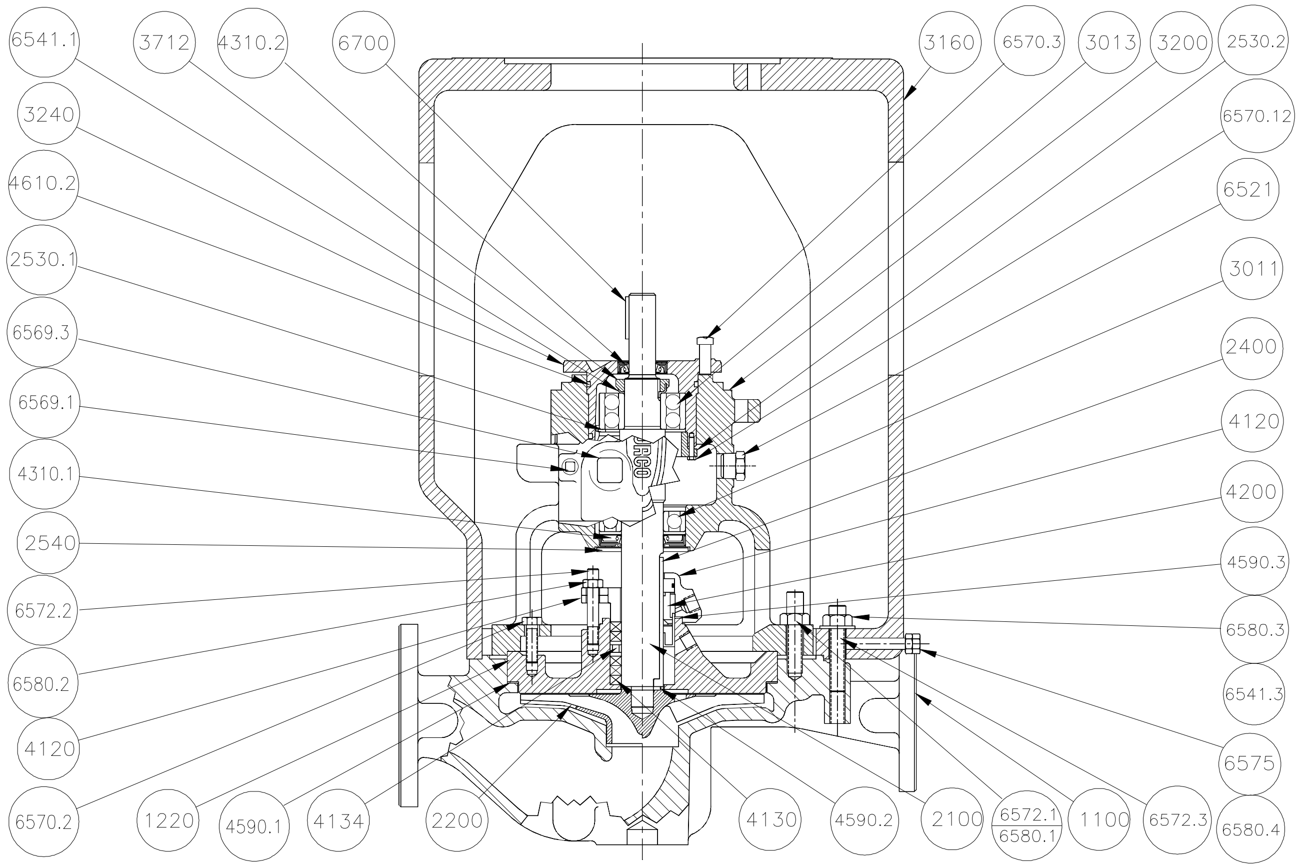


8.6 Mark 3 Recessed Impeller pump, Group 2



Item	Description
1100	Casing
2200	Impeller
4590.1	Gasket – cover
4590.2	Gasket - impeller
6572.1	Stud - casing
6580.1	Nut - casing

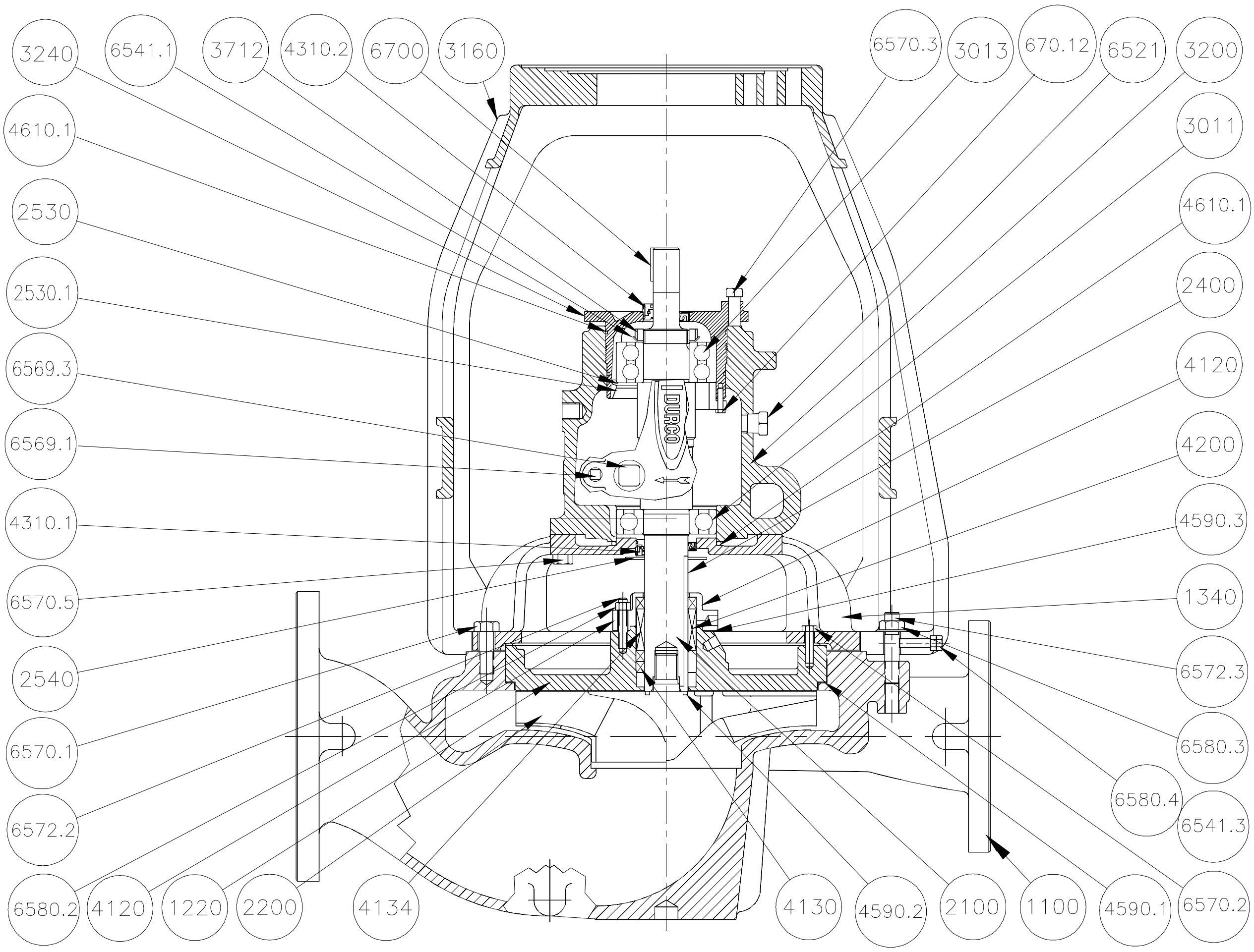
8.7 Mark 3 In-Line pump, Group 1



Item	**Description**	4120	Gland	6570.3	Screw - bearing carrier set
1100	Casing	4130	Packing - optional	6570.12	Screw - clamp
1220	Cover	4134	Seal cage – packing optional,	6570.15*	Screw – pump stand
2100	Shaft	4200	Mechanical seal	6572.1	Stud - casing
2200	Impeller	4310.1	Oil seal inboard	6572.2	Stud - gland
2400	Sleeve, optional	4310.2	Oil seal outboard	6572.3	Stud – pedestal casing
2530.1	Retaining ring - bearing	4590.1	Gasket - cover	6575	Jackscrew
2530.2	Retaining ring - clamp type	4590.2	Gasket - impeller	6580.1	Nut - casing
2540	Deflector - inboard optional	4590.3	Gasket - Gland	6580.2	Nut - gland
3011	Ball bearing - inboard	4610.2	O-ring - bearing carrier	6580.3	Nut – pedestal casing
3013	Ball bearing - outboard	6521	Plug - bearing housing vent	6580.4	Nut – jackscrew jam nut
3160	Motor pedestal	6541.1	Lockwasher - bearing	6700	Key - shaft/coupling
3170*	Pump stand	6541.3	Washer		
3200	Bearing housing	6569.1	Plug		
3240	Bearing carrier	6569.3	Plug – sight gage		
3712	Bearing locknut	6570.2	Screw - cover/adapter		

* Not shown

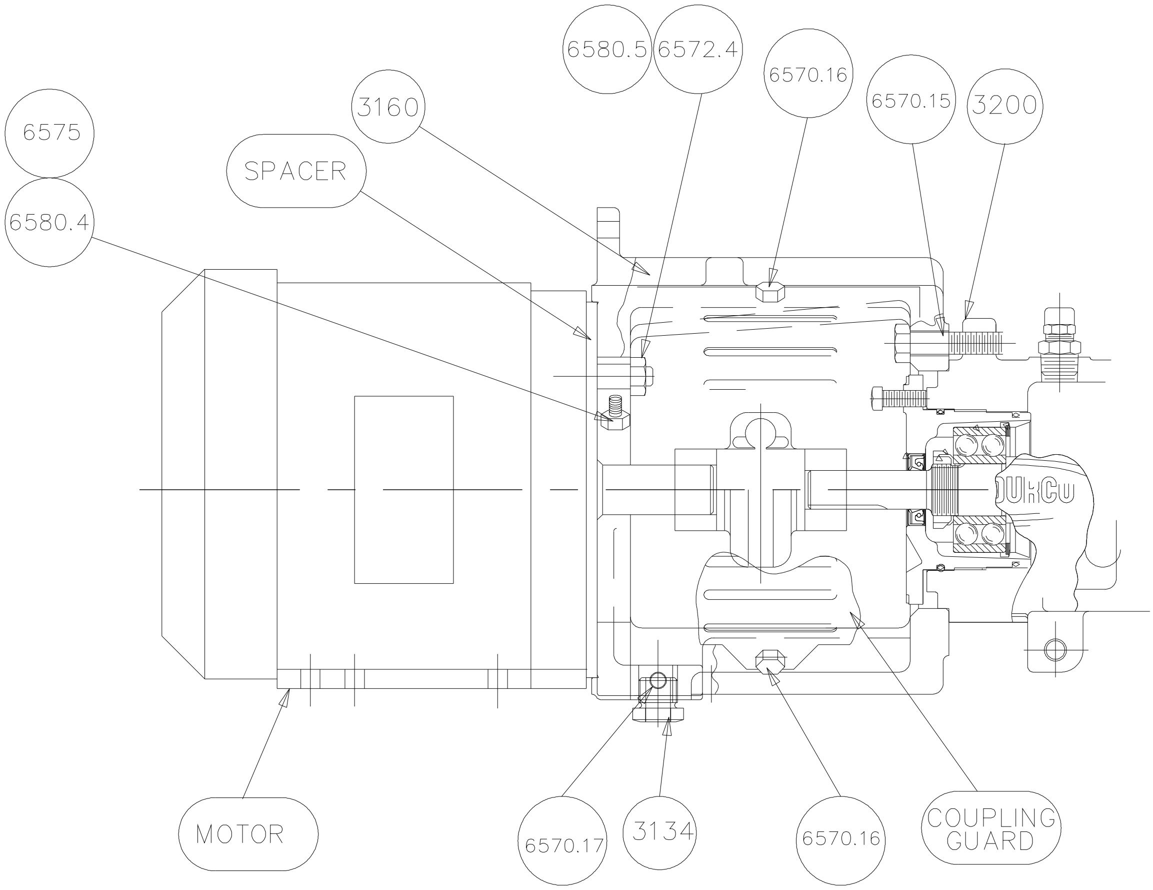
8.8 Mark 3 In-Line pump, Group 2



Item	Description	3712	Bearing locknut	6569.3	Plug – sight gage
1100	Casing	4120	Gland	6570.1	Screw - casing
1220	Cover	4130	Packing - optional	6570.2	Screw - cover/adapter
1340	Adapter - bearing housing	4134	Seal cage – packing optional,	6570.3	Screw - bearing carrier set
2100	Shaft	4200	Mechanical seal	6570.5	Screw - bearing housing
2200	Impeller	4310.1	Oil seal inboard	6570.12	Screw - clamp
2400	Sleeve, optional	4310.2	Oil seal outboard	6570.15*	Screw – pump stand
2530.1	Retaining ring - bearing	4590.1	Gasket - cover	6572.2	Stud - gland
2530.2	Retaining ring - clamp type	4590.2	Gasket - impeller	6572.3	Stud – pedestal casing
2540	Deflector - inboard optional	4590.3	Gasket - gland	6575	Jackscrew
3011	Ball bearing - inboard	4610.1	O-ring - adapter	6580.2	Nut - gland
3013	Ball bearing - outboard	4610.2	O-ring - bearing carrier	6580.3	Nut – pedestal casing
3160	Motor pedestal	6521	Plug - bearing housing vent	6580.4	Nut – jackscrew jam nut
3170*	Pump stand	6541.1	Lockwasher - bearing	6700	Key - shaft/coupling
3200	Bearing housing	6541.3	Washer		
3240	Bearing carrier	6569.1	Plug		

* Not shown

8.9 Mark 3 C-Face Adapter, Group 1 and Group 2



Item	Description	6570.17	Screw – foot set screw
3134	Support foot	6572.4	Stud - motor
3160	Motor pedestal – C-Face	6575	Jackscrew
3200	Bearing housing	6580.4	Nut - jackscrew
6570.15	Screw – bearing housing	6580.5	Nut - motor
6570.16	Screw – coupling guard		

8.10 General arrangement drawing

The typical general arrangement drawing and any specific drawings required by the contract will be sent to the Purchaser separately unless the contract specifically calls for these to be included into the User Instructions. If required, copies of other drawings sent separately to the Purchaser should be obtained from the Purchaser and retained with these User Instructions.

9 CERTIFICATION

Certificates, determined from the contract requirements are provided with these instructions where applicable. Examples are certificates for CE marking and ATEX marking etc. If required, copies of other certificates sent separately to the Purchaser should be obtained from Purchaser for retention with these User Instructions.

10 OTHER RELEVANT DOCUMENTATION AND MANUALS

10.1 Supplementary User Instructions

Supplementary instructions such as for a driver, instrumentation, controller, seals, sealant systems etc are provided as separate documents in their original format. If further copies of these are required they should be obtained from the supplier for retention with these User Instructions.

10.2 Change notes

If any changes, agreed with Flowserve Pump Division, are made to the product after it is supplied, a record of the details should be maintained with these User Instructions.

10.3 Additional sources of information

The following are excellent sources for additional information on Flowserve Mark 3 pumps, and centrifugal pumps in general.

Pump Engineering Manual
R.E. Syska, J.R. Birk,
Flowserve Corporation, Dayton, Ohio, 1980.

Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process, ASME B73.1M
The American Society of Mechanical Engineers,
New York, NY.

Specification for Vertical In-Line Centrifugal Pumps for Chemical Process, ASME B73.2M
The American Society of Mechanical Engineers,
New York, NY.

American National Standard for Centrifugal Pumps for Nomenclature, Definitions, Design and Application (ANSI/HI 1.1-1.3)
Hydraulic Institute, 9 Sylvan Way, Parsippany,
New Jersey 07054-3802.

American National Standard for Vertical Pumps for Nomenclature, Definitions, Design and Application (ANSI/HI 2.1-2.3)
Hydraulic Institute, 9 Sylvan Way, Parsippany,
New Jersey 07054-3802.

American National Standard for Centrifugal Pumps for Installation, Operation, and Maintenance (ANSI/HI 1.4)
Hydraulic Institute, 9 Sylvan Way, Parsippany,
New Jersey 07054-3802.

Flowserve Durco Pump Parts Catalog.

Flowserve Mark 3 Sales Bulletin.

Flowserve Mark 3 Technical Bulletin (P-10-501).

RESP73H Application of ASME B73.1M-1991, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process, Process Industries Practices
Construction Industry Institute, The University of Texas at Austin, 3208 Red River Street, Suite 300, Austin, Texas 78705.

Pump Handbook
2nd edition, Igor J. Karassik et al, McGraw-Hill, Inc.,
New York, NY, 1986.

Centrifugal Pump Sourcebook
John W. Dufour and William E. Nelson,
McGraw-Hill, Inc., New York, NY, 1993.

Pumping Manual, 9th edition
T.C. Dickenson, Elsevier Advanced Technology,
Kidlington, United Kingdom, 1995.

Notes:

Your Flowserve factory contacts:

Flowserve Pump Division
3900 Cook Boulevard
Chesapeake, VA 23323-1626 USA

Telephone +1 757 485 8000
Fax +1 757 485 8149

Flowserve Pumps Limited
PO Box 17, Newark, Notts NG24 3EN
United Kingdom

Telephone (24 hours) +44 (0)1636 494 600
Sales & Admin Fax +44 (0)1636 705 991
Repair & Service Fax +44 (0)1636 494 833
E.mail inewark@flowserve.com

Your local Flowserve representative:

To find your local Flowserve representative please use the Sales Support Locator System found at www.flowserve.com

FLOWSERVE REGIONAL SALES OFFICES:

USA and Canada
Flowserve Corporation
5215 North O'Connor Blvd.,
Suite 2300
Irving, Texas 75039-5421, USA
Telephone +1 972 443 6500
Fax +1 972 443 6800

Europe, Middle East, Africa
Worthing S.P.A.
Flowserve Corporation
Via Rossini 90/92
20033 Desio (Milan), Italy
Telephone +39 0362 6121
Fax +39 0362 303 396

Latin America and Caribbean
Flowserve Corporation
6840 Wynnwood Lane
Houston, Texas 77008, USA
Telephone +1 713 803 4434
Fax +1 713 803 4497

Asia Pacific
Flowserve Pte. Ltd
200 Pandan Loop #06-03/04
Pantech 21
Singapore 128388
Telephone +65 6775 3003
Fax +65 6779 4607

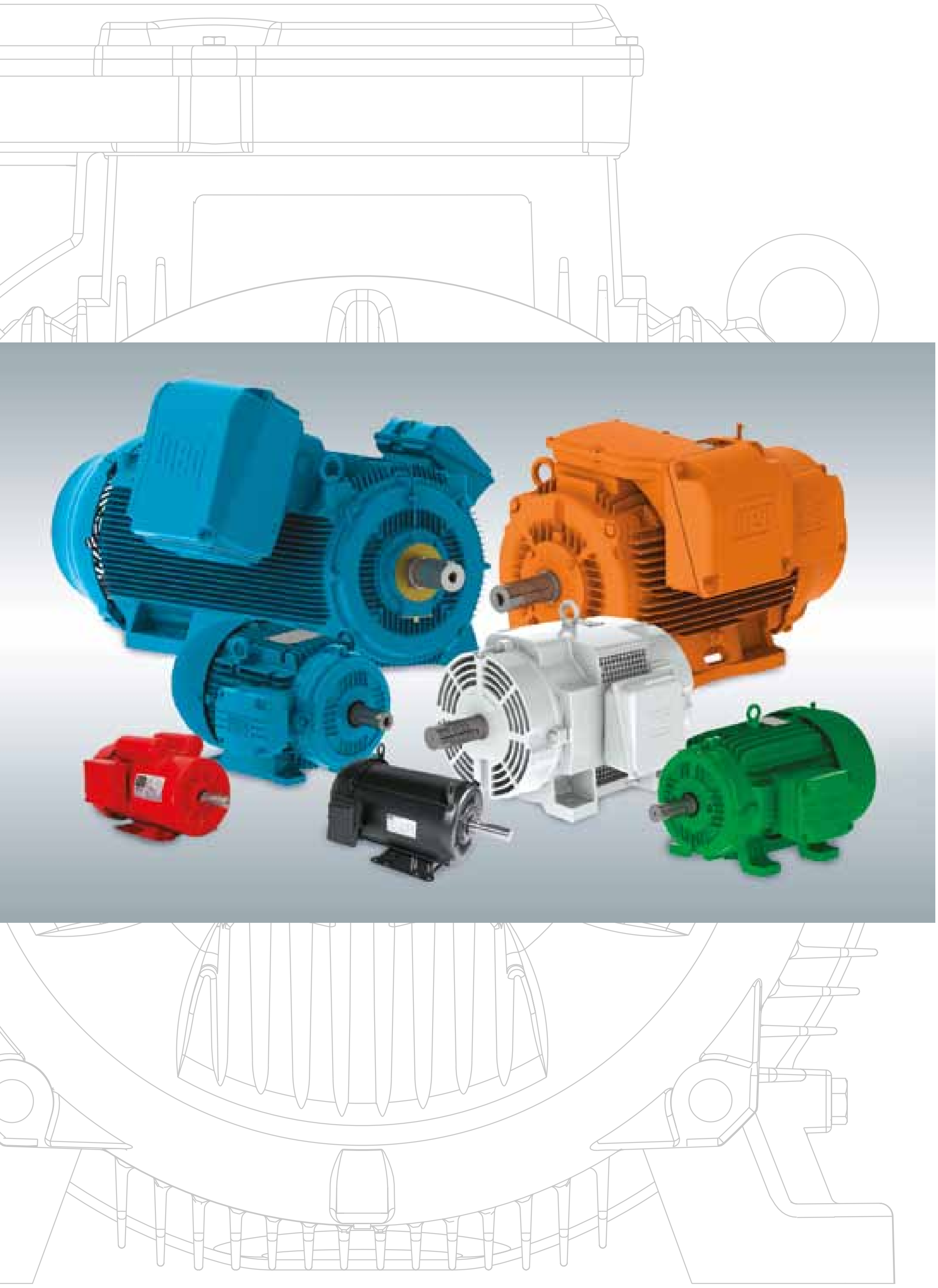
PUMPS • VALVES & ACTUATORS
MECHANICAL SEALS • PROCESS EQUIPMENT

POWER & MINE SUPPLY CO. LTD

Section 3
Motor IO&M

Winnipeg: 4 – 75 Meridian Drive, Winnipeg MB R2R 2V9 • **Phone** (204) 694-9300 • **Fax** (204) 694-7876
Saskatoon: 901 First Avenue, Saskatoon SK S7K 1Y4 •**Phone** (306) 244-7274 • **Fax** (306) 244-9911
Regina: 306 – 845 Broad Street, Regina SK S4R 8G9 • **Phone** (306) 791-0417 • **Fax** (306) 791-0418
Thunder Bay: 675 Harold Crescent, Thunder Bay ON P7C 5H6 • **Phone** (807) 622-4044 •**Fax** (807) 622-3235

Installation, Operation and Maintenance Manual of Electric Motors



Installation, Operation and Maintenance Manual of Electric Motors

This manual provides information about WEG induction motors fitted with squirrel cage, permanent magnet or hybrid rotors, low and high voltage, in frame size IEC 56 to 630 and NEMA 42 to 9606/10.
The motor lines indicated below have additional information that can be checked in their respective manuals:

- Smoke Extraction Motors;
- Electromagnetic Brake Motors;
- Hazardous Area Motors.

These motors meet the following standards, if applicable:

- NBR 17094-1: Máquinas Elétricas Girantes - Motores de Indução - Parte 1:
  - Trifásicos
- NBR 17094-2: Máquinas Elétricas Girantes - Motores de Indução - Parte 1:
  - Monofásicos
- IEC 60034-1: Rotating Electrical Machines - Part 1:
  - Rating and Performance
- NEMA MG 1: Motors and Generators
- CSA C 22.2 N°100: Motors and Generators
- UL 1004-1: Rotating Electrical Machines – General Requirements

If you have any questions regarding this material please contact your local WEG branch, contact details can be found at www.weg.net.

TABLE OF CONTENTS

ENGLISH

1. TERMINOLOGY

Balancing: the procedure by which the mass distribution of a rotor is checked and, if necessary, adjusted to ensure that the residual unbalance or the vibration of the journals and/or forces on the bearings at a frequency corresponding to service speed are within specified limits in International Standards.
[ISO 1925:2011, definition 4.1]

Balance quality grade: indicates the peak velocity amplitude of vibration, given in mm/s, of a rotor running free-in-space and it is the product of a specific unbalance and the angular velocity of the rotor at maximum operating speed.

Grounded Part: metallic part connected to the grounding system.

Live Part: Conductor or conductive part intended to be energized in normal operation, including a neutral conductor.

Authorized personnel: employee who has formal approval of the company.

Qualified personnel: employee who meets the following conditions simultaneously:
- Receives training under the guidance and responsibility of a qualified and authorized professional;
- Works under the responsibility of a qualified and approved professional.

Note*: The qualification is only valid for the company that trained the employee in the conditions set out by the authorized and qualified professional responsible for training.*

2. INITIAL RECOMMENDATIONS

Electric motors have energized circuits, exposed rotating parts and hot surfaces that may cause serious injury to people during normal operation. Therefore, it is recommended that transportation, storage, installation, operation and maintenance services are always performed by qualified personnel.
Also the applicable procedures and relevant standards of the country where the machine will be installed must be considered.
Noncompliance with the recommended procedures in this manual and other references on the WEG website may cause severe personal injuries and/or substantial property damage and may void the product warranty.

For practical reasons, it is not possible to include in this Manual detailed information that covers all construction variables nor covering all possible assembly, operation or maintenance alternatives.
This Manual contains only the required information that allows qualified and trained personnel to carry out their services. The product images are shown for illustrative purpose only.

For *Smoke Extraction Motors*, please refer to the additional instruction manual 50026367 available on the website www.weg.net.

For brake motors, please refer to the information contained in WEG 50006742 / 50021973 brake motor manual available on the website www.weg.net.

The user is responsible for the correct definition of the installation environment and application characteristics.

During the warranty period, all repair, overhaul and reclamation services must be carried out by WEG authorized Service Centers to maintain validity of the warranty.

2.1. WARNING SYMBOL

During the warranty period, all repair, overhaul and reclamation services must be carried out by WEG authorized Service Centers to maintain validity of the warranty.

2.2. RECEIVING INSPECTION

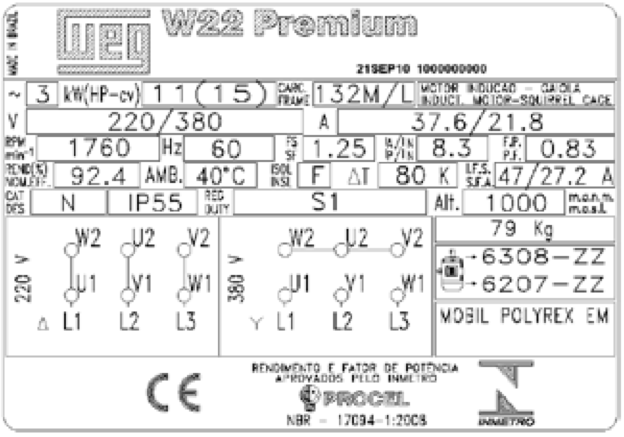
All motors are tested during the manufacturing process.
The motor must be checked when received for any damage that may have occurred during the transportation.
All damages must be reported in writing to the transportation company, to the insurance company and to WEG. Failure to comply with such procedures will void the product warranty.
You must inspect the product:

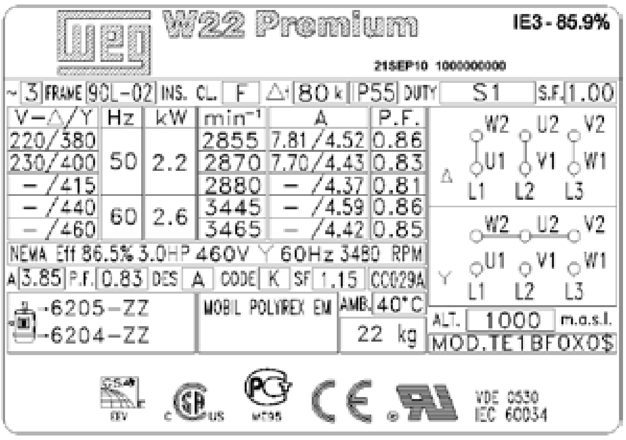
- Check if nameplate data complies with the purchase order;
- Remove the shaft locking device (if any) and rotate the shaft by hand to ensure that it rotates freely.
- Check that the motor has not been exposed to excessive dust and moisture during the transportation.

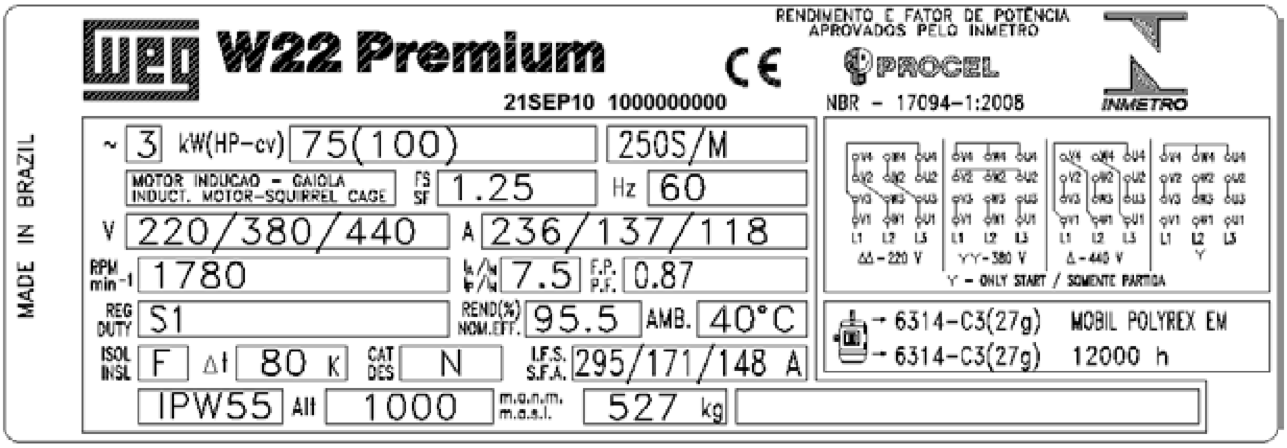
Do not remove the protective grease from the shaft, or the plugs from the cable entries. These protections must remain in place until the installation has been completed.

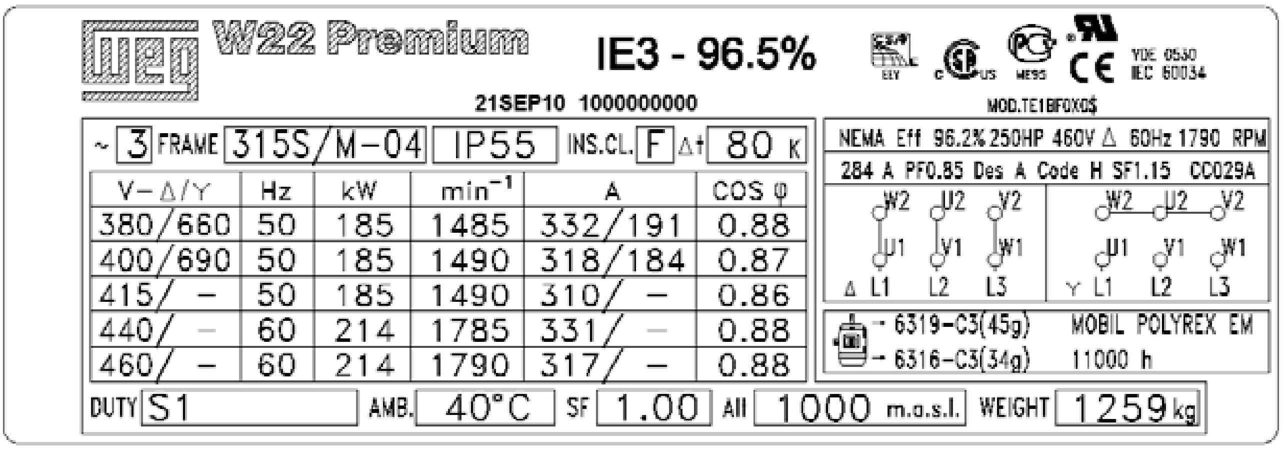
2.3. NAMEPLATES

The nameplate contains information that describes the construction characteristics and the performance of the motor. Figure 2-1 and Figure 2-2 show nameplate layout examples.









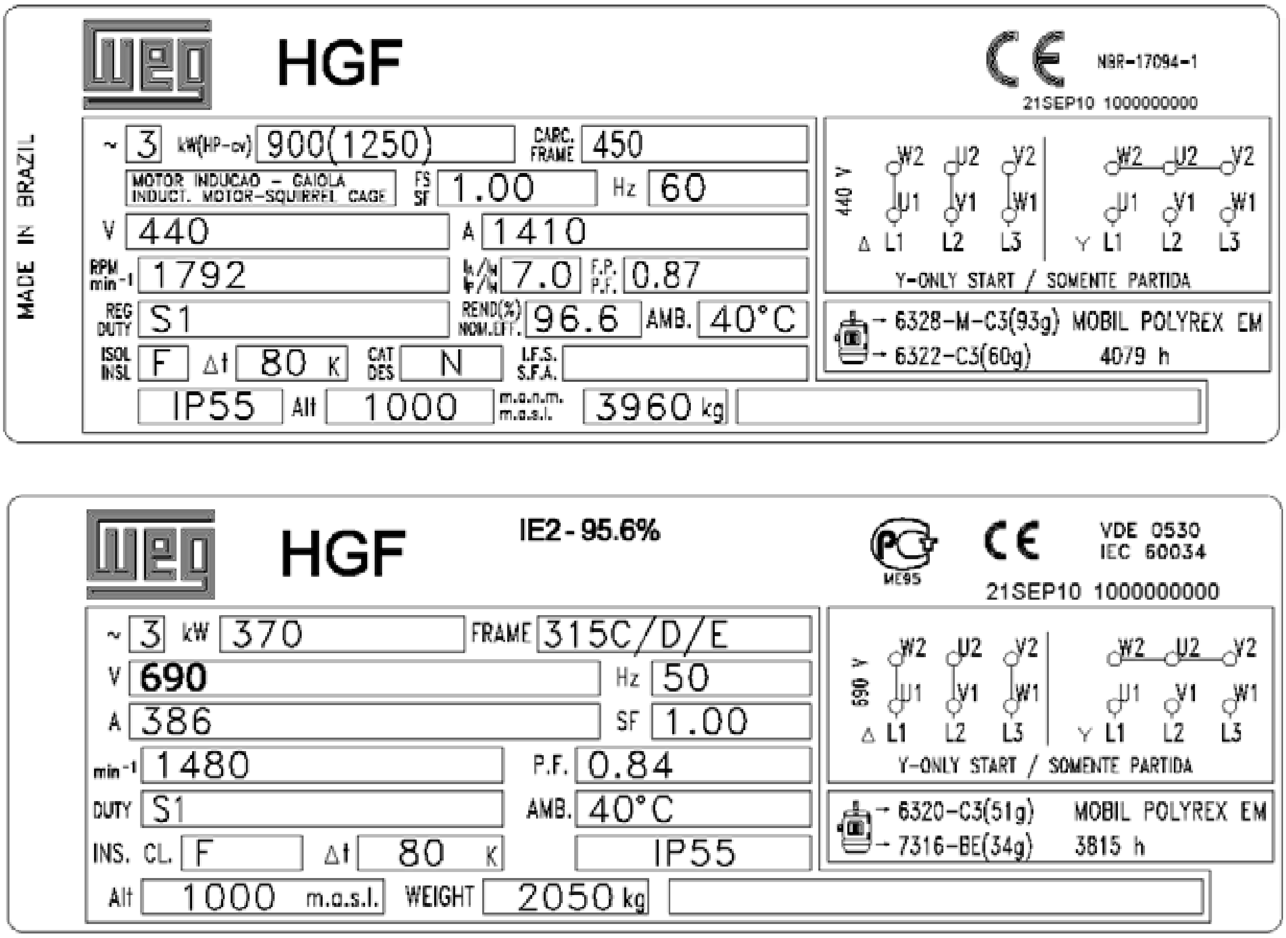
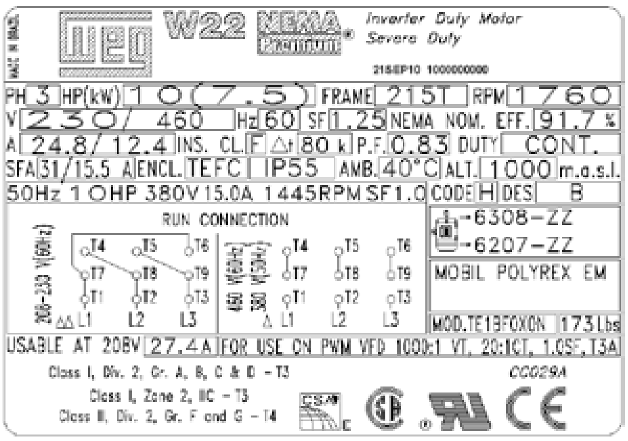
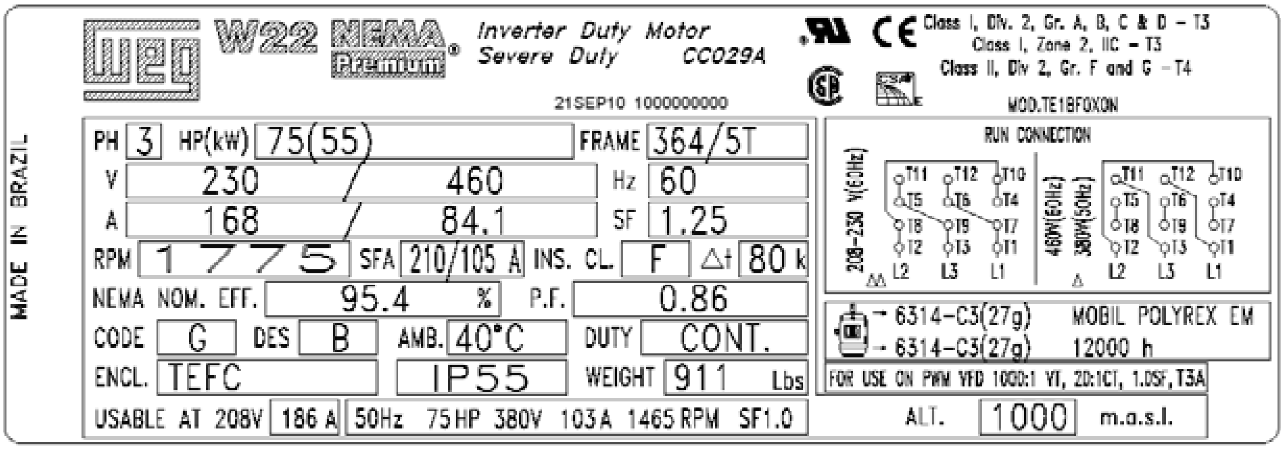


Figure 2-1 – IEC motor nameplate



ENGLISH



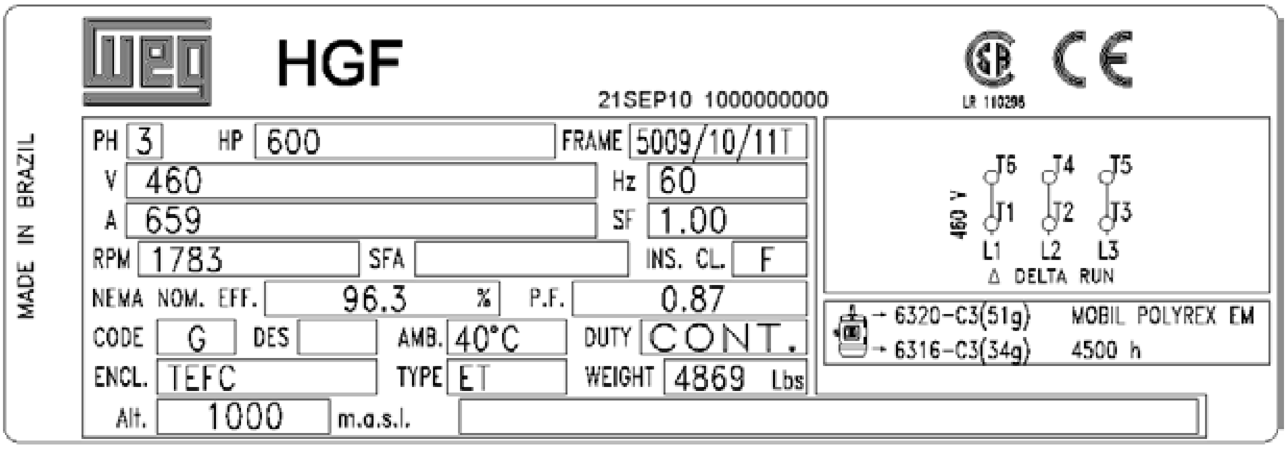


Figure 2-2 *– IEC motor nameplate*

ENGLISH

3. SAFETY INSTRUCTIONS

The motor must be disconnected from the power supply and be completely stopped before conducting any installation or maintenance procedures. Additional measures should be taken to avoid accidental motor starting.

Professionals working with electrical installations, either in the assembly, operation or maintenance, should use proper tools and be instructed on the application of standards and safety requirements, including the use of Personal Protective Equipment (PPE) that must be carefully observed in order to reduce risk of personal injury during these services.

Electric motors have energized circuits, exposed rotating parts and hot surfaces that may cause serious injury to people during normal operation. It is recommended that transportation, storage, installation, operation and maintenance services are always performed by qualified personnel.

Always follow the safety, installation, maintenance and inspection instructions in accordance with the applicable standards in each country.

4. HANDLING AND TRANSPORT

Individually packaged motors should never be lifted by the shaft or by the packaging. They must be lifted only by means of the eyebolts, when supplied. Use always suitable lifting devices to lift the motor. Eyebolts on the frame are designed for lifting the machine weight only as indicated on the motor nameplate. Motors supplied on pallets must be lifted by the pallet base.

The package should never be dropped. Handle it carefully to avoid bearing damage.

Eyebolts provided on the frame are designed for lifting the machine only. Do not use these eyebolts for lifting the motor with coupled equipment such as bases, pulleys, pumps, reducers, etc.

Never use damaged, bent or cracked eyebolts. Always check the eyebolt condition before lifting the motor.

Eyebolts mounted on components, such as on end shields, forced ventilation kits, etc. must be used for lifting these components only. Do not use them for lifting the complete machine set.

Handle the motor carefully without sudden impacts to avoid bearing damage and prevent excessive mechanical stresses on the eyebolts resulting in its rupture.

To move or transport motors with cylindrical roller bearings or angular contact ball bearings, use always the shaft locking device provided with the motor.
All HGF motors, regardless of bearing type, must be transported with shaft locking device fitted.

4.1. LIFTING

Before lifting the motor ensure that all eyebolts are tightened properly and the eyebolt shoulders are in contact with the base to be lifted, as shown in Figure 4-1. Figure 4-2 shows an incorrect tightening of the eyebolt.
Ensure that lifting machine has the required lifting capacity for the weight indicated on the motor nameplate.

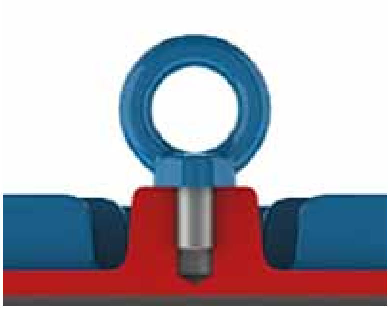


Figure 4-1 *– Correct tightening of the eyebolt*

Figure 4-2 *– Incorrect tightening of the eyebolt*

The center-of-gravity may change depending on motor design and accessories. During the lifting procedures the maximum allowed angle of inclination should never be exceeded as specified below.

4.1.1. Horizontal motors with one eyebolt

For horizontal motors fitted with only one eyebolt, the maximum allowed angle-of-inclination during the lifting process should not exceed 30º in relation to the vertical axis, as shown in Figure 4-3.

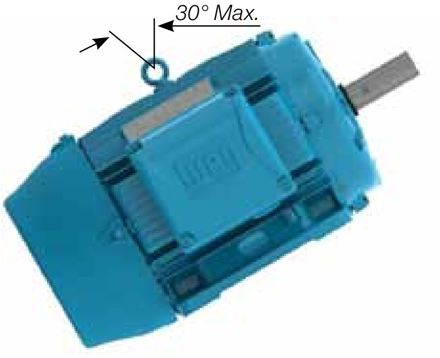


Figure 4-3 *– Maximum allowed angle-of-inclination for motor with one eyebolt*

ENGLISH

4.1.2. Horizontal motor with two eyebolts

When motors are fitted with two or more eyebolts, all supplied eyebolts must be used simultaneously for the lifting procedure.

There are two possible eyebolt arrangements (vertical and inclined), as shown below:

- For motors with vertical lifting eyebolts, as shown in Figure 4-4, the maximum allowed lifting angle should not exceed 45° in relation to the vertical axis. We recommend to use a spreader bar for maintaining the lifting elements (chain or rope) in vertical position and thus preventing damage to the motor surface.

Figure 4-4 *– Maximum resulting angle for motors with two or more lifting eyebolts*

- For HGF motors, as shown in Figure 4-5, the maximum resulting angle should not exceed 30° in relation to the vertical axis.

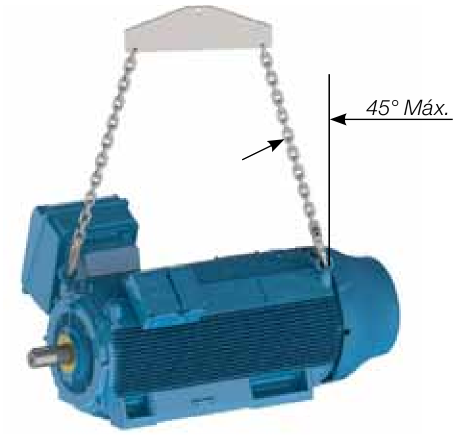


Figure 4-5 *– Maximum resulting angle for horizontal HGF motors*

- For motors fitted with inclined eyebolts, as shown in Figure 4-6, the use of a spreader bar is required for maintaining the lifting elements (chain or rope) in vertical position and thus preventing damage to the motor surface.

Figure 4-6 *– Use of a spreader bar for lifting*

ENGLISH

4.1.3. Vertical Motors

For vertical mounted motors, as shown in Figure 4-7, the use of a spreader bar is required for maintaining the lifting element (chain or rope) in vertical position and thus preventing damage to the motor surface.

Figure 4-7 *– Lifting of vertical mounted motors*

Use always the eyebolts mounted on the top side of the motor, diametrically opposite, considering the mounting position. See Figure 4-8.

Figure 4-8 *– Lifting of HGF motors*

4.1.3.1. Procedures to place W22 motors in the vertical position

For safety reasons during the transport, vertical mounted Motors are usually packed and supplied in horizontal position.
To place W22 motors fitted with eyebolts (see Figure 4-6), to the vertical position, proceed as follows:

1. Ensure that the eyebolts are tightened properly, as shown in Figure 4-1;
2. Remove the motor from the packaging, using the top mounted eyebolts, as shown in Figure 4-9;

Figure 4-9 *– Removing the motor from the packaging*

3. Install a second pair of eyebolts, as shown in Figure 4-10;

Figure 4-10 *– Installation of the second pair of eyebolts*

4. Reduce the load on the first pair of eyebolts to start the motor rotation, as shown in Figure 4-11. This procedure must be carried out slowly and carefully.

Figure 4-11 *– End result: motor placed in vertical position*

These procedures will help you to move motors designed for vertical mounting. These procedures are also used to place the motor from the horizontal position into the vertical position and vertical to horizontal.

4.1.3.2. Procedures to place HGF motors in the vertical position

HGF motors are fitted with eight lifting points: four at drive end and four at non-drive end. The HGF motors are usually transported in horizontal position, however for the installation they must be placed in the vertical position.
To place an HGF motor in the vertical position, proceed as follows:

1. Lift the motor by using the four lateral eyebolts and two hoists, see Figure 4-12;

Figure 4-12 *– Lifting HGF motor with two hoists*

ENGLISH

2. Lower the hoist fixed to motor drive end while lifting the hoist fixed to motor non-drive end until the motor reaches its equilibrium, see Figure 4-13.

Figure 4-13 *– Placing HGF motor in vertical position*

3. Remove the hoist hooks from the drive end eyebolts and rotate the motor 180° to fix the removed hooks into the two eyebolts at the motor non-drive end, see Figure 4-14.

Figure 4-14 *– Lifting HGF motors by the eyebolts at the non-drive end*

4. Fix the removed hoist hooks in the other two eyebolts at the non-drive end and lift the motor until the vertical position is reached, see Figure 4-15.

Figure 4-15 *– HGF motor in the vertical position*

These procedures will help you to move motors designed for vertical mounting. These procedures are also used to place the motor from the horizontal position into the vertical position and vertical to horizontal.

5. STORAGE

If the motor is not installed immediately, it must be stored in a dry and clean environment, with relative humidity not exceeding 60%, with an ambient temperature between 5 ºC and 40 ºC, without sudden temperature changes, free of dust, vibrations, gases or corrosive agents. The motor must be stored in horizontal position, unless specifically designed for vertical operation, without placing objects on it. Do not remove the protection grease from shaft end to prevent rust. Store the motor in such position that the condensed water can be easily drained. If fitted, remove pulleys or couplings from the shaft end.

If the motor are fitted with space heaters, they must always be turned on during the storage period or when the installed motor is out of operation. Space heaters will prevent water condensation inside the motor and keep the winding insulation resistance within acceptable levels.

The space heaters should never be energized when the motor is in operation.

5.1. EXPOSED MACHINED SURFACES

All exposed machined surfaces (like shaft end and flange) are factory-protected with temporary rust inhibitor. A protective film must be reapplied periodically (at least every six months), or when it has been removed and/or damaged.

5.2. STORAGE

The stacking height of the motor packaging during the storage period should not exceed 5 m, always considering the criteria indicated in Table 5-1:

Table 5-1 *– Max. recommended stacking height*

Packaging Type	Frame sizes	Maximum stacking quantity
Cardboard box	IEC 63 to 132 NEMA 143 to 215	Indicated on the top side of the cardboard box
Wood crate	IEC 63 to 315 NEMA 48 to 504/5	06
	IEC 355 NEMA 586/7 and 588/9	03
	HGF IEC 315 to 630 HGF NEMA 5000 to 9600	Indicated on the packaging

Notes:
1) Never stack larger packaging onto smaller packaging.
2) Align the packaging correctly (see Figure 5-1 and Figure 5-2).

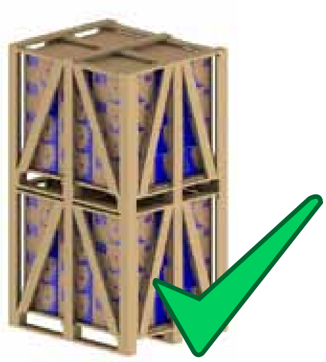


Figure 5-1 *– Correct stacking*

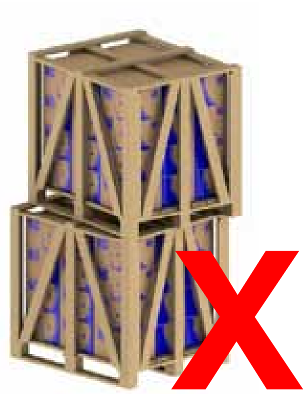


Figure 5-2 *– Incorrect stacking*

3) The feet of the crates above should always be supported by suitable wood battens (Figure 5-3) and never stand on the steel tape or without support (Figure 5-4).

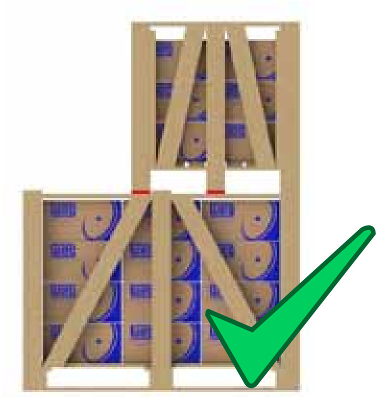


Figure 5-3 – Correct stacking

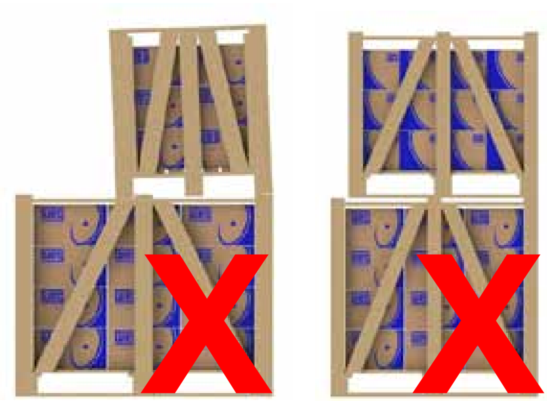


Figure 5-4 – Incorrect stacking

4) When stacking smaller crates onto longer crates, always ensure that suitable wooden supports are provided to withstand the weight (see Figure 5-5). This condition usually occurs with motor packaging above IEC 225S/M (NEMA 364/5T) frame sizes.

***Figure 5-5** – Use of additional battens for stacking*

5.3 BEARINGS

5.3.1 Grease lubricated bearings

We recommend rotating the motor shaft at least once a month (by hand, at least five revolutions, stopping the shaft at a different position from the original one). If the motor is fitted with shaft locking device, remove it before rotating the shaft and install it again before performing any handling procedure. Vertical motors may be stored in the vertical or in horizontal position. If motors with open bearings are stored longer than six months, the bearings must be relubricated according to Item 8.2 before commissioning of the motor.
If the motor is stored for longer than 2 years, the bearings must be replaced or removed, washed, inspected and relubricated according to Item 8.2.

5.3.2 Oil Lubricated bearings

The motor must be stored in its original operating position and with oil in the bearings. Correct oil level must be ensured. It should be in the center of the sight glass.
During the storage period, remove the shaft locking device and rotate the shaft by hand every month, at least five revolutions, thus achieving an even oil distribution inside the bearing and maintaining the bearing in good operating conditions. Reinstall the shaft locking device every time the motor has to be moved.
If the motor is stored for a period of over six months, the bearings must be relubricated according to Item 8.2 before starting the operation. If the motor is stored for a period of over two years, the bearings must be replaced or removed, washed according to manufacturer instructions, checked and relubricated according to Item 8.2. The oil of vertical mounted motors that are transported in horizontal position is removed to prevent oils leaks during the transport. These motors must be stored in vertical position after receiving and the bearing must be lubricated.

5.3.3 Oil Mist lubricated bearings

The motor must be stored in its horizontal position. Lubricate the bearings with ISO VG 68 mineral oil in the amount indicated in the Table 5.2 (this is also valid for bearings with equivalent dimensions). After filling with oil, rotate the shaft by hand, at least five revolutions)
During the storage period, remove the shaft locking device (if any) and rotate the shaft by hand every week, at least five revolutions, stopping it at a different position from the original one. Reinstall the shaft locking device every time the motor has to be moved. If the motor is stored for a period of over two years, the bearings must be replaced or removed, washed according to manufacturer instructions, checked and relubricated according to Item 8.2.

Table 5-2 – *Amount of oil per bearing*

Bearing Size	Amount of Oil (ml)	Bearing Size	Amount of Oil (ml)
6201	15	6309	65
6202	15	6311	90
6203	15	6312	105
6204	25	6314	150
6205	25	6315	200
6206	35	6316	250
6207	35	6317	300
6208	40	6319	350
6209	40	6320	400
6211	45	6322	550
6212	50	6324	600
6307	45	6326	650
6308	55	6328	700

The oil must always be removed when the motor has to be handled. If the oil mist system is not operating after installation, fill the bearings with oil to prevent bearing rusting. During the storage period, rotate the shaft by hand, at least five revolutions, stopping it at a different position from the original one. Before starting the motor, all bearing protection oil must be drained from the bearing and the oil mist system must be switched ON.

5.3.4 Sleeve Bearing

The motor must be stored in its original operating position and with oil in the bearings. Correct oil level must be ensured. It should be in the middle of the sight glass. During the storage period, remove the shaft locking device and rotate the shaft by hand every month, at least five revolutions, thus achieving an even oil distribution inside the bearing and maintaining the bearing in good operating conditions. Reinstall the shaft locking device every time the motor has to be moved.
If the motor is stored for a period of over six months, the bearings must be relubricated according to the Item 8.2 before starting the operation.

If the motor is stored for a period longer than the oil change interval, or if it is not possible to rotate the motor shaft by hand, the oil must be drained and a corrosion protection and dehumidifiers must be applied.

5.4. SPACE HEATER

We recommend measuring the winding insulation resistance at regular intervals to follow-up and evaluate its electrical operating conditions. If any reduction in the insulation resistance values are recorded, the storage conditions should be evaluated and corrected, where necessary.

5.4.1. Insulation resistance measurement

We recommend measuring the winding insulation resistance at regular intervals to follow-up and evaluate its electrical operating conditions. If any reduction in the insulation resistance values are recorded, the storage conditions should be evaluated and corrected, where necessary.

The insulation resistance must be measured in a safe environment.

ENGLISH

The insulation resistance must be measured with a megohmmeter. The machine must be in cold state and disconnected from the power supply.

To prevent the risk of an electrical shock, ground the terminals before and after each measurement. Ground the capacitor (if any) to ensure that it is fully discharged before the measurement is taken.

It is recommended to insulate and test each phase separately. This procedure allows the comparison of the insulation resistance between each phase. During the test of one phase, the other phases must be grounded. The test of all phases simultaneously evaluates the insulation resistance to ground only but does not evaluate the insulation resistance between the phases.
The power supply cables, switches, capacitors and other external devices connected to the motor may considerably influence the insulation resistance measurement. Thus all external devices must be disconnected and grounded during the insulation resistance measurement.
Measure the insulation resistance one minute after the voltage has been applied to the winding. The applied voltage should be as shown in Table 5-3.

***Table 5-3** – Voltage for the insulation resistance*

Winding rated voltage (V)	Testing voltage for measuring the insulation resistance (V)
< 1000V	500
1000 - 2500	500 - 1000
2501 - 5000	1000 - 2500
5001 - 12000	2500 - 5000
> 12000	5000 - 10000

The reading of the insulation resistance must be corrected to 40°C as shown in the Table 5-4.

***Table 5-4** – Correction Factor for the Insulation Resistance corrected to 40°C*

Measuring temperature of the insulation resistance (°C)	Correction factor of the insulation resistance corrected to 40°C	Measuring temperature of the insulation resistance (°C)	Correction factor of the insulation resistance corrected to 40°C
10	0,125	30	0,500
11	0,134	31	0,536
12	0,144	32	0,574
13	0,154	33	0,616
14	0,165	34	0,660
15	0,177	35	0,707
16	0,189	36	0,758
17	0,203	37	0,812
18	0,218	38	0,871
19	0,233	39	0,933
20	0,250	40	1,000
21	0,268	41	1,072
22	0,287	42	1,149
23	0,308	43	1,231
24	0,330	44	1,320
25	0,354	45	1,414
26	0,379	46	1,516
27	0,406	47	1,625
28	0,435	48	1,741
29	0,467	49	1,866
30	0,500	50	2,000

The motor insulation condition must be evaluated by comparing the measured value with the values indicated in Table 5-5 (corrected to 40 °C):

***Table 5-5** – Evaluation of the insulation system*

Limit value for rated voltage up to 1.1 kV (MΩ)	Limit value for rated voltage above 1.1 kV (MΩ)	Situation
Up to 5	Up to 100	Dangerous. The motor can not be operated in this condition
5 to 100	100 to 500	Regular
100 to 500	Higher than 500	Good
Higher than 500	Higher than 1000	Excellent

The values indicated in the table should be considered only as reference values. It is advisable to log all measured values to provide a quick and easy overview on the machine insulation resistance.
If the insulation resistance is low, moisture may be present in the stator windings. In this case the motor should be removed and transported to a WEG authorized Service Center for proper evaluation and repair (This service is not covered by the warranty). To improve the insulation resistance through the drying process, see section 8.4.

6. INSTALLATION

The insulation resistance must be measured in a safe environment.

Check some aspects before proceeding with the installation:

1. Insulation resistance: must be within the acceptable limits. See item 5.4.
2. Bearings:
   a. Rolling bearings: oxidized bearings must be replaced. If no oxidation is detected, lubricate the bearings as described in Item 8.2. If the motor is stored for a period of over two years, the bearings must be replaced before starting the motor.
   b. Sleeve bearing: if sleeve bearing motors are stored longer than the recommended oil change interval, the oil must be changed before machine starting. Don't forget to remove the dehumidifiers when you drain the oil from the motor and to fill it again with new oil before starting the machine. For more details, see item 8.2.
3. Operating conditions of the start capacitors: If single-phase motors are stored for a period of over two years, it is recommended to change the start capacitors before motor starting since they lose their operating characteristics.
4. Terminal box:
   a. the inside of the terminal box must be clean and dry.
   b. the contacts must be correctly connected and corrosion free. See 6.9 and 6.10.
   c. the cable entries must be correctly sealed and the terminal box cover properly mounted in order to ensure the degree of protection indicated on the motor nameplate.
5. Cooling: the cooling fins, air inlet and outlet openings must be clean and unobstructed. The distance between the air inlet openings and the wall should not be shorter than ¼ (one quarter) of the diameter of the air inlet. Ensure sufficient space to perform the cleaning services. See item 7.
6. Coupling: remove the shaft locking device (where fitted) and the corrosion protection grease from the shaft end and flange just before installing the motor. See item 6.4.
7. Drain hole: the motor must always be positioned so the drain hole is at the lowest position. (If there is any indication arrow, the drain must be so installed that the arrow points downwards).
   On Motors with IP 55 degree of protection, the rubber drain plugs (where fitted) may be always in open position (see Figure 6-1).
   For higher degrees of protections (for instance, IP56, IP65 and IP66), the drain plugs (regardless of type) should remain in closed position (see Figure 6-2). These drain plugs are opened only during motor repair services to drain the condensed water from inside the motor. (See Section 8.1)
   The drain system of motors with Oil Mist lubrication system must be connected to a specific collection system (see Figure 6-12 on page 27).

Figure 6-1 *– Detail of the rubber drain plug mounted in open position*

Figure 6-2 *– Detail of the rubber drain plug mounted in closed position*

8.Additional recommendations:
   a. Check the direction of motor rotation, starting the motor at no-load before coupling it to the load.
   b. Vertical mounted motors with shaft end down must be fitted with drip cover to protect them from liquids or solids that may drop onto the motors.
   c. Vertical mounted motors with shaft end up must be fitted with water slinger ring to prevent water penetration inside the motor.

> Remove or fix the shaft key before starting the motor.

6.1. FOUNDATIONS

The foundation is the structure, structural element, natural or prepared base, designed to withstand the stresses produced by the installed equipment, ensuring safe and stable performance during operation. The foundation design should consider the adjacent structures to avoid the influences of other installed equipment and no vibration is transferred through the structure

The foundation must be flat and its selection and design must consider the following characteristics:

a) The features of the machine to be installed on the foundation, the driven loads, application, maximum allowed deformations and vibration levels (for instance, motors with reduced vibration levels, foot flatness, flange concentricity, axial and radial loads, etc. lower than the values specified for standard motors).

b) Adjacent buildings, conservation status, maximum applied load estimation, type of foundation and fixation and vibrations transmitted by theses constructions.

If the motor is supplied with leveling/alignment bolts, this must be considered in the base design.

> Please consider for the foundation dimensioning all stresses that are generated during the operation of the driven load.
> The user is responsible for the foundation designing and construction.

The motors may be mounted on:
- Concrete bases: are most used for large-size motors (see Figure 6-3);
- Metallic bases: are generally used for small-size motors (see Figure 6-4).

***Figure 6-3** – Motor installed on concrete base*

***Figure 6-4** – Motor installed on metallic base*

The metallic and concrete bases may be fitted with sliding system. These types of foundations are generally used where the power transmission is achieved by belts and pulleys. This power transmission system is easier to assemble/disassemble and allows the belt tension adjustment. Other important aspect of this foundation type is the location of the base locking screws that must be diagonally opposite. The rail nearest the drive pulley is placed in such a way that the positioning bolt is between the motor and the driven machine. The other rail must be placed with the bolt on the opposite side (diagonally opposite), as shown in Figure 6-5.

To facilitate assembly, the bases may have the following features:

- shoulders and/or recesses;
- anchor bolts with loose plates;
- bolts cast in the concrete;
- leveling screws;
- positioning screws;
- steel & cast iron blocks, plates with flat surfaces.

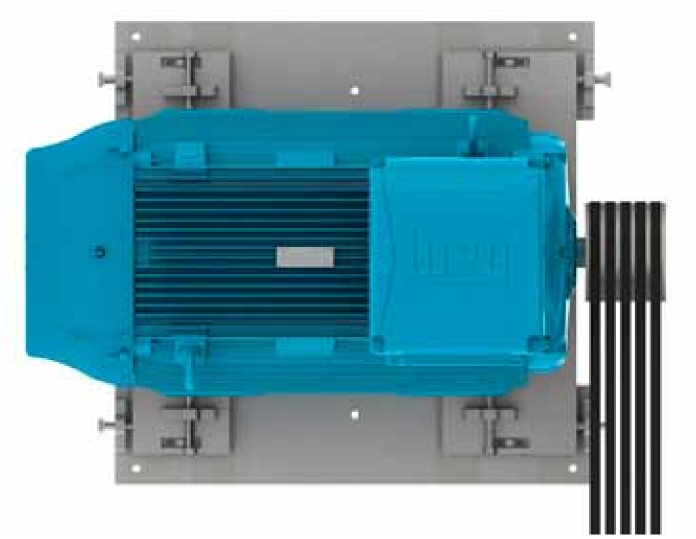


Figure 6-5 *– Motor installed on sliding base*

After completing the installation, it is recommended that all exposed machined surfaces are coated with suitable rust inhibitor.

6.2. MOTOR FIXATION

6.2.1. Foot mounted motors

The drawings of the mounting hole dimensions for NEMA or IEC motors can be checked in the respective technical catalogue.
The motor must be correctly aligned and leveled with the driven machine. Incorrect alignment and leveling may result in bearing damage, generate excessive vibration and even shaft distortion/breakage.
For more details, see section 6.3 and 6.6. The thread engagement length of the fixing bolt should be at least 1.5 times the bolt diameter. This thread engagement length should be evaluated in more severe applications and increased accordingly.
Figure 6-6 shows the fixation system of a foot mounted motor indicating the minimum required thread engagement length.

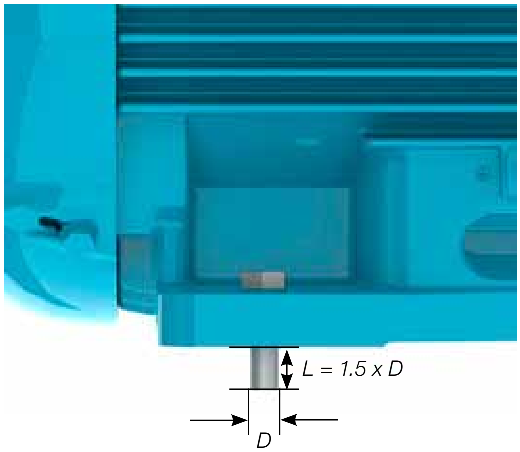


Figure 6-6 *– Fixation system of a foot mounted motor*

6.2.2. Flange mounted motors

The drawings of the flange mounting dimensions, IEC and NEMA flanges, can be checked in the technical catalogue.
The coupling of the driven equipment to the motor flange must be properly dimensioned to ensure the required concentricity of the assembly.
Depending on the flange type, the fixation can be performed from the motor to the driven equipment flange (flange FF (IEC) or D (NEMA)) or from the driven equipment flange to the motor (flange C (DIN or NEMA)).
For the fixing process from the driven equipment flange to the motor, you must consider the bolt length, flange thickness and the thread depth of the motor flange.

> If the motor flange has tapped through-holes, the length of the fixing bolts must not exceed the tapped through-hole length of the motor flange, thus preventing damage to the winding head.

For flange fixation the thread engagement length of the fixing bolt should be at least 1.5 times the bolt diameter. In severe applications, longer thread engagement length may be required.
In severe applications or if large motors are flange mounted, a foot or pad fixation may be required in addition to the flange fixation (Figure 6-7). The motor must never be supported on its cooling fins.

ENGLISH

***Figure 6-7** – Fixing method of flange mounted motors with frame base support*

***Note**:*
When liquid (for example oil) is likely to come into contact with the shaft seal, please contact your local WEG representative.

6.2.3. Pad mounted motors

Typically, this method of fixation is used in axial fans. The motor is fixed by tapped holes in the frame. The dimensions of these tapped holes can be checked in the respective product catalogue. The selection of the motor fixing rods/bolts must consider the dimensions of the fan case, the installation base and the thread depth in the motor frame.
The fixing rods and the fan case wall must be sufficiently stiff to prevent the transmission of excessive vibration to the machine set (motor & fan). Figure 6-8 shows the pad mounting system.

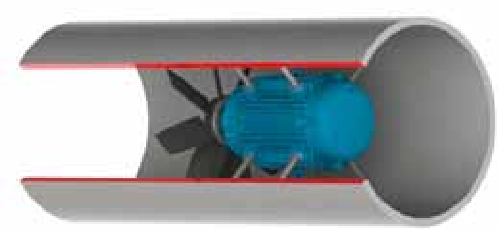


***Figure 6-8** – Fixation of the motor inside the cooling duct*

6.3. BALANCING

Unbalanced machines generate vibration which can result in damage to the motor. WEG motors are dynamically balanced with “half key” and without load (uncoupled). Special balancing quality level must be stated in the Purchase Order.

⚠ The transmission elements, such as pulleys, couplings, etc., must balanced with “half key” before they are mounted on the motor shaft.

The balance quality grade meets the applicable standards for each product line.

The maximum balancing deviation must be recorded in the installation report

6.4. COUPLINGS

Couplings are used to transmit the torque from the motor shaft to the shaft of the driven machine. The following aspects must be considered when couplings are installed:
- Use proper tools for coupling assembly & disassembly to avoid damages to the motor and bearings.
- Whenever possible, use flexible couplings, since they can absorb eventual residual misalignments during the machine operation.
- The maximum loads and speed limits informed in the coupling and motor manufacturer catalogues cannot be exceeded.
- Level and align the motor as specified in sections 6.5 and 6.6, respectively.

Remove or fix the shaft key firmly when the motor is operated without coupling in order to prevent accidents.

6.4.1. Direct coupling

Direct coupling is characterized when the Motor shaft is directly coupled to the shaft of the driven machine without transmission elements. Whenever possible, use direct coupling due to lower cost, less space required for installation and more safety against accidents.

Do not use roller bearings for direct coupling.

6.4.2. Gearbox coupling

Gearbox coupling is typically used where speed reduction is required.
Make sure that shafts are perfectly aligned and strictly parallel (in case of straight spur gears) and in the right meshing angle (in case of bevel and helical gears).

6.4.3. Pulley and belt coupling

Pulleys and belts are used when speed increase or reduction between motor shaft and driven load is required.

Excessive belt tension will damage the bearings and cause unexpected accidents such as breakage of the motor shaft.

6.4.4. Coupling of sleeve bearing motors

Motors designed with sleeve bearings must be operated with direct coupling to the driven machine or a gearbox. Pulley and belts can not be applied for sleeve bearing motors.

Motors designed with sleeve bearings have 3 (three) marks on the shaft end. The center mark is the indication of the magnetic center and the 2 (two) outside marks indicate the allowed limits of the rotor axial movement, as shown in Figure 6-9.
The motor must be so coupled that during operation the arrow on the frame is placed over the central mark indicating the rotor magnetic center. During start-up, or even during operation, the rotor may freely move between the two outside marks when the driven machine exerts an axial load on the motor shaft. However, under no circumstance, the motor can operate continuously with axial forces on the bearing.

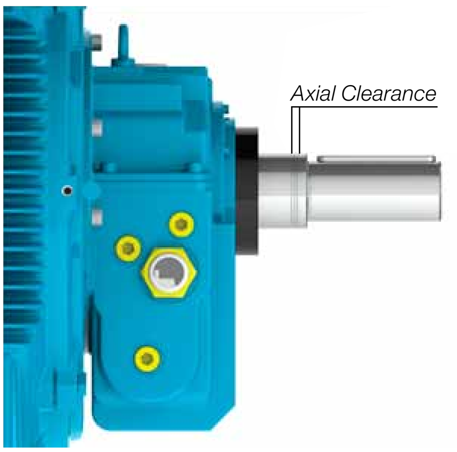


***Figure 6-9** – Axial clearance of motor designed with sleeve bearing*

For coupling evaluation consider the maximum axial bearing clearance as shown in Table 6-1.
The axial clearance of the driven machine and coupling influence the maximum bearing clearance.

***Table 6-1** – Clearance used for sleeve bearings*

Bearing size	Total axial clearance (mm)
9*	3 + 3 = 6
11*	4 + 4 = 8
14*	5 + 5 =10
18	7,5 + 7,5 = 15

** For Motors in accordance with API 541, the total axial clearance is 12.7 mm*

The sleeve bearings used by WEG were not designed to support axial load continuously.
Under no circumstance must the motor be operated continuously at its axial clearance limits.

6.5. LEVELING

The motor must be leveled to correct any deviations in flatness arising from the manufacturing process and the material structure rearrangement. The leveling can be carried out by a leveling screw fixed on the motor foot or on the flange or by means of thin compensation plates. After the leveling process, the leveling height between the motor fixation base and the motor cannot exceed 0.1 mm.
If a metallic base is used to level the height of the motor shaft end and the shaft end of the driven machine, level only the metallic base relating to the concrete base.

Record the maximum leveling deviations in the installation report.

6.6. ALIGNMENT

The correct alignment between the motor and the driven machine is one of the most important variables that extends the useful service life of the motor. Incorrect coupling alignment generates high loads and vibrations reducing the useful life of the bearings and even resulting in shaft breakages. Figure 6-10 illustrates the misalignment between the motor and the driven machine.

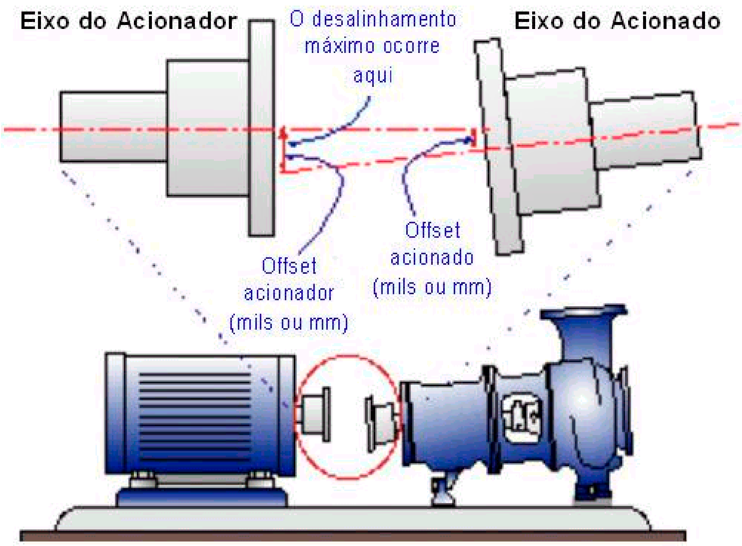
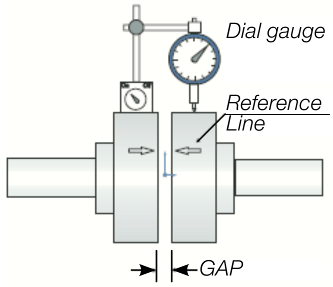


***Figure 6-10** – Typical misalignment condition*

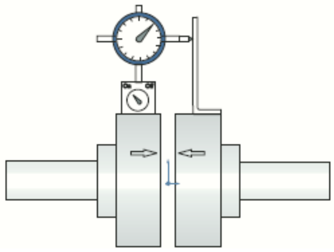
Alignment procedures must be carried out using suitable tools and devices, such as dial gauge, laser alignment instruments, etc. The motor shaft must be aligned axially and radially with the driven machine shaft.

The maximum allowed eccentricity for a complete shaft turn should not exceed 0.03 mm, when alignment is made with dial gauges, as shown in Figure 6-11. Ensure a gap between couplings to compensate the thermal expansion between the shafts as specified by the coupling manufacturer.

ENGLISH



Parallel alignment



Angular alignment

Figure 6-11 *– Alignment with dial gauge*

If alignment is made by a laser instrument, please consider the instructions and recommendations provided by the laser instrument manufacturer.
The alignment should be checked at ambient temperature with machine at operating temperature.

The coupling alignment must be checked periodically

Pulley and belt couplings must be so aligned that the driver pulley center lies in the same plane of the driven pulley center and the motor shaft and the shaft of the driven machine are perfectly parallel.
After completing the alignment procedures, ensure that mounting devices do not change the motor and machine alignment and leveling resulting into machine damage during operation.

It is recommended to record the maximum alignment deviation in the Installation Report.

6.7. CONNECTION OF OIL LUBRICATED OR OIL MIST LUBRICATED MOTORS

When oil lubricated or oil mist lubricated motors are installed, connect the existing lubricant tubes (oil inlet and oil outlet tubes and motor drain tube), as shown in Figure 6-12. The lubrication system must ensure continuous oil flow through the bearings as specified by the manufacturer of the installed lubrication system.

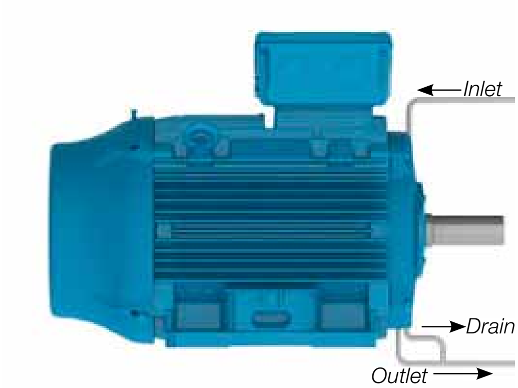


Figure 6-12 *– Oil supply and drain system of oil lubricated or oil mist lubricated motors*

6.8. CONNECTION OF THE COOLING WATER SYSTEM

When water cooled motors are installed, connect the water inlet and outlet tubes to ensure proper motor cooling. According to item 7.2, ensure correct cooling water flow rate and water temperature in the motor cooling system.

6.9. ELECTRICAL CONNECTION

Consider the rated motor current, service factor, starting current, environmental and installation conditions, maximum voltage drop, etc. to select appropriate power supply cables and switching and protection devices. All motors must be installed with overload protection systems. Three-phase motors should be fitted with phase fault protection systems.

Before connecting the motor, check if the power supply voltage and the frequency comply with the motor nameplate data. All wiring must be made according to the connection diagram on the motor nameplate. To prevent accidents, check if motor has been solidly grounded in accordance with the applicable standards.

If motors are supplied without terminal blocks, insulate the cable terminals with suitable insulation material that meets the power supply voltage and the insulation class indicated on the motor nameplate.

Ensure correct tightening torque for the power cable and grounding connections as specified in Table 8-7 (Page 55).

The clearance distance (see Figure 6-13) between non-insulated live parts with each other and between grounded parts must be as indicated in Table 6-2.

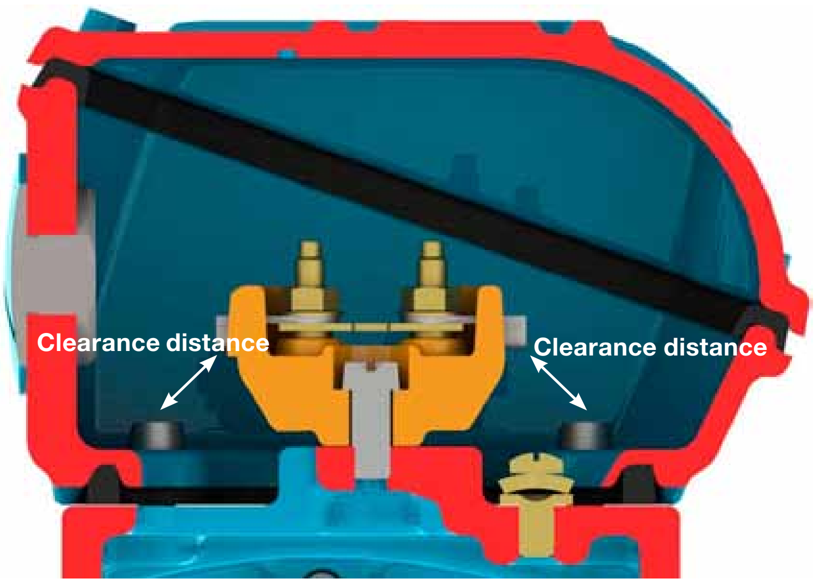


***Figure 6 -13** – Clearance distance representation*

Table 6-2 – *Minimum clearance distance (mm) x supply voltage.*

Voltage	Minimum clearance distance (mm)
U ≤ 440 V	4
440 < U ≤ 690V	5.5
690 < U ≤ 1000V	8
1000 < U ≤ 6900V	45
6900 < U ≤ 11000V	70
11000<U ≤ 16500V	105

Even when the motor is off, dangerous voltages may be present inside the terminal box used for the space heater supply or winding energization when the winding is used as heating element.
Motor capacitors will hold a charge even after the power has been cut off. Do not touch the capacitors and/or motor terminals, before discharging the capacitors completely.

After the motor connection has been completed, ensure that no tool or foreign body has been left inside the terminal box.

Unused cable inlet holes in the terminal box must be properly closed to ensure the degree of protection indicated on the motor nameplate.
The cable inlets used for power supply and control must be fitted with components (for example, cable-glands and conduits) that meet the applicable standards and regulations in each country.

If the motor is fitted with accessories, such as brakes and forced cooling systems, these devices must be connected to the power supply according to the information provided on their nameplates and with special care as indicated above.

All protection devices, including overcurrent protection, must be set according to the rated machine conditions. These protection devices must protect the machine against short circuit, phase fault or locked rotor condition. The motor protections devices must be set according to the applicable standards.

Check the direction of rotation of the motor shaft. If there is no limitation for the use of unidirectional fans, the shaft rotation direction can be changed by reversing any two of the phase connections. For single-phase motor, check the connection diagram indicated on the motor nameplate.

6.10. CONNECTION OF THE THERMAL PROTECTION DEVICES

If the motor is supplied with temperature monitoring devices, such as, thermostat, thermistors, automatic thermal protectors, PT-100 (RTD), etc., they must be connected to the corresponding control devices as specified on the accessory nameplates. The non-compliance with this procedure may void the product warranty and cause serious material damages.

Do not apply test voltage above 2.5 V on thermistors and current above 5 mA on RTDs (PT-100).

Figure 6-14 and Figure 6-15 show the connection diagram of the bimetal thermal protector (thermostats) and thermistors, respectively.

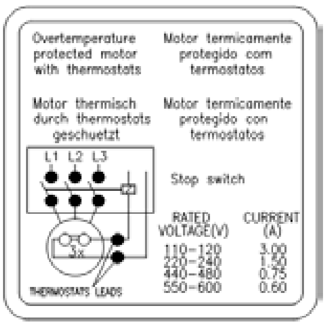


Figure 6-14 – *Connection of the bimetal thermal protectors (thermostats)*

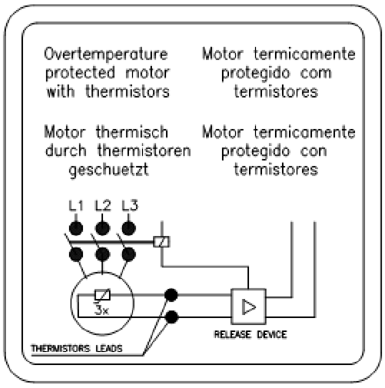


Figure 6-15 *– Thermistor connection*

The alarm temperature limits and thermal protection shutdowns can be defined according to the application; however these temperature limits can not exceed the values in Table 6-3.

Table 6-3 *– Maximum activation temperature of the thermal protections*

Component	Insulation class	Maximum temperature of the protection setting (°C)	
		Alarm	Tripping
Winding	B	-	130
	F	130	155
	H	155	180
Bearing	All	110	120

Notes*:*
1) The number and type of the installed protection devices are informed on the accessory nameplate of the motor.
2) If the motor is supplied with calibrated resistance, (for example, Pt 100), the motor protection system must be set according to the operating temperatures indicated in Table 6-3.

6.11. THERMORESISTANCES (PT-100)

The thermocouples PT-100 are made of materials, whose resistance depends on the temperature variation, intrinsic property of some materials (usually platinum, nickel or copper), calibrated resistance. Its operation is based on the principle that the electric resistance of a metallic conductor varies linearly with the temperature, thus allowing a continuous monitoring of the motor warm-up through the controller display ensuring a high level of precision and answer stability. These devices are widely used for measuring temperatures in various industry sectors.
In general these devices are used in installations where precise temperature control is required, for example, in installation for irregular or intermittent duty.
The same detector may be used for alarm and tripping purposes.

Table 6-4 and Figure 6-16 show the equivalence between the PT-100 resistance and the temperature.

Table 6-4 – *Equivalence between the PT-100 resistance and the temperature.*

°C	Ω	°C	Ω	°C	Ω	°C	Ω	°C	Ω
-29	88.617	17	106.627	63	124.390	109	141.908	155	159.180
-28	89.011	18	107.016	64	124.774	110	142.286	156	159.553
-27	89.405	19	107.404	65	125.157	111	142.664	157	159.926
-26	89.799	20	107.793	66	125.540	112	143.042	158	160.298
-25	90.193	21	108.181	67	125.923	113	143.420	159	160.671
-24	90.587	22	108.570	68	126.306	114	143.797	160	161.043
-23	90.980	23	108.958	69	126.689	115	144.175	161	161.415
-22	91.374	24	109.346	70	127.072	116	144.552	162	161.787
-21	91.767	25	109.734	71	127.454	117	144.930	163	162.159
-20	92.160	26	110.122	72	127.837	118	145.307	164	162.531
-19	92.553	27	110.509	73	128.219	119	145.684	165	162.903
-18	92.946	28	110.897	74	128.602	120	146.061	166	163.274
-17	93.339	29	111.284	75	128.984	121	146.438	167	163.646
-16	93.732	30	111.672	76	129.366	122	146.814	168	164.017
-15	94.125	31	112.059	77	129.748	123	147.191	169	164.388
-14	94.517	32	112.446	78	130.130	124	147.567	170	164.760
-13	94.910	33	112.833	79	130.511	125	147.944	171	165.131
-12	95.302	34	113.220	80	130.893	126	148.320	172	165.501
-11	95.694	35	113.607	81	131.274	127	148.696	173	165.872
-10	96.086	36	113.994	82	131.656	128	149.072	174	166.243
-9	96.478	37	114.380	83	132.037	129	149.448	175	166.613
-8	96.870	38	114.767	84	132.418	130	149.824	176	166.984
-7	97.262	39	115.153	85	132.799	131	150.199	177	167.354
-6	97.653	40	115.539	86	133.180	132	150.575	178	167.724
-5	98.045	41	115.925	87	133.561	133	150.950	179	168.095
-4	98.436	42	116.311	88	133.941	134	151.326	180	168.465
-3	98.827	43	116.697	89	134.322	135	151.701	181	168.834
-2	99.218	44	117.083	90	134.702	136	152.076	182	169.204
-1	99.609	45	117.469	91	135.083	137	152.451	183	169.574
0	100.000	46	117.854	92	135.463	138	152.826	184	169.943
1	100.391	47	118.240	93	135.843	139	153.200	185	170.313
2	100.781	48	118.625	94	136.223	140	153.575	186	170.682
3	101.172	49	119.010	95	136.603	141	153.950	187	171.051
4	101.562	50	119.395	96	136.982	142	154.324	188	171.420
5	101.953	51	119.780	97	137.362	143	154.698	189	171.789
6	102.343	52	120.165	98	137.741	144	155.072	190	172.158
7	102.733	53	120.550	99	138.121	145	155.446	191	172.527
8	103.123	54	120.934	100	138.500	146	155.820	192	172.895
9	103.513	55	121.319	101	138.879	147	156.194	193	173.264
10	103.902	56	121.703	102	139.258	148	156.568	194	173.632
11	104.292	57	122.087	103	139.637	149	156.941	195	174.000
12	104.681	58	122.471	104	140.016	150	157.315	196	174.368
13	105.071	59	122.855	105	140.395	151	157.688	197	174.736
14	105.460	60	123.239	106	140.773	152	158.061	198	175.104
15	105.849	61	123.623	107	141.152	153	158.435	199	175.472
16	106.238	62	124.007	108	141.530	154	158.808	200	175.840

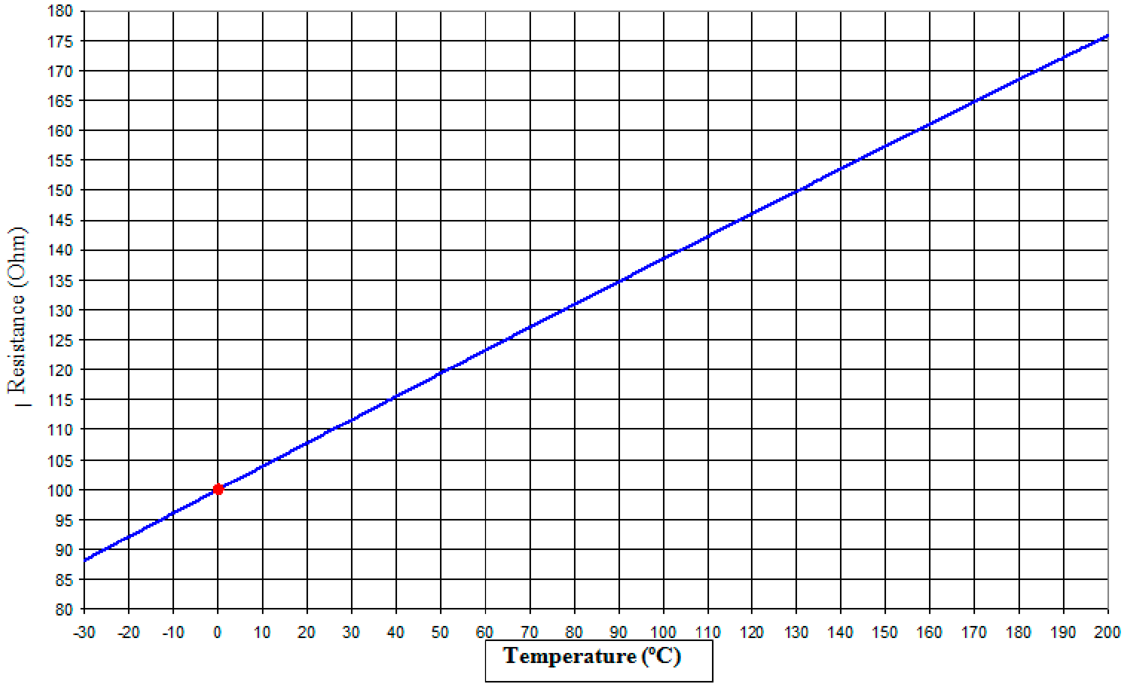


Figure 6-16 *– Ohmic resistance of the PT-100 x temperature*

6.12. STARTING METHODS

Whenever possible, the motor starting must be Direct On Line (DOL) at rated voltage. This is the most simple and feasible starting method. However, it must only be applied when the starting current does not affect the power supply. Please consider the local electric utility regulations when installing a motor.
High inrush current may result in:
a) high voltage drop in the power supply line creating unacceptable line disturbance on the distribution system;
b) requiring oversized protection system (cables and contactor) increasing the installation costs.

If DOL starting is not allowed due to the reasons mentioned above, an indirect starting method compatible with the load and motor voltage to reduce the starting current may be used.
If reduced voltage starters are used for starting, the motor starting torque will also be reduced.

Table 6-5 shows the possible indirect starting methods that can be used depending on the number of the motor leads.

Table 6-5 *– Starting method x number of motor leads.*

Number of leads	Possible starting methods
3 leads	Autotransformer Soft-starter
6 leads	Star-Delta Switch Autotransformer Soft-Starter
9 leads	Series/Parallel Switch Autotransformer Soft-Starter
12 leads	Star-Delta Switch Series/Parallel Switch Soft-Starter

Table 6-6 shows examples of possible indirect starting methods to be used according to the voltage indicated on the motor nameplate and the power supply voltage.

***Table 6-6** – Starting methods x voltage*

Nameplate voltage	Operating voltage	Star-delta switch	Autotransformer Starting	Starting by series/ parallel switch	Starting by soft-starter
220/380 V	220 V 380 V	YES NO	YES YES	NO NO	YES YES
220/440 V	220 V 440 V	NO NO	YES YES	YES NO	YES YES
230/460 V	230 V 460 V	NO NO	YES YES	YES NO	YES YES
380/660 V	380 V	YES	YES	NO	YES
220/380/440 V	220 V 380 V 440 V	YES NO YES	YES YES YES	YES YES NO	YES YES YES

The WQuattro line motors must be started direct on-line (DOL) or driven by a frequency inverter in scalar mode.

6.13. MOTORS DRIVEN BY FREQUENCY INVERTER

The operation with frequency inverter must be stated in the Purchase Order since this drive type may require some changes of the motor design.

Wmagnet Motors must only be driven by WEG frequency inverter.

The frequency inverter used to drive motors up to 690 V must be fitted with Pulse With Modulation (PWM) with vector control.

When a motor is driven by a frequency inverter at lower frequencies than the rated frequency, you must reduce the motor torque to prevent motor overheating. The torque reduction (derating torque) can be found in the item 6.4 of the “Technical Guidelines for Induction Motors driven by PWM Frequency inverters” available on the site www.weg.net.

If the motor is operated above the rated frequency, please note:

- That the motor must be operated at constant output;
- That the motor can supply max. 95% of its rated output;
- Do not exceed the maximum speed and please consider:
  - max. operating frequency informed on the additional nameplate;
  - mechanical speed limitation of the motor;
  - max. motor torque, according to equation:

$$\text{Maximum speed} = \frac{\text{Rated speed x Cmax/Cn}}{1.5}$$

Information on the selection of the power cables between the frequency inverter and the motor can be found in the item 6.4 of the “Technical Guidelines for Induction Motors driven by PWM Frequency inverters” available at www.weg.net.

6.13.1. Use of dV/dt filter

6.13.1.1. Motor with enameled round wire

Motors designed for rated voltages up to 690 V, when driven by frequency inverter, do not require the use of dV/dT filters, provided that following criteria are considered.

Criteria for the selection of motors with round enameled wire when driven by frequency inverter [1]				
Motor rated votage [2]	**Peak voltage at the motor terminals (max)**	**dV/dt inverter output (max)**	**Inverter Rise Time [3] (min.)**	**MTBP [3] Time between pulses (min)**
Vnon ≤ 460 V	≤ 1600 V	≤ 5200 V/µs	≥ 0,1 µs	≥ 6 µs
460 < Vnon ≤ 575 V	≤ 1800 V	≤ 6500 V/µs		
575 < Vnon ≤ 690 V [4]	≤ 1600 V	≤ 5200 V/µs		
575 < Vnon ≤ 690 V [5]	≤ 2200 V	≤ 7800 V/µs		

***Notes**:*
1. For the application of motors with round enameled wires designed for 690 < Vnom ≤ 1100 V, please contact WEG.
2. For the application of dual voltage motors, example 380/660 V, consider the lower voltage (380 V).
3. Information supplied by the inverter manufacturer.
4. When not stated in the Purchase Order that the motor will be driven by frequency inverter.
5. When stated in the Purchase Order that the motor will be driven by frequency inverter.

6.13.1.2. Motor with prewound coils

Motors with prewound coils (medium voltage motors regardless of frame sizes, and low voltage motors from IEC 500 / NEMA 80 frame on), designed for the use with frequency inverters, do not require the use of filters, provided they comply with the criteria in Table 6-7.

***Table 6-7** – Criteria to be considered when using motor with prewound coils to be drive by frequency inverters*

Motor rated voltage	Type of modulation	Turn to turn insulation (phase-phase)		Phase-ground insulation	
		Peak voltage at the motor terminals	dV/dt at the motor terminals	Peak voltage at the motor terminals	dV/dt at the motor terminals
690 < Vnon ≤ 4160 V	Sinusoidal	≤ 5900 V	≤ 500 V/µs	≤ 3400 V	≤ 500 V/µs
	PWM	≤ 9300 V	≤ 2700 V/µs	≤ 5400 V	≤ 2700 V/µs
4160 < Vnon ≤ 6600 V	Sinusoidal	≤ 9300 V	≤ 500 V/µs	≤ 5400 V	≤ 500 V/µs
	PWM	≤ 12700 V	≤ 1500 V/µs	≤ 7400 V	≤ 1500 V/µs

ENGLISH

6.13.2. Bearing insulation

Only the motors in IEC frame size 400 (NEMA 68) and larger are supplied, as standard, with insulated bearing. If motor must be driven by frequency inverter, insulate the bearing according to Table 6-8.

***Table 6-8** – Recommendation on the bearing insulation for inverter driven motors*

Frame size	Recommendation
IEC 315 and 355 NEMA 445/7, 447/9, L447/9, 504/5, 5006/7/8, 5009/10/11, 586/7, 5807/8/9, 5810/11/12 and 588/9	■ Insulated bearing/end shield ■ Grounding between shaft and frame by grounding brush
IEC 400 and larger NEMA 6800 and larger	■ Insulated NDE bearing ■ Grounding between shaft and frame by grounding brush

When motors are supplied with shaft grounding system, monitor the grounding brush constantly during its operation and, when it reaches the end of its useful life, it must be replaced by another brush with the same quality.

6.13.3. Switching Frequency

The minimum inverter switching frequency must not be lower than 2.5 kHz and should not exceed 5 kHz.

The non-compliance with the criteria and recommendations indicated in this manual may void the product warranty.

6.13.4. Mechanical speed limitation

Table 6-9 shows the maximum speeds allowed for motors driven by frequency inverter.

***Table 6-9** – Maximum motor speed (in rpm).*

Frame size	2 poles	4 poles	6 poles	8 poles
90 – 100	7000	7000	7000	7000
112	7000	6000	6000	6000
132	6000	5500	5500	5500
160	5000	5000	5000	5000
180	4500	4000	4000	4000
200	4000	3800	3800	3800
225	3600	3600	3600	3600
250	3600	3600	3600	3600
280	3600	3000	3000	3000
315	3600	2500	2500	2500
355	3600	1800	1800	1800

***Note**:*
to select the maximum allowed motor speed, consider the motor torque derating curve.

For more information on the application of frequency inverters, contact WEG or check the "Technical Guidelines for Induction Motors driven by PWM Frequency inverters" available at www.weg.net.

ENGLISH

7. COMMISSIONING

7.1. INITIAL START-UP

After finishing the installation procedures and before starting the motor for the first time or after a long period without operation, the following items must be checked:

- If the nameplate data (voltage, current, connection diagram, degree of protection, cooling system, service factor, etc.) meet the application requirements.
- If the machine set (motor + driven machine) has been mounted and aligned correctly.
- If the motor driving system ensures that the motor speed does not exceed the max. allowed speed indicated in Table 6-9.
- Measure the winding insulation resistance, making sure it complies with the specified values in item 5.4.
- Check the motor rotation direction.
- Inspect the motor terminal box for damage and ensure that it is clean and dry and all contacts are rust-free, the seals are in perfect operating conditions and all unused threaded holes are properly closed thus ensuring the degree of protection indicated on the motor nameplate.
- Check if the motor wiring connections, including grounding and auxiliary equipment connection, have been carried out properly and are in accordance with the recommendations in item 6.9.
- Check the operating conditions of the installed auxiliary devices (brake, encoder, thermal protection device, forced cooling system, etc.).
- Check bearing operating conditions. If signs of oxidation are detected, replace the bearings. If no sign of oxidation is detected, relubricate the bearings as described in item 8.2. If the motors are stored for more than two years, the bearings must be replaced before starting the motor.

- When motors are fitted with sleeve bearings, ensure:
  - correct oil level for the sleeve bearing. The oil level should be in the center of the sight glass (see Figure 6-9);
  - that the motor is not started or operated with axial or radial loads;
  - that if the motor is stored for a period equal or longer than the oil change interval, the oil must be changed before starting the motor.
- Inspect the capacitor operating condition, if any. If motors are installed for more than two years, but were never commissioned, it is recommended to change the start capacitors since they lose their operating characteristics.
- Ensure that the air inlet and outlet opening are not blocked. The minimum clearance to the nearest wall (L) should be at least ¼ of the fan cover diameter (D), see Figure 7-1. The intake air temperature must be at ambient temperature.

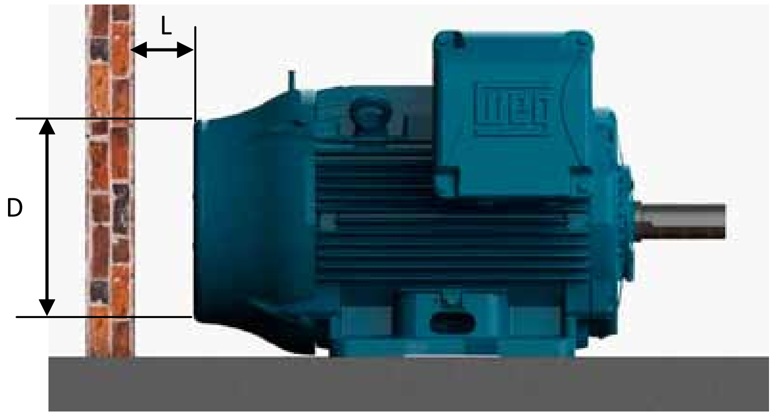


Figure 7-1- *Minimum clearance to the wall*

ENGLISH

Please consider the minimum distances shown in the Table 7-1 as reference value

Table 7-1 *– Minimum distance between the fan cover and wall*

Frame size		Distance between the fan cover and the wall (L)	
IEC	**NEMA**	**mm**	**inches**
63	-	25	0,96
71	-	26	1,02
80	-	30	1,18
90	143/5	33	1,30
100	-	36	1,43
112	182/4	41	1,61
132	213/5	50	1,98
160	254/6	65	2,56
180	284/6	68	2,66
200	324/6	78	3,08
225 250	364/5 404/5	85	3,35
280	444/5 445/7 447/9	108	4,23
315	L447/9 504/5	122	4,80
355	586/7 588/9	136	5,35

- ensure correct water flow rate and water temperature when water cooled motors are used. See item 7.2.
- ensure that all rotating parts, such as pulleys, couplings, external fans, shaft, etc. are protected against accidental contact.

Other tests and inspections not included in the manual may be required, depending on the specific installation, application and/or motor characteristics.

After all previous inspections have been carried out, proceed as follows to start the motor:

- Start the motor on no-load (if possible) and check the motor direction of rotation. Check for the presence of any abnormal noise, vibration or other abnormal operating conditions.
- Ensure the motor starts smoothly. If any abnormal operating condition is noticed, switch off the motor, check the assembly system and connections before the motor is started again.
- If excessive vibrations are noticed, check if the motor fixation bolts are well tightened or if the vibrations are not generated and transmitted from adjacent installed equipment. Check the motor vibration periodically and ensure that the vibration limits are as specified in item 7.2.1.
- Start the motor at rated load during a short time and compare the operating current with the rated current indicated on the nameplate.
- Continue to measure the following motor variables until thermal equilibrium is reached: current, voltage, bearing and motor frame temperature, vibration and noise levels.
- Record the measured current and voltage values on the Installation Report for future comparisons.

As induction motors have high inrush currents during start-up, the acceleration of high inertia load requires an extended starting time to reach full speed resulting in fast motor temperature rise. Successive starts within short intervals will result in winding temperature increases and can lead to physical insulation damage reducing the useful life of the insulation system. If the duty S1 is specified on the motor nameplate, this means that the motor has been designed for:

- two successive starts: first start from cold condition, i. e., the motor windings are at room temperature and the second start immediately after the motor stops.
- one start from hot condition, i. e., the motor windings are at rated temperature.

The Troubleshooting Chart in section 10 provides a basic list of unusual cases that may occur during motor operation with the respective corrective actions

7.2. OPERATING CONDITIONS

Unless otherwise stated in the Purchase Order, electric motors are designed and built to be operated at altitudes up to 1000 meters above sea level and in a temperature range from -20°C to +40°C. Any deviation from the normal condition of motor operation must be stated on the motor nameplate. Some components must be changed if the ambient temperature is different from the specified one. Please contact WEG to check the required special features.

Motors installed inside enclosures (cubicles) must be ensured an air renewal rate in the order of one cubic meter per second for each 100 kW installed power or fraction of installed power. Totally Enclosed Air Over motors - TEAO (fan and exhaust / smoke extraction) are supplied without cooling fan and the manufacturer of the driven machine is responsible for sufficient motor cooling. If no minimum required air speed between motor fins is indicated on the motor nameplate, ensure the air speed indicated in the table 7-2 is provided. The values shown in Table 7-2 are valid for 60 Hz motors. To obtain the minimum air speed for 50 Hz motors, multiply the values in the table by 0.83.

Table 7-2 *– Minimum required air speed between motor fins (metres/second)*

Frame		Poles			
IEC	NEMA	2	4	6	8
63 to 90	143/5	14	7	5	4
100 to 132	182/4 to 213/5	18	10	8	6
160 to 200	254/6 to 324/6	20	20	12	7
225 to 280	364/5 to 444/5	22	22	18	12
315 to 355	445/7 to 588/9	25	25	20	15

The voltage and frequency variations may affect the performance characteristics and the electromagnetic compatibility of the motor. The power supply variations should not exceed the values specified in the applicable standards. Examples.

- ABNT NBR-17094 - Parts 1 and 2. The motor has been designed to supply the rated torque for a combined variation in voltage and frequency:
  - Zone A: ±5% of the rated voltage and ±2% of the rated frequency.
  - Zone B: ±10% of the rated voltage and +3% -5% of the rated frequency.

When operated continuously in Zone A or B, the motor may show performance variations and the operating temperature may increase considerably. These performance variations will be higher in Zone B. Thus it is not recommended to operate the motor in Zone B during extended periods.

- IEC 60034-1. The motor has been designed to supply the rated torque for combined variation in voltage and frequency:
  - Zone A: ±5% of the rated voltage and ±2% of the rated frequency.
  - Zone B: ±10% of the rated voltage and +3% -5% of the rated frequency.

When operated continuously in Zone A or B, the motor may show performance variations and the operating temperature may increase considerably. These performance variations will be higher in Zone B. Thus it is not recommended to operate the motor in Zone B during extended periods. For multivoltage motors (example 380-415/660 V), a ±5% voltage variation from the rated voltage is allowed.

- NEMA MG-1 Part 12. The motor has been designed to be operated in one of the following variations:
  - ±10% of the rated voltage, with rated frequency;
  - ±5% of the rated frequency, with rated voltage;
  - A combined variation in voltage and frequency of ±10%, provided the frequency variation does not exceed ±5%.

If the motor is cooled by ambient air, clean the air inlet and outlet openings and cooling fins at regular intervals to ensure a free airflow over the frame surface. The hot air should never be returned to the motor. The cooling air must be at room temperature limited to the temperature range indicated on the motor nameplate (if no room temperature is specified, please consider a temperature range between -20°C and +40°C).

Table 7-3 shows the minimum required water flow for water cooled motors considering the different frame sizes and the maximum allowed temperature rise of the cooling water after circulating through the motor. The inlet water temperature should not exceed 40°C.

Table 7-3 *– Minimum required water flow and the maximum allowed temperature rise of the cooling water after circulating through the motor*

Frame size		Flow rate (litres/minute)	Maximum allowed water temperature rise (°C)
IEC	NEMA		
180	284/6	12	5
200	324/6	12	5
225	364/5	12	5
250	404/5	12	5
280	444/5 445/7 447/9	15	6
315	504/5	16	6
355	586/7 588/9	25	6

Motors fitted with oil mist lubrication systems can be operated continuously for a maximum of one hour after the failure of the oil pumping system. Considering the sun's heat increases the operating temperature, externally mounted motors should always be protected from direct sunlight exposure.

Each and every deviation from the normal operating condition (tripping of the thermal protection, noise and vibration level increase, temperature and current rise) should be investigated and corrected by WEG Authorized Service Centers.

Motors fitted with cylindrical roller bearings require a minimum radial load to ensure a normal operation. For information regarding the radial preload, please contact WEG.

7.2.1.Limits of vibration

The vibration severity is the maximum vibration value measured at all positions and in all directions as recommended in the standard IEC 60034-14. Table 7-4 below specifies the limits of the maximum vibrations magnitudes according to standard IEC 60034-14 for shaft heights IEC 56 to 400, for vibrations grades A and B. The vibration severity limits in Table 7-4 are given as RMS values (Root Mean Square values or effective values) of the vibration speed in mm/s measured in free suspension condition.

Table 7-4 *– Recommended limits for the vibration severity according to standard IEC 60034-14*

Shaft height [mm]	$56 \le H \le 132$	$132 \le H \le 280$	$H > 280$
Vibration Grade	**Vibration severity on elastic base [mm/s RMS]**		
A	1.6	2.2	2.8
B	0.7	1.1	1.8

Notes:
1 – The values in Table 7-4 are valid for measurements carried out with decoupled machines (without load) operated at rated voltage and frequency.
2 - The values in Table 7-4 are valid regardless of the direction of rotation of the machine.
3 – The values in Table 7-4 are not applicable to single-phase motors, three-phase motors powered by a single-phase system or to machines mounted in situ or coupled with inertia flywheels or to loads.

According to NEMA MG-1, the allowed vibration limit for standard motors is 0.15 in/s (peak vibration in in/s).

Note:
For the load operation condition, the use of the standard ISO 10816-3 is recommended for evaluating the motor vibration limits. In the load condition the motor vibration will be influenced by several factors, such as, type of the coupled load, condition of the motor fixation, alignment condition under load, structure or base vibration due to other equipments, etc.

8. MAINTENANCE

The purpose of the maintenance is to extend the useful life of the equipment. The non-compliance with one of these previous items can cause unexpected machine failures.

If motors with cylindrical roller or angular contact bearings are to be transported during the maintenance procedures, the shaft locking device must always be fitted. All HGF motors, regardless of the bearing type, must always be transported with the shaft locking device fitted.

All repairs, disassembly and assembly related services must be carried out only by qualified and well-trained personnel by using proper tools and techniques. Make sure that the machine has stopped and it is disconnected from the power supply, including the accessory devices (space heater, brake, etc.), before any servicing is undertaken.
The company does not assume any responsibility or liability for repair services or maintenance operations executed by non-authorized Service Centers or by non qualified service personnel. The company shall have no obligation or liability whatsoever to the buyer for any indirect, special, consequential or incidental loss or damage caused or arising from the company's proven negligence

8.1. GENERAL INSPECTION

The inspection intervals depend on the motor type, application and installation conditions. Proceed as follows during inspection:

- Visually inspect the motor and coupling. Check if abnormal noises, vibrations, excessive heating, wear signs, misalignment or damaged parts are noticed. Replace the damaged parts as required.
- Measure the insulation resistance according to the item 5.4.
- Clean the motor enclosure. Remove oil spills and dust accumulation from the motor frame surface to ensure a better heat transfer to the surrounding ambient.
- Check cooling fan condition and clean the air inlet & outlet openings to ensure a free air flow over the motor.
- Investigate the actual condition of the seals and replace them, if required.
- Drain the condensed water from inside the motor. After draining, reinstall the drain plugs to ensure the degree of protection as indicated on the motor nameplate. The motor must always be positioned so the drain hole is at the lowest position (see item 6).
- Check the connections of the power supply cables, ensuring the correct clearance distance between live and grounded parts, as specified in Table 6-2.
- Check if the tightening torque of the bolted connections and fixation bolts meets the tightening torque specified in Table 8-7.
- Check the status of the cable passages, the cable gland seals and the seals inside the terminal box and replace them, if required.
- Check the bearing operating conditions. Check for the presence of any abnormal noise, vibration or other abnormal operating conditions, like motor temperature rise. Check the oil level, the lub oil condition and compare the workings hours with the informed life time.
- Record and file all changes performed on the motor.

Do not reuse damaged or worn parts. Damaged or worn parts must be replaced by parts supplied by the manufacturer and must be installed as if they were the original parts.

8.2. LUBRICATION

Proper lubrication plays a vital role in the motor performance. Only use the grease or oil types, amounts and lubrication intervals recommended for the bearings. This information is available on the motor nameplate and the lubrication procedures must be carried out according to the type of lubricant (oil or grease).
When the motor is fitted with thermal protection devices for bearing temperature control, consider the operating temperature limits shown in Table 6-3.
The maximum operating temperature of motors used in special applications may differ from those shown in Table 6-3. The grease and oil disposal should be made in compliance with applicable laws in each country

Please contact WEG when motors are to be installed in special environments or used for special applications.

ENGLISH

8.2.1. Grease lubricated rolling bearings

Excess grease causes bearing overheating, resulting in bearing failure.

The lubrication intervals specified in Table 8-1, Table 8-2, Table 8-3 and Table 8-4 consider a room temperature of 40°C, the motor running at rated speed, a motor mounted in horizontal position, greased with Mobil Polyrex EM grease. The lubrication intervals are determined according to the standard ISO 281 and they estimate for the basic rating life that 90% of a group of identical bearings will theoretically meet or exceed the calculated value with 90% reliability. Any variation of the parameters listed above must be evaluated.

Table 8-1 *– Lubrication intervals for ball bearings*

Frame		Poles	Bearing designation	Amount of grease (g)	LUBRICATION INTERVALS (hours)					
					ODP (Open Drip Proof)		W21 TEFC (Totally Enclosed Fan Cooled)		W22 TEFC (Totally Enclosed Fan Cooled)	
IEC	NEMA				50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
160	254/6	2	6309	13	20000	20000	18100	15700	22000	20000
		4					20000	20000	25000	25000
		6								
		8								
180	284/6	2	6311	18	20000	20000	13700	11500	17000	14000
		4					20000	20000	25000	25000
		6								
		8								
200	324/6	2	6312	21	20000	20000	11900	9800	15000	12000
		4					20000	20000	25000	25000
		6								
		8								
225 250 280 315 355	364/5 404/5 444/5 445/7 447/9 L447/9 504/5 5008 5010/11 586/7 588/9	2	6314	27	18000	14400	4500	3600	5000	4000
		4			20000	20000	11600	9700	14000	12000
		6					16400	14200	20000	17000
		8					19700	17300	24000	20000
		2	6316	34	14000	*Upon request	3500	*Upon request	4000	*Upon request
		4			20000	20000	10400	8500	13000	10000
		6					14900	12800	18000	16000
		8					18700	15900	20000	20000
		2	6319	45	9600	*Upon request	2400	*Upon request	3000	*Upon request
		4			20000	20000	9000	7000	11000	8000
		6					13000	11000	16000	13000
		8					17400	14000	20000	17000
		4	6322	60	20000	20000	7200	5100	9000	6000
		6					10800	9200	13000	11000
		8					15100	11800	19000	14000

Table 8-2 – *Lubrication intervals for cylindrical roller bearings*

Frame		Poles	Bearing designation	Amount of grease (g)	LUBRICATION INTERVALS (hours)					
					ODP (Open Drip Proof)		W21 TEFC (Totally Enclosed Fan Cooled)		W22 TEFC (Totally Enclosed Fan Cooled)	
IEC	NEMA				50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
160	254/6	2	NU309	13	20000	19600	13300	9800	16000	12000
		4				20000	20000	20000	25000	25000
		6								
		8								
180	284/6	2	NU311	18	18400	12800	9200	6400	11000	8000
		4			20000	20000	20000	19100	25000	25000
		6						20000		
		8								
200	324/6	2	NU312	21	15200	10200	7600	5100	9000	6000
		4			20000	20000	20000	17200	25000	21000
		6						20000		25000
		8								
225 250 280 315 355	364/5 404/5 444/5 445/7 447/9 L447/9 504/5 5008 5010/11 586/7 588/9	4	NU314	27	17800	14200	8900	7100	11000	9000
		6			20000	20000	13100	11000	16000	13000
		8					16900	15100	20000	19000
		4	NU316	34	15200	12000	7600	6000	9000	7000
		6			20000	19000	11600	9500	14000	12000
		8				20000	15500	13800	19000	17000
		4	NU319	45	12000	9400	6000	4700	7000	5000
		6			19600	15200	9800	7600	12000	9000
		8			20000	20000	13700	12200	17000	15000
		4	NU322	60	8800	6600	4400	3300	5000	4000
		6			15600	11800	7800	5900	9000	7000
		8			20000	20000	11500	10700	14000	13000

Table 8-3 – *Lubrication intervals for ball bearings – HGF line*

Frame		Poles	Bearing designation	Amount of grease (g)	Lubrication intervals (hours)	
IEC	NEMA				50Hz	60Hz
315L/A/B and 315C/D/E	5006/7/8T and 5009/10/11T	2	6314	27	3100	2100
		4 – 8	6320	50	4500	4500
			6316	34	4500	4500
355L/A/B and 355C/D/E	5807/8/9T and 5810/11/12T	2	6314	27	3100	2100
		4 – 8	6322	60	4500	4500
			6319	45	4500	4500
400L/A/B and 400 C/D/E	6806/7/8T and 6809/10/11T	2	6315	30	2700	1800
		4 – 8	6324	72	4500	4500
			6319	45	4500	4500
450	7006/10	2	6220	31	2500	1400
		4	6328	93	4500	3300
			6322	60	4500	4500
		6 – 8	6328	93	4500	4500
			6322	60	4500	4500
500	8006/10	4	6330	104	4200	2800
			6324	72	4500	4500
		6 – 8	6330	104	4500	4500
			6324	72	4500	4500
500	8006/10	4	6330	104	4200	2800
			6324	72	4500	4500
		6 – 8	6330	104	4500	4500
			6324	72	4500	4500
560	8806/10	4 - 8	*Upon request			
630	9606/10	4 - 8				

Table 8-4 – Lubrication intervals for cylindrical roller bearings – HGF line

Frame		Poles	Bearing designation	Amount of grease (g)	Lubrication intervals (hours)	
IEC	NEMA				50 Hz	60 Hz
315L/A/B and 315C/D/E	5006/7/8 and 5009/10/11	4	NU320	50	4300	2900
		6 - 8			4500	4500
355L/A/B and 355C/D/E	5807/8/9 and 5810/11/12	4	NU322	60	3500	2200
		6 - 8			4500	4500
400L/A/B and 400C/D/E	6806/7/8 and 6809/10/11	4	NU324	72	2900	1800
		6 - 8			4500	4500
450	7006/10	4	NU328	93	2000	1400
		6			4500	3200
		8			4500	4500
500	8006/10	4	NU330	104	1700	1000
		6			4100	2900
		8			4500	4500
560	8806/10	4	NU228 + 6228	75	2600	1600
		6 - 8		106	4500	4500
630	9606/10	4	NU232 + 6232	92	1800	1000
		6		120	4300	3100
		8		140	4500	4500

For each increment of 15 ºC above the room temperature, the relubrication intervals given in the Table must be halved. The relubrication interval of motors designed by the manufacturer for mounting in horizontal position, but installed in vertical position (with WEG authorization), must be halved.
For special applications, such as: high and low temperatures, aggressive environments, driven by frequency inverter (VFD – frequency inverter), etc., please contact WEG about the required amount of grease and the relubrication intervals.

8.2.1.1. Motor without grease fitting

Motors without grease fittings must be lubricated in accordance with the existing Maintenance Plan. Motor disassembly must be carried out as specified in Item 8.3. If motors are fitted with shielded bearings (for example, ZZ, DDU, 2RS, VV), these bearings must be replaced at the end of the grease service life.

8.2.1.2. Motor with grease fitting

Motors with grease fittings must be stopped to be lubricated. Proceed as follows:

- Before lubricating, clean the grease nipple and immediate vicinity thoroughly
- Lift grease inlet protection;
- Remove the grease outlet plug;
- Pump in approximately half of the total grease and run the motor for about 1 (one) minute at rated speed;
- Switch-off the motor and pump in the remaining grease;
- Lower again the grease inlet protection and reinstall the grease outlet protection

For lubrication, use only manual grease gun.

If Motors are provided with a spring device for grease removal, the grease excess must be removed by pulling the rod and cleaning the spring until the spring does not remove more grease.

8.2.1.3. Compatibility of the Mobil Polyrex EM grease with other greases

The Mobil Polyrex EM grease has a polyurea thickener and a mineral oil thus being compatible with greases that contain:
- Lithium based thickener, lithium-based complex thickener, polyurea thickener and refined mineral oil;
- The used grease must have in its formulation corrosion and oxidation inhibitors.

In general terms, greases with the same type of soap are compatible to each other. However, depending on the proportion of the mixture there may be incompatibility. In such a case, it is not recommended to mix different types of greases without contacting the supplier or WEG beforehand.

ENGLISH

8.2.2. Oil lubricated bearings

To change the oil of oil lubricated motor proceed as follows:
- switch-off the motor;
- remove threaded oil drain plug;
- open the valve and drain the oil;
- close the drain vale again;
- reinstall the threaded oil drain plug;
- fill-up with the type and amount of oil as specified on the nameplate;
- check oil level. The oil level is OK when the lubricant can be viewed approximately in the center of the sight glass;
- reinstall oil inlet plug;
- check for oil leaks and ensure that all not used threaded plugs are closed with plugs.

The bearing lubricating oil must be replaced as specified on the nameplate or whenever changes on the oil properties are noticed. The oil viscosity and pH must be checked periodically. The oil level must be checked every day and must be kept in the center of the sight glass.
Please contact WEG, when oils with different viscosities should be used.

Note:
The HGF vertical mounted motors with high axial thrust are supplied with grease lubricated DE-bearings and with oil lubricated NDE-bearings. The DE-bearings must be lubricated according to recommendations in item 8.2.1. Table 8-5 specifies the oil type and the amount of oil required for this motor lubrication.

Table 8-5 *– Oil properties for HGF vertical mounted motors with high axial thrust*

Mounting	Frame IEC	Frame NEMA	Poles	Bearing designation	Oil (liters)	Interval (h)	Lubricant	Lubricant specification
High axial thrust	315L/A/B e 315C/D/E	5006/7/8T e 5009/10/11T	4 - 8	29320	20	8000	Renolin DTA 40 / SHC 629	ISO VG150 mineral oil with antifoam and antioxidant additives
	355L/A/B e 355C/D/E	5807/8/9T e 5810/11/12T	4 - 8	29320	26			
	400L/A/B e 400C/D/E	6806/7/8T e 6809/10/11T	4 - 8	29320	37			
	450	7006/10	4 - 8	29320	45			

8.2.3. Oil mist lubricated bearings

Check the service conditions of the seals and if replacement is required use only original components. Clean the seal components before assembly (bearing caps, end shields, etc.).
Apply joint sealant between the bearing caps and end shields. The joint sealant must be compatible with the used lubricating oil. Connect the oil lubricant tubes (oil inlet and oil outlet tubes and motor drain tube), as shown in Figure 6-12.

8.2.4. Sleeve bearings

The lubricating oil of sleeve bearings must be changed at the intervals specified in Table 8-6. To replace the oil, proceed as follows:
- NDE-bearing: remove the protection plate from the fan cover
- Drain the oil through the drain hole located at the bottom of the bearing (see Figure 8-1)
- Close the oil drain hole
- Remove the oil inlet plug
- Fill the sleeve bearing with the specified oil and with the amount of oil specified in
- Check the oil level and ensure it is kept close to the center of the sight glass
- Install the oil inlet plug
- Check for oil leaks

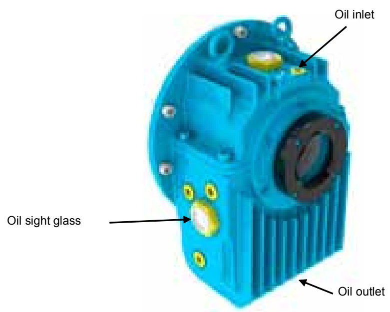


Figure 8-1 – *Sleeve bearing*

ENGLISH

***Table 8-6** – Oil properties for sleeve bearings.*

Frame (IEC)	Frame (NEMA)	Poles	Bearing designation	Oil (liters)	Interval (h)	Lubricant	Lubricant Specification
315L/A/B and 315C/D/E	5006/7/8T and 5009/10/11T	2	9-80	2.8	8000	Renolin DTA 10	ISO VG32 mineral oil with antifoam and antioxidant additives
355L/A/B and 355C/D/E	5807/8/9T and 5810/11/12T						
400L/A/B and 400C/D/E	6806/7/8 and 6809/10/11T						
450	7006/10						
315L/A/B and 315C/D/E	5006/7/8T and 5009/10/11T	4 - 8	9-90	2.8	8000	Renolin DTA 15	ISO VG46 mineral oil with antifoam and antioxidant additives
355L/A/B and 355C/D/E	5807/8/9T and 5810/11/12T		9-100				
400L/A/B and 400C/D/E	6806/7/8 and 6809/10/11T		11-110	4.7			
450	7006/10		11-125				
500	8006/10						

The lubricating oil must be replaced as specified on the nameplate or whenever changes on the oil properties are noticed. The oil viscosity and pH must be checked periodically. The oil level must be checked every day and kept in the center of the sight glass.
Please contact WEG, when oils with different viscosities are to be used.

8.3. MOTOR ASSEMBLY AND DISASSEMBLY

All repair services on motors should be always performed by qualified personnel and in accordance with the applicable laws and regulations in each country. Always use proper tools and devices for motor disassembly and assembly.

Disassembly and assembly services can be carried out only after the motor has been disconnected from the power supply and is completely stopped.

Dangerous voltages may be present at the motor terminals inside the terminal box since capacitors can retain electrical charge for long periods of time even when they are not connected directly to a power source or when space heaters are connected to the motor or when the motor windings are used as space heaters. Dangerous voltages may be present at the motor terminals when they are driven by frequency inverter even when they are completely stopped.

Record the installation conditions such as terminal connection diagram, alignment / leveling conditions before starting the disassembly procedures. These records should be considered for later assembly.

Disassemble the motor carefully without causing scratches on machined surfaces or damaging the threads.

Assemble the motor on a flat surface ensuring a good support base. Footless motors must be fixed/locked on the base to prevent accidents.

Handle the motor carefully to not damage the insulated components such as windings, insulated rolling bearings, power cables etc.

Seal elements, such as joint seals and bearing seals should always be replaced when wear or damage is noticed.

Motors with degree of protection higher than IP 55 are supplied with joint and screw seal Loctite 5923 (Henkel) Clean the components and apply a new coat of Loctite 5923 on the surfaces before assembly.

8.3.1. Terminal box

Proceed as follows to remove the terminal box cover and to disconnect/connect the power supply cables and the cables of the accessory devices:

- Ensure that during the screw removal the terminal box cover does not damage the components installed inside the terminal box.
- If the terminal box cover is fitted with lifting eyebolt, lift the terminal box cover always by its lift eyebolt.
- If motors are supplied with terminal blocks, ensure the correct tightening torque on the motor terminals as specified in Table 8-7.
- Ensure that the cables do not contact sharp edges.
- Ensure that the original IP degree of protection is not changed and is maintained as indicate on the motor nameplate. The power supply cables and the control cables must always be fitted with components (cable glands, conduits) that meet the applicable standards and regulations of each country.
- Ensure that the pressure relief device is in perfect operating condition, if provided. The seals in the terminal box must be in perfect condition for reuse and must be reinstalled correctly to ensure the specified degree of protection.
- Ensure the correct tightening torque for the securing bolts of the terminal box cover as specified in Table 8-7.

Table 8-7 *– Tightening torque for the securing bolts [Nm]*

Hex bolt/hex socket bolt (without seal)	-	4 to 7	7 to 12	16 to 30	30 to 50	55 to 85	120 to 180	230 to 360
Combined slotted screw (without seal)	-	3 to 5	5 to 10	10 to 18	-	-	-	-
Hex bolt/hex socket bolt (with seal with metallic stop/cord)	-	-	-	13 to 20	25 to 37	40 to 55	50 to 65	-
Combined slotted screw (with flat seal and/or mettallic stop/ cord)	-	3 to 5	4 to 8	8 to 15	-	-	-	-
Hex bolt/hex socket bolt (with flat seal)	-	-	-	8 to 15	18 to 30	25 to 40	35 to 50	-
Terminal blocks	1 to 1,5	1,5 to 4	4 to 6,5	6,5 to 9	10 to 18	18 to 30	35 to 50	-
Grounding terminals	-	3 to 5	5 to 10	10 to 18	30 to 50	55 to 85	120 to 180	-

8.4. DRYING THE STATOR WINDING INSULATION

Dismantle the motor completely. Remove the end shields, the rotor with the shaft, the fan cover, the fan and the terminal box before the wound stator with the frame is transferred to the oven for the drying process. Store the wound stator during two hours in the oven heated to max. 120 ºC. For larger motors a longer drying time may be required. After the drying process has been concluded, allow the stator to cool to room temperature. Measure the insulation resistance again as described in item 5.4. Repeat the stator drying process if the required insulation resistance does not meet the values specified in Table 5-3. If the insulation resistance does not improve despite several drying processes, evaluate the causes of the insulation resistance drop carefully and an eventual replacement of the motor winding may be required. If in doubt contact WEG.

To prevent electrical shock, discharge the motor terminals immediately before, and after each measurement. If the motor is equipped with capacitors, these must be discharged before beginning any repair.

8.5. SPARE PARTS

When ordering spare parts, always provide complete motor designation, indicating the motor type, the code number and the serial number, which are stated on the motor nameplate.

Spare parts must always be purchased from WEG authorized Service Centers. The use of non-original spare parts can cause motor failure, performance drop and void the product warranty.

The spare parts must be stored in a clean, dry and properly ventilated room, with relative air humidity not exceeding 60%, with ambient temperature between 5°C and 40°C, free of dust, vibrations, gases, corrosive smokes and at constant temperature. The spare parts must be stored in their normal mounting position without placing other components onto them.

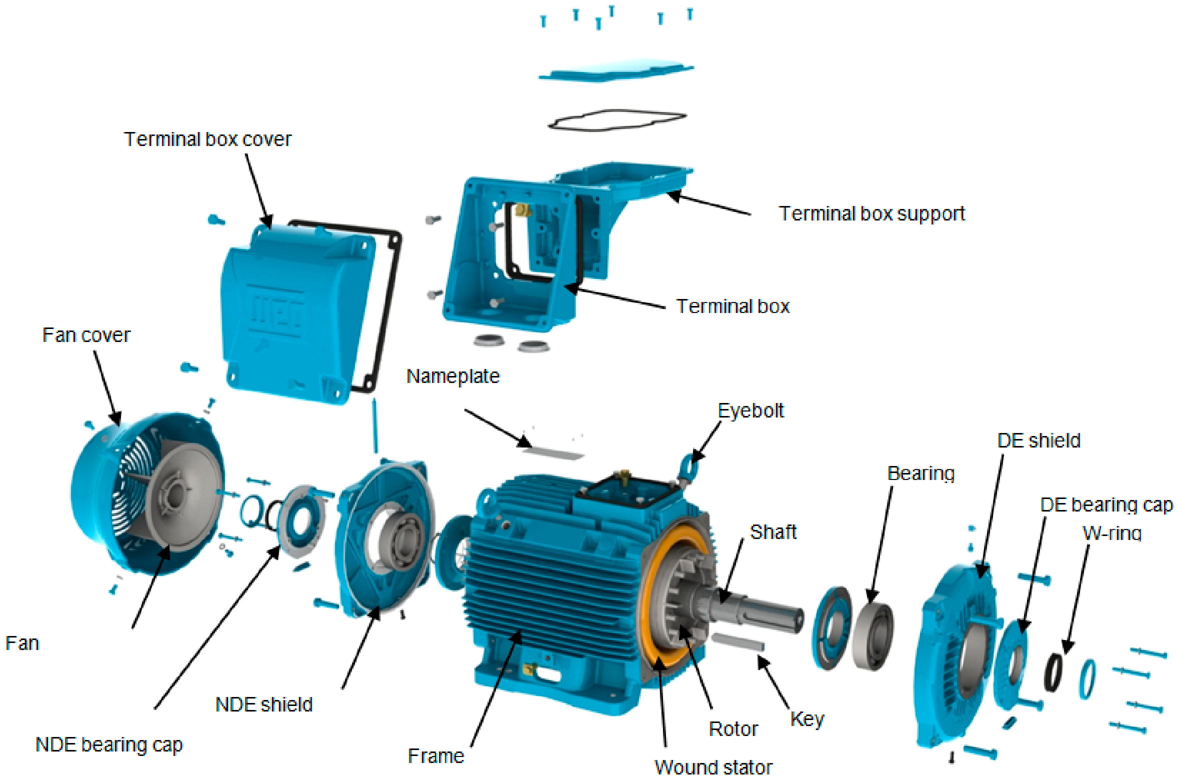


Figure 8-2 *- Exploded view of the components of a W22 motor*

ENGLISH

9. ENVIRONMENTAL INFORMATION

9.1. PACKAGING

WEG electric motors are supplied in cardboard, plastic or wooden packaging. These materials can be recycled and must be disposed according to the applicable laws and regulations in each country. All wood used in the packaging of WEG motors come from the company reforestation program and is not submitted to any chemical conservation treatment.

9.2. PRODUCT

Electric motors consist mainly of ferrous metals (steel plates and cast iron), non ferrous metals (cooper and aluminum) and plastic materials.

In general, electric motors have relatively long service live. However when they must be discarded, WEG recommends to dismantle the motor, sort the different materials and send them for recycling.

No-recyclable materials should be disposed of at industrial landfills according to the applicable environmental laws and regulations in each country, or co-processed in cement kilns or incinerated.

The recycling service providers, the disposal in industrial landfills, the waste co-processing or the incineration process must be properly authorized by the state environment agency to carry out these activities.

10. TROUBLESHOOTING CHART X SOLUTIONS

This troubleshooting chart provides a basic list of problems that may occur during motor operation, possible causes and recommended corrective actions. In case of doubts, please contact WEG Service Center.

Problem	Possible cause	Corrective action
Motor does not start, neither coupled nor decoupled	Power cables are interrupted.	Check the control panel and the motor power supply cables.
	Blown fuses.	Replace blown fuses.
	Wrong motor connection.	Correct the motor connection according to connection diagram.
	Locked rotor.	Check motor shaft to ensure that it rotates freely.
The motor starts at no-load, but fails when load is applied. It starts very slowly and does not reach the rated speed.	Load toque is too high during start-up.	Do not start the motor on load.
	Too high voltage drop in the power cables	Check the installation dimensioning (transformer, cable cross section, relays, circuit breakers, etc.)
Abnormal / excessive noise	Defective transmission component or defective driven machine.	Check the transmission force, the coupling and the alignment.
	Misaligned / unleveled base.	Align / level the motor with the driven machine
	Unbalanced components or unbalanced driven machine	Balance the machine set again
	Different balancing methods used for motor and coupling balancing (halve key, full key)	Balance the motor again
	Wrong motor direction of rotation	Reverse the direction of rotation
	Loose bolts	Retighten the bolts
	Foundation resonance	Check the foundation design
	Damaged bearings	Replace the bearings
Motor overheating	Insufficient cooling	Clean air inlet and outlet and cooling fins
		Check the minimum required distance between the fan cover and nearest walls. See item 7
		Check air temperature at inlet
	Overload	Measure motor current, evaluate motor application and if required, reduce the load
	Number of starts per hour is too high or the load inertia moment is too high	Reduce the number of starts per hour
	Power supply voltage too high	Check the motor power supply voltage. Power supply voltage must not exceed the tolerance specified in item 7.2
	Power supply voltage too low	Check the motor power supply voltage and the voltage drop. Power supply voltage must not exceed the tolerance specified in item 7.2
	Interrupted power supply	Check the connection of the power cables
	Voltage unbalance at the motor terminals	Check for blown fuses, wrong commands, voltage unbalance in the power line, phase fault or interrupted power cables
	Direction of rotation is not compatible with the unidirectional fan	Check if the direction of rotation matches the rotation arrow indicated on end shield
Bearing overheating	Excessive grease / oil	Clean the bearing and lubricate it according to the provided recommendations
	Grease / oil aging	
	The used grease / oil does not matches the specified one	
	Lack of grease / oil	Lubricate the bearing according to the provided recommendations
	Excessive axial or radial forces due to the belt stretching	Reduce the belt stretching
		Reduce the load applied to the motor

ENGLISH

11. WARRANTY TERM

WEG Equipamentos Elétricos S/A, Motor Unit, offers warranty against defects in workmanship and materials for their products for a period of 18 months from the invoice issue date by factory or distributor / dealer, limited to 24 months from date of manufacture. Motors of the HGF Line are covered for a period of 12 months from the invoice issue date by the factory or distributor / dealer, limited to 18 months from the date of manufacture.

The paragraph above contains the legal warranty periods. If a warranty period is defined in a different way in the commercial, technical proposal of a particular sale, that will override the time limits set out above.
The periods above are independent of installation date and provided that the following requirements are met: proper transportation, handling and storage; correct installation in specified environmental conditions free of aggressive agents; operation within the capacity limits and observation of the Installation, Operation and Maintenance Manual; execution of regular preventive maintenance; execution of repairs and/or changes only by personnel with WEG's written authorization; in the occurrence of an anomaly, the product must be available to the supplier for the minimum period necessary to identify the cause of the anomaly and to repair it properly; the buyer must immediately notify WEG of any defects occurred and they must be later confirmed as manufacturing defects by WEG. The warranty does not include assembly and disassembly services at the buyer's premises, costs of product transportation, as well as travel, lodging and meals expenses for the technical assistance staff when requested by the customer. The warranty service will be provided exclusively at a WEG authorized Technical Assistance or at the plant.
Components, parts and materials whose useful life is usually less than 12 (twelve) months are not covered by the warranty.
Under no circumstance will warranty services extend the warranty period of the equipment. However, new warranty equivalent to the original one will be due only to the components repaired or replaced by WEG.
The present warranty is limited to the product supplied. WEG will not be liable for damages to people, third parties, other equipment and facilities, loss of profits or other incidental or consequential damages.

12. EC DECLARATION OF CONFORMITY

WEG Equipamentos Elétricos S/A
Av. Prefeito Waldemar Grubba, 3000
89256-900 - Jaraguá do Sul – SC – Brazil,

and its authorised representative established in the European Community,
WEGeuro – Industria Electrica SA
Rua Eng Frederico Ulrich, Apartado 6074
4476-908 – Maia – Porto – Portugal

hereby declare that the products:

WEG induction motors and components for using in these motors:

Three-phase
IEC frames 63 to 630
Nema frames 42, 48, 56 and 143 to 9610
……………

Single-phase
IEC frames 63 to 132
Nema frames 42, 48, 56 and 143 to 215
……………

when installed, maintained and used in applications for which they were designed, and in compliance with the relevant installation standards and manufacturer's instructions, comply with the requirements of the following European Directives and standards where applicable:

Directives:
Low Voltage Directive 2006/95/EC
Regulation (EC) No 640/2009
Directive 2009/125/EC
EMC Directive 2004/108/EC (induction motors are considered inherently benign in terms of electromagnetic compatibility)

Standards:
EN 60034-1/2-1/5/6/7/8/9/11/12/14/30 and 60204-1

From 29/12/2009 on low voltage electric motors are no longer considered under the scope of the current Machinery Directive 2006/42/EC.

CE marking in: 1996

Milton Oscar Castella
Engineering Director

Jaraguá do Sul, May 31st, 2011

ENGLISH

WEG Equipamentos Elétricos S.A.
International Division
Av. Prefeito Waldemar Grubba, 3000
89256-900 - Jaraguá do Sul - SC - Brazil
Phone: 55 (47) 3276-4002
Fax: 55 (47) 3276-4060
www.weg.net

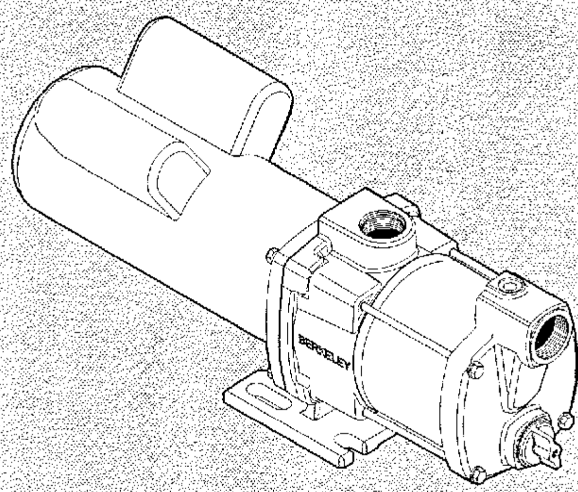
Cod: 50033244 | Rev: 00 | Date (m/y): 08/2011
The values shown are subject to change without prior notice.

BERKELEY®

293 Wright Street, Delavan, WI 53115
Phone: 888-237-5353
Fax: 800-321-7893
Web Site: BerkeleyPumps.com

OWNER'S MANUAL

Self-Priming Horizontal Three and Four Stage Pumps



SSHM-2

Installation/Operation/Parts

For further operating, installation, or maintenance assistance:

Call 1-888-237-5353

BE652 (02/27/12)

Important Safety Instructions

SAVE THESE INSTRUCTIONS - This manual contains important instructions that should be followed during installation, operation, and maintenance of the product. Save this manual for future reference.

⚠ This is the safety alert symbol. When you see this symbol on your pump or in this manual, look for one of the following signal words and be alert to the potential for personal injury!

⚠ DANGER indicates a hazard which, if not avoided, *will* result in death or serious injury.

⚠ WARNING indicates a hazard which, if not avoided, *could* result in death or serious injury.

⚠ CAUTION indicates a hazard which, if not avoided, *could* result in minor or moderate injury.

NOTICE addresses practices not related to personal injury.

Carefully read and follow all safety instructions in this manual and on pump.

Keep safety labels in good condition.

Replace missing or damaged safety labels.

Electrical Safety

⚠ WARNING **Hazardous voltage.** Follow these rules to avoid potential harm:

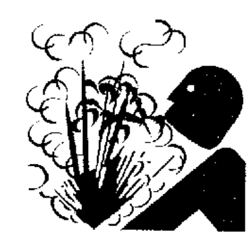
- Wire motor for correct voltage. See "Electrical" section of this manual and motor nameplate.
- Ground motor before connecting to power supply.
- Meet National Electrical Code, Canadian Electrical Code, and local codes for all wiring.
- Follow wiring instructions in this manual when connecting motor to power lines.
- Make workshops childproof; use padlocks and master switches; remove starter keys.

⚠ WARNING **Risk of burns.** Do not touch an operating motor. Motors can operate at high temperatures. To avoid burns when servicing pump, allow it to cool for 20 minutes after shut-down before handling.

⚠ WARNING

Hazardous voltage.
Can shock, burn, or cause death.

Ground pump before connecting to power supply.



⚠ WARNING

Hazardous pressure!
Do not run pump against closed discharge.

Release all pressure on system before working on any component.

General Safety

To avoid heat built-up in pump, over pressure hazard and possible injury, do not use in a pressure tank (domestic water) system. Do not use as a booster pump; pressurized suction may cause pump body to explode.

Do not allow pump or piping system to freeze. Freezing can damage pump and pipe, may lead to injury from equipment failure and will void warranty.

Pump water only with this pump.

Periodically inspect pump and system components.

Wear safety glasses at all times when working on pumps.

Keep work area clean, uncluttered and properly lighted; store properly all unused tools and equipment.

Keep visitors at a safe distance from the work areas.

Maximum inlet pressure	30 psi
Maximum operating pressure	130 psi
Maximum liquid temperature	120° F
Maximum motor starts per hour	15

Limited Warranty

BERKELEY warrants to the original consumer purchaser ("Purchaser" or "You") of the products listed below, that they will be free from defects in material and workmanship for the Warranty Period shown below.

Product	Warranty Period
Water Systems:	
Water Systems Products — jet pumps, small centrifugal pumps, submersible pumps and related accessories	*whichever occurs first:* 12 months from date of original installation, or 18 months from date of manufacture
Pro-Source™ Composite Tanks	5 years from date of original installation
Pro-Source™ Steel Pressure Tanks	5 years from date of original installation
Pro-Source™ Epoxy-Lined Tanks	3 years from date of original installation
Sump/Sewage/Effluent Products	12 months from date of original installation, or 18 months from date of manufacture
Agricultural/Commercial:	
Centrifugals – close-coupled motor drive, frame mount, SAE mount, engine drive, VMS, SSCX, SSHM, solids handling, submersible solids handling	12 months from date of original installation, or 24 months from date of manufacture
Submersible Turbines, 6" diameter and larger	12 months from date of original installation, or 24 months from date of manufacture

Our limited warranty will not apply to any product that, in our sole judgement, has been subject to negligence, misapplication, improper installation, or improper maintenance. Without limiting the foregoing, operating a three phase motor with single phase power through a phase converter will void the warranty. Note also that three phase motors must be protected by three-leg, ambient compensated, extra-quick trip overload relays of the recommended size or the warranty is void.

Your only remedy, and BERKELEY's only duty, is that BERKELEY repair or replace defective products (at BERKELEY's choice). You must pay all labor and shipping charges associated with this warranty and must request warranty service through the installing dealer as soon as a problem is discovered. No request for service will be accepted if received after the Warranty Period has expired. This warranty is not transferable.

BERKELEY SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, OR CONTINGENT DAMAGES WHATSOEVER.

THE FOREGOING LIMITED WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE FOREGOING LIMITED WARRANTIES SHALL NOT EXTEND BEYOND THE DURATION PROVIDED HEREIN.

Some states do not allow the exclusion or limitation of incidental or consequential damages or limitations on the duration of an implied warranty, so the above limitations or exclusions may not apply to You. This warranty gives You specific legal rights and You may also have other rights which vary from state to state.

This Limited Warranty is effective June 1, 2011 and replaces all undated warranties and warranties dated before June 1, 2011.

In the U.S.: BERKELEY, 293 Wright St., Delavan, WI 53115
In Canada: 269 Trillium Dr., Kitchener, Ontario N2G 4W5

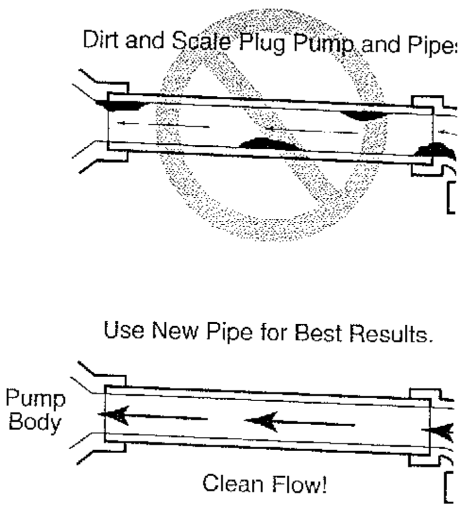


Figure 1 – No Dirt or Scale in Suction Pipe

Before you install your pump

NOTICE: Well must not be more than 20′ depth to water.

1. Long runs and many fittings increase friction and reduce flow. Locate pump as close to well as possible: use as few elbows and fittings as possible.
2. Be sure well is clear of sand. Sand will plug the pump and void the warranty.
3. Protect pump and all piping from freezing. Freezing will split pipe, damage pump and void the warranty. Check locally for frost protection requirements (usually pipe must be 12″ below frost line and pump must be insulated).
4. Be sure all pipes and foot valve are clean and in good shape.
5. No air pockets in suction pipe.
6. No leaks in suction pipe. Use PTFE pipe thread sealant tape to seal pipe joints.
7. Unions installed near pump and well will aid in servicing. Leave room to use wrenches.
8. ⚠WARNING **Risk of explosion.** Pump body may explode if used as a booster pump. DO NOT use in a booster application.

   NOTICE: Use the installation method which matches your well type.
9. Install a check valve in the pump suction port. Be sure that the flow arrow points toward the pump. Failure to install a check valve on the inlet side of the pump may allow the pump body to drain between pump cycles, causing dry running, seal or internal failure, and voiding the warranty.

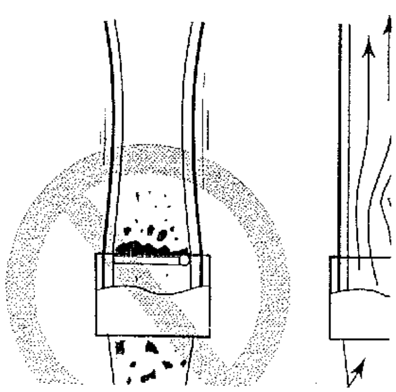


Figure 2 – Foot Valve Must Work Freely

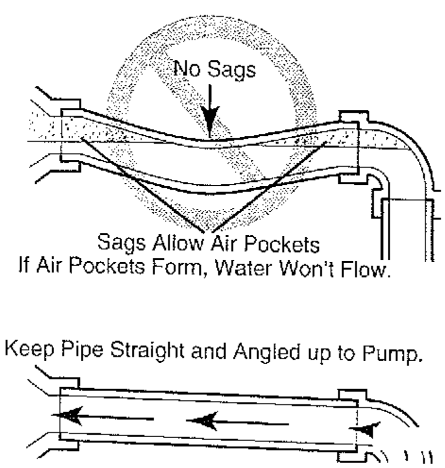


Figure 3 – No Air Pockets in Suction Pipe

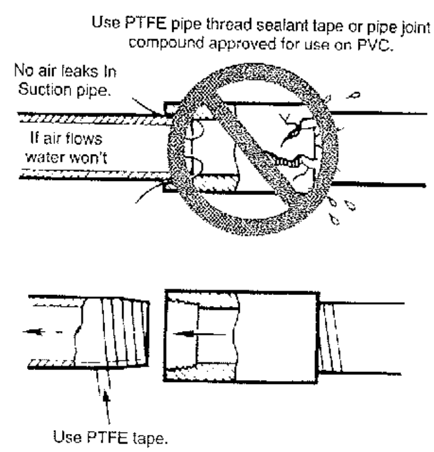


Figure 4 – Suction Pipe Must Not Leak

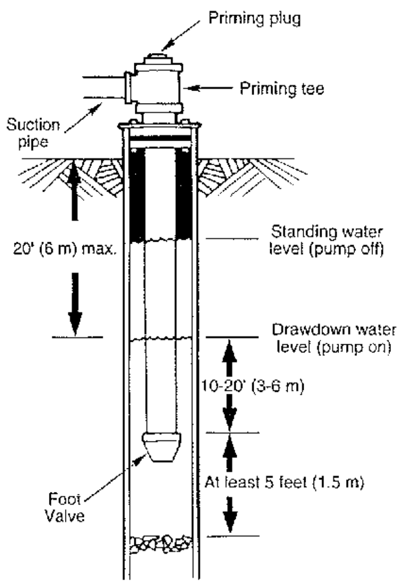


Figure 5 – Cased/Dug Well Installation

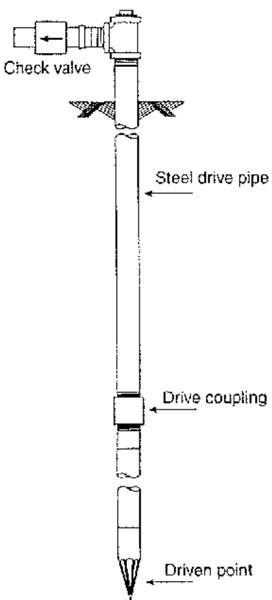


Figure 6 – Driven Point Installation

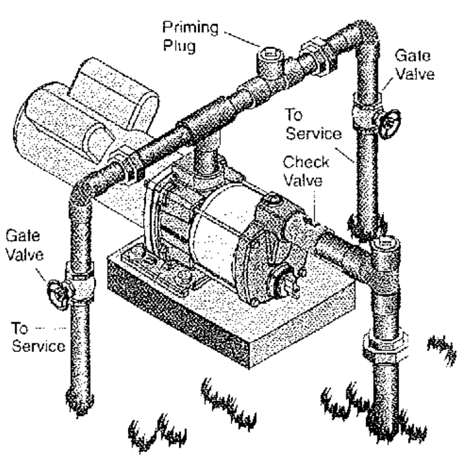


Figure 7 – Multiple Discharge

Cased Well Installation

1. Inspect foot valve to be sure it works freely. Inspect strainer to be sure it is clean.
2. Connect foot valve and strainer to the first length of suction pipe and lower pipe into well. Add sections of pipe as needed, using PTFE tape on male threads. Be sure that all suction pipe is leakproof or pump will lose prime and fail to pump. Install foot valve 10 to 20 feet below the lowest level to which water will drop while pump is operating (pumping water level). Your well driller can furnish this information.
3. To prevent sand and sediment from entering the pumping system, the foot valve/strainer should be at least 5 feet above the bottom of the well.
4. When the proper depth is reached, install a sanitary well seal over the pipe and in the well casing. Tighten the bolts to seal the casing.
5. When using a foot valve, a priming tee and plug as shown in Figure 5 are recommended.

Dug Well Installation

Same as cased well installation.

Driven Point Installation

1. Connect the suction pipe to the drive point as illustrated in Figure 6. Keep horizontal pipe run as short as possible. Use PTFE pipe thread sealant tape on male pipe threads. Multiple well points may be necessary to provide sufficient water to pump.
2. Install a check valve in horizontal pipe. Flow arrow on check valve must point toward pump.

Horizontal Piping From Well To Pump

1. Never install a suction pipe that is smaller than the suction port of the pump.
2. To aid priming on well point installations, install a line check valve as shown in Figure 6. Be sure check valve flow arrow points toward pump.

Discharge Pipe Sizes

1. If increasing discharge pipe size, install reducer in pump discharge port. Do not increase pipe size by stages.
2. When the pump is set away from the points of water use, the discharge pipe size should be increased to reduce pressure losses caused by friction.
   - Up to 100′ run: Same size as pump discharge port.
   - 100′ to 300′ run: Increase one pipe size.
   - 300′ to 600′ run: Increase two pipe sizes.

Sprinkling Application

This pump is designed to deliver plenty of water at full sprinkler pressure. It can pump from a pond, cistern or well points.

Pump discharge can be divided to supply two (2) or more sprinkler systems. A suggested multiple discharge to service is shown in Figure 7.

Do not use in a pressure tank or booster pump application.

Pump Installation

Make sure that all pipe joints in the suction pipe are air tight as well as water tight. If the suction pipe can suck air, the pump will not be able to pull water from the well.

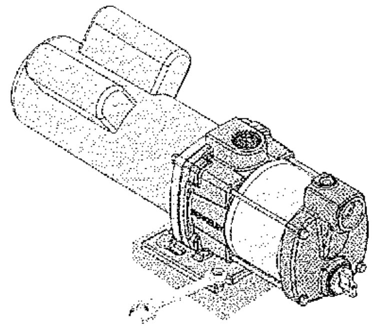


Figure 8 – Bolt Pump Down

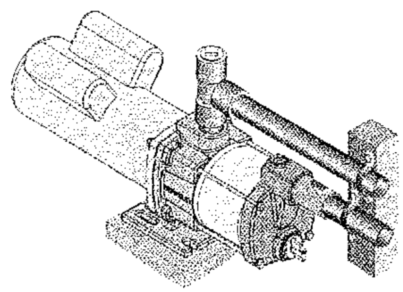


Figure 9 – Independently Support All Piping Attached to Pump

1. Bolt pump to solid, level foundation.
2. Support all piping connected to the pump.
3. Wrap 1-1/2 to two layers of PTFE tape clockwise (as you face end of pipe) on all male threads being attached to pump.
4. Tighten joints hand tight plus 1-1/2 turns. Do not overtighten.

NOTICE : Install pump as close to well head as possible. Long piping runs and many fittings create friction and reduce flow.

NOTICE: For long horizontal pipe runs, install a priming tee between check valve and well head as shown in Figure 6. For driven point installations, install a check valve as shown in Figure 6. Be sure check valve flow arrow points toward pump.

Use schedule 80 or iron pipe. See *Well Pipe Installation* for more information.

Wiring

⚠WARNING **Hazardous voltage.** Follow these rules to avoid potential harm:

- Ground motor before connecting to electrical power supply. Failure to ground motor can cause severe or fatal electrical shock hazard.
- Do not ground to a gas supply line.
- To avoid dangerous or fatal electrical shock, turn OFF power to motor before working on electrical connections.
- Supply voltage must be within ±10% of nameplate voltage. Incorrect voltage can cause fire or damage motor and voids warranty. If in doubt consult a licensed electrician.
- Use wire size specified in *Wiring Chart*. If possible, connect pump to a separate branch circuit with no other appliances on it.
- Wire motor as shown (Figure 12B). If motor nameplate diagram does not match either Figure 12A or 12B, follow nameplate diagram.

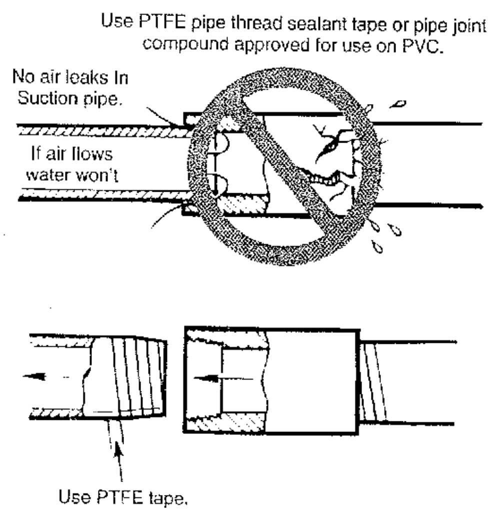


Figure 10 – Use PTFE pipe thread sealant tape on pipe joints and connections to pump.

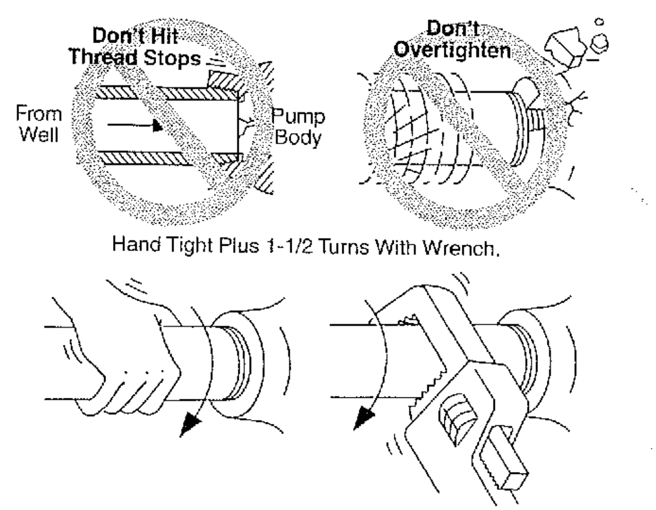


Figure 11 – Don't overtighten.

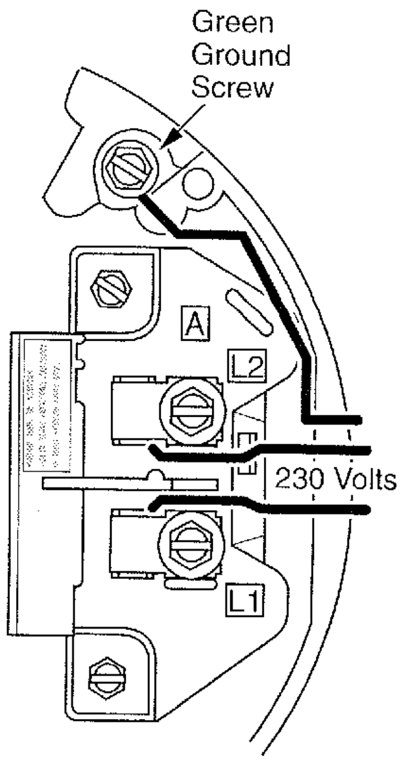


Figure 12A – 230V Single Phase Wiring Diagram

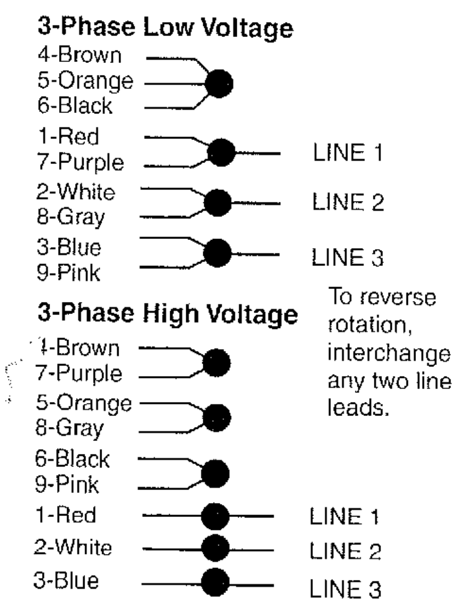


Figure 12B – 3-Phase Wiring Diagram

Connection Diagram for Single-Phase Motors

Your motor's terminal board (under the motor end cover) should match the diagram in Figure 12A or 12B.

For single-phase motors, follow Figure 12A. For 3-phase motors, follow Figure 12B. If motor does not match this picture, follow the connection diagram on the motor nameplate or in the motor connection box.

⚠WARNING **Hazardous voltage.** Can shock, burn, or cause death. Disconnect power to motor before working on pump or motor. Ground motor before connecting to power supply.

1. Install, ground, wire and maintain this pump in accordance with electrical code requirements. Consult your local building inspector for information about codes.
2. Provide a correctly fused disconnect switch for protection while working on motor. Consult local or national electrical codes for switch requirements.
3. Disconnect power before servicing motor or pump. If the disconnect switch is out of sight of pump, lock it open and tag it to prevent unexpected power application.
4. Ground the pump permanently using a wire of the same size as that specified in wiring chart (below). Make ground connection to green grounding terminal under motor canopy marked GRD. or ⏚.
5. Connect ground wire to a grounded lead in the service panel or to a metal underground water pipe or well casing at least 10 feet long. Do not connect to plastic pipe or insulated fittings.
6. Protect current carrying and grounding conductors from cuts, grease, heat, oil, and chemicals.
7. Connect current carrying conductors to terminals L1 and L2 under motor canopy (single phase) or in motor connection box (3-phase). When replacing motor, check wiring diagram on motor nameplate against Figures 12A and 12B. If the motor wiring diagram does not match one of the diagrams in Figures 12A and 12B, follow the diagram on the motor.
8. Motor has automatic internal thermal overload protection. If motor has stopped for unknown reasons, thermal overload may restart it unexpectedly, which could cause injury or property damage. Disconnect power before servicing motor.
9. If this procedure or the wiring diagram is confusing, consult a licensed electrician.

Wiring Chart – Recommended Wire and Fuse Sizes

Model	Motor HP	Volts/Hz/Phase	Service Factor Amp	Branch Fuse* Rating Amp	Distance In Feet(Meters) From Motor To Supply				
					0 - 100 (0 - 30)	101 - 200 (31 - 61)	201 - 300 (62 - 91)	301 - 400 (92 - 122)	401 - 500 (123 - 152)
					AWG Wire Size (mm²)				
B82456	2	230/60/1	13.3	20	12 (3)	12 (3)	10 (5.5)	10 (5.5)	8 (8.4)
B82639	2	208-230/460/60/3	10.2/5.1	15/15	14 (2)/14 (2)	14 (2)/14 (2)	12 (3)/14 (2)	10 (5.5)/14 (2)	10 (5.5)/14 (2)
B86073	2	230/60/1	9.8	20	14 (2)	14 (2)	12 (3)	10 (5.5)	10 (5.5)
B86074	2	208-230/460/60/3	9.2/4.6	15/15	14 (2)/14 (2)	14 (2)/14 (2)	12 (3)/14 (2)	10 (5.5)/14 (2)	10 (5.5)/12 (3)

* Dual element time delay fuse

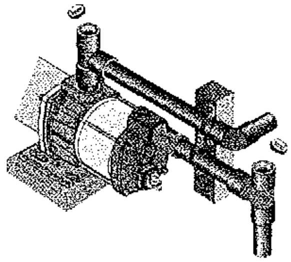


Figure 13 – Remove Priming Plugs

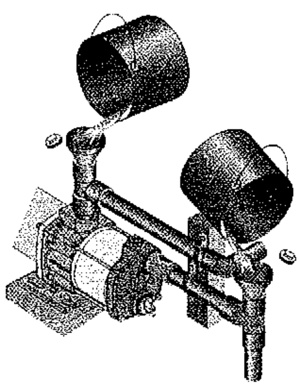


Figure 14 – Fill Pump Before Starting

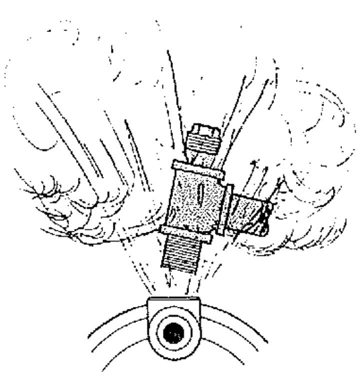


Figure 15 – Do Not Run Pump with Discharge Shut-off.

Priming The Pump

NOTICE: The term 'priming' refers to the process of pumping all the air out of the system, filling the pump and suction piping with water, and beginning to move water through the pump and out into the system. A 'self-priming' pump generally will repeat this process without attention once the pump and system are full of water. If the water drains out of the pump (back into the well, for example), then the whole priming process must be repeated before operating the pump again.

To make sure that the pump will 'retain its prime' (that is, that the pump and its piping will stay full of water), BE SURE to install a check valve in the pump inlet port with the flow arrow pointing towards the pump. The check valve will prevent water from siphoning out of the pump body and back down into the well, which will keep the pump full and allow it to restart on its own.

DO NOT remove the recirculation valve cover (there are spring-loaded parts inside the recirculation valve – see Figure 16) when priming or draining the pump. The drain is a hex-head pipe plug underneath the pump body. To drain the pump, remove the hex plug (Ref. No. 17, *Repair Parts* diagram). **Do not disturb the recirculation valve** (Ref. No. 19).

- If the pump or the suction pipe have been drained for any reason, BE SURE to reprime the pump before starting it.

NOTICE: NEVER run the pump dry. Running the pump without water in it will damage the seals, can melt the impellers and diffusers, and voids the warranty. To prevent damage, fill the pump with water before starting.

1. Remove priming plug (Figure 13).
2. Make sure suction and discharge valves and any hoses on discharge side of pump are open.
3. Fill pump and suction pipe with water.
4. Replace priming plug, using PTFE tape on thread; tighten plug.
   NOTICE: If a priming tee and plug have been provided for a long horizontal run, be sure to fill suction pipe through this tee and replace plug. (Don't forget to PTFE tape the plug.)
5. Start pump: water should be produced in 5 minutes or less, the time depending on depth to water (not more than 20') and length of horizontal run (10' of horizontal suction pipe = 1' of vertical lift due to friction losses in the pipe).
   If no water is produced within 5 minutes, stop pump, release all pressure, remove priming plug, refill and try again.

⚠WARNING **Hazardous pressure and risk of explosion and scalding.** If pump is run continuously at no flow (that is, with discharge shut off or without priming), water may boil in pump and piping system. Under steam pressure, pipes may rupture, blow off of fittings or blow out of pump ports and scald anyone near.

To prevent explosion, do the following:

A. Be sure discharge (valve, pistol grip hose nozzle, etc.) is open whenever pump is running.
B. If pump fails to produce water when attempting to prime, release all pressure, drain pump and refill with cold water after every two attempts.
C. When priming, monitor pump and piping temperature. If pump or piping begin to feel warm to the touch, shut off pump and allow system to cool off. Release all pressure in system and refill pump and piping with cold water.

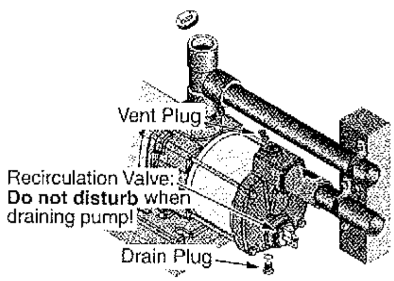


Figure 16

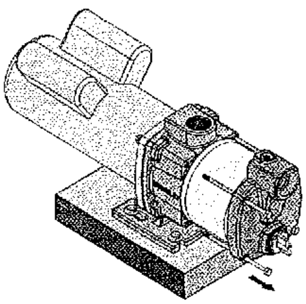


Figure 17

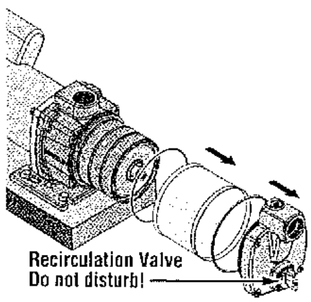


Figure 18

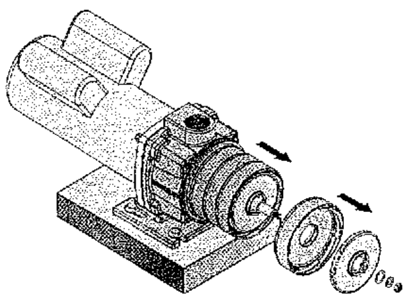


Figure 19

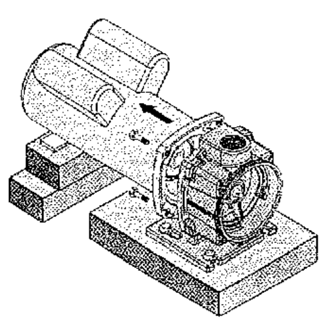


Figure 20

Maintenance

If motor is replaced, replace the shaft seal and O-Rings. Keep a seal and O-Rings on hand for future use.

Be sure to prime pump before starting.

NOTICE: The mechanical shaft seal in the pump is water lubricated and self-adjusting.

NOTICE: Drain pump (see Figure 16) when disconnecting from service or when it might freeze. You can fill the pump with RV anti-freeze (propylene glycol) to prevent it from freezing. DO NOT remove the Recirculation Valve to drain the pump (Figure 16). Remove the hex head plug on the bottom of the Pump Suction Body to drain the pump.

Pump Disassembly

See *Repair Parts* for Ref. No. references.

NOTICE: **Do not disturb the recirculation valve** (see Figure 16). It is NOT a drain plug!

1. Shut off power to the pump before working on it.
2. Close all suction and discharge valves to isolate the pump before proceeding further.
3. Remove the hex head drain plug (Ref. No. 17) from the suction body and drain the pump.
4. Disconnect the suction line.
5. Remove four capscrews (Ref. No. 18) from the pump (see Figure 17).
6. Pull the pump suction body forward (see Figure 18). Remove the sleeve (Ref. No. 9) by pulling it straight forward. Be careful not to damage the O-rings on the bracket and suction body.
7. Remove the motor canopy, hold the motor shaft with a 7/16" open end wrench, and remove the nut and two washers (Ref. Nos. 14, 13, 12) from the end of the shaft. See Figure 19.
8. Slide the impellers and diffusers (Ref. Nos. 11, 10) off of the shaft (Figure 19).
9. Slide the spacer (Ref. No. 7) off of the shaft, then pull the rotating half of the seal (Ref. No. 6) forward on the shaft and remove it.
10. Block up the motor (so that the shaft will not take the weight of the motor when you loosen the capscrews holding the motor to the bracket), remove four capscrews (Ref. No. 2), and slide the motor and shaft back out of the bracket (see Figure 20).

    NOTICE: To avoid springing the shaft, be sure that the shaft does not take the weight of the motor as you remove it.

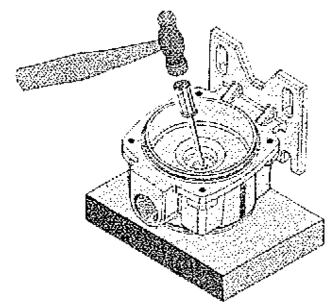


Figure 21

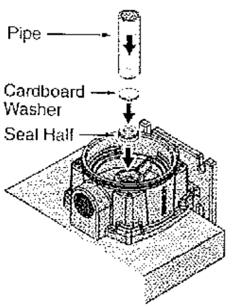


Figure 22

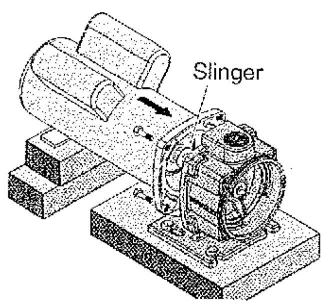


Figure 23

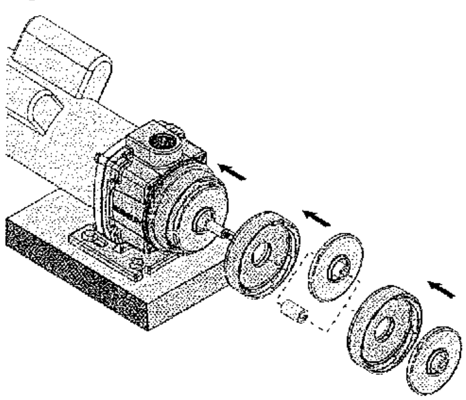


Figure 24

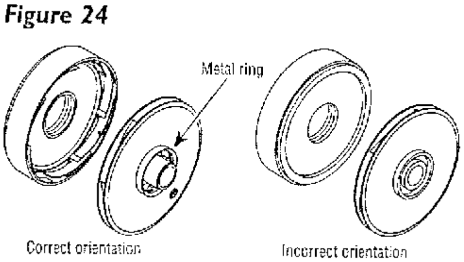


Figure 25

Seal Removal

1. Follow the instructions under "Pump Disassembly", above.
2. Remove the discharge pipe from the bracket (Ref. No. 4).
3. Remove the hold down bolts from the bracket.
4. Turn the bracket motor side up on the bench and use a screwdriver to carefully tap the stationary seal half out of the bracket (see Figure 21).
5. Clean the seal seat cavity in the bracket.

Seal Installation

1. Turn the bracket pump side up on the bench. You will need to block it up to do this (See Figure 22).
2. Clean the seal cavity in the bracket.
3. Wet the outer edge of the rubber cup on the ceramic seat with liquid soap. Be sparing!
4. Put a clean cardboard washer on the seal face. With thumb pressure, press the ceramic seal half firmly and squarely into the seal cavity. The polished face of the ceramic seat is up. If the seal will not seat correctly, remove it, placing the seal face up on the bench. Reclean the cavity. The seal should now seat correctly.
5. If the seal does not seat correctly after recleaning the cavity, place a clean cardboard washer over the polished seal face and carefully press it into place using a piece of standard 3/4" pipe as a press.
   NOTICE: Be sure you do not scratch the seal face.
6. Dispose of the cardboard washer and recheck the seal face to be sure it is free of dirt, foreign particles, scratches and grease.
7. Inspect the shaft to be sure it is free of nicks and scratches.

Pump Reassembly

1. Bolt the bracket down to the foundation (see Figure 23).
2. Slide the motor shaft through the seal and bolt up the motor (see Figure 23). Make sure that the slinger is on the shaft between the bracket and the motor flange. Make sure that you don't chip the seal face with the shaft shoulders and that the shaft does not take the weight of the motor at any time.
2. CAREFULLY slide the rotating seal half onto the shaft, seal face first. Make sure that you don't chip the seal face on the shaft shoulders.
3. Follow the seal half with the spacer (Ref. No. 7). Slide the washer up against the seal.
4. Slide a diffuser onto the shaft (open face out) until it seats on the bracket (see Figure 24). Follow the diffuser with an impeller on a four-stage pump or with the stainless steel spacer if a three-stage pump. Engage the molded impeller key in the slot in the shaft. Don't force it! Be sure that the impeller eye, with metal ring, faces out (forward - see Figure 25).
5. Repeat step 4 with the remaining impellers and diffusers.
6. Reinstall the toothed washer, the flat washer, and the impeller nut (in that order – Ref. Nos. 12,13,14) onto the motor shaft (see Figure 26). Hold the shaft and tighten the impeller nut to 10 ft.-lbs. torque.
7. Check the sleeve O-Rings; if they show any damage or wear, replace them. Reinstall the sleeve O-Rings (Ref. No. 8) on the bracket and the suction body.

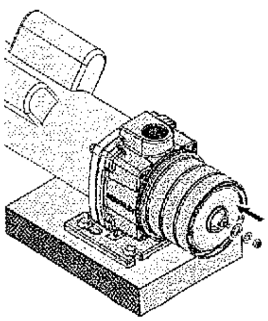


Figure 26

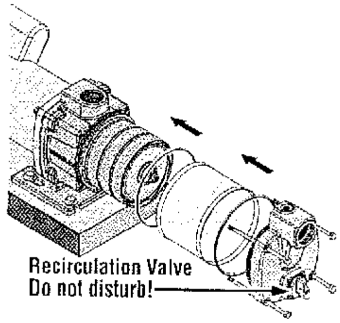


Figure 27

8. Reinstall the sleeve on the bracket and the pump suction body in the sleeve. Be sure that you do not pinch or damage the O-Ring. See Figure 27.
9. Install four capscrews (Ref. No. 18) through the pump head and into the bracket. Tighten the capscrews to 22 ft.-lbs. torque.
10. Reinstall the drain plug and washer (Ref. Nos. 17 and 16) in the suction body.

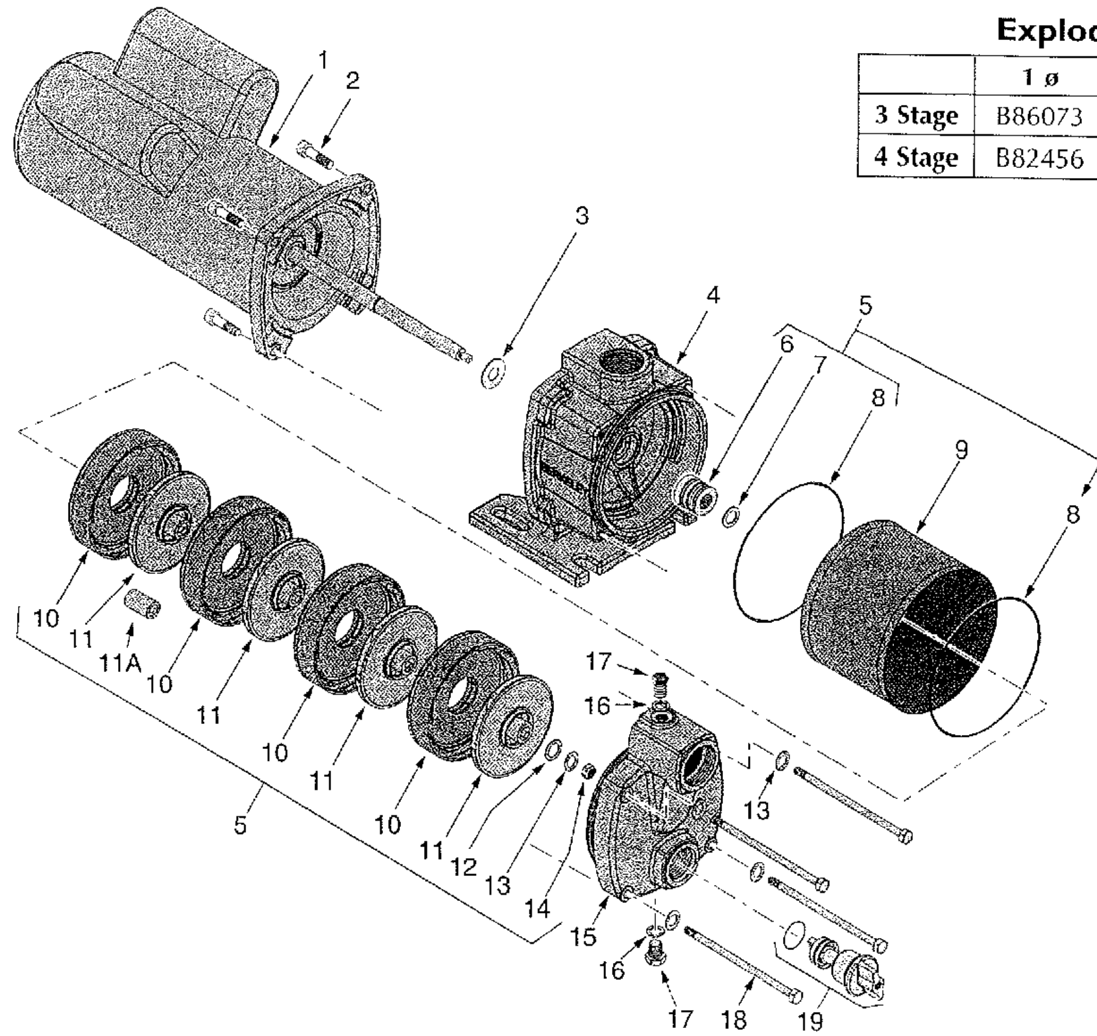
    NOTICE: **Do not disturb the recirculation valve.**
11. Reinstall the suction and discharge piping and open all valves. Check for leaks.
12. Prime the pump according to the instructions on Page 8.

Troubleshooting

Symptom	Possible Cause(s)	Corrective Action(s)
Motor will not run	Disconnect switch is off	Be sure switch is on.
	Fuse is blown or circuit breaker tripped.	Replace fuse or reset circuit breaker.
	Starting switch is defective.	DISCONNECT POWER; Replace starting switch.
	Wires at motor are loose, disconnected, or wired incorrectly.	Refer to instructions on wiring. DISCONNECT POWER; check and tighten all wiring. **⚠WARNING Risk of electrical shock.** Capacitor voltage may be hazardous. To discharge capacitor, hold insulated handle screwdriver BY THE HANDLE and short capacitor terminals together. Do not touch metal screwdriver blade or capacitor terminals. If in doubt, consult a qualified electrician.
Motor runs hot and overload kicks off.	Motor is wired incorrectly.	Refer to instructions on wiring.
	Voltage is too low	Check with power company. Install heavier wiring if wire size is too small (See Electrical / Wiring Chart).
Motor runs but no water is delivered in new installation:*	1. Improper priming	1. Re-prime according to instructions.
	2. Air leaks	2. Check all connections on suction line, with soapy water or shaving cream.
	3. Leaking foot valve or check valve	3. Replace foot valve or check valve.
* Stop pump; then check prime before looking for other causes. Unscrew priming plug and see if water is in priming hole.	1. Air leaks	1. Check all connections on suction line and shaft seal.
	2. Water level below suction pipe inlet	2. Lower suction line into water and re-prime. If receding water level in well exceeds 20' (6.1M), a deep well pump is needed.
	Foot valve or strainer is plugged	Clean foot valvye or strainer.
	Impeller is plugged	Clean impeller.
Pump has lost prime in installation already in use:	Check valve or foot valve is stuck shut	Replace check valve or foot valve.
	Pipes are frozen	Thaw pipes. Bury pipes below frost line. Heat pit or pump house.
	Foot valve and/or strainer are buried in sand or mud.	Raise foot valve and/or strainer above bottom of water source. Clean foot valve and strainer.
	Water level is too low for shallow well setup to deliver water.	Pump will not lift water more than 20' (6.1M).
Pump does not deliver water to full capacity.	Water level in well is lower than estimated.	A deep well jet will be needed if depth to water in your well is more than 20' (6.1m).
	Steel piping (if used) is corroded or limed, causing excess friction.	Replace with plastic pipe where possible, otherwise with new steel pipe.
	Piping is too small in size	Use larger piping.
	Packed well point	Backflush well point or sink new point.

Exploded View

	1 ø	3 ø
3 Stage	B86073	B86077
4 Stage	B82456	B82639



Ref.	Part Description	Qty.	B82456	B82639	B86073	B86074
1	Motor	1	B85740	B86076	B86075	B86077
2	Socket Head Capscrew	4	U30-104ZP			
3	Slinger	1	17351-0009			
4	Bracket	1	M13784			
5	Impeller Repair Kit (Includes Ref. Nos. 6–8 and 10–14)	1	B85604		B86078	
6	Shaft Seal	1	U9-469			
7	Spacer	1	121P1710			
8	O-Ring	2	111P2700			
9	Sleeve	1	251A4310			
10	Diffuser	4	101P6290			
11	Impeller	3 or 4	101P6210			
11A	Spacer (3 Stg pump only)	1	M15780			
12	Washer, Flat	1	121P1760			
13	Washer, Toothed	5	M13975			
14	Impeller Nut	1	U36-204SSW			
15	Pump Body (Suction)	1	75154800			
16	Washer	2	121P0810			
17	Pipe Plug	2	171P1180			
18	Capscrew	4	121P1690			
19	Recirculation Valve Complete (Includes O-Ring)	1	ZBR05820			