Operation & Maintenance Manual

Project: Harding Drain Bypass Pump Station & Pipeline

Equipment Name:

Vertical Turbine Pumps

Equipment Tag Number:

OPS-PUM-100

OPS-PUM-200

OPS-PUM-300

Owner's Name:

City of Turlock

Date:

January 2014

EQUIPMENT SUMMARY FORM

1. EQUIPMENT ITEM - Vertical Turbine Pump

2. MANUFACTURER- National Pump Company

3. EQUIPMENT IDENTIFICATION NUMBERS-
OPS-PUM-100, OPS-PUM-100, OPS-PUM-100

4. LOCATION OF EQUIPMENT- Outfall Pump Station

---

5. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS)

1. Motor: 3300 lbs., 2. Discharge Head: 1300 lbs., 3. Column: 1750 lbs., 4. Bowl Assembly: 2200 lbs.

NAMEPLATE DATA -
Horsepower: 150
Amperage: 183
Voltage: 460
Service Factor (S.F.) 1.15
Speed- 900RPM
ENC Type- TEFC
Capacity 5100 GPM at 87′ Head
Other N/A

7. MANUFACTURER'S LOCAL REPRESENTATIVE

Name Bruce Akin

Address – 7706 N. 71st Ave Glendale, AZ 85303

Telephone Number – 623-979-3560 ext. 235

8. MAINTENANCE REQUIREMENTS – See Pump Maintenance Tab
See Motor Maintenance Tab

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9. LUBRICANT LIST – See Pump Lubricants Tab
See Motor Lubricants Tab

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10. SPARE PARTS (recommendations) – See Pump Spare Parts Tab
See Motor Spare Parts Tab

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11. COMMENTS

Vertical Turbine Pump
Final Data
Installation, Operation
& Maintenance Manual

H24LC-2 Stage
Tertiary Effluent

Manufactured for

Sierra Mountain Construction
55 New Montgomery Street, Suite 304
San Francisco, CA 94105
Purchase Order No. WQCF-6859

Project

City of Turlock

Manufactured by

National Pump Co.
7706 N. 71st Avenue
Glendale, AZ 85303

Factory Customer Order Number

849460A

Final Data
Installation, Operation
& Maintenance Manual

INDEX OF CONTENTS

Final Data
Installation, Operation
& Maintenance Manual

INDEX OF CONTENTS

Section 6 – Supplementary Documents

SECTION 1

EQUIPMENT GENERAL DESCRIPTION

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

EQUIPMENT GENERAL DESCRIPTION

NPC Shop Order Number 849460

Item A - Serial Number/s 849460A-1 Thru -3
Customer Tag Number/s OPS-PUM-100 Thru -300

Vertical Turbine Pump (VS1)

Bowl Assembly:

- Model: H24LC – 2 stage
- Bowls: C.I.-Coat (Flanged)
- Suction Bell: C.I.
- Shaft: 2.69" diameter, 416 SS
- Impellers: Bronze (Keyed)
  - Dynamically balanced: 16 W/N
- Dual wear rings (Bowl & impeller): 416 SS / 304 SS
- Bearings: Bismuth Bronze
- Basket strainer: 316 SS
- Fasteners: 316 SS
- Paint/Coating: Exterior – Tnemec 141 High Solid Epoxy

Column Assembly

- 18" Pipe: A53 grade B steel
  - Type: Flanged
- Shaft: 1.94", 416 SS
- Spider retainer: Neoprene
- Bearings: Bronze
- Enclosing tube: 3", Steel (Schedule 80)
- Shaft coupling: Keyed, 416 SS
- Paint/Coating: Exterior & Interior – Tnemec 141 High Solid Epoxy

Discharge Head

- Type F: 18" AWWA Class D (F.F.)
- Fabrication: A36 / A53 grade B steel
- Coupling type: Standard threaded
- Oil Lubrication Assembly: 1-gallon oil reservoir, 115V Solenoid Valve, manual oil dripper, copper tubing and fittings
- Paint/Coating: Exterior – Sherwin Williams paint per NPC PRO-PAI01

EQUIPMENT GENERAL DESCRIPTION

Electric Motor:

- NIDEC (US Motors): 150 HP, 900 RPM, 3/60/460, VHS, TEFC

Motor Data:

- OPS-PUM-100:
  Catalog#: 6219-J/C3
  Model#: 7226-BCB
  ID#: U 06 20121843-001 R 00 01
  Model#: Titan VHS TEFC

- OPS-PUM-200:
  Catalog#: 6219-J/C3
  Model#: 7226-BCB
  ID#: U 06 20121843-001 R 00 02
  Model#: Titan VHS TEFC

- OPS-PUM-300:
  Catalog#: 6219-J/C3
  Model#: 7226-BCB
  ID#: U 06 20121843-001 R 00 03
  Model#: Titan VHS TEFC

Spare Parts Lists:

(1) set of tension nut assembly
(1) set of wear rings
(2) bowl wear rings
(2) impeller wear rings
(1) set of bowl bearings
(1) suction bearing
(1) bowl bearing
(1) top bowl bearing w/ o-ring
(1) bowl assembly tube bearing

Pump Data Sheet - National Pump Company

Company: National Pump Company
Name:
Date: 11/30/2012

849460A-PCURVE
GUARANTEE POINT: 5100 GPM, 87 FT, 84% MIN, BOWL
ACCEPTANCE GRADE = 1U

Pump:

Size: H24LC (2 stage)

Type: VERT.TURB.ENCLOSED
Synch speed: 900 rpm

Speed: 880 rpm
Dia: 18.54 in

Curve: CVH24LC8P6CY

Impeller: H24LC

Specific Speeds:

Ns: 4100
Nss: 9200

Dimensions:

Suction: ---
Discharge: ---

Vertical Turbine:

Bowl size: 23.3 in
Max lateral: 1.25 in
Thrust K factor: 53.8 lb/ft

Pump Limits:

Temperature: 180 °F
Pressure: 280 psi g
Sphere size: 1.5 in

Power: 921 hp
Eye area: 110 in²

Search Criteria:

Flow: 5100 US gpm
Head: 87 ft

Fluid:

Water
Density: 62.32 lb/ft³
Viscosity: 0.9946 cP

Temperature: 68 °F
Vapor pressure: 0.3391 psi a
Atm pressure: 14.7 psi a

NPSHa: ---

Motor:

Standard: NEMA
Enclosure: WP-1

Size: 150 hp
Speed: 900
Frame: 449

Sizing criteria: Max Power on Design Curve

---- Data Point ----

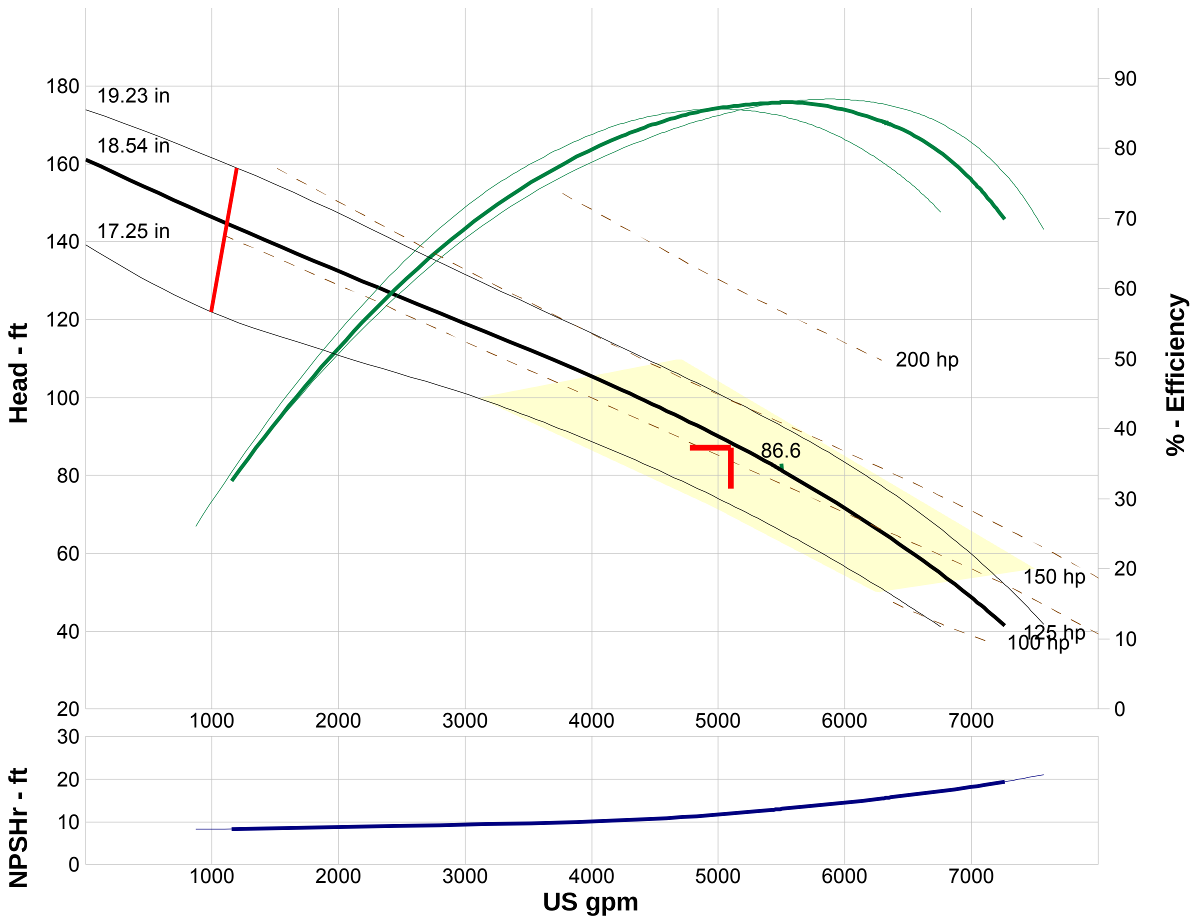
Flow: 5100 US gpm
Head: 88.2 ft
Eff: 85.8%
Power: 132 hp
NPSHr: 12 ft

---- Design Curve ----

Shutoff head: 161 ft
Shutoff dP: 69.7 psi
Min flow: 1100 US gpm
BEP: 86.6% @ 5501 US gpm
NOL power:
133 hp @ 4237 US gpm

-- Max Curve --

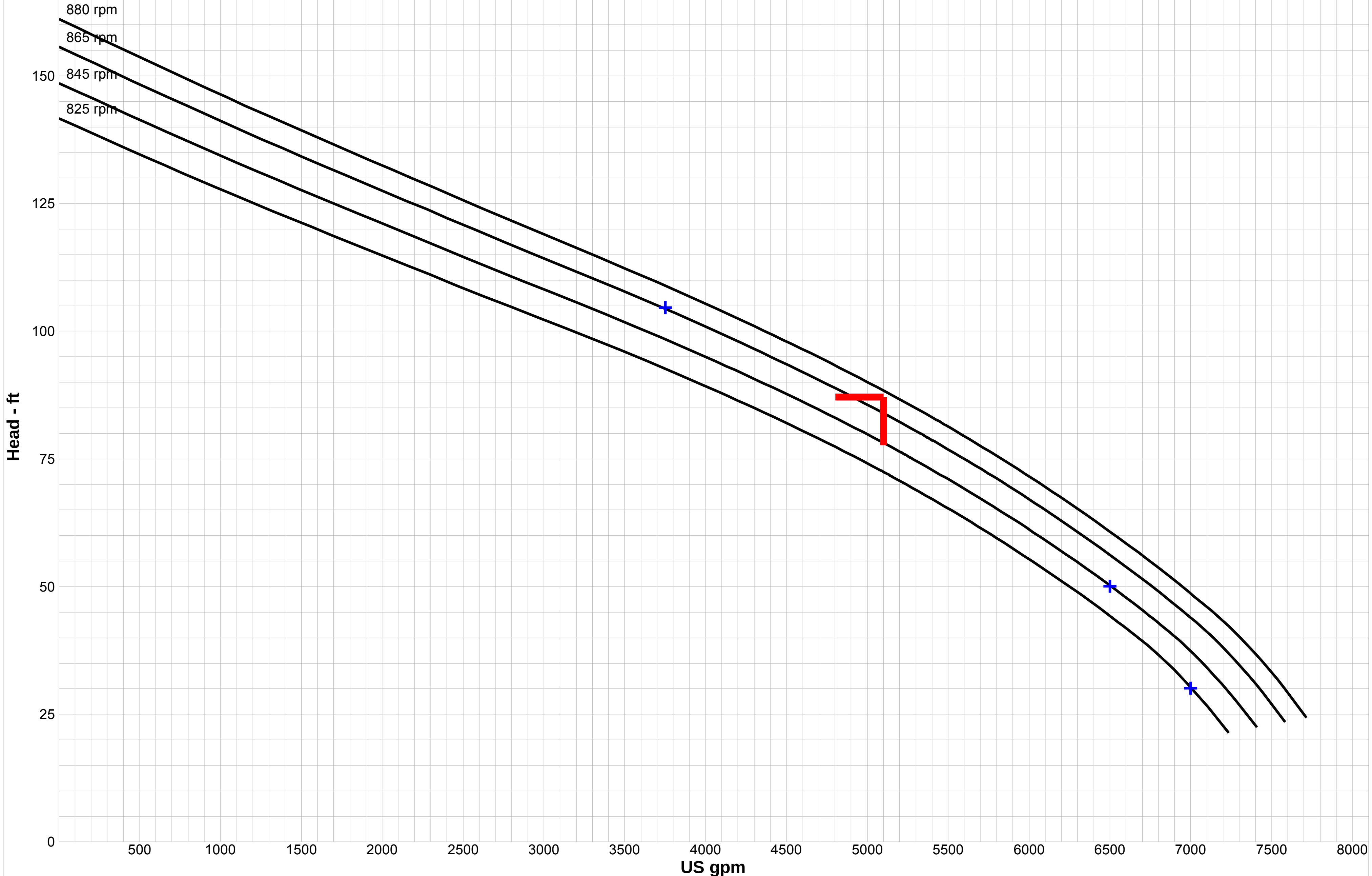
Max power:
151 hp @ 4475 US gpm



NOTES (UNLESS OTHERWISE SPECIFIED): [1] PUMP LIMITS AND PERFORMANCE BASED ON STANDARD MATERIALS OF CONSTRUCTION. [2] PERFORMANCE SHOWN AS TYPICAL WHICH MEETS HI 14.6-2011 GRADE 1B TOLERANCES AT THE RATED CONDITION WITHIN THE SELECTION WINDOW.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
6120	880	68.7	84.4	125	15
5100	880	88.2	85.8	132	12
4080	880	104	79.9	133	10.3
3060	880	118	67.4	131	9.51
2040	880	132	51.4	130	8.8



Company: National Pump Company
Name:
2/20/2013

National Pump Company
Catalog: H24 SPECIAL, Vers 6c120927
VERT.TURB.ENCLOSED - 900

Size: H24LC 2 stage
Speed: 825 - 880 rpm
Dia: 18.54 in
Curve: CVH24LC8P6CY
Impeller: H24LC

Powered By PUMP-FLO™

Company: National Pump Company
Name:
2/20/2013

National Pump Company
Catalog: H24 SPECIAL, Vers 6c120927
VERT.TURB.ENCLOSED - 900

Size: H24LC 2 stage
Speed: 352 - 880 rpm
Dia: 18.54 in
Curve: CVH24LC8P6CY
Impeller: H24LC

Powered By PUMP-FLO™

carollo

MOTOR DATA SHEET

MOTOR NUMBER ________ MOTOR / EQUIPMENT NAME ________

SPECIFICATION NUMBER OF DRIVEN MACHINE 16222 - LOW BOLTAGE MOTORS UP TO 500 HP

MOTOR NAMEPLATE DATA

MANUFACTURER NIDEC (US MOTORS) MODEL/SERIES ________ MODEL NO. ________

FRAME 449TP	ENCLOSURE TEFC	NEMA DESIGN B
HP 150	SERVICE FACTOR 1.15	RPM 900
INSULATION CLASS F AMBIENT TEMP +40C DESIGN TEMP RISE "B" @ 1.0 SF	VOLTS 460 PHASE 3 HERTZ 60	FULL LOAD AMPS 183 NO LOAD AMPS 62.1 LOCK ROTOR AMPS 1091 INRUSH CODE LETTER G

	100 PERCENT LOAD	75 PERCENT LOAD	50 PERCENT LOAD
GUARANTEED MINIMIMUM EFFICIENCIES:	94.1	____	____
GUARANTEED MINIMIMUM POWER FACTOR:	____	____	____

MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: ________ KVAR

ACCESSORIES

MOTOR WINDING HEATER 115 VOLTS 288 WATTS

WINDING THERMAL PROTECTION

WINDING TEMP SWITCHES (YES/NO) YES - THERMOSTATS N/C

RTD: TYPE BEARING - 100 OHM QUANTITY PER PHASE N/A # OF WIRES 3

NOMINAL RESISTANCE ________ NOMINAL TEMP ________ COEFFICIENT ________

RECOMMENDED ALARM 120 DEGREES CELSIUS RECOMMENDED TRIP 130 DEGREES CELSIUS

SPECIAL APPLICATIONS

INVERTER DUTY* (YES/NO) YES PART WINDING (YES/NO) NO WYE - DELTA (YES/NO) NO

2 SPEED, 1 WINDING (YES/NO) NO 2 SPEED, 2 WINDING (YES/NO) NO

AREA CLASSIFICATION:

CLASS ________ DIVISION ________ GROUP ________ TEMP CODE ________

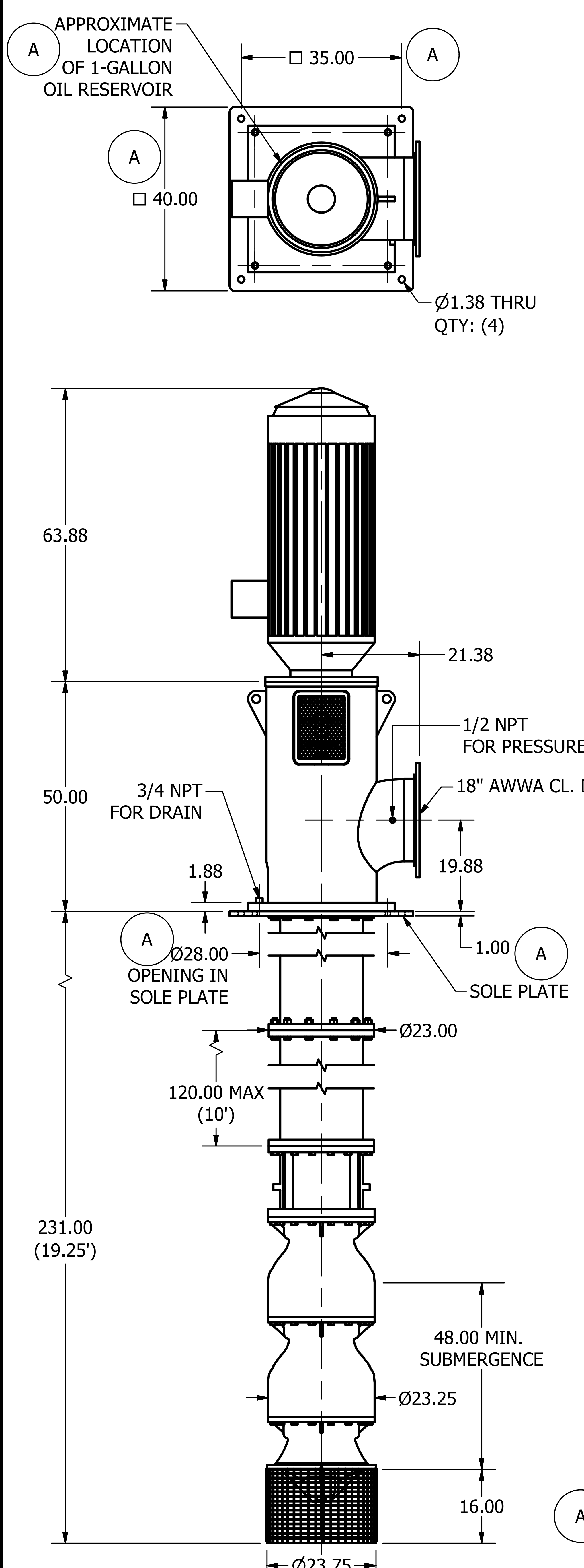
* Conforms to NEMA MG-1 Part 31.

END OF SECTION

SECTION 2

NPC ENGINEERING DRAWINGS

VERTICAL TURBINE PUMP WITH 'F' DISCHARGE HEAD & ROUND BASE



CUSTOMER: SIERRA MOUNTAIN		
CUSTOMER PO#: WQCF-6859		
PROJECT: CITY OF TURLOCK		
EQUIPMENT TAG#: OPS-PUM-100,-200,-300		
FURNISHED BY: NATIONAL PUMP COMPANY		
SALES ORDER #: 849460		
QUANTITY: 3		
PUMP SERIAL #: 849460A-1,-2,-3		
MOTOR DATA		
POWER: 150 HP PHASE: 3 CYCLE: 60 VOLTS: 460		
SPEED: 900 RPM MFG: NIDEC		
TYPE: VHS EFFICIENCY: PREMIUM BD: 24.50"		
ENCLOSURE: TEFC		
SERVICE FACTOR: 1.15 COUPLING: NRR		
MOTOR TO PUMP COUPLING: RIGID FLANGE (B)		
DISCHARGE HEAD		
DISCHARGE HEAD: FABRICATED, TYPE-F		
DISCHARGE FLANGE: 18" AWWA CL. D (F.F.) SLIP-ON		
COLUMN ASSEMBLY		
COLUMN SIZE: 18" x 0.38 WALL TYPE: FLANGED		
TUBE SIZE: 3.50" R/H SHAFT SIZE: 1.94" (B)		
BOWL ASSEMBLY		
MODEL: H24LC STAGES: 2		
FLOW: 5100 GPM HEAD: 87 FT		
LIQUID: WATER SPEC GR: 1.00		
COLUMN SIZE: 18" LINESHAFT: 1.94"		
MATERIALS		
DISCHARGE HEAD: A36 / A53 GR B STEEL		
COLUMN PIPE: A 53 GR B (FLANGED)		
BOWL BEARINGS: ~~BRZ~~		
LINE SHAFT: 416 SS (A) BOWL SHAFT: 416 SS		
LINE SHAFT BEARING: ~~BRZ~~		
SHAFT COUPLINGS: 416 SS (B)		
BOWL: C.I.-COAT SUCTION ~~BEL~~: C.I.		
BOWL WEAR RING: 416 SS		
IMPELLER WEAR RING: 304 SS		
IMPELLERS: BRZ		
DYNAMICALLY ~~BALANCED~~: 16 W/N		
IMPELLER KEYS: 416 SS (A)		
FASTENERS: 316 SS		
BASKET STRAINER: 316 SS		
APPROXIMATE WEIGHTS		LBS
	MOTOR:	3300
	DISCHARGE HEAD	1300
	COLUMN	1750
	BOWL ASSEMBLY	2200
	TOTAL	8550

NOTES (UNLESS OTHERWISE SPECIFIED):

1. PUMPS BUILT IN ACCORDANCE WITH HI STANDARDS
2. NON-WITNESS TESTING AS FOLLOWS:
   - HYDROSTATIC TEST: BOWLS AND DISCHARGE HEAD
3. WITNESSED TESTING AS FOLLOWS:
   - PERFORMANCE TEST (BOWL ASSEMBLY ONLY)
4. ANALYSIS AS FOLLOWS (PER API 610):
   LATERAL AND TORSIONAL ANALYSIS
5. PAINT WITH STANDARD SHERWIN WILLIAMS PAINT PER PRO-PAI01 AS FOLLOWS:
   - EXTERIOR SURFACE OF DISCHARGE HEAD
6. COAT WITH TNEMEC 141 HIGH SOLIDS EPOXY AS FOLLOWS:
   - EXTERIOR SURFACE OF BOWL ASSEMBLY & COLUMN ASSY.
   - INTERIOR SURFACE OF COLUMN ASSEMBLY (A)

REV	DESCRIPTION	DATE	APPROVED
B	UPDATED PER APPROVED SUBMITTAL NOTES	7/20/2013	ABT
A	UPDATED PER SUBMITTAL COMMENTS BY DARREN BAUNE DATED 1/31/2013	2/21/2013	ABT

REVISION HISTORY

UNLESS OTHERWISE SPECIFIED:
1. REMOVE ALL DURRS AND SHARP EDGES .010 - .020
2. FILLETS .020 R MAX
3. CUT OR MACHINED SURFACES TO HAVE .063 MICROFINISH
4. DIMENSIONS ARE IN INCHES
5. TOLERANCES ARE: FRACTIONS ±1/32; DECIMAL .XX ±.02, .XXX ±.010; ANGLES ±30'

NATIONAL PUMP COMPANY
GLENDALE, ARIZONA, USA

APPROVALS	DATE
DRAWN: MP	11/21/2012
CHECKED:	
APPROVED:	

DESCRIPTION: S/O 849460 H24LC-2 STAGE GA DRAWING

DRAWING NO. 849460AGA

SHEET: 1 OF 1

CAD CODE: 849460AGA.iam

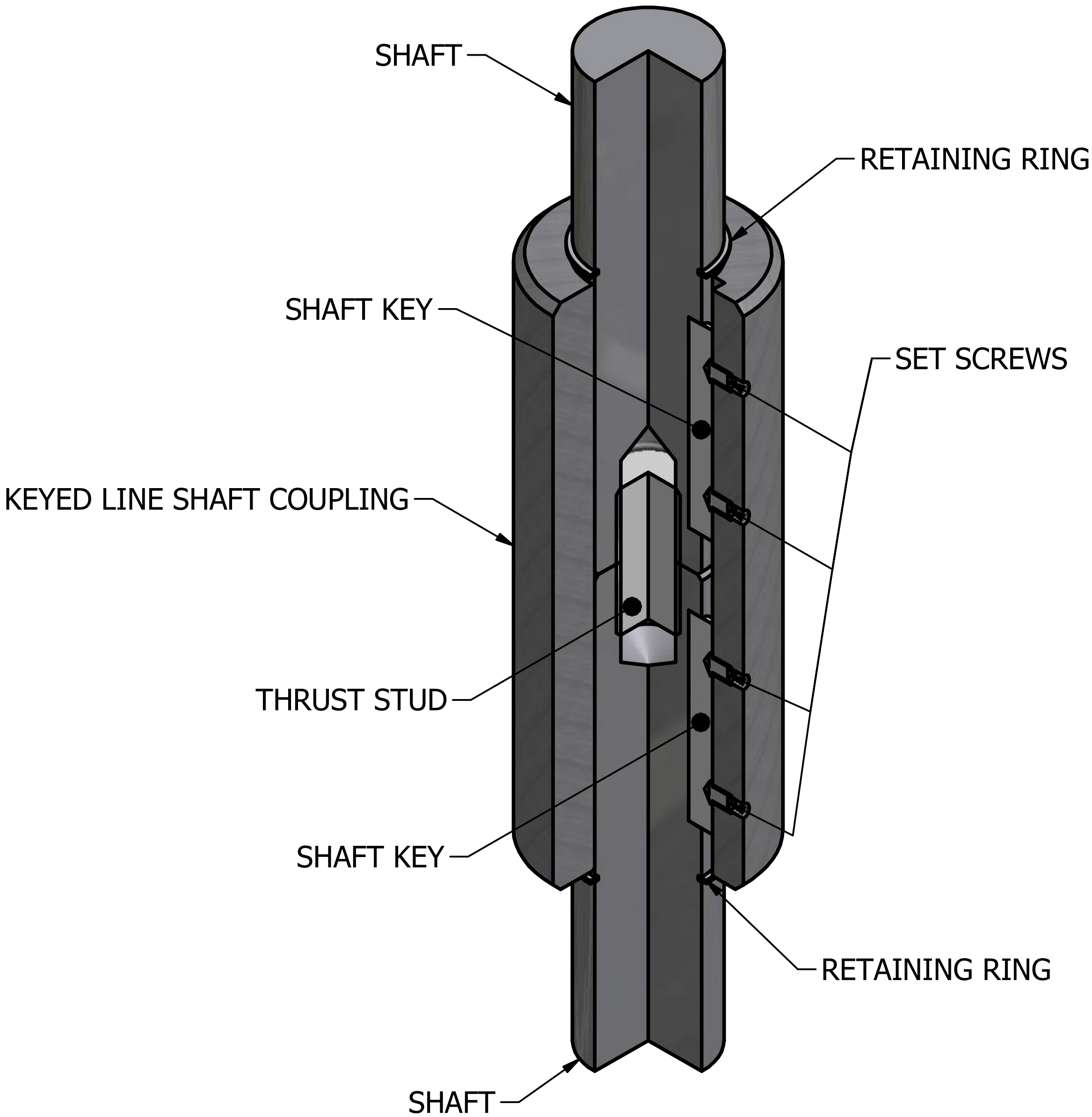
MATERIAL: AS NOTED

WEIGHTS	LBS	KGS
CASTING		
MACHINED		

CROSS REFERENCE

SCALE: NTS

DIMENSIONS: INCHES



UNLESS OTHERWISE SPECIFIED:
1. REMOVE ALL DURRS AND SHARP EDGES .010 - .020
2. FILLETS .020 R MAX
3. CUT OR MACHINED SURFACES TO HAVE .063 MICROFINISH
4. DIMENSIONS ARE IN INCHES
5. TOLERANCES ARE:

FRACTIONS	DECIMAL	ANGLES
±1/32	.XX ±.02 .XXX ±.010	±30'

NATIONAL PUMP COMPANY
GLENDALE, ARIZONA, USA

APPROVALS	DATE
DRAWN: ABT	2/20/2013
CHECKED:	
APPROVED:	

DESCRIPTION: KEYED LINE SHAFT COUPLING

DRAWING NO. 849460ZLSCA

SHEET: 1 OF 1

CAD CODE: KEYED COUPLING ASSY.iam

MATERIAL:

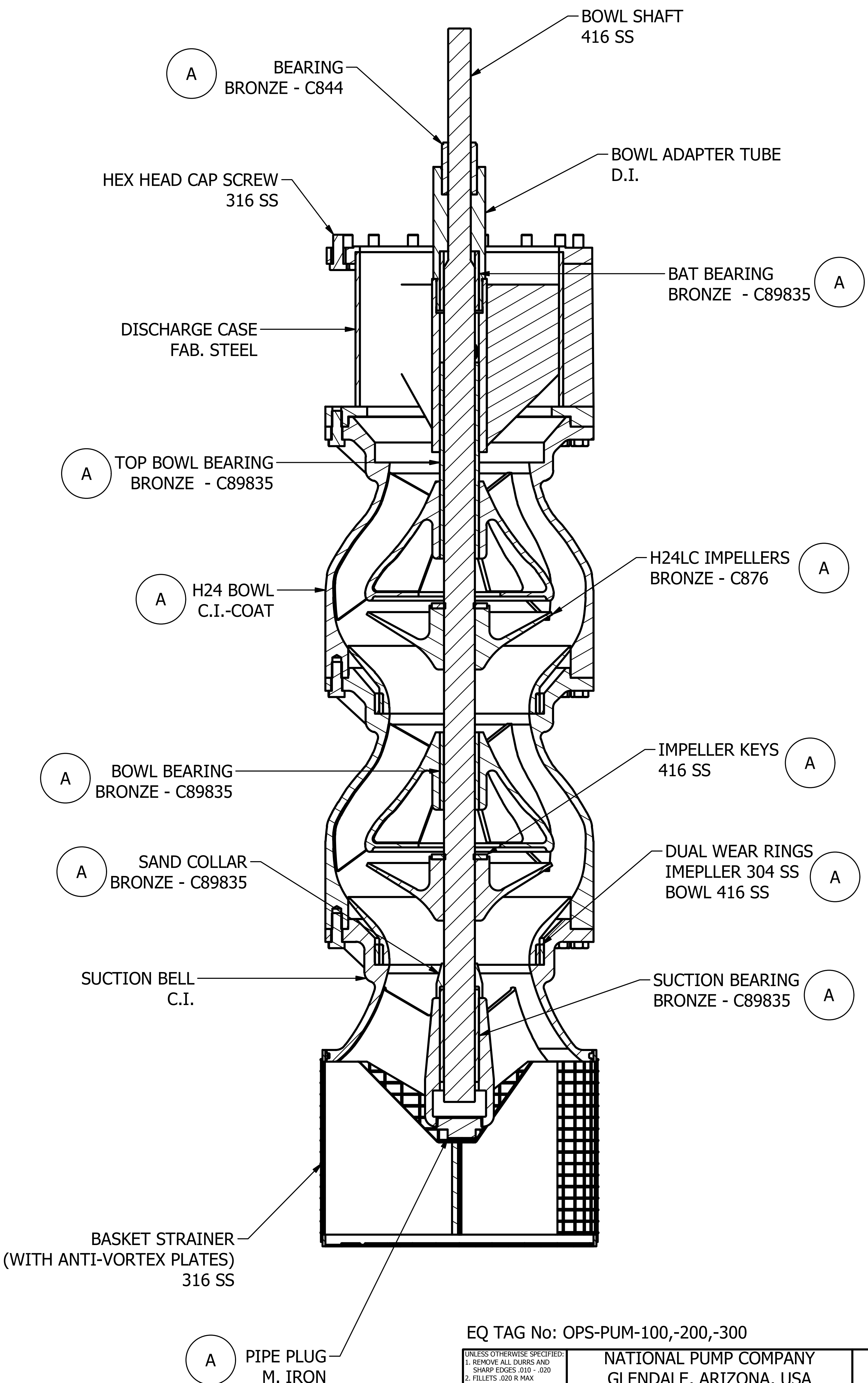
WEIGHTS	LBS	KGS
CASTING		
MACHINED		

CROSS REFERENCE

SCALE:

DIMENSIONS: INCHES

PRODUCT LUBRICATED BOWL ASSEMBLY
ENCLOSED LINESHAFT CONSTRUCTION



EQ TAG No: OPS-PUM-100,-200,-300

REV	DESCRIPTION	DATE	APPROVED
A	ADDED MAT'L CLARIFICATIONS ADDED SAND COLLAR & PIPE PLUG	2/20/2013	ABT

REVISION HISTORY

UNLESS OTHERWISE SPECIFIED:
1. REMOVE ALL DURRS AND SHARP EDGES .010 - .020
2. FILLETS .020 R MAX
3. CUT OR MACHINED SURFACES TO HAVE .063 MICROFINISH
4. DIMENSIONS ARE IN INCHES
5. TOLERANCES ARE:

FRACTIONS	DECIMAL	ANGLES
±1/32	.XX ±.02 .XXX ±.010	±30'

MATERIAL: AS NOTED

WEIGHTS	LBS	KGS
CASTING		
MACHINED		

NATIONAL PUMP COMPANY
GLENDALE, ARIZONA, USA

APPROVALS		DATE
DRAWN:	M P	11/26/2012
CHECKED:		
APPROVED:		

DESCRIPTION: BOWL SECTIONAL: H24LC-2 STAGE NPC SO# 849460

DRAWING NO. 849460ABASEC

SHEET: 1 OF 1

CAD CODE: 849460ABA.iam

CROSS REFERENCE

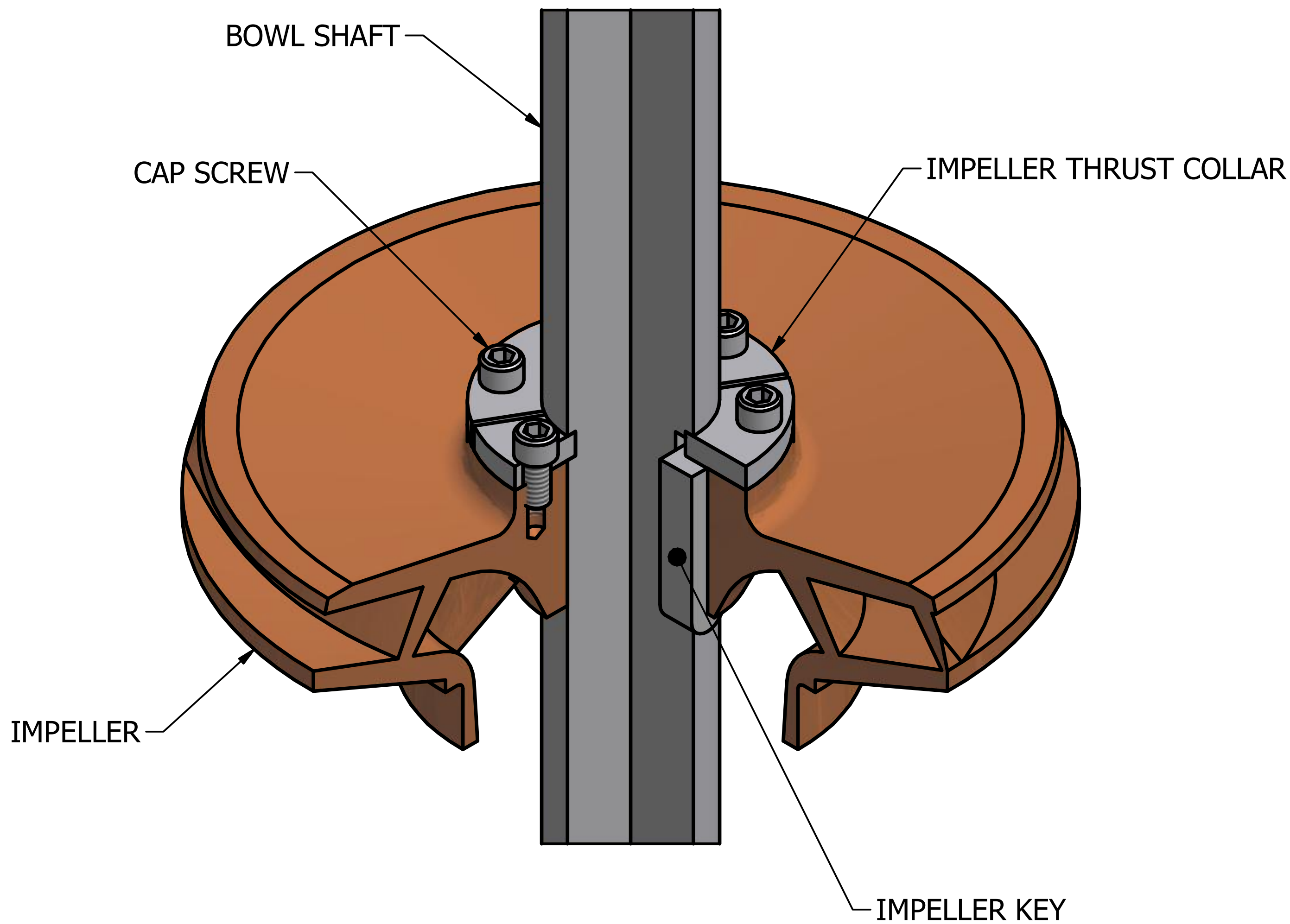
SCALE: NTS

DIMENSIONS: INCHES

NOTES (UNLESS OTHERWISE SPECIFIED):

1. THIS TYPE OF CONSTRUCTION IS SHOWN IN HI 2.1-2.2-2008 IN FIGURES 2.1.3.2a & 2.1.3.2b

2. THE IMPELLER THRUST COLLAR IS A SPLIT RING WHICH IS HELD IN PLACE BY CAP SCREWS. THIS PREVENTS THE IMPELLER FROM MOVING AXIALLY ON THE SHAFT.



UNLESS OTHERWISE SPECIFIED:
1. REMOVE ALL DURRS AND SHARP EDGES .010 - .020
2. FILLETS .020 R MAX
3. CUT OR MACHINED SURFACES TO HAVE .063 MICROFINISH
4. DIMENSIONS ARE IN INCHES
5. TOLERANCES ARE:

FRACTIONS	DECIMAL	ANGLES
±1/32	.XX ±.02	±30'
	.XXX ±.010	

MATERIAL:

WEIGHTS	LBS	KGS
CASTING		
MACHINED		

NATIONAL PUMP COMPANY
GLENDALE, ARIZONA, USA

APPROVALS	DATE
DRAWN: ABT	2/20/2013
CHECKED:	
APPROVED:	

DESCRIPTION: IMPELLER DOUBLE KEYED CONSTRUCTION

DRAWING NO. 849460ZKEYA

SHEET: 1 OF 1

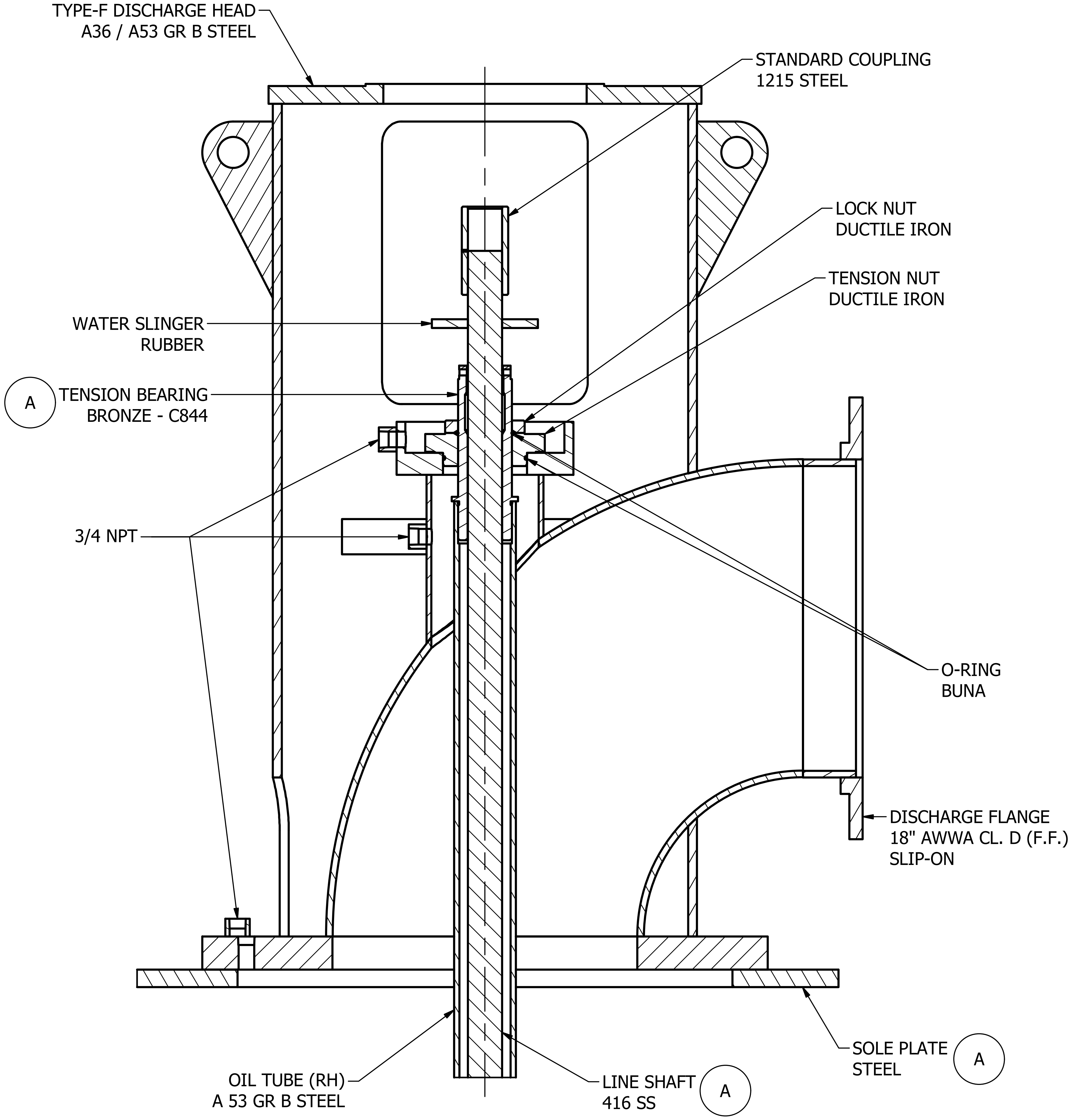
CAD CODE: 849460ZKEYA.iam

CROSS REFERENCE

SCALE:

DIMENSIONS: INCHES

FABRICATED DISCHARGE HEAD ASSEMBLY
OPEN LINESHAFT CONSTRUCTION
(SHORT RADIUS ELBOW)



TAG #: OPS-PUM-100,-200,-300,-400

NOTES:

1. 1/2 NPT ON DISCHARGE FOR PRESSURE GUAGE. (NOT SHOWN)
2. 3/4 NPT ON DISCHARGE HEAD FOR VENT.

REV	DESCRIPTION	DATE	APPROVED
A	UPDATED PER SUBMITTAL COMMENTS BY DARREN BAUNE DATED 1/31/2013	2/21/2013	ABT

REVISION HISTORY

UNLESS OTHERWISE SPECIFIED:
1. REMOVE ALL DURRS AND SHARP EDGES .010 - .020
2. FILLETS .020 R MAX
3. CUT OR MACHINED SURFACES TO HAVE .063 MICROFINISH
4. DIMENSIONS ARE IN INCHES
5. TOLERANCES ARE:
FRACTIONS ±1/32 DECIMAL .XX ±.02 .XXX ±.010 ANGLES ±30'

NATIONAL PUMP COMPANY
GLENDALE, ARIZONA, USA

APPROVALS		DATE
DRAWN:	M P	11/26/2012
CHECKED:		
APPROVED:		

DESCRIPTION: TYPE-F DISCHARGE HEAD SECTION NPC SO# 849460

DRAWING NO. 849460ZDHSEC

SHEET: 1 OF 1

CAD CODE: 849460ZDH.iam

MATERIAL: AS NOTED

WEIGHTS	LBS	KGS
CASTING		
MACHINED		

CROSS REFERENCE

SCALE: NTS

DIMENSIONS: INCHES

7706 North 71st Ave
Glendale, AZ. 85303
Phone: (623) 979-3560
Fax: (623) 979-2177

CERTIFIED BILL OF MATERIALS AND RECOMMENDED SPARE PARTS

CUSTOMER NAME: SIERRA MOUNTAIN
CUSTOMER PO# WQCF-6859
END USER:
PROJECT NAME: CITY OF TURLOCK
SITE LOCATION:
EQUIPMENT DESCRIPTION: TERTIARY EFFLUENT
EQUIPMENT TAG# OPS-PUM-100 THUR -300
SALES ORDER# 849460A
PUMP MODEL: H24LC-2 STAGE
EQUIPMENT S/N: 849460A-1 THRU -3

REV	ITEM	P/N	QTY	U/M	DESCRIPTION	MAT'L	RECOMMENDED SPARE PARTS		
							START-UP	1 YEAR	2 YEAR
		849460A-A01	1	EA	MOTOR: US, 150HP, 900RPM, VHS	-			
		849460ZDH	1	EA	DISCHARGE HEAD, TYPE-F: 18" AWWA CL D F.F.	FAB STL			
		EXP0198000670	4	EA	HEX HEAD CAP SCREW: 0.63-11 X 1.75 LG	GR5			
		849460ZSP	1	EA	SOLE PLATE: 40.00 SQ X 1.00 THK	STL			
		849460Z-H08	4	EA	WASHER, FLAT: 1.313 ID X 2.50 OD X 0.16 THK	316SS			
		849460Z-H09	4	EA	HEX HEAD CAP SCREW: 1.25-7 X 3.00 LG	316SS			
		849460Z-C01	1	EA	COUPLING, RIGID FLANGE: 1.94-10 LH X 1.94-10 LH	STL			
		849460ZBRGTEN	1	EA	BEARING, TENSION: 3.50 R/H X 1.94, NPC/PEER	BRZ			
		08Y0010500	1	EA	NUT, TENSION: 3.50 R/H NPC/PEER	DI			
		08Y0010502	1	EA	NUT, LOCK: 3.50 R/H NPC/PEER	CI			
		EXP0198004070-SS	1	EA	SET SCREW: 0.25-20 X 0.38 LG	SS			
		EXP0198000410-SS	4	EA	HEX HEAD CAP SCREW: 0.50-13 X 1.50 LG	316SS			
		EXP0158000620	1	EA	O-RING: 0.103 X 4.487, #157	BUNA	1		1
		EXP0158000470	1	EA	O-RING: 0.210 X 3.475, #341	BUNA	1		1
		EXP0038000000	3	EA	FITING, ADAPTER: 0.13 NPT X 0.25 TUBE	BRASS			
		EXP0168000020	1	EA	PIPE PLUG: 0.13 NPT	M IRON			
		22Y1000616	1	EA	WATER SLINGER: 1.94 SHAFT	RUBBER	1		1
		849460Z-H06	12	EA	WASHER, FLAT: 1.188 ID X 2.25 OD X 0.14 THK	316SS			
		849460Z-H07	12	EA	HEX HEAD CAP SCREW: 1.13-7 X 2.50 LG	316SS			
		849460AHS	1	EA	SHAFT, HEAD: 1.94-10-LH X 68.38 LG	416SS			
		25Y0210605-10	1	EA	NUT, HEAD: 1.94-10-LH	BRZ			
		0078009060	1	EA	KEY, GIB: 0.50 X 3.00 LG	STL			
		EXP0198003060	1	EA	SCREW: 0.25-20 X 2.25 LG	GR5			
		EXP0168000240	2	EA	PIPE PLUG: 0.75 NPT	M IRON			
		31Y0020011	1	EA	OIL POT: 1 GAL W/ NPC LOGO	AL			
		31Y0080000	1	EA	VALVE, SOLENOID: 115V, 0.13 NPT				
		31Y0130000	1	EA	OIL DRIPPER				
		31Y0140000	36	IN	TUBE: 0.25 OD	COPPER			
		EXP0148005050	1	EA	NAMEPLATE: DISCHARGE HEAD	SS			
		EXP0198005520	4	EA	DRIVE SCREW: #6 X 0.38 LG	SS			
		849460ZCFT	1	EA	COLUMN, FLANGE: 18.00 X 0.38 X 84.50 LG	FAB STL			
		849460ZCFB	1	EA	COLUMN, FLANGE: 18.00 X 0.38 X 60.00 LG	FAB STL			
		849460ZTT	1	EA	ENCLOSING TUBE: 3.50 R/H X 42.75 LG, NPC/PEER	STL			

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave
Glendale, AZ. 85303
Phone: (623) 979-3560
Fax: (623) 979-2177

CERTIFIED BILL OF MATERIALS AND RECOMMENDED SPARE PARTS

CUSTOMER NAME: SIERRA MOUNTAIN
CUSTOMER PO# WQCF-6859
END USER:
PROJECT NAME: CITY OF TURLOCK
SITE LOCATION:
EQUIPMENT DESCRIPTION: TERTIARY EFFLUENT
EQUIPMENT TAG# OPS-PUM-100 THUR -300
SALES ORDER# 849460A
PUMP MODEL: H24LC-2 STAGE
EQUIPMENT S/N: 849460A-1 THRU -3

							RECOMMENDED SPARE PARTS		
REV	ITEM	P/N	QTY	U/M	DESCRIPTION	MAT'L	START-UP	1 YEAR	2 YEAR
		05T0500010	2	EA	ENCLOSING TUBE: 3.50 R/H X 60.00 LG, NPC/PEER	STL			
		849460ZBRGLS	2	EA	BEARING, ENCLOSED LINE SHAFT: 3.50 R/H X 1.94	BRZ			
		849460ZTS	1	EA	SHAFT, TOP: 1.94 X 170.00 LG	416SS			
		849460ZLSC	1	EA	COUPLING, LINE SHAFT: 1.94 KEYED	416SS			
		EXP0188001940-SS	2	EA	RETAINING RING: 1.94 SHAFT, 2-TURN	SS			
		849460ZSTUD1	1	EA	STUD: 1.13-7 X 2.50 LG	316SS			
		849460ZKEYLS	2	EA	KEY, LINE SHAFT: 0.50 SQ X 3.00 LG	416SS			
		EXP0198004050-SS	4	EA	SET SCREW: 0.38-16 X 0.50 LG	SS			
		849460Z-H04	24	EA	HEX HEAD CAP SCREW: 1.13-7 X 4.50 LG	316SS			
		849460Z-H05	24	EA	NUT, HEX: 1.13-7	316SS			
		849460Z-H06	48	EA	WASHER, FLAT: 1.188 ID X 2.25 OD X 0.14 THK	316SS			
		849460ZBS	1	EA	SHAFT, BOWL: H24-2STG O/L KEYED	416SS			
		849460ZBAT	1	EA	BOWL ADAPTER TUBE (BAT): H24 X 3.50 R/H	STL			
		849460ZBRGLS	1	EA	BEARING, ENCLOSED LINE SHAFT: 3.50 R/H X 1.94	BRZ			
		849460ZBRGBAT	1	EA	BEARING, SLEEVE: 2.69 X 3.38 X 5.13 LG	BRZ			1
		849460ZDC	1	EA	DISCHARGE CASE: H24	FAB STL			
		24H100-011	1	EA	BOWL, M/C: H24	CI/COAT			
		EXP0158000480	2	EA	O-RING: 0.210 X 19.250	BUNA			2
		849460ZBRGTB	1	EA	BEARING, TOP BOWL: 2.69 X 3.38 X 12.00 LG	BRZ			1
		849460Z-J01	1	EA	O-RING: 0.139 X 3.109 ID, #235	BUNA			1
		849460AIBWR	1	EA	BOWL, MOD: H24 W/ WEAR RING	CI/COAT			
		02X0090005	1	EA	BEARING, SLEEVE: 2.69 X 3.38 X 6.69 LG	BRZ			1
		849460ZWRB	2	EA	WEAR RING, BOWL: H24	416SS			2
		849460AIM	2	EA	IMPELLER, MOD: H24LC W/ WEAR RING	BRZ			
		01X0110909	2	EA	IMPELLER THRUST COLLAR: 2.69 SHAFT	416SS			
		849460ZIKEY	2	EA	KEY, IMPELLER: 0.63 SQ X 5.69 LG	416SS			
		849460Z-H02	12	EA	SOCKET HEAD CAP SCREW: 0.50-13 X 1.00 LG	316SS			
		849460ZWRI	2	EA	WEAR RING, IMPELLER: H24	304SS			2
		849460ZSBWR	1	EA	SUCTION BELL, MOD: H24 W/ WEAR RING & PIPE PLUG	CI			
		849460ZSDC	1	EA	SAND COLLAR: 2.69 SHAFT	BRZ			
		EXP0198004065-SS	2	EA	SET SCREW: 0.25-20 X 0.25 LG	316SS			
		02X0090105	1	EA	BEARING, SLEEVE: 2.69 X 3.38 X 8.00 LG	BRZ			1
		849460Z-D01	1	EA	PIPE PLUG: 3.50 NPT	M IRON			
		849460ZBST	1	EA	STRAINER, BASKET: H24 ANTI-VORTEX	316SS			

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave
Glendale, AZ. 85303
Phone: (623) 979-3560
Fax: (623) 979-2177

CERTIFIED BILL OF MATERIALS AND RECOMMENDED SPARE PARTS

CUSTOMER NAME: SIERRA MOUNTAIN
CUSTOMER PO# WQCF-6859
END USER:
PROJECT NAME: CITY OF TURLOCK
SITE LOCATION:
EQUIPMENT DESCRIPTION: TERTIARY EFFLUENT
EQUIPMENT TAG# OPS-PUM-100 THUR -300
SALES ORDER# 849460A
PUMP MODEL: H24LC-2 STAGE
EQUIPMENT S/N: 849460A-1 THRU -3

							RECOMMENDED SPARE PARTS		
REV	**ITEM**	**P/N**	**QTY**	**U/M**	**DESCRIPTION**	**MAT'L**	**START-UP**	**1 YEAR**	**2 YEAR**
		EXP0198000125-SS	4	EA	HEX HEAD CAP SCREW: 0.38-16 X 1.00 LG	316SS			
		849460Z-H01	48	EA	HEX HEAD CAP SCREW: 0.88-9 X 2.50 LG	316SS			
		EXP0148005010	1	EA	NAMEPLATE: BOWL ASSEMBLY	SS			
		EXP0198005520	4	EA	DRIVE SCREW: #6 X 0.38 LG	SS			

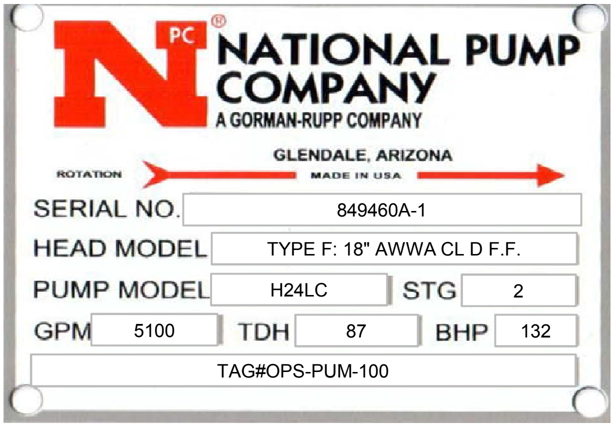
NOTES:
1. PLEASE CONSULT THE FACTORY FOR CURRENT PRICING.
2. NOT ALL ITEMS ARE ILLUSTRATED ON THE SECTIONAL DRAWING(S).

REVISION HISTORY			
REV	BY	DATE	DESCRIPTION
0	ABT	1/15/2014	INITIAL RELEASE

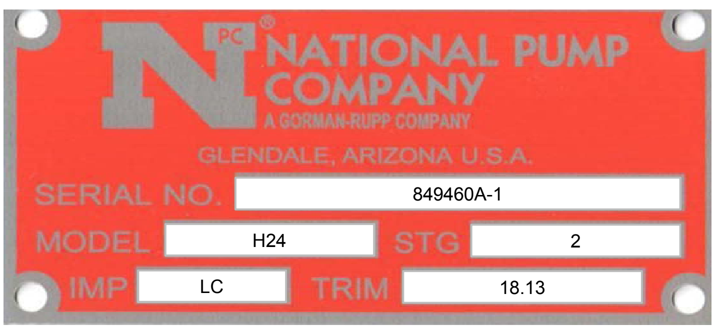
NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave
Glendale, AZ. 85303
Phone: (623) 979-3560
Fax: (623) 979-2177

TAGGING FORM



STANDARD DISCHARGE HEAD TAG
(P/N: EXP0148005050)



BOWL ASSEMBLY TAG
(P/N: EXP0148005010)

SALES ORDER# 849460
QTY: 3
CUSTOMER NAME: SIERRA MOUNTAIN
CUSTOMER PO# WQCF-6859
PROJECT NAME: CITY OF TURLOCK
EQUIPMENT DESC.: TERTIARY EFFLUENT

HEAD MODEL: TYPE F: 18" AWWA CL D F.F.
PUMP MODEL: H24LC
STAGES: 2
FLOW: 5100 GPM
HEAD: 87 FT
POWER: 132 HP

NOTE LINE TEXT
CUSTOMER PO# NO
TAG# YES
AWWA E103 NO
OTHER: NO
BOWL: H24
IMPELLER: LC
TRIM: 18.13 IN

ROOT S/N: 849460A

	S/N	TAG#
1	849460A-1	OPS-PUM-100
2	849460A-2	OPS-PUM-200
3	849460A-3	OPS-PUM-300

REVISION HISTORY			
REV	BY	DATE	DESCRIPTION
A	ABT	7/20/2013	CHANGE FLANGE FROM 150# TO AWWA CL D
B	AW	11/20/2013	UPDATED IMPELLER TRIM INFORMATION

SECTION 3

SUB-VENDOR EQUIPMENT DATA

NIDEC MOTOR CORPORATION
8050 WEST FLORISSANT AVE.
ST. LOUIS, MO 63136

DATE: 12/5/2012

P.O. NO.: 84946A-1
Order/Line NO.: 20121843 SO 100

TO: NATIONAL PUMP COMPANY
7706 North 71st Avenue
Glendale, AZ, 85303-1703
ATTN: JOE MOONEY

Model Number: NA
Catalog Number:
Titan VHS TEFC
CONF,MOTOR,TITAN VHS TEFC

REVISIONS:
(NONE)

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY NIDEC MOTOR CORPORATION.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Features:

```
HOLD PRODUCTION
Horsepower ............. 00150.00~00000.00 ~ KW: 111.9
Enclosure .............. TEFC
Poles .................. 08~00 ~ RPM: 900~0
Frame Size ............. 449~TP
Phase/Frequency/Voltage.. 3~060~460 ~ Random Wound
Service Factor .......... 1.15
Insulation Class ........ Class "F" ~ VPI-2000
Altitude In Feet (Max) .. 3300 Ft.(1000 M)
Ambient In Degree C (Max) +40 C
Efficiency Class ........ Premium Efficiency
Application ............. Vertical Centrifugal Pump
Customer Part Number ....
Base Diameter (Inches) ....... 24.5
Coupling Size ................ 1-15/16" Bore, 1/2" Key
NRR/SRC/Bolted Coupling ...... Non-Reverse Ratchet
Steady Bushing ............... Steady Bushing Not Requested
Pricebook Thrust Value (lbs).. 13250
Customer Down Thrust (lbs) ... 5600
Customer Shutoff Thrust (lbs).
Up Thrust (lbs) ............. 30%
Momentary Up Thrust
Inverter Duty Rating:
Load Type (Base Hz & Below) .. Variable Torque
Speed Range (Base Hz & Below). 5:1
Temperature Rise (Sine Wave): "B" Rise @ 1.0 SF (Resist)
KVA Code Letter ......... "G"
Starting Method ......... Direct-On-Line Start
Duty Cycle .............. Continuous Duty
Sound Level Value (dBa).. 85 dBa @ 1M Sound Pressure
Load Inertia (lb-ft2): NEMA ~ NEMA Inertia: 3456.00 ~ 1.00
Number Of Starts Per Hour: NEMA
Motor Type Code ............ JUEI
Rotor Inertia (LB-FT²)       150. LB-FT²
Qty. of Bearings PE (Shaft)  1
Qty. of Bearings SE (OPP)    1
Bearing Number PE (Shaft)    6219-J/C3
Bearing Number SE (OPP)      7226 BCB
```

NIDEC MOTOR CORPORATION
8050 WEST FLORISSANT AVE.
ST. LOUIS, MO 63136

DATE: 12/5/2012

P.O. NO.: 84946A
Order/Line NO.: 20121843 SO 100

TO: NATIONAL PUMP COMPANY
7706 North 71st Avenue
Glendale, AZ, 85303-1703
ATTN: JOE MOONEY

Model Number: NA
Catalog Number:
Titan VHS TEFC
CONF,MOTOR,TITAN VHS TEFC

REVISIONS:
(NONE)

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY NIDEC MOTOR CORPORATION.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Accessories:
```
60,000 Hours L-10 Bearing Life
Inpro MGS Ground Seal
Brass Drain - Lower Bracket
Counter CW Rotation FODE
Ground Lug In Conduit Box
Insul. Bearing - Upper Bracket
115 Volt Space Heaters
Stainless Steel Hardware
Brg RTD-100 Ohm,3 Ld TCR.00385
Short End (Upper) Bearing
Thermostats - Normally Closed
.
Conduit Box Information: ~ Size 2 Conduit Box-Cast Iron
Conduit Opening Size (AA) .. 3.5" NPT
1 Conduit Opening ~ Bottom Of Conduit Box
Lead Positioning Gasket
Q-1 Accessory Outlet Box ~ Opposite Side of Main O/B
3/4" NPT Conduit Opening
PMC/Beta 440S-R Vib. Switch
Q-1 Upper/Short End Bracket
Std. Mounting Position
No Vib Detect On Lower/PE Brk
Test Requirements:
Complete Initial Test-Unwit.
```

USE THE DATA PROVIDED BELOW TO SELECT THE APPROPRIATE DIMENSION PRINT

Horsepower	150
Pole(s)	08
Voltage(s)	460
Frame Size	449TP
Outlet Box AF	8.06
Outlet Box AA	3.5
Accessory Outlet Box DM	0.75

NAMEPLATE DATA

CATALOG NUMBER:				NAMEPLATE PART #:	422707-006		
MODEL		FR	449TP	TYPE	JUEI	ENCL	TE
SHAFT END BRG	6219-J/C3 - QTY 1			OPP END BRG	7226 BCB - QTY 1		
PH	3	MAX AMB	40 C	ID#	(ref: Order#: 20121843, Type: SO, Line#: 100)		
INSUL CLASS	F	Asm. Pos.		DUTY	CONT		

HP	150		RPM	890		HP			RPM		
VOLTS	460					VOLTS					
FL AMPS	183.0					FL AMPS					
SF AMPS	209.0					SF AMPS					
SF	1.15	DESIGN	B	CODE	G	SF		DESIGN		CODE	
NEMA NOM EFFICIENCY	95.0	NOM PF	81.0	KiloWatt	111.900	NEMA NOM EFFICIENCY		NOM PF			
GUARANTEED EFFICIENCY	94.1	MAX KVAR		HZ	60	GUARANTEED EFFICIENCY		MAX KVAR		HZ	

UL DATA (IF APPLICABLE):

DIVISION		CLASS I		GROUP I	
TEMP CODE		CLASS II		GROUP II	

VFD DATA (IF APPLICABLE):

VOLTS	460	
AMPS	192.2	

TORQUE 1	883.1LB-FT	TORQUE 2	
VFD LOAD TYPE 1	VT/PWM	VFD LOAD TYPE 2	
VFD HERTZ RANGE 1	12-60	VFD HERTZ RANGE 2	
VFD SPEED RANGE 1	180-900	VFD SPEED RANGE 2	
SERVICE FACTOR	1.00	FL SLIP	
NO. POLES		MAGNETIZING AMPS	
VECTOR MAX RPM		Encoder PPR	
Radians / Seconds		Encoder Volts	

TEAO DATA (IF APPLICABLE):

HP (AIR OVER)		HP (AIR OVER M/S)		RPM (AIR OVER)		RPM (AIR OVER M/S)	
FPM AIR VELOCITY		FPM AIR VELOCITY M/S		FPM AIR VELOCITY SEC			

ADDITIONAL NAMEPLATE DATA:

Decal / Plate	WD=499495	Customer PN	
Notes		Non Rev Ratchet	NRR
Max Temp Rise	80C RISE/RES@1.00SF	OPP/Upper Oil Cap	22 QT/20.8 L
Thermal (WDG)	OVER TEMP PROT 2	SHAFT/Lower Oil Cap	GREASE
Altitude			
Regulatory Notes		Regulatory Compliance	
COS		Marine Duty	
Balance	0.06 IN/SEC	Arctic Duty	
3/4 Load Eff.	95.7	Inrush Limit	
Motor Weight (LBS)	3400	Direction of Rotation	
Sound Level	85 DBA @ 1M	Special Note 1	
Vertical Thrust (LBS)	13250	Special Note 2	
Thrust Percentage	100% HT	Special Note 3	
Bearing Life	60K	Special Note 4	
Starting Method		Special Note 5	
Number of Starts		Special Note 6	
200/208V 60Hz Max Amps		SH Max. Temp.	
190V 50 hz Max Amps		SH Voltage	SH VOLTS=115V
380V 50 Hz Max Amps		SH Watts	SH WATTS=288W
NEMA Inertia		Load Inertia	
Sumpheater Voltage		Sumpheater Wattage	
Special Accessory Note 1	BEARING SET POINTS	Special Accessory Note 16	
Special Accessory Note 2	ALARM= 120C	Special Accessory Note 17	AFFIX N/P 915592
Special Accessory Note 3	SHUTDOWN= 130C	Special Accessory Note 18	
Special Accessory Note 4		Special Accessory Note 19	
Special Accessory Note 5		Special Accessory Note 20	
Special Accessory Note 6		Special Accessory Note 21	
Special Accessory Note 7		Special Accessory Note 22	
Special Accessory Note 8		Special Accessory Note 23	
Special Accessory Note 9		Special Accessory Note 24	
Special Accessory Note 10		Special Accessory Note 25	
Special Accessory Note 11		Special Accessory Note 26	
Special Accessory Note 12		Special Accessory Note 27	
Special Accessory Note 13		Special Accessory Note 28	
Special Accessory Note 14		Special Accessory Note 29	
Special Accessory Note 15		Special Accessory Note 30	

NIDEC MOTOR CORPORATION

ST. LOUIS, MO

TYPICAL NAMEPLATE DATA
ACTUAL MOTOR NAMEPLATE LAYOUT MAY VARY
SOME FIELDS MAY BE OMITTED

MOTOR PERFORMANCE

MODEL NO.	CATALOG NO.	PHASE	TYPE	FRAME
NA	NA	3	JUEI	449TP

ORDER NO.	20121843	LINE NO.	100

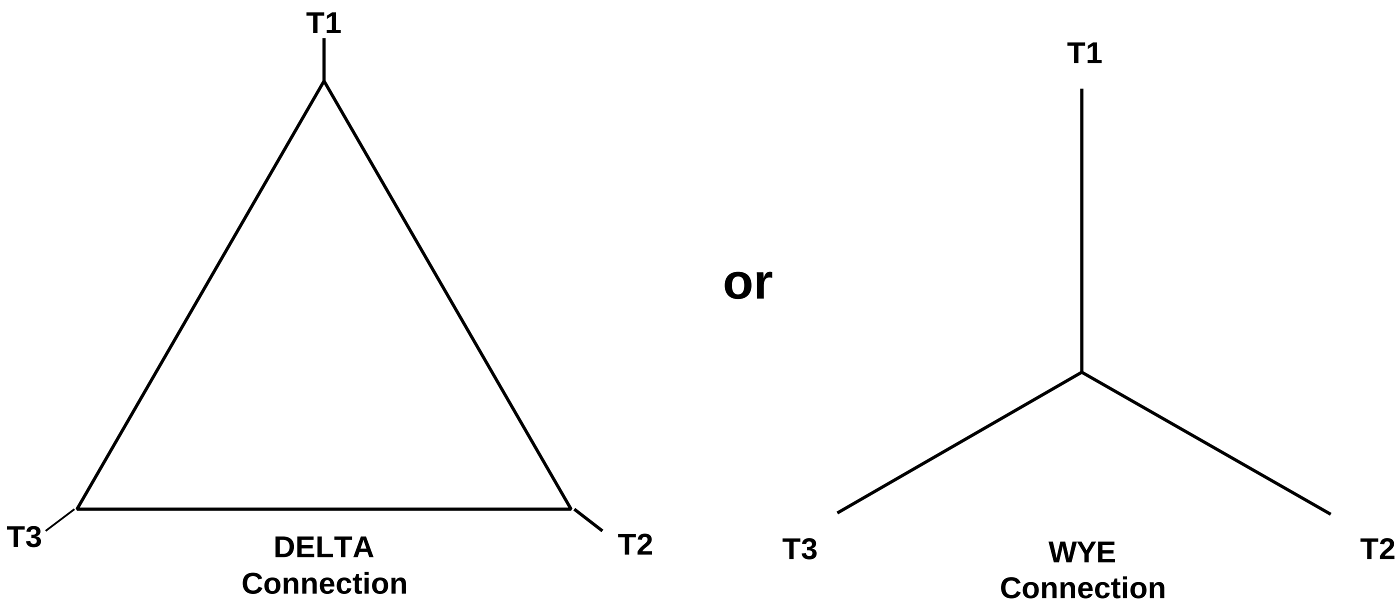
MPI:	97376
HP:	150
POLES:	8
VOLTS:	460
HZ:	60
SERVICE FACTOR:	1.15
EFFICIENCY (%):	
S.F.	94.9
FULL	95
3/4	95.7
1/2	95.2
1/4	92.6
POWER FACTOR (%):	
S.F.	81.3
FULL	81
3/4	78.5
1/2	70.9
1/4	50.6
NO LOAD	3.8
LOCKED ROTOR	21.6
AMPS:	
S.F.	209
FULL	183
3/4	140
1/2	104
1/4	75
NO LOAD	62.1
LOCKED ROTOR	1091
NEMA CODE LETTER	G
NEMA DESIGN LETTER	B
FULL LOAD RPM	890
NEMA NOMINAL EFFICIENCY (%)	95
GUARANTEED EFFICIENCY (%)	94.1
MAX KVAR	42.1
AMBIENT (°C)	40
ALTITUDE (FASL)	3300
SAFE STALL TIME-HOT (SEC)	30
SOUND PRESSURE (DBA @ 1M)	85
TORQUES:	
BREAKDOWN{% F.L.}	200
LOCKED ROTOR{% F.L.}	120
FULL LOAD{LB-FT}	883.1

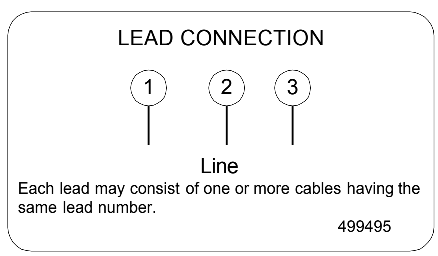
The Above Data Is Typical, Sinewave Power Unless Noted Otherwise

NIDEC MOTOR CORPORATION

ST. LOUIS, MO

Motor Wiring Diagram





To reverse direction of rotation interchange connections L1 and L2.

Each lead may be comprised of one or more cables.
Each cable will be marked with the appropriate lead number.

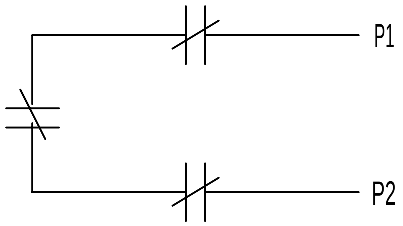
EFFECTIVE: 2/27/96
SUPERCEDES: X736618, 96441, 179879, 284138
Connection Plate: 499495
Connection Decal: 912113

THERMOSTATS

1. MOTOR IS EQUIPPED WITH QTY-3 (1 PER PHASE) NORMALLY CLOSED THERMOSTATS. THERMOSTATS ARE SET TO OPEN AT HIGH TEMPERATURE.

2. CONTACT RATINGS FOR THERMOSTATS: 120-600 VAC, 720 VA

N. C. THERMOSTATS



NOTE: THERMOSTATS LEADS MAY BE LOCATED IN EITHER THE MAIN OUTLET BOX OR IF SO EQUIPPED, AN AUXILIARY BOX.

ACCESSORY LISTING
QTY-3 N.C. THERMOSTATS

REVISION DESCRIPTION FOR: MISC

STL0211 - UPDATED FORMAT .

MATERIAL: ---

MUST BE COMPLIANT TO RoHS DIRECTIVE EU 2002/95/IEC AND REGULATION EC 1907/2006 (REACH) AS AMENDED

SCALE: NONE | UNITS: IN

TOLERANCES ON DIMENSIONS (UNLESS OTHERWISE SPECIFIED)

INCHES | mm

ANGLES X°= ±1°

TITLE: CUSTOMER CONNECTION DIAGRAM

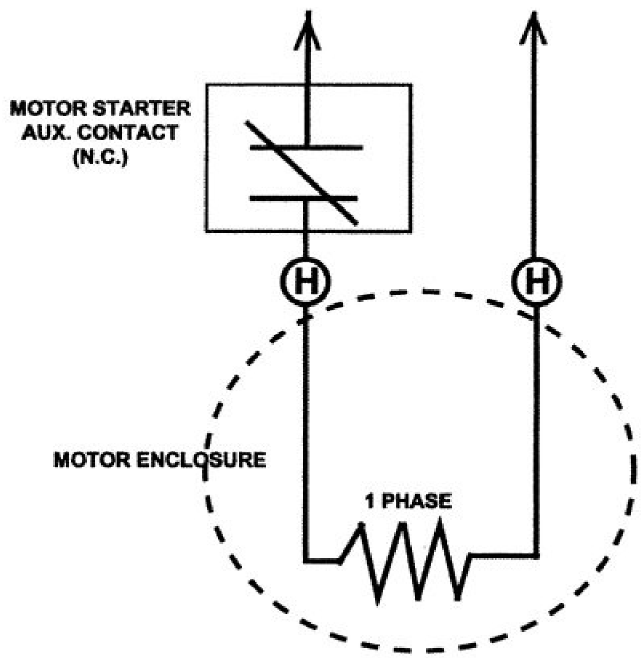
NIDEC MOTOR CORPORATION

ISSUED BY: R. KING | APPROVED BY: C. CADE | REVISION DATE: 24-FEB-11

CODE | DWG NO. 0834066 | REV G | SHEET NUMBER 1 OF 1 | DWG SIZE A

SPACE HEATER CONNECTION DIAGRAM

SPACE HEATER LEADS MAY BE LOCATED IN EITHER THE MAIN OUTLET BOX OR IF SO EQUIPPED, AN AUXILIARY BOX



THIS EQUIPMENT IS SUPPLIED WITH ANTI-CONDENSATION HEATERS. HEATERS SHOULD BE ENERGIZED WHEN EQUIPMENT IS NOT OPERATING TO PROTECT UNIT BY PREVENTING INTERNAL CONDENSATION. CONNECT THE "H" OR HEATER LEADS TO	
115V VOLTS	**288W** WATTS RATING

SPACE HEATER NAMEPLATE (ON MOTOR)

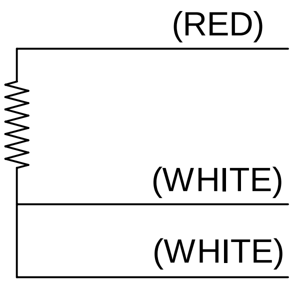
Revision: 7/30/2008
Mike Cullen

BEARING RTD'S

1. THERE ARE QTY-1 OR 2 (3 LEAD) BEARING RTD'S INSTALLED,
   ONE PER BEARING.

   A = UPPER/ODE (OPPOSITE DRIVE END)
   B = LOWER/DE (DRIVE END)

BEARING RTD'S



LEAD	UPPER/ODE	LOWER/DE
(RED)	A1	B1
(WHITE)	A2	B2
(WHITE)	A2	B2

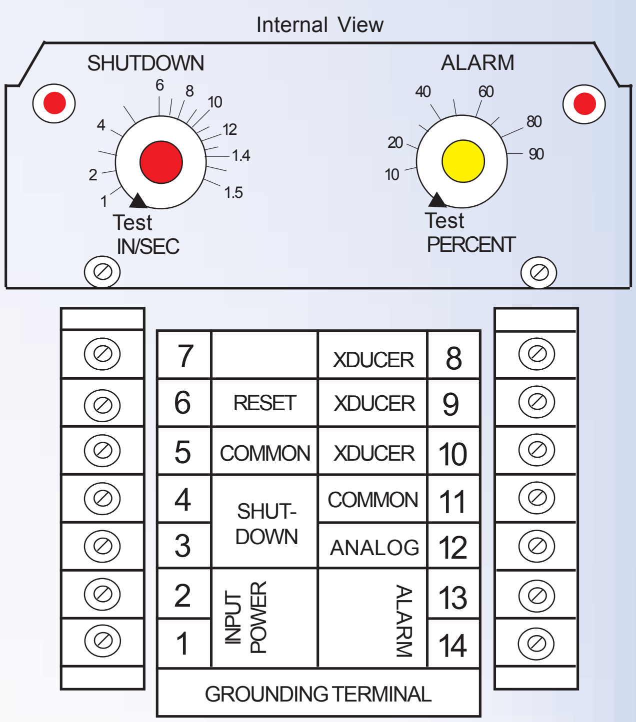
ACCESSORY LISTING
QTY 1 OR 2 BEARING RTD'S (3 LEAD)

REVISION DESCRIPTION FOR: MISC	SCALE NONE	UNITS IN	TITLE CUSTOMER CONNECTION DIAGRAM
STL0211 - UPDATED FORMAT.	TOLERANCES ON DIMENSIONS (UNLESS OTHERWISE SPECIFIED)		NIDEC MOTOR CORPORATION
MATERIAL:	INCHES	mm	ISSUED BY R. KING / APPROVED BY C. CADE / REVISION DATE 24-FEB-11
MUST BE COMPLIANT TO RoHS DIRECTIVE EU 2002/95/IEC AND REGULATION EC 1907/2006 (REACH) AS AMENDED	ANGLES X°= ±1°		CODE / DWG NO. 0338312 / REV C / SHEET NUMBER 1 OF 1 / DWG SIZE A

SOLID STATE VIBRATION SWITCHES

The PMC/BETA electronic vibration switch makes available in a relatively low-cost device many of the benefits formerly found only in high-end protection systems.

- **Adjustable time delay**
- **High accuracy**
- **No false triggering**
- **Analog output available**
- **Self-test function**
- **Built-in or remote transducer**



Model 450

Model 440

METRIX INSTRUMENT CO. PMC/BETA

Machinery Vibration Protection

Protect Your Rotating Machinery with Solid State Vibration Switches for Alarm and Shutdown

Provide Early Warning Avoid Catastrophic Failure

Vibration is an excellent early warning of machine deterioration.

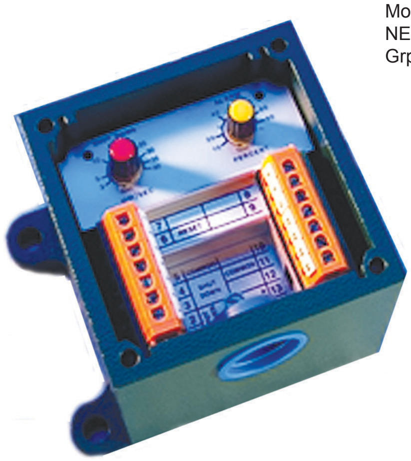
The PMC/BETA 440 Series vibration switches sense the causes of excessive machine vibration and machine failure. The major causes are: imbalance of a rotating member (about 40% of the time), misalignment (15%), defective bearings (15%) and defective belts (15%).

The PMC/BETA vibration switch responds to destructive vibration by shutting down your machine when the vibration trip level is exceeded, preventing catastrophic damage and extensive repairs and downtime.

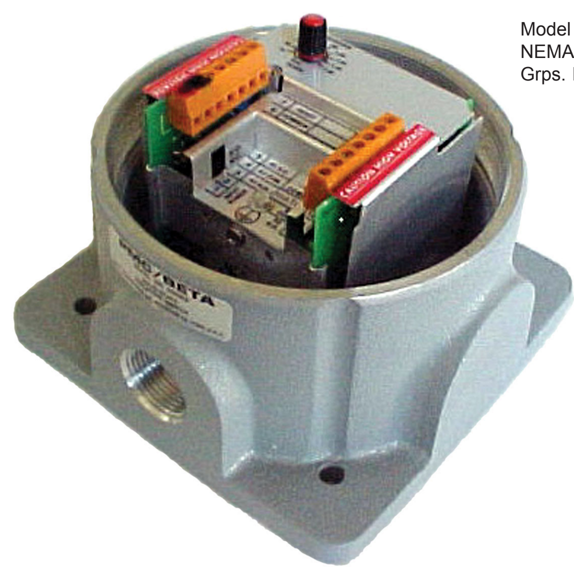
Small and gradual machine deterioration shows up as significantly increased vibration. Early detection usually permits continued operation until a scheduled shutdown.

Unique Features

- Built-in time delay, field adjustable.
- No false triggering.
- Velocity triggering provides protection at all frequencies. Displacement triggering available for low speed machinery.
- Sensitivity is not affected by rotating speed of machinery.
- Calibrated dial for setting limits.
- Solid state relay contacts used for alarm and/or shutdown. Field settable for N.O. or N.C.
- Remote reset capability.
- Provision for self-test and calibration.
- 4-20 mA output proportional to vibration level (on Models 440SR and 440DR) can be used for remote readout and trending of vibration levels.
- Built-in transducer or optional remote transducer.
- Cast aluminum enclosures meet NEMA 3, 4, and 12 standards. Explosion-proof models (450 Series) available.



Model 440D,
NEMA 4, Class I, Div. 2,
Grps. B,C & D



Model 450D,
NEMA 4, Class I, Div. 1,
Grps. B, C & D

Model 440S/450S (Single Trip)
One limit for alarm or shutdown.

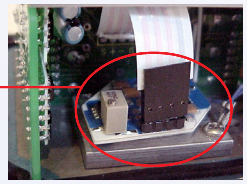
Model 440SR/450SR (Single Trip w/4-20 mA output)
One limit for alarm or shutdown, and 4-20 mA output for remote vibration readout or computer interface.

Model 440D/450D (Dual Trip)
One limit for alarm, a second limit for shutdown.

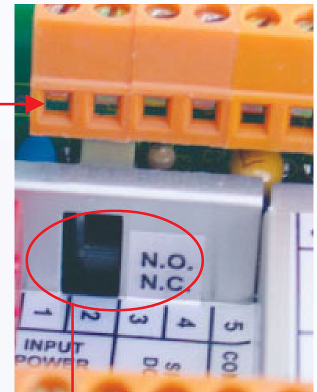
Model 440DR/450DR (Dual Trip w/4-20 mA output)
One limit for alarm, a second limit for shutdown, and 4-20 mA output for remote vibration readout or computer interface.

Unique Design Features

Built-in piezoelectric transducer module with integral amplifier provides 120 to 60,000 CPM capability.

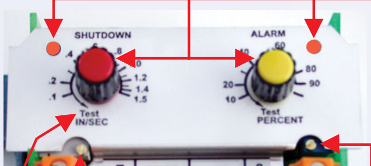


VDE approved terminal strip accepts #12 wire. Screw adjustable clamping yoke rather than screw terminal permits easy, vibration proof connection. All hardware is captive.



Each solid-state contact is independently field settable to open on alarm (N.C.) or close on alarm (N.O.).

Calibrated set point controls enable operator to set specific velocity trip points.



Light comes on immediately when vibration exceeds set point (alarm or shutdown will trip after 3 second time delay).

Adjustable time delay of 2-15 seconds. Factory set at 3 seconds.

Test position sets in minimum set point so that any vibration will cause trip condition. Light will come on immediately, and trip will occur after duration of the time delay, proving that the complete system is operational. If test position is maintained for less than the duration of the time delay, trip will not occur, thus permitting system test without shutdown.

Specifications

Model No.	440S	440SR	440D	440DR
No. of Trips	ONE: for alarm or shutdown. Set in in/sec (velocity model) or mils (displacement model).		TWO: One for alarm and one for shutdown. Shutdown set in in/sec (velocity model) or mils (displacement model). Alarm set as percent of shutdown.	
Analog Output for Remote Indication	N/A	± 10% accuracy over 4-20 mA DC range. 4 mA is 0 vibration; 14 mA is set point; 20 mA is 160% of setpoint. Termination load resistance, less than 450 ohms	N/A	± 10% accuracy over 4-20 mA DC range. 4 mA is 0 vibration; 14 mA is set point; 20 mA is 160% of setpoint. Termination load resistance, less than 450 ohms
Velocity Set Point	0.1 to 1.5 in in/sec or 0.2 to 3 in/sec peak. Metric ranges: 3 to 40 mm/sec or 6 to 80 mm/sec peak (Select one)			
Displacement Model	1 to 15 mils or 10 to 150 mils peak to peak. Metric ranges: 30µm to 400µm or 300µm to 4 mm peak to peak (Select one)			
Frequency Range	2 to 1000 Hz (120 to 60,000 RPM)			
Time Delay	Field adjustable 2-15 sec. Factory set for 3 sec unless specified otherwise			
Alarm or Shutdown Output(s)	Solid state relay (triac). One in 440S, 440SR; Two in 440D, 440DR Isolated (dry) contact Each triac field settable for close on alarm (N.O.) or open on alarm (N.C.) 5 A continuous, 100A for 10 msec. Max. off-state leakage current: 1 mA Min holding current: 50 mA typical Max. voltage across SS relay: 140VAC (280VAC on 230V input units) **NOTE:** If the relay output is connecting to a PLC or DCS, DO NOT use 5A Triac. See options for D & E on Designation page.			
Remote Reset	Connection between terminals 5 and 6 latches triac output in alarm state after setpoint is exceeded. Opening the connection will reset the output to non-alarm state.			
Set Point Accuracy	± 10% of setting with repeatability of ± 2%. Circuitry utilizes RMS detector			
Vibration Sensitive Axis	Perpendicular to base. Unit can be mounted in any orientation without affecting setting			
Temperature Limits	-20°F to +140°F (-30°C to +60°C) including internal transducer. -65°F to +190°F (-55°C to +88°C) for optional external transducer			
Humidity	1% to 100% (non-condensing)			
Input Power	100-130 VAC 50/60 Hz standard. 200-260 VAC 50/60 Hz optional. DC input power optional. 440S, 3 Watt, 440D, 4 Watt			
Enclosure	Rugged, water-tight, dust-tight, cast aluminum. Meets NEMA, 3, 4 and 12 standards. Optional explosion-proof Model 450 available.			
Weight	3.5 lbs (1.6 Kg)			
Mounting	1/4" hardware, 3 mounting bosses			
Terminals	All terminals will accept #12 AWG wire in clamping type yoke without need for termination hardware. ALL hardware is captive.			
Self Test	Test position on set point control and light emitting diode provide functional test of trip circuitry, time delay and triac closure. Also permits on-line calibration of switch.			
Circuitry	Proprietary hybrid circuitry throughout for minimum size and maximum reliability in vibration environment.			
Remote Transducer Option	The standard 440 includes a built-in transducer. A separate transducer can be specified. Please request separate transducer when placing order. See Designation page. We recommend Model 165 ICP Accelerometer with Cable 031L-XX, where XX is the length of the cable in feet.			

More Features and Benefits

Single or Dual Trip Switches Provide Early Warning

The 440S provides a single switch closure which can be used for alarm or shutdown. However, it is often desired to provide a warning before shutdown. The 440D is ideal for this requirement. It provides two trips: one for alarm and one for shutdown.

The first trip is set at a vibration alarm level to provide early warning that the condition of the machine is deteriorating. When the alarm trip occurs, the operator can evaluate the condition and schedule corrective maintenance - at a time that does not interrupt the production schedule. If the machine condition continues to deteriorate, the shutdown trip provides protection against catastrophic failure.

The 440/450 as a Vibration Transmitter

The 4-20 mA output available on Models 440SR and 440DR can be utilized for remote readout of vibration level or as a transmitter to interface with customer computers and data handling systems presently used with pressure, flow and temperature transmitters, etc. The user can detect vibration levels which may be increasing, but which are not yet serious enough to trip the alarm.

How the 440/450 Works

These electronic switches utilize a solid state crystal accelerometer which provides an electrical output when it is deformed by the vibration forces. The output is electronically converted to a signal proportional to velocity. This signal is compared with a present limit and triggers a solid state relay if the limit is exceeded. There are no moving parts in the 440 vibration switches except when configured with mechanical relays.

While the 440 costs more than a mechanical switch, it uses the same technology as sophisticated remote monitoring systems and provides most of the capabilities of these systems at 1/3 to 1/2 the cost per monitor point.

Velocity Trip

The different causes of machinery failure (imbalance, misalignment, bearings, etc.) result in increased vibration at different frequencies (CPM) on a given machine. Therefore, it is important that the vibration protection device be equally sensitive to damaging vibration at all frequencies.

International standards for rotating machinery (ISO 2372, 3945) specify that vibration severity is directly related to vibratory velocity. The PMC/BETA 440/450 series electronic vibration switches measure and trip on velocity.

In mechanical switches, sensing and tripping are inherently limited to impact/acceleration. Since severity (damage potential) is proportional to velocity, acceleration tripping is oversensitive to some frequencies and not sensitive enough to others - with the result of either false trips in some cases, or not enough protection in others.

Built-in Time Delay Avoids False Trips

An important feature of PMC/BETA switches is the built-in time delay. This prevents triggering of the alarm or shutdown functions from transient increases in vibration levels. It also avoids shutdown due to transitory vibrations occurring during start-up.

Almost all machines experience a few seconds of high vibration during start-up before reaching operating speed. When no time delay function is included, as with mechanical switches, this start-up vibration causes a trip. Frequently, the operator turns the trip setting up until he can get through start-up. The resultant trip level is too high to afford protection at the machine's operating speed.

Three-second time delay is provided as standard on all PMC/BETA switches. The time delays are independently adjustable in the field over a range of 2 to 15 seconds.

Why Use Remote Sensors

Vibration switches can be configured to work with external sensors (accelerometers, velocity pickups or transmitters). When an external sensor is used, the internal accelerometer is not present.

Mounting location size, temperature considerations, vibrating environment and application would determine when to use an external sensor. For example, if the vibration switch is too large to fit a machine location, consider using a remote accelerometer and an interconnecting cable.

Model 440/450 Designation

Model 440 A - BCDE - FGHI - JKLMN Model 450 A - BCDE - FGHI - JKLMN

Notes: **1** 440 units, except those w/ mechanical relays and external transducers carry a CSA label.
2 450 enclosure is coated with epoxy paint. Rated CSA, NEMA 4, Class I, Grps B, C & D; Class II, Grps, E, F & G
3 Special modifications and options will receive an "M" number, assigned by the factory.

A = Single or Dual Trip/Analog Signal Output

S = Single Trip
SR = Single Trip, Analog Signal Output
D = Dual Trip
DR = Dual Trip, Analog Signal Output

B = Analog Signal Output

0 = None
1 = 4-20 mA, dependent
2 = 4-20 mA, absolute
3 = 0-10 Vdc, absolute
4 = 0-10 Vdc, dependent
5 = 0-1 Vdc, absolute
6 = 0-1 Vdc, dependent

C = Scale

0 = 0.1 - 1.5 in/sec
1 = 0.2 - 3.0 in/sec
2 = 3 - 40 mm/sec
3 = 6 - 80 mm/sec
4 = 1 - 15 mils displacement, pk-pk
5 = 10-150 mils displacement, pk-pk
6 = 30 - 400 microns displacement, pk-pk
7 = 0.3 - 4 mm displacement, pk-pk
8* = 0 - 16 Impacts
9* = 0 - 100% of transmitter scale

*NOTE: For use with a 24 Vdc loop-powered transmitter.

D = Shutdown Circuit

0 = Triac, 5A, SPST (for switching heavy AC loads)
2 = 170 mA, 250 Volts, Pk, analog, SPST switch, good selection for use with PLC or DCS
3 = OBSOLETE, .5 Amp SPDT relay (replace w/ x4, 10A SPST relay)
4* = 10A SPDT relay
5 = 10A DPDT relay where A = S or SR only
6 = 1A, 200V pk, Analog Switch
7 = 150 mA, 400 V, pk, Analog Switch

E = Alarm Circuit (Always 0 if A = S or SR)

0 = None
1 = Triac, 5A Standard
2 = 170 mA, 250 Volts Pk, Analog SPST Switch (Use for PLC or DCS)
3 = OBSOLETE, .5 Amp SPDT relay (replace w/ x4, 10A SPST relay)
4 = 10A SPDT relay Alarm Only
5 = OBSOLETE, 2A DPDT Relay, Internal Xducer only
6 = 200V, pk, 1A Analog Switch
7 = 150 mA, 400 V, pk, Analog Switch

F = Enclosure

0 = Standard
1 = OBSOLETE, All 450's have epoxy paint
2 = Pushbutton reset
3 = OBSOLETE, See F = 1 or 2
4 = OBSOLETE, All 450's are Grps B,C & D
5 = Velocity signal out via BNC connector, 278 mV, rms/ips, pk
6 = Pushbutton reset and Velocity out
7 = Acceleration signal out via BNC connector, 100 mV/g
8 = Pushbutton reset and BNC Accel. out

G = Input Power

0 = 115 Vac, 50/60 Hz
1 = 230 Vac, 50/60 Hz
2 = 24 Vdc ± 10%
3 = OBSOLETE, 12 Vdc ± 10%
4 = OBSOLETE, 48 Vac, 50/60 Hz

H = Lockout Function

0 = None
1 = Lockout
2 = 20 sec startup, lockout delay
3 = OBOLETE, 30-90 sec variable startup, lockout delay
4 = OBSOLETE, 24 Vdc enabled lockout, input power must be 24 Vdc

I = Configured for which Transducer

0 = Internal
1 = 160A, FM or E Accelerometer
2 = 258 Velocity Xducer
3 = 260C Piezo-Velocity Xducer
4 = 160A-E X-proof Accelerometer
5 = 165 Constant Current Accelerometer
6 = 258E X-proof velocity Xducer
7 = Other Constant Current 100 mV/g Accelerometer
8* = 24 Vdc loop-power transmitter

*NOTE: Available with 0 to 100% of transmitter input range or 0 to 16 impacts.

J = Other Special

7 = CE mark for 440 only
Leave BLANK if not applicable.

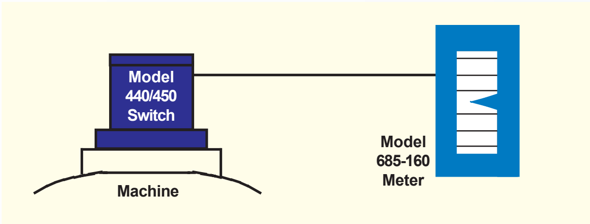
K = Type Scale

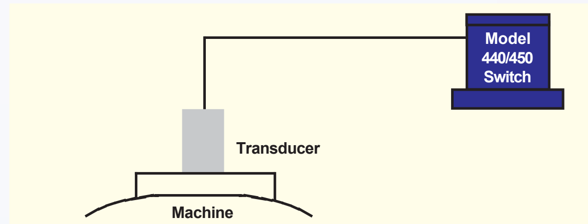
0 = 0 to pk
1 = RMS
2 = pk to pk

L, M, N = External Transducer Sensitivity mV/unit use when applicable

Please contact factory for options and pricing.

Remote Readout and Remote Transducer Options

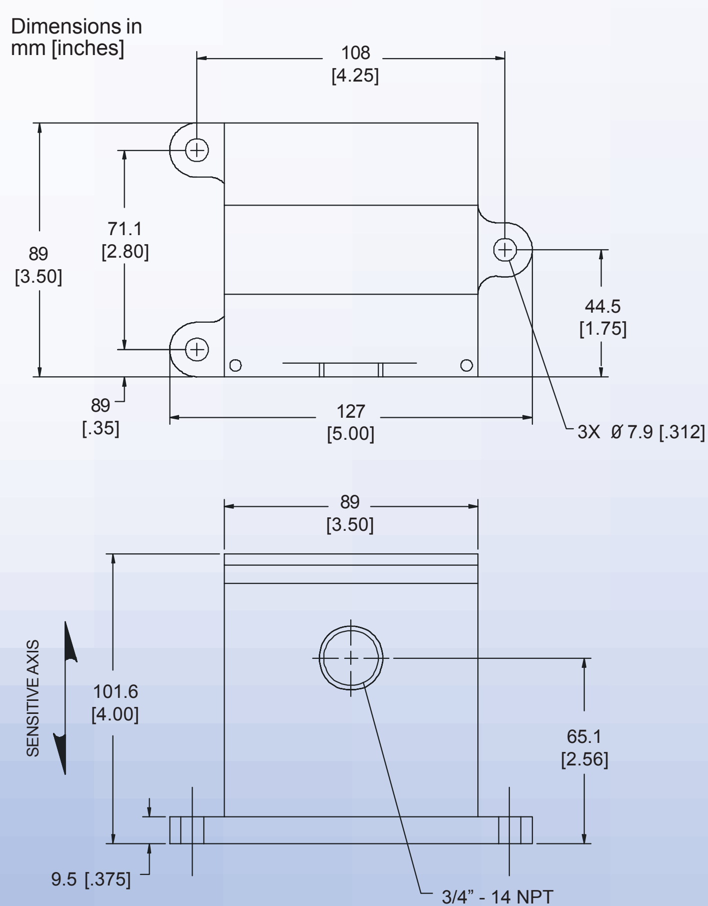




Remote indicator with Model 440/450 vibration switch.

The Model 685-160 meter will provide continuous readings of vibration level from the 4-20 mA analog output of the 440SR or the 440DR. The meter reads from 0 to 160% of shutdown setpoint. The 4-20 mA output can also be used to drive a strip chart recorder or PLC input.

Outline Drawing of Model 440



Weight: 1.6 kg [3.5 lbs]

Remote sensors with Model 440/450.

The standard 440/450 includes a built-in transducer. For some applications, a remotetransducer is desirable as an option in place of the internal transducer. The 440 can then be mounted in any convenient location up to 1,000 feet away. The 440/450 can be configured for up to 2 remote sensors with a variety of input sensors and transmitters.

Available Transducers

- SA6200 Accelerometer, available with two pin MS style connector or integrated cable.
- 258 Velocity Transducer, available with a three pin MS style connector
- SA6350 High Temp. Accelerometer, available with two pin MS style connector
- ST5484E or 162VTS Slim design Velocity Transmitter, available with flying leads, terminal blocks or MS connector

Available Cables

- Two (2) pin socket connector with integral, molded splash proof boot with 6.4 mm (0.25') diameter polyurethane jacketed cable with twisted shielded pair wires. XXX.X = cable length in meters. P/N 8978-111-XXXX Splashproof Cable Assembly
- Two (2) pin socket connector with integral, molded splash proof boot with 7.1 mm (0.28") diameter, SS armored jacket with cable, twisted shielded pair wires. XXX.X = cable length in meters. P/N 9334-111-XXXX Splashproof Cable Assembly w/SS Armor
- Two (2) pin socket connector w/o cable. P/N 8978-200-0000 Connector Assembly
- Three (3) pin socket MS style connector with cable. P/N 031L-XX.

March 2004

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COMPLETE SHAFT GROUNDING SOLUTIONS

Current Diverter Ring™
and Motor Grounding Seal™

INPRO/SEAL®
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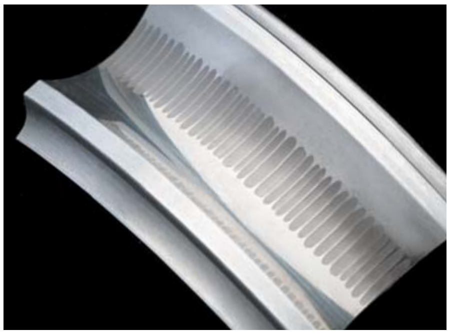
SAFEGUARD YOUR INVESTMENT FROM BEARING DAMAGE

The VFD Challenge

Variable frequency drives (VFDs) are becoming the system of choice across a variety of industries because of their ability to reduce energy consumption – generating significant cost savings. However, these systems may also contribute to unplanned downtime.

VFDs induce high frequency voltages on the shaft that seek a path to ground through the motor's bearings or the bearings of the coupled equipment. When these voltages exceed the insulation breakdown of the lubricant, they discharge through the bearings to ground.



Stray shaft currents discharging through the bearings on rotating equipment can cause fluting on the bearing race, resulting in premature bearing failure.

The Cost of Electrical Damage

This discharge, called electrical discharge machining (EDM), causes fusion craters, pitting, frosting, and fluting. These effects make EDM a leading cause of premature bearing failure in VFD-driven motors.

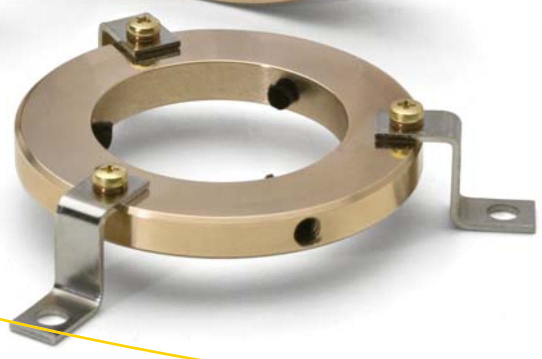
Even if the motor itself has insulated bearings, shaft currents can travel to the coupled equipment, such as pumps, pillow blocks and gearboxes, and damage those bearings. The results are costly and include reduced equipment reliability, increased maintenance costs, unscheduled downtime and lost revenue.

SHAFT GROUNDING OPTIONS						
	CDR®	CERAMIC BEARING	COPPER METAL BRUSH	CARBON BRUSH	CONDUCTIVE GREASE	FILTERS ON VFD
EASY MOUNTING	✓				✓	✓
MAINTENANCE FREE	✓	✓				
HIGH ROI	✓					
LOW INITIAL COST	✓			✓	✓	
LONG LIFE	✓					
NO RPM LIMIT	✓	✓				✓

Reducing Electrical Damage

Diverting shaft currents and controlling EDM needs to be a priority for your business. Various methods have been used over the years to mitigate shaft currents, but they have all had limitations...**until now.**

The Inpro/Seal® Current Diverter Ring™ and Motor Grounding Seal™ protect bearings from harmful stray shaft currents.



SAME-DAY
SHIPPING AVAILABLE

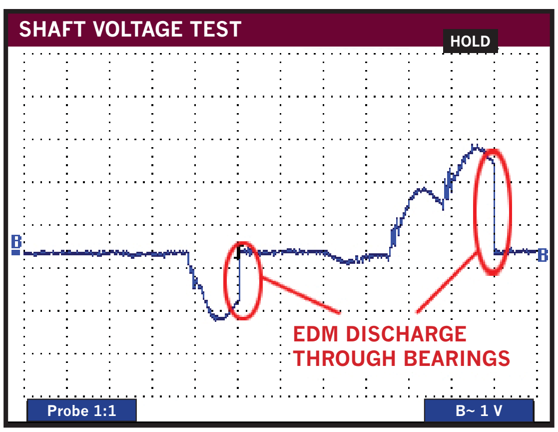
The Inpro/Seal® Solution

The Inpro/Seal Current Diverter Ring™ (CDR®) uses proprietary conductive filaments to protect bearings from stray shaft currents by providing a low impedance path to ground – drawing the currents safely away from the bearings.

For severe duty applications, the Inpro/Seal Motor Grounding Seal™ (MGS®) combines proven shaft-grounding technology with the patented VBXX® Bearing Isolator to provide complete bearing protection against stray shaft currents and contamination ingress.

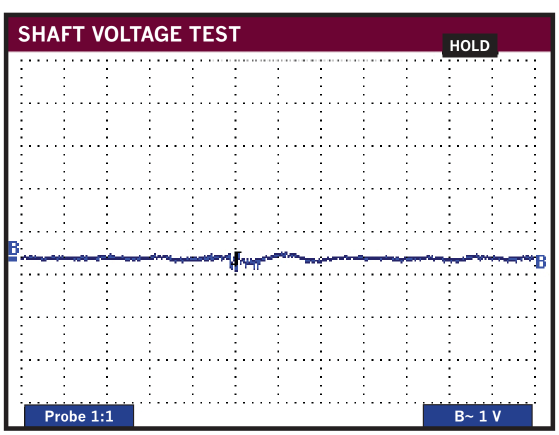
Benefits:

- Split designs available for easy installation
- Can be installed by OEMs or retrofitted on site
- Maintenance free at all RPMs
- Modular design allows for use with any size motor
- Multi-stage product can handle high shaft currents found in larger rotating equipment
- Can accommodate shaft sizes of 0.625 – 48.0 in. (1.59 – 121.92 cm)
- Manufactured in bronze, stainless steel and aluminum



5HP 3PH MOTOR VFD DRIVEN
SHAFT VOLTAGE 1200 RPM

Stray shaft currents discharging through the motor's bearings.



SHAFT VOLTAGE WITH CDR® INSTALLED

No discharges with the Inpro/Seal® CDR® installed.

GUARANTEED PERFORMANCE

The Inpro/Seal® CDR® and MGS® are backed by a performance guarantee. See our website for complete details.

Unmatched Customer Service

Inpro/Seal's responsive global sales network is committed to making sure you have the right technology for your application, right when you need it. We know that time means money for you. That's why we offer same-day shipping on most products, even new designs. No matter what your application, we can deliver a custom engineered solution designed to meet your specific needs.

Technology you can rely on, supported by customer service you'll appreciate.

Inpro/Seal® Multi-Stage CDR® for high voltage systems.

Experience You Can Trust

Reducing EDM damage requires a custom engineered solution that takes into account all these factors:

- Motor size
- Bearing type
- Bearing insulation
- Existing circulating currents
- Existing system grounding configuration
- Operating equipment
- Coupled equipment

You don't need to be an expert; our knowledgeable team will help. You can count on Inpro/Seal®, the leader in bearing and system protection, to maximize the uptime of your rotating equipment. We've been the trusted source for bearing isolator technology for more than 30 years, and now we're expanding our product offerings to deliver protection from electrical damage. Inpro/Seal's line of complete shaft grounding solutions is ideal for HVAC, industrial, and wind energy applications.

The Inpro/Seal Advantage

Inpro/Seal is committed to delivering innovative technology and superior customer support...standard with every solution. When you work with Inpro/Seal, you can expect:

- Same-day shipments available on most products, including new designs
- Custom engineered solutions for your application and operating environment
- Knowledgeable sales network providing localized support
- Performance guarantee– see website for complete details

Engineering Specifications

To ensure that your equipment is protected by Inpro/Seal's shaft grounding technology, simply include the following with your specifications:

"All motors driven by variable frequency drives (VFD) shall include bearing protection in the form of a device to divert shaft currents to ground. The device shall be maintenance free and constructed of highly conductive bronze. Recommended device: Inpro/Seal Current Diverter Ring™ (CDR®)."

"All VFD driven motors operating in harsh environments shall employ complete bearing protection through the use of a non-contact or non-contacting-while-rotating type seal to obtain an IP55 degree of protection as well as an integrated device to divert shaft currents to ground. Recommended device: Inpro/Seal Motor Grounding Seal™ (MGS®)."

READY TO GET STARTED?

Visit www.inpro-seal.com to contact your local Inpro/Seal representative or request a quote.

The Inpro/Seal® CDR® is a custom engineered solution and some designs may be protected by US patents and pending patent applications as installed including US Pat. #D615,996 and #7,521,827.

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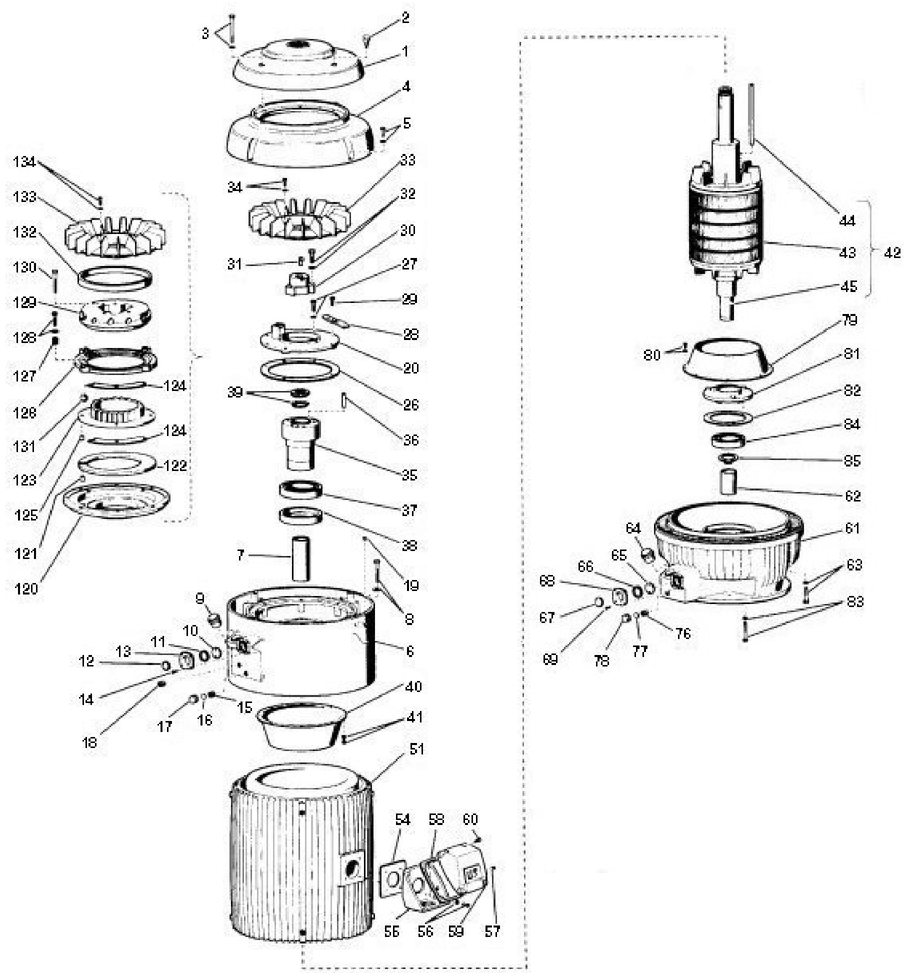
RENEWAL PARTS

FRAMES 5008P THRU 5811PH - TOTALLY ENCLOSED AND EXPLOSION PROOF MOTORS
TYPES: EU, EV4, EVC4, JU, JUC, JUCE, JUCEI, JUCI, JUE, JUEI, JV, JV4, JVC, JVC4, JVC9, JVCE, JVCE4, JVCEI, JVCI4, JVCI, JVE, JVEI, JVE4, JVEI4, JVI, JVI4, NVC4, NVCE4, NVE4
HOLLOSHAFT & SOLIDSHAFT MOTORS (EXCEPT 3600 RPM)



WARNING:
Any disassembly or repair work on explosionproof motors will void the Underwriters Laboratories, Inc. label unless done by the manufacturer, or a facility approved by the Underwriters Laboratories, Inc. Refer to your nearest sales office for assistance.

BEARINGS:
Refer to motor nameplate for the bearing numbers.

PRICES:
Parts stocking distributors: refer to renewal parts numerical index. All Others: refer to your nearest parts distributor.

reference: Renewal Parts Section 700, Pages 159 & 160

RENEWAL PARTS

FRAMES 5008P THRU 5811PH - TOTALLY ENCLOSED AND EXPLOSION PROOF MOTORS
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HOLLOSHAFT & SOLIDSHAFT MOTORS (EXCEPT 3600 RPM)

ITEM NO.	QTY	NAME OF PART
1	1	Canopy Cap
2	2	Eyebolt
3	3	Hex Head Cap Screw / Split Lockwasher
4	1	Fan Cover
5	4	Hex Head Cap Screw / Split Lockwasher
6	1	Upper Bracket Assembly (Includes item 7)
7	1	Oil Retaining Tube
8	8	Hex Head Cap Screw / Split Lockwasher
9	1	Special Plug
10	1	Reflector Disc
11	2	Gasket
12	1	Sight Gauge Window
13	1	Special Housing
14	4	Oval Head Screw
15	1	Nipple Fitting
16	1	Gasket
17	1	Drain Cap
18	1	Pipe Plug
19	2	Caplug
20	1	Dust Ring
21-25	-	NOT USED IN THIS ASSEMBLY
26	1	Gasket
27	8	Hex Head Cap Screw / Split Lockwasher
28	1	Locking Arm
29	1	Hex Head Cap Screw
30	1	Coupling EU & JU Only
31	1	Gib Key
32	3	Headless Slot Screw or Hex Head Cap Screw / Split Lockwasher
33	1	Fan
34	6	Hex Head Cap Screw / Lockwasher
35	1	Bearing Mounting
36	1	Square Key
37	1	Ball Bearing (Refer to Section 775)
38	1	Bearing Spacer
39	1	Locknut and Lockwasher
40	1	Upper Air Deflector
41	8	Hex Head Cap Screw / Lockwasher
42	1	Rotor Assembly (Includes itesm 43-45)
43	1	Rotor Core
44	1	Square Key
45	1	Shaft
46-50	-	NOT USED IN THIS ASSEMBLY
51	1	Wound Stator Assembly
52	1	Shroud (Not Illustrated)
53	8	Hex Head Cap Screw (Shroud) (Not Illustrated) Plain Washer (Not Illustrated) Lockwasher (Not Illustrated)
54	1	Gasket (Outlet Box Assembly) (JU Only)
55	1	Outlet Box Base
56	4	Hex Head Cap Screw / Lockwasher
57	1	Hex Countersunk Pipe Plug (JU Only)
58	1	Gasket (Outlet Box Cover) (JU Only)
59	1	Outlet Box Cover
60	4	Hex Head Cap Screws (Outlet Box Cover)
61	1	Lower Bracket Assembly
62	1	Oil Retaining Tube
63	8	Hex Head Cap Screw / Lockwasher
64	1	Special Plug
65	1	Reflector Disc
66	2	Gasket
67	1	Sight Guage Window
68	1	Special Housing
69	4	Oval Head Screw
70-75	-	NOT USED IN THIS ASSEMBLY
76	1	Nipple Fitting
77	1	Gasket
78	1	Drain Cap
79	1	Lower Air Deflector
80	8	Hex Head Cap Screw / Lockwasher
81	1	Bearing Cap
82	1	Gasket
83	3	Hex Head Cap Screw / Lockwasher
84	1	Ball Bearing (Refer to Section 775)
85	1	Snap Ring
86	1	Baffle Plate
FOR UNITS WITH NRR - OMIT ITEMS 20, 2829, 33, 34, &AMP, ADD:		
120	1	Ratchet Adaptor Assembly (Includes Items 121)
121	1	Dowel Pin
122	1	Expansion Spring
123	1	Stationary Ratchet Assembly (Includes items 124 & 125)
124	8	Friction Plate
125	1	Dowel Pin
126	1	Pressure Plate Assembly
127	4	Compression Spring
128	4	Hex Head Cap Screw & washer
129	1	Rotating Ratchet
130	3	Hex Head Cap Screw
131	12	Steel Ball
132	1	Ball Retaining Ring
133	1	Fan
134	6	Hex Head Cap Screw / Lockwasher

WARNING:
Any disassembly or repair work on explosionproof motors will void the Underwriters Laboratories, Inc. label unless done by the manufacturer, or a facility approved by the Underwriters Laboratories, Inc. Refer to your nearest sales office for assistance.

BEARINGS:
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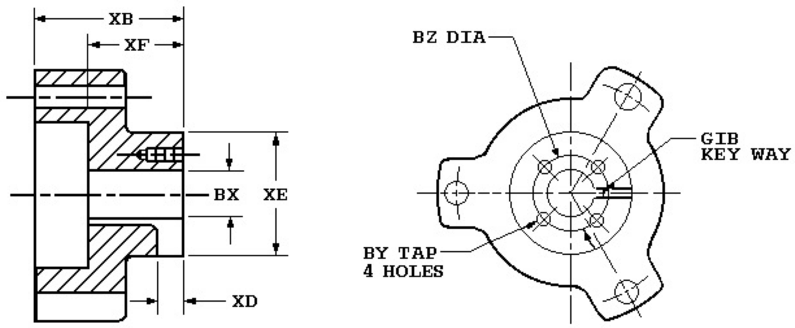
reference: Renewal Parts Section 700, Pages 159 & 160

Vertical HOLLOSHAFT Coupling Dimensions

Standard Coupling Dimensions



Coupling Part Number	113288
BX Nominal	1 15/16
Actual Bore	1.938
BY	1/4-20
BZ	2 1/2
XB	4 3/8
XD	11/16
XE	4 3/4
XF	3 1/16
SQ. KEY	1/2

Notes:

1. All Rough casting dimensions may vary by 0.25" due to casting variations.
2. All tapped holes are Unified National Course, Right Hand thread.
3. Coupling bore dimension "BX" is machined with a tolerance of - .000", +.001" up to 1.50" bore inclusive. Larger bores: -.000", +.002".

TYPICAL REED CRITICAL FREQUENCY DATA

USEM MODEL NO: NA
USEM CATALOG NO: NA

Frame: 449TP Type: JUEI

REED CRITICAL FREQUENCY:	31	HZ
CENTER OF GRAVITY:	26	IN
DEFLECTION @ CENTER OF GRAVITY:	0.0102	IN
UNIT WEIGHT:	3300	LBS.
BASE DIAMETER:	24.5	IN.
MAXIMUM MOTOR DIAMETER:	26.25	IN.
DATE:	12/5/2012	

Suitability of Integral Horsepower (IHP)* Motors on Variable Frequency Drives

Variable Frequency Drives (VFD)

Nidec Motor Corporation's Inverter Grade® insulated motors exceeded NEMA®† MG-1 Part 30 & 31 before the standards were established.

We are a leader in the development of electric motors to withstand pulse width modulated (PWM) drives evolution from power transistors to higher switching frequency insulated gate bipolar transistors (IGBTs).

Today, as the need for light and medium duty motor inverter applications grows, Nidec Motor Corporation provides products to meet these demands.

Through continued research and development, Nidec Motor Corporation has included the insulation wire from its Inverter Grade® motors on all Premium, Energy and Standard Efficient motors, enhancing their potential inverter compatibility.

Inverter compatibility with motors is complex. As a result, many variables must be considered when determining the suitability of certain types of motors. These variables include:

- Torque requirements (Constant or Variable)
- Speed Range
- Line/System Voltage
- Cable Length between VFD & Motor
- Drive Switching (Carrier) Frequency
- Motor Construction

Wider speed ranges, higher voltages, higher switching frequencies and increased cable lengths all add to the severity of the application and therefore the potential for premature motor failure. Nidec Motor Corporation has differentiated its products into families for your ease of selection for various inverter applications.

Warranty Guidelines

The information within this section refers to the motor and drive application guidelines and limitations for warranty.

Hazardous Location Motors

Use of a variable frequency drive with the motors in this catalog, intended for use in hazardous locations, is only approved for Division 1, Class I, Group D hazardous location motors with a T2B temperature code, with a limitation of 2:1 constant torque or 10:1 variable torque output. No other stock hazardous location motors are inherently suitable for operation with a variable frequency drive. If other requirements are needed, including non-listed Division 2, please contact your Nidec Motor Corporation territory manager to conduct an engineering inquiry.

Applying Inverter Grade® Insulated Motors on Variable Frequency Drives

The products within this catalog labeled "Inverter Duty" or "Vector Duty" are considered Inverter Grade® insulated motors. Inverter Grade® motors exceed the NEMA®† MG-1 Part 31 standard.

Nidec Motor Corporation provides a three-year limited warranty (see page ix) on all Inverter Grade® insulated motors and allows long cable runs between the motor and the VFD (limited to 400 feet without output filters). These motors may be appropriate for certain severe inverter application or when the factors relating to the end use application are undefined (such as spares).

Nidec Motor Corporation's U.S. Motors® brand is available in the following Inverter Grade® insulated motors:

- Inverter Duty motors good for 10:1 Variable Torque & 5:1 Constant Torque, including Vertical Type RUSI
- Inverter Duty motors good for 10:1 Constant Torque
- ACCU-Torq® and Vector Duty Motors with full torque to 0 Speed & 1024 PPR, 5-28VDC Encoder
- 841 Plus® motors that meet IEEE®† 841 Standards and are suitable for 5:1 Constant Torque

Applying Premium Efficient Motors on Variable Frequency Drives

Meet NEMA®† MG-1, Section IV, Part 31.4.4.2. They can be used with adjustable frequency drives under the following parameters: Up to 4:1 speed range on constant torque loads, standard two-year limited warranty (see page ix).

Cable Distances for Applying Premium Motors			
Maximum Cable Distance VFD to Motor			
Switching Frequency	460 Volt	230 Volt	380 Volt
3 Khz	196 ft	481 ft	295 ft
6 Khz	168 ft	340 ft	209 ft
9 Khz	113 ft	278 ft	170 ft
12 Khz	98 ft	241 ft	148 ft
15 Khz	88 ft	215 ft	132 ft
20 Khz	76 ft	186 ft	114 ft

Applying Standard & Energy Efficient Motors on Variable Frequency Drives

Meet NEMA®† MG-1, Section IV, Part 30.2.2.8. They can be used with adjustable frequency drives under the following parameters: Up to 2:1 speed range on constant torque loads, one year limited warranty (see page ix).

Cable Distances for Applying EPAct & Standard Motors			
Maximum Cable Distance VFD to Motor			
Switching Frequency	460 Volt	230 Volt	380 Volt
3 Khz	103 ft	435 ft	218 ft
6 Khz	73 ft	307 ft	154 ft
9 Khz	59 ft	251 ft	126 ft
12 Khz	51 ft	217 ft	109 ft
15 Khz	46 ft	194 ft	98 ft
20 Khz	40 ft	168 ft	85 ft

All Nidec Motor Corporation motors have 40°C ambient, 1.0 SF on Inverter Power, 3300 ft. max altitude, 460 voltage or less line power, up to 10:1 speed range on Variable Torque and Class F Insulation. 575-volt motors can be applied on inverters when output filters are used.

*This information applies only to Integral Horsepower (IHP) motors as defined on the Agency Approval page, under UL®† & CSA®† listings where indicated.
† All marks shown within this document are properties of their respective owners

Motor/ Inverter Compatibility

Thermal Overloads and Single Phase Motors

Motors with thermal overloads installed may not operate properly on a VFD. The current carrying thermal overload is designed for sine wave power. Operation on a VFD may cause nuisance tripping or potentially not protect the motor as would be expected on line power. Thermostats or thermistors installed in the motor and connected properly to the VFD may provide suitable thermal overload protection when operating on a VFD. (Consult Codes)

Single phase motors and other fractional horsepower ratings are not designed to be operated on a VFD. Within Nidec Motor Corporation standard products, all motors NEMA®† 48 frame (5.5" diameter) and smaller are not suitable for VFD applications. Three phase 56 and 143/145 frame applications should be noted on the catalog price page; or if in doubt ask an Nidec Motor Corporation technical representative for recommendations on compatibility with a VFD.

Slow Speed Motors

Motors with a base design of slower than six poles require special consideration regarding VFD sizing and minimizing harmonic distortion created at the motor terminals due to cable installation characteristics. Additional external PWM waveform filters and shielded motor cables designed for PWM power may be required to provide acceptable motor life. Harmonic distortion on the output waveform should be kept to a minimum level (less than 10%).

690V Applications

Motors that will be applied to 690Vac PWM VFDs require the use of an external filter to limit peak voltage spikes and the use of an Inverter Grade® motor. Where available, an alternative to using an output filter is to upgrade to a 2300V insulation system.

Low Voltage TITAN® Motors

The use of 449 frame and larger motors on PWM type VFDs should use the cable length limits of the second chart from the previous page as a guide for inverter application or consider the use of an external filter and shielded motor cables designed for PWM power to minimize harmonic distortion and peak voltages at the motor terminals. Harmonic distortion on the output waveform should be kept to a minimum level (less than 10%).

Bearing Currents related to PWM waveform

Due to the uniqueness of this condition occurring in the field, protection of the motor bearings from shaft currents caused by common mode voltages is not a standard feature on sinewave or Inverter Duty motor products, unless explicitly noted. Some installations may be prone to a voltage discharge condition through the motor bearings called fluting.

Fluting damage is related to characteristics of the PWM waveform, VFD programming and characteristics and installation.

Bearing fluting as a result of VFD sine wave characteristics may be prevented by the installation of a shaft grounding device such as a brush or ring and/or correction of the installation characteristics causing the shaft voltage condition.

Multiple Motors on a Single VFD

Special considerations are required when multiple motors are powered from a single VFD unit. Most VFD manufacturers can provide guidelines for proper motor thermal considerations and starting/stopping of motors. Cable runs from the VFD and each motor can create conditions that will cause extra stress on the motor winding. Filters may be required at the motor to provide maximum motor life.

Grounding and Cable Installation Guidelines

Proper output winding and grounding practices can be instrumental in minimizing motor related failures caused by PWM waveform characteristics and installation factors. VFD manufacturers typically provide detailed guidelines on the proper grounding of the motor to the VFD and output cable routing. Cabling manufacturers provide recommended cable types for PWM installations and critical information concerning output wiring impedance and capacitance to ground.

Vertical Motors on VFDs

Vertical motors operated on VFD power present unique conditions that may require consideration by the user or installation engineer:

- Slowest rpm that can be utilized and not cause the non-reversing ratchet to operate properly (in the range of 200 –300 rpm)
- Unexpected / unacceptable system vibration and or noise levels caused by the torque pulsation characteristics of the PWM waveform, a system critical frequency falling inside the variable speed range of the process or the added harmonic content of the PWM waveform exciting a system component
- Application related problems related to the controlled acceleration/deceleration and torque of the motor on VFD power and the building of system pressure/ load.
- The impact the reduction of pump speed has on the down thrust reflected to the pump motor and any minimum thrust requirements of the motor bearings
- Water hammer during shutdown damaging the non-reversing ratchet

Humidity and Non-operational Conditions

The possible build-up of condensation inside the motor due to storage in an uncontrolled environment or non-operational periods in an installation, can lead to an increased rate of premature winding or bearing failures when combined with the stresses associated with PWM waveform characteristics. Moisture and condensation in and on the motor winding over time can provide tracking paths to ground, lower the Megohm resistance of the motor winding to ground and lower the Corona Inception Voltage level of the winding.

Proper storage and maintenance guidelines are important to minimize the potential of premature failures. Space heaters or trickle voltage heating methods are the preferred methods for drying out a winding that has low megaohm readings. Damage caused by these factors are not covered by the limited warranty provided unless appropriate heating methods are properly utilized during non-operational periods and prior to motor start-up.

NEMA®† Application Guide for AC Adjustable Speed Drive Systems: http://www.nema.org/stds/acadjustable.cfm#download

*This information applies only to Integral Horsepower (IHP) motors as defined on the Agency Approval page, under UL®† & CSA®† listings where indicated.
† All marks shown within this document are properties of their respective owners

CUSTOMER: NATIONAL PUMP CO
ORDER NO.: 20121843-100

BEARING LIFE CALCULATION FOR VERTICAL MOTOR

With 40° angular contact ball bearings (assuming no radial load)

Bearing life can be calculated with various degrees of sophistication,
depending on the accuracy with which the operating conditions can be defined.

Basic rating life equation:

$$L_{10} = \frac{16667}{N}\left(\frac{C}{.57\,(F_a)}\right)^3$$

Where:

$L_{10} =$ Basic rating life in hours
C = Basic dynamic load rating
N = Revolutions per minute
$F_a =$ Axial load in lbs + rotor weight.

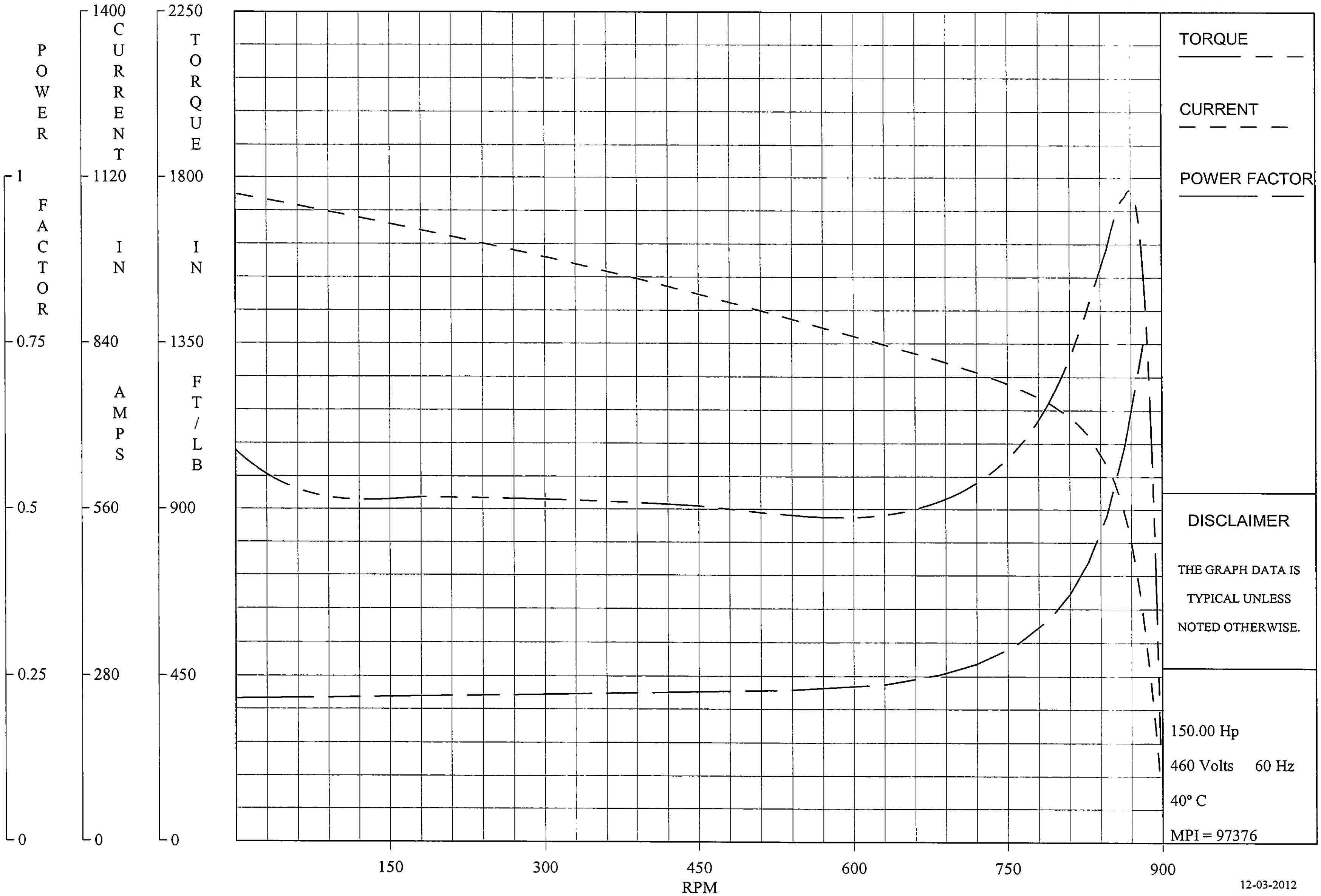
Size	Qty. (1) 7226
C=	41800
N=	900
$F_a =$	6545

Bearing Life (hrs) = 26,000

BY: Thomas Pallett
DATE: 12/05/12

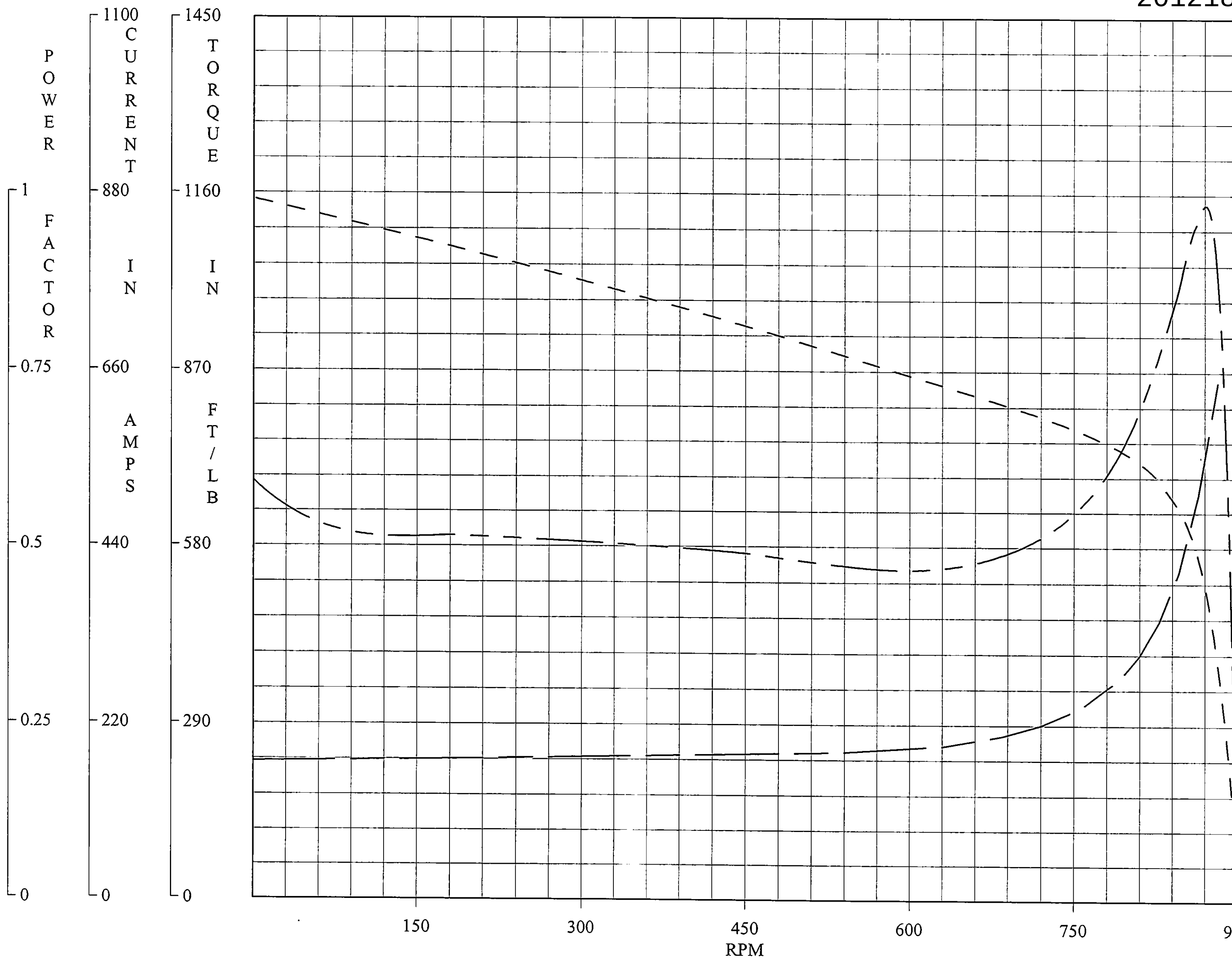
NIDEC MOTOR CORPORATION
ST. LOUIS, MISSOURI

20121843-100



NIDEC MOTOR CORPORATION
ST. LOUIS, MISSOURI

20121843-100



DISCLAIMER

THE GRAPH DATA IS TYPICAL UNLESS NOTED OTHERWISE.

150.00 Hp
368 Volts 60 Hz
40° C
MPI = 97376

12-03-2012

NIDEC MOTOR CORPORATION
ST. LOUIS, MISSOURI

ASCO® RedHat

Direct Acting, Normally Closed

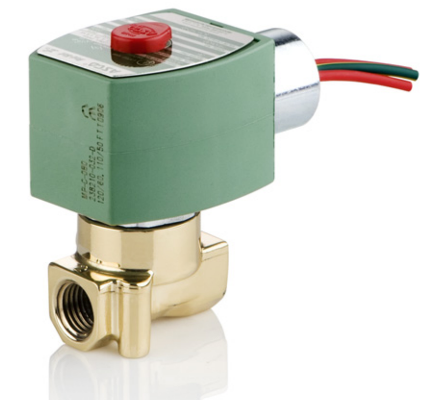
General Service Solenoid Valves

Brass or Stainless Steel Bodies

1/8" to 3/8" NPT

Features

- Welded core tube provides higher pressure ratings
- Reliable, proven design with high flows
- Small poppet valves for tight shutoff
- Wide range of elastomers for specialty service applications
- Mountable in any position
- Tapped mounting holes in body standard



Construction

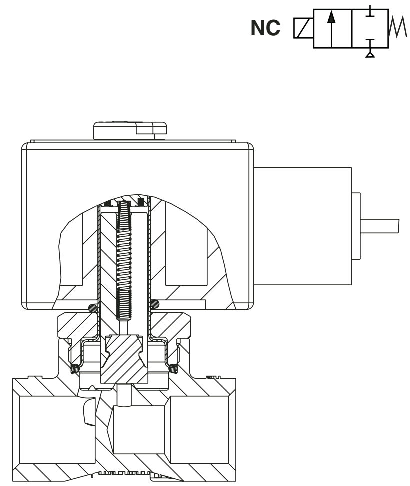
Valve Parts in Contact with Fluids		
Body	Brass	Cast 304 Stainless Steel
Seals and Discs	NBR or Cast UR	
Core Tube	305 Stainless Steel	
Core and Plugnut	430F Stainless Steel	
Springs	302 Stainless Steel	
Shading Coil	Copper	Silver

Electrical

Watt Rating and Power Consumption				Spare Coil Part No.			
	AC			General Purpose		Explosionproof	
DC Watts	Watts	VA Holding	VA Inrush	AC	DC	AC	DC
10.6	6.1*	16	30	238210	238510	238214	238514
18.6	9.1*	20	45	238210	238510	238214	238514
11.6	10.1	25	50	238610	238910	238614	238914
22.6	17.1	40	70	238610	238910	238614	238914

Standard Voltages: 24, 120, 240, 480 volts AC, 60 Hz (or 110, 220 volts AC, 50 Hz). 6, 12, 24, 120, 240 volts DC. Must be specified when ordering. Other voltages available when required.

*On 50 hertz service, the rating for the 6.1/F solenoid is 8.1 watts, and the rating for the 9.1/F solenoid is 11.1 watts.



Solenoid Enclosures

Standard: Watertight, Types 1, 2, 3, 3S, 4, and 4X.

Optional: Explosionproof and Watertight, Types 3, 3S, 4, 4X, 6, 6P, 7, and 9. (To order, add prefix "EF" to catalog number)

See Optional Features Section for other available options.

Options

Mounting bracket (suffix MB)
Quarter-turn manual operator with screw slot (suffix MS)
Panel mount (prefix GP for conduit; *consult ASCO for other electrical connections*)
Vacuum service (suffix VVM, VVH; *see Vacuum Section for more details.*)
Oxygen service (suffix N)
Silicone Free (suffix SF)

Elastomers: FKM (suffix V), Ethylene Propylene (suffix E), CR (suffix J), Teflon (suffix T), Low Temp NBR (suffix A)

Note: For suffix A, Fluid temp. range -40˚F to 167˚F only for valves with 10.1, 17.1, 11.6, and 22.6 watt coils.

Refer to Engineering Section for fluid and temperature compatibility.

Nominal Ambient Temp. Ranges

The nominal limitation of 32°F (0°C) is advisable for any valve that might contain moisture (water vapor).

AC: -13˚F to 131˚F (-25˚C to 55˚C)

DC: -13˚F to 104˚F (-25˚C to 40˚C)
-13˚F to 131˚F (-25˚C to 55˚C)

Note: Max ambient for explosionproof (EF) is 125˚F (52˚C) for AC, 131˚F (55˚C) for DC.

Optional: For AC, the max. ambient temperature is 140˚F (60˚C) with Class H coil (with or without prefix EF)

Refer to Engineering Section for details.

Approvals

CSA certified. UL listed, as indicated. Safety Shutoff Valves FM approved. Meets applicable CE directives.

Refer to Engineering Section for details.

ASCO®

Specifications (English units)

Pipe Size (in)	Orifice size (in)	Cv Flow Factor	Operating Pressure Differential (psi)									Max. Fluid Temp. °F		Catalog Number		Const. Ref.	UL Listing	Watt Rating/ Class of Coil Insulation	
			Max. AC@131°F			Max. DC@104°F			Max. DC@131°F										
			Air-Inert Gas	Water	Lt. Oil @ 300ssu	Air-Inert Gas	Water	Lt. Oil @ 300ssu	Air-Inert Gas	Water	Lt. Oil @ 300ssu	AC	DC	Brass	Stainless Steel			AC	DC
NORMALLY CLOSED (Closed when de-energized), NBR Disc																			
1/8	3/64	0.06	2200	2200	1700	-	-	-	-	-	-	140	-	-	8262H175 ①	1	●	10.1/F	-
1/8	3/64	0.06	-	-	-	2000	2000	1725	1900	1900	1700	-	140	-	8262H176 ①	1	●	-	22.6/H
1/8	3/64	0.06	-	-	-	1500	1500	1500	1500	1500	1500	-	140	8262H089 ①	-	1	●	-	22.6/H
1/8	3/64	0.06	2025	1710	825	965	745	720	920	700	675	140	140	-	8262H079 ①	2	●	9.1/F	18.6/H
1/8	3/64	0.06	1500	1350	825	750	620	565	700	565	530	140	140	8262H096 ①	-	2	●	6.1/F	10.6/H
1/8	3/64	0.06	1500	1350	825	-	-	-	-	-	-	140	-	-	8262H173 ①	2	●	6.1/F	-
1/8	3/64	0.06	1500	1500	1500	1170	1145	945	1000	965	855	140	140	8262H099 ①	-	1	●	10.1/F	11.6/H
1/8	3/64	0.06	750	750	725	750	640	550	750	600	500	180	180	8262H001	8262H012	2	❍	6.1/F	10.6/H
1/8	3/32	0.21	720	410	410	610	410	410	600	410	400	180	180	8262H277	8262H178	1	❍	17.1/F	22.6/H
1/8	3/32	0.21	-	-	-	290	290	270	240	240	255	180	180	-	8262H177	1	❍	-	11.6/H
1/8	3/32	0.21	500	350	325	295	210	205	285	200	195	180	180	8262H011	-	2	❍	9.1/F	18.6/H
1/8	3/32	0.21	370	330	190	235	160	160	215	150	145	180	180	8262H014	8262H015	2	❍	6.1/F	10.6/H
1/8	1/8	0.35	500	380	355	275	275	235	250	250	225	180	180	8262H105	8262H174	1	❍	17.1/F	22.6/H
1/8	1/8	0.35	340	300	215	-	-	-	-	-	-	-	180	-	8262H179	1	❍	10.1/F	-
1/8	1/8	0.35	275	260	195	165	130	130	155	120	120	180	180	8262H016	-	2	❍	9.1/F	18.6/H
1/8	1/8	0.35	185	180	120	130	110	95	120	100	90	180	180	8262H002	8262H006	2	❍	6.1/F	10.6/H
1/4	3/64	0.06	2200	2200	1700	1170	1145	945	1000	965	855	140	140	-	8262H214 ①	3	●	10.1/F	11.6/H
1/4	3/64	0.06	1500	1500	1500	1170	1145	945	1000	965	855	140	140	8262H200 ①	-	3	●	10.1/F	11.6/H
1/4	3/64	0.06	1500	1500	1500	1500	1500	1500	1500	1500	1500	140	140	8262H107 ①	-	3	●	17.1/F	22.6/H
1/4	3/64	0.06	-	-	-	2000	2000	1725	1900	1900	1700	-	140	-	8262H181 ①	3	●	-	22.6/H
1/4	3/64	0.06	1500	1350	825	750	620	530	700	565	495	140	140	8262H106 ①	8262H180 ①	4	●	6.1/F	10.6/H
1/4	3/64	0.06	750	750	725	750	640	550	750	600	500	180	180	8262H019	8262H080	4	❍	6.1/F	10.6/H
1/4	3/32	0.21	720	410	410	610	410	410	600	410	400	180	180	8262H109	8262H183	3	❍	17.1/F	22.6/H
1/4	3/32	0.21	590	410	410	290	290	270	240	240	225	180	180	8262H108	8262H182	3	❍	10.1/F	11.6/H
1/4	3/32	0.21	500	350	270	295	210	205	285	200	195	180	180	8262H021	-	4	❍	9.1/F	18.6/H
1/4	3/32	0.21	370	330	160	235	160	160	215	150	145	180	180	8262H020	8262H086	4	❍	6.1/F	10.6/H
1/4	1/8	0.35	500	380	355	275	275	235	250	250	225	180	180	8262H110	8262H185	3	❍	17.1/F	22.6/H
1/4	1/8	0.35	340	300	215	130	125	115	110	105	100	180	180	8262H232	-	3	❍	10.1/F	11.6/H
1/4	1/8	0.35	340	300	215	-	-	-	-	-	-	180	-	-	8262H184	3	❍	10.1/F	-
1/4	1/8	0.35	275	260	150	165	130	120	155	120	115	180	180	8262H023	-	4	❍	9.1/F	18.6/H
1/4	1/8	0.35	185	180	90	130	110	90	120	100	85	180	180	8262H022	8262H007	4	❍	6.1/F	10.6/H
1/4	5/32	0.52	300	210	210	135	135	135	115	115	115	180	180	8262H112	8262H187	3	❍	17.1/F	22.6/H
1/4	5/32	0.52	210	200	145	65	63	63	55	54	54	180	180	8262H202	-	3	❍	10.1/F	11.6/H
1/4	5/32	0.52	210	200	145	-	-	-	-	-	-	180	180	-	8262H220	3	❍	10.1/F	-
1/4	5/32	0.52	150	140	100	95	75	75	85	72	70	180	180	8262H113	-	4	❍	9.1/F	18.6/H
1/4	5/32	0.52	100	100	55	72	60	55	67	53	52	180	180	8262H111	8262H186	4	❍	6.1/F	10.6/H
1/4	7/32	0.73	125	125	125	70	70	70	65	65	65	180	180	8262H114	8262H188	3	❍	17.1/F	22.6/H
1/4	7/32	0.73	100	100	100	35	35	35	30	30	30	180	180	8262H208	-	3	❍	10.1/F	11.6/H
1/4	7/32	0.73	100	100	100	-	-	-	-	-	-	180	-	-	8262H226	3	❍	10.1/F	-
1/4	7/32	0.73	55	54	40	38	33	31	35	30	28	180	180	8262H013	8262H036	4	❍	6.1/F	10.6/H
1/4	9/32	0.88	90	90	90	53	50	47	48	46	44	180	180	8262H212	8262H230	3	❍	17.1/F	22.6/H
1/4	9/32	0.88	65	75	60	25	25	22	22	22	20	180	180	8262H210	-	3	❍	10.1/F	11.6/H
1/4	9/32	0.88	65	75	60	-	-	-	-	-	-	180	-	-	8262H189	3	❍	10.1/F	-
1/4	9/32	0.88	36	36	33	27	23	21	24	22	20	180	180	8262H090	8262H038	4	❍	6.1/F	10.6/H
3/8	1/8	0.35	500	380	355	275	275	160	250	250	150	180	180	8263H115	8263H191	5	❍	17.1/F	22.6/H
3/8	1/8	0.35	340	300	215	130	125	85	110	105	75	180	180	8263H232	-	5	❍	10.1/F	11.6/H
3/8	1/8	0.35	340	300	215	-	-	-	-	-	-	180	-	-	8263H190	5	❍	10.1/F	-
3/8	1/8	0.35	275	260	140	165	130	110	155	120	105	180	180	8263H003	-	6	❍	9.1/F	18.6/H
3/8	1/8	0.35	185	180	90	130	110	80	120	100	75	180	180	8263H002	8263H330	6	❍	6.1/F	10.6/H
3/8	5/32	0.52	300	210	195	135	135	100	115	115	90	180	180	8263H118	8263H193	5	❍	17.1/F	22.6/H
3/8	5/32	0.52	210	185	100	65	63	50	55	54	44	180	180	8263H200	-	5	❍	10.1/F	11.6/H
3/8	5/32	0.52	210	185	100	-	-	-	-	-	-	180	-	-	8263H331	5	❍	10.1/F	-
3/8	5/32	0.52	150	140	80	95	75	75	85	72	70	180	180	8263H117	-	6	❍	9.1/F	18.6/H
3/8	5/32	0.52	100	100	50	72	60	55	67	53	52	180	180	8263H116	8263H192	6	❍	6.1/F	10.6/H
3/8	7/32	0.73	125	100	100	70	70	70	65	65	65	180	180	8263H206	8263H332	5	❍	17.1/F	22.6/H
3/8	7/32	0.73	100	86	70	35	35	35	30	30	30	180	180	8263H124	-	5	❍	10.1/F	11.6/H
3/8	7/32	0.73	100	86	70	-	-	-	-	-	-	180	-	-	8263H195	5	❍	10.1/F	-
3/8	7/32	0.73	55	54	29	38	33	31	35	30	28	180	180	8263H119	8263H194	6	❍	6.1/F	10.6/H
3/8	9/32	0.88	100	85	70	53	50	47	48	46	44	180	180	8263H210	8263H333	5	❍	17.1/F	22.6/H
3/8	9/32	0.88	65	63	47	-	-	-	-	-	-	180	180	8263H125	8263H197	5	❍	10.1/F	-
3/8	9/32	0.88	35	32	21	27	23	21	24	22	20	180	180	8263H054	8263H196	6	❍	6.1/F	10.6/H

① Only available with UR disc, limits min. ambient temp. to 32˚F (0˚C); ● = General Purpose Valve, ❍ = Safety Shutoff Valve

Specifications (Metric units)

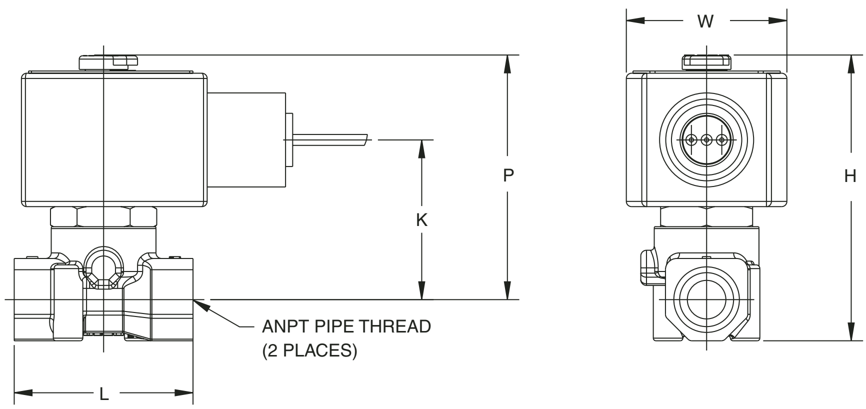
Pipe Size (in)	Orifice size (mm)	Kv Flow Factor (m^3/h)	Operating Pressure Differential (bar) Max. AC@55°C Air-Inert Gas	Max. AC@55°C Water	Max. AC@55°C Lt. Oil @ 300ssu	Max. DC@40°C Air-Inert Gas	Max. DC@40°C Water	Max. DC@40°C Lt. Oil @ 300ssu	Max. DC@55°C Air-Inert Gas	Max. DC@55°C Water	Max. DC@55°C Lt. Oil 300ssu	Max. Fluid Temp. °C AC	Max. Fluid Temp. °C DC	Catalog Number Brass	Catalog Number Stainless Steel	Const. Ref.	UL Listing	Watt Rating/ Class of Coil Insulation AC	Watt Rating/ Class of Coil Insulation DC
NORMALLY CLOSED (Closed when de-energized), NBR Disc																			
1/8	1.2	0.05	152	152	117	-	-	-	-	-	-	60	-	-	8262H175 ①	1	●	10.1/F	-
1/8	1.2	0.05	-	-	-	138	138	119	131	131	117	-	60	-	8262H176 ①	1	●	-	22.6/H
1/8	1.2	0.05	-	-	-	103	103	103	103	103	103	-	60	8262H089 ①	-	1	●	-	22.6/H
1/8	1.2	0.05	140	118	57	67	51	50	63	48	47	60	60	-	8262H079 ①	2	●	9.1/F	18.6/H
1/8	1.2	0.05	103	93	57	52	43	39	48	39	37	60	60	8262H096 ①	-	2	●	6.1/F	10.6/H
1/8	1.2	0.05	103	93	57	-	-	-	-	-	-	60	-	-	8262H173 ①	2	●	6.1/F	-
1/8	1.2	0.05	103	103	103	81	79	65	69	67	59	60	60	8262H099 ①	-	1	●	10.1/F	11.6/H
1/8	1.2	0.05	52	52	50	52	44	38	52	41	34	82	82	8262H001	8262H012	2	❍	6.1/F	10.6/H
1/8	2.4	0.18	50	28	28	42	28	28	41	28	28	82	82	8262H277	8262H178	1	❍	17.1/F	22.6/H
1/8	2.4	0.18	-	-	-	20	20	19	17	17	18	-	82	-	8262H177	1	❍	-	11.6/H
1/8	2.4	0.18	34	24	22	20	14	14	20	14	13	82	82	8262H011	-	2	❍	9.1/F	18.6/H
1/8	2.4	0.18	26	23	13	16	11	11	15	10	10	82	82	8262H014	8262H015	2	❍	6.1/F	10.6/H
1/8	3.2	0.30	34	26	24	19	19	16	17	17	16	82	82	8262H105	8262H174	1	❍	17.1/F	22.6/H
1/8	3.2	0.30	23	21	15	-	-	-	-	-	-	82	-	-	8262H179	1	❍	10.1/F	-
1/8	3.2	0.30	19	18	13	11	9	9	11	8	8	82	82	8262H016	-	2	❍	9.1/F	18.6/H
1/8	3.2	0.30	13	12	8	9	8	7	8	7	6	82	82	8262H002	8262H006	2	❍	6.1/F	10.6/H
1/4	1.2	0.05	152	152	117	81	79	65	69	67	59	60	60	-	8262H214 ①	3	●	10.1/F	11.6/H
1/4	1.2	0.05	103	103	103	81	79	65	69	67	59	60	60	8262H200 ①	-	3	●	10.1/F	11.6/H
1/4	1.2	0.05	103	103	103	103	103	103	103	103	103	60	60	8262H107 ①	-	3	●	17.1/F	22.6/H
1/4	1.2	0.05	-	-	-	138	138	119	131	131	117	-	60	-	8262H181 ①	3	●	-	22.6/H
1/4	1.2	0.05	103	93	57	52	43	37	48	39	34	60	60	8262H106 ①	8262H180 ①	4	●	6.1/F	10.6/H
1/4	1.2	0.05	52	52	50	52	44	38	52	41	34	82	82	8262H019	8262H080	4	❍	6.1/F	10.6/H
1/4	2.4	0.18	50	28	28	42	28	28	41	28	28	82	82	8262H109	8262H183	3	❍	17.1/F	22.6/H
1/4	2.4	0.18	41	28	28	20	20	19	17	17	16	82	82	8262H108	8262H182	3	❍	10.1/F	11.6/H
1/4	2.4	0.18	34	24	19	20	14	14	20	14	13	82	82	8262H021	-	4	❍	9.1/F	18.6/H
1/4	2.4	0.18	26	23	11	16	11	11	15	10	10	82	82	8262H020	8262H086	4	❍	6.1/F	10.6/H
1/4	3.2	0.30	34	26	24	19	19	16	17	17	16	82	82	8262H110	8262H185	3	❍	17.1/F	22.6/H
1/4	3.2	0.30	23	21	15	9	9	8	8	7	7	82	82	8262H232	-	3	❍	10.1/F	11.6/H
1/4	3.2	0.30	23	21	15	-	-	-	-	-	-	82	-	-	8262H184	3	❍	10.1/F	-
1/4	3.2	0.30	19	18	10	11	9	8	11	8	8	82	82	8262H023	-	4	❍	9.1/F	18.6/H
1/4	3.2	0.30	13	12	6	9	8	6	8	7	6	82	82	8262H022	8262H007	4	❍	6.1/F	10.6/H
1/4	4.0	0.45	21	14	14	9	9	9	8	8	8	82	82	8262H112	8262H187	3	❍	17.1/F	22.6/H
1/4	4.0	0.45	14	14	10	4	4	4	4	4	4	82	82	8262H202	-	3	❍	10.1/F	11.6/H
1/4	4.0	0.45	14	14	10	-	-	-	-	-	-	82	-	-	8262H220	3	❍	10.1/F	-
1/4	4.0	0.45	10	10	7	7	5	5	6	5	5	82	82	8262H113	-	4	❍	9.1/F	18.6/H
1/4	4.0	0.45	7	7	4	5	4	4	5	4	4	82	82	8262H111	8262H186	4	❍	6.1/F	10.6/H
1/4	5.6	0.63	9	9	9	5	5	5	4	4	4	82	82	8262H114	8262H188	3	❍	17.1/F	22.6/H
1/4	5.6	0.63	7	7	7	2	2	2	2	2	2	82	82	8262H208	-	3	❍	10.1/F	11.6/H
1/4	5.6	0.63	7	7	7	-	-	-	-	-	-	82	-	-	8262H226	3	❍	10.1/F	-
1/4	5.6	0.63	4	4	3	3	2	2	2	2	2	82	82	8262H013	8262H036	4	❍	6.1/F	10.6/H
1/4	7.1	0.76	6	6	6	4	3	3	3	3	3	82	82	8262H212	8262H230	3	❍	17.1/F	22.6/H
1/4	7.1	0.76	4	5	4	2	2	2	2	2	1	82	82	8262H210	-	3	❍	10.1/F	11.6/H
1/4	7.1	0.76	4	5	4	-	-	-	-	-	-	82	-	-	8262H189	3	❍	10.1/F	-
1/4	7.1	0.76	2	2	2	2	2	1	2	2	1	82	82	8262H090	8262H038	4	❍	6.1/F	10.6/H
3/8	3.2	0.30	34	26	24	19	21	11	17	19	10	82	82	8263H115	8263H191	5	❍	17.1/F	22.6/H
3/8	3.2	0.30	23	21	15	9	9	6	8	7	5	82	82	8263H232	-	5	❍	10.1/F	11.6/H
3/8	3.2	0.30	23	21	15	-	-	-	-	-	-	82	82	-	8263H190	5	❍	10.1/F	-
3/8	3.2	0.30	19	18	10	11	9	8	11	8	7	82	82	8263H003	-	6	❍	9.1/F	18.6/H
3/8	3.2	0.30	13	12	6	9	8	6	8	7	5	82	82	8263H002	8263H330	6	❍	6.1/F	10.6/H
3/8	4.0	0.45	21	14	13	9	9	7	8	8	6	82	82	8263H118	8263H193	5	❍	17.1/F	22.6/H
3/8	4.0	0.45	14	13	7	4	4	3	4	4	3	82	82	8263H200	-	5	❍	10.1/F	11.6/H
3/8	4.0	0.45	14	13	7	-	-	-	-	-	-	82	-	-	8263H331	5	❍	10.1/F	-
3/8	4.0	0.45	10	10	6	7	5	5	6	5	5	82	82	8263H117	-	6	❍	9.1/F	18.6/H
3/8	4.0	0.45	7	7	3	5	4	4	5	4	4	82	82	8263H116	8263H192	6	❍	6.1/F	10.6/H
3/8	5.6	0.63	9	7	7	5	5	5	4	4	4	82	82	8263H206	8263H332	5	❍	17.1/F	22.6/H
3/8	5.6	0.63	7	6	5	2	2	2	2	2	2	82	82	8263H124	-	5	❍	10.1/F	11.6/H
3/8	5.6	0.63	7	6	5	-	-	-	-	-	-	82	-	-	8263H195	5	❍	10.1/F	-
3/8	5.6	0.63	4	4	2	3	2	2	2	2	2	82	82	8263H119	8263H194	6	❍	6.1/F	10.6/H
3/8	7.1	0.76	7	6	5	4	3	3	3	3	3	82	82	8263H210	8263H333	5	❍	17.1/F	22.6/H
3/8	7.1	0.76	4	4	3	-	-	-	-	-	-	82	-	8263H125	8263H197	5	❍	10.1/F	-
3/8	7.1	0.76	2	2	1	2	2	1	2	2	1	82	82	8263H054	8263H196	6	❍	6.1/F	10.6/H

① Only available with UR disc, limits min. ambient temp. to 32˚F (0˚C); ● = General Purpose Valve, ❍ = Safety Shutoff Valve

Dimensions: inches (mm)

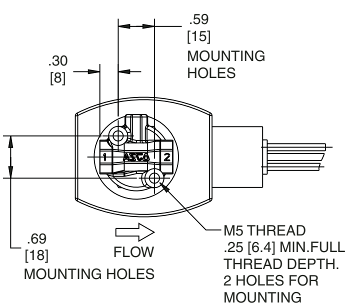
Const. Ref.		H	K	L	P	W
1	ins	3.05	1.71	1.19	2.69	1.95
	mm	77	43	30	68	50
2	ins	2.85	1.60	1.19	2.50	1.69
	mm	72	41	30	63	43
3	ins	3.12	1.79	1.56	2.76	1.95
	mm	79	45	40	70	50
4	ins	2.96	1.72	1.56	2.60	1.69
	mm	75	44	40	66	43
5	ins	3.20	1.79	1.88	2.77	1.95
	mm	81	45	48	70	50
6	ins	3.03	1.72	1.88	2.60	1.69
	mm	77	44	48	66	43

Const. Ref. 1-6

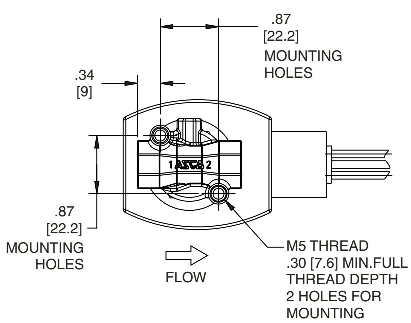


Mounting Dimensions

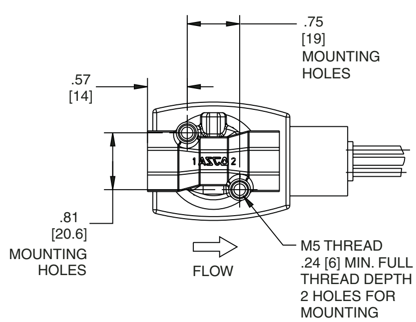
Const. Ref. 1, 2
(1/8" Pipe)



Const. Ref. 3, 4
(1/4" Pipe)



Const. Ref. 5, 6
(3/8" Pipe)



Note: Mounting holes will accept a standard #10-32 machine screw.

SECTION 4

TEST REPORTS AND CERTIFICATES

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

Certificate of Registration

nqa global assurance

This is to certify that the Quality Management System of:

National Pump Company
7706 N. 71st Avenue
Glendale, AZ 85303

applicable to:

Design, manufacture, and administration of industrial, agricultural, municipal, and American Petroleum Institute (API) vertical and submersible pumps utilizing light-machining of components, assembly, and testing

has been assessed and approved by
National Quality Assurance, U.S.A., against the provisions of:

ISO 9001:2008

Certificate Number:	13778
EAC Code:	18
First Issued:	June 6, 2011
Valid Until:	June 6, 2014

K M Beard

For and on behalf
of NQA, USA, Acton, MA 01720

ANAB ACCREDITED

This approval is subject to the company maintaining its system to the required standard, which will be monitored by NQA, USA, an accredited organization under the ANSI-ASQ National Accreditation Board.

Nidec
All for dreams

Report Of Complete Initial Test
Induction Motor (Single Speed)

6/28/2013

Purchaser NATIONAL PUMP COMPANY
Serial No. U06 20121843-0001 R 0001
TR# 13375R-1

Purchaser's Order No. 84946A
NMC Order No. 20121843-SO-1
Date Of Test 6/20/2013

Nameplate Rating

HP	150	**Phase**	3	**Volts**	460
SYN. Speed RPM	900	**Cycles**	60	**Amperes Full-Load**	182.0
Full-Load Speed-RPM	890	**Type**	JUEI	**Frame Number**	449TP

Temperature Rise

Conditions Of Test				Rise °C		Heat Run
Hours Run	Line Volts	Line Amperes	Cooling Air °C	Frame By (T'Couple)	Winding By RES	@HP
4.0	470	177	22.2	21.3	45.4	150

Characteristics

Slip (Percent)	No Load Current (Amperes)	Locked Rotor Current (Amps) At 460 Volts	Locked Rotor Torque (LB-FT) At 460 Volts	B.D.T (LB-FT) At 460 Volts	Resistance At 25°C Line-Line OHMS By RES	Stator HI-POT Voltage 60Sec
0.69	62	1029	1099	1889	0.0271	1920V AC

Efficiency, Percent			Power Factor, Percent		
Full-Load	3/4-Load	1/2-Load	Full-Load	3/4-Load	1/2-Load
95.2	95.4	94.9	82.0	79.1	71.7

Data from test on actual motor

Comments:

Approved By: Kenny Buntin
Date: 06/28/2013

US MOTORS

Nidec — All for dreams

Report Of Complete Initial Test
Induction Motor (Single Speed)

6/28/2013

Purchaser NATIONAL PUMP COMPANY
Serial No. U06 20121843-0001 R 0002
TR# 13375R-2

Purchaser's Order No. 84946A
NMC Order No. 20121843-SO-1
Date Of Test 6/24/2013

Nameplate Rating

HP	150	**Phase**	3	**Volts**	460
SYN. Speed RPM	900	**Cycles**	60	**Amperes Full-Load**	182.0
Full-Load Speed-RPM	890	**Type**	JUEI	**Frame Number**	449TP

Temperature Rise

Conditions Of Test				Rise °C		Heat Run
Hours Run	Line Volts	Line Amperes	Cooling Air °C	Frame By (T'Couple)	Winding By RES	@HP
4.5	464	178	22.3	24.8	47.1	150

Characteristics

Slip (Percent)	No Load Current (Amperes)	Locked Rotor Current (Amps) At 460 Volts	Locked Rotor Torque (LB-FT) At 460 Volts	B.D.T (LB-FT) At 460 Volts	Resistance At 25°C Line-Line OHMS By RES	Stator HI-POT Voltage 60Sec
0.67	63	1070	1132	1907	0.0270	1920V AC

Efficiency, Percent			Power Factor, Percent		
Full-Load	3/4-Load	1/2-Load	Full-Load	3/4-Load	1/2-Load
95.4	95.5	95.0	81.9	78.8	71.2

Data from test on actual motor

Comments:

Approved By: Kenny Buntin
Date: 06/28/2013

US MOTORS

Nidec
All for dreams

Report Of Complete Initial Test
Induction Motor (Single Speed)

6/28/2013

Purchaser NATIONAL PUMP COMPANY
Serial No. U06 20121843-0001 R 0003
TR# 13375R-3

Purchaser's Order No. 84946A
NMC Order No. 20121843-SO-1
Date Of Test 6/21/2013

Nameplate Rating

HP	150	**Phase**	3	**Volts**	460
SYN. Speed RPM	900	**Cycles**	60	**Amperes Full-Load**	182.0
Full-Load Speed-RPM	890	**Type**	JUEI	**Frame Number**	449TP

Temperature Rise

Conditions Of Test				Rise °C		Heat Run
Hours Run	Line Volts	Line Amperes	Cooling Air °C	Frame By (T'Couple)	Winding By RES	@HP
3.5	473	174	23.0	22.5	45.2	150

Characteristics

Slip (Percent)	No Load Current (Amperes)	Locked Rotor Current (Amps) At 460 Volts	Locked Rotor Torque (LB-FT) At 460 Volts	B.D.T (LB-FT) At 460 Volts	Resistance At 25°C Line-Line OHMS By RES	Stator HI-POT Voltage 60Sec
0.61	61	1067	1120	1934	0.0270	1920V AC

Efficiency, Percent			Power Factor, Percent		
Full-Load	3/4-Load	1/2-Load	Full-Load	3/4-Load	1/2-Load
95.3	95.4	95.0	82.2	79.1	71.9

Data from test on actual motor

Comments:

Approved By: Kenny Buntin
Date: 06/28/2013

US MOTORS

CERTIFICATION OF HYDROSTATIC TEST

Vertical Turbine Specialists, Inc.
1802 E. 50th Street, Suite 106
Lubbock, TX 79404

Phone **(806) 743-5555**
Fax **(806) 743-5556**
E-Mail acarroll@vtsfabs.com

Customer: **National Pump**
Purchase Order Number: **84946F**
Shop Order Number:

Procedure Number: **VTS Work Instruction QMSWI07** Revision: **0**

VTS SO# 132305

The parts and/or assemblies noted below have been hydrostatically tested to the pressures and duration of time indicated; in accordance with the provisions of the procedure and purchase order referenced above.

P.O. Line #	Qty	Part Name	Part Number	Revision	Discharge Pressure	Test Duration	*Suction Pressure	*Test Duration
1	4	Head 1824 F	849460ZDH/AZ		225 PSI	10 MIN		
2	4	Col Flg 18"	849460ZCFT/AZ		225 PSI	10 MIN		
3	4	Col Flg 18"	849460ZCFB/AZ		225 PSI	10 MIN		
5	1	Col Flg 18"w/spd	849460BSPOOL/AZ		225 PSI	10 MIN		

Serial number of test gage: **9834877** Last calibration date: **11/14/12** Next calibration date: **11/14/13**
Test gage pressure range: **0-400** **PSI**

Customer Witness Name: Date:

Comments:

Test results certified by: [signature]
Alnoris J. Carroll,Jr.
Title: **Quality Inspector**
Date: **08/30/13**

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave
Glendale, AZ. 85303
Phone: (623) 979-3560
Fax: (623) 979-2177

HYDROSTATIC TEST REPORT

TEST NUMBER: TST11645
CUSTOMER NAME: SIERRA MOUNTAIN
PROJECT NAME: CITY OF TURLOCK
EQUIPMENT DESCRIPTION: TERTIARY EFFLUENT
SALES ORDER NUMBER: 849460A
COMPONENT DESCRIPTION: H24 BOWL
COMPONENT P/N: 24H100-011
TEST STANDARD: CUSTOMER

TEST REQUIREMENTS		AS TESTED	
PRESSURE:	250 PSI	PRESSURE:	280 PSI
DURATION:	10 MIN	START TIME:	9:19 AM
LIQUID:	WATER	STOP TIME:	9:29 AM
OTHER:	N/A	DURATION:	10 MIN

NOTES:

RESULTS OF TEST

# COMPONENTS TESTED:	4
# COMPONENTS PASSED:	4

TESTED BY:	DATE:
[signature]	7-Nov-2013
WITNESSED BY:	DATE:

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave
Glendale, AZ. 85303
Phone: (623) 979-3560
Fax: (623) 979-2177

HYDROSTATIC TEST REPORT

TEST NUMBER: TST11650
CUSTOMER NAME: SIERRA MOUNTAIN
PROJECT NAME: CITY OF TURLOCK
EQUIPMENT DESCRIPTION: TERTIARY EFFLUENT
SALES ORDER NUMBER: 849460
COMPONENT DESCRIPTION: H24 BOWL
COMPONENT P/N: 24H100-011
TEST STANDARD: CUSTOMER

TEST REQUIREMENTS		AS TESTED	
PRESSURE:	250 PSI	PRESSURE:	300 PSI
DURATION:	10 MIN	START TIME:	8:25 AM
LIQUID:	WATER	STOP TIME:	8:35 AM
OTHER:	N/A	DURATION:	10 MIN

NOTES:

RESULTS OF TEST

# COMPONENTS TESTED:	3
# COMPONENTS PASSED:	3

TESTED BY:	DATE:
[signature]	8-Nov-2013
WITNESSED BY:	DATE:

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave
Glendale, AZ. 85303
Phone: (623) 979-3560
Fax: (623) 979-2177

DYNAMIC BALANCE CERTIFICATION

Customer Name: SIERRA MOUNTAIN CONSTRUCTION
Project Name: CITY OF TURLOCK
Sales Order Number: 849460A

Impeller Model: H24LC
Impeller Part Number: 849460AIM
Quantity to Balance: 6

Impeller Weight: 150 lbs
Balance Grade: 16W/N
Balance Constant (K): 16
Rotational Speed: 900 rpm

$$U_{,per} = \frac{K * W}{N}$$

Permissible Unbalance: 2.67 oz-in

By	Date	Qty
Jose Garcia	11-8-2013	~~7~~ 6 (initialed) 21 NOV 2013

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information			
Test Number:	TST11654		
Customer Name:	SIERRA MOUNTAIN		
Project Name:	CITY OF TURLOCK		
S/N:	849460A-1	Tag #:	OPS-PUM-100
Model:	Number STG:	Trim:	
H24MC	2	18.130	

Primary Design Condition	
Type	Bowl
Flow	5100 gpm
Head	87 ft
Min. Eff.	84.0 %
Speed	890 rpm
Spec. Gr.	1.00

Collected Data						Calculated Data					Bowl Performance @ 890 rpm			
Test Point	Speed rpm	Flow gpm	Pressure Gauge ID	Gauge ft	In. Power kW	Vel. Head ft	DH Loss ft	Col Loss ft	BRG Loss hp	Kfactor	Flow gpm	Head ft	Power hp	Efficiency %
1	898	0.0	200FT	151.0	104.6	0.00	0.00	0.00	0.57	1.276	0.0	154.8	129.3	0.0
2	897	1512.0		134.0	108.2	0.30	0.00	0.00	0.51	1.277	1500.2	138.7	134.5	39.1
3	897	3021.0		111.0	106.4	1.20	0.00	0.00	0.43	1.276	2997.4	116.9	132.2	66.9
4	897	4082.0		98.5	108.3	2.20	0.00	0.00	0.39	1.277	4050.1	105.6	134.7	80.2
5	897	4514.0		93.0	109.6	2.68	0.00	0.00	0.37	1.278	4478.8	100.7	136.4	83.5
6	897	4854.0		87.8	109.3	3.10	0.00	0.00	0.35	1.277	4816.1	95.9	136.0	85.8
7	897	5153.0		82.0	108.3	3.50	0.00	0.00	0.33	1.277	5112.8	90.6	134.8	86.8
8	897	5353.0		78.8	107.4	3.77	0.00	0.00	0.32	1.277	5311.2	87.7	133.6	88.0
9	897	5817.0		70.5	106.1	4.46	0.00	0.00	0.30	1.276	5771.6	80.3	132.0	88.7
10	897	6151.0		63.0	103.4	4.98	0.00	0.00	0.27	1.275	6103.0	73.4	128.5	88.0
11	897	6527.0		55.0	100.0	5.61	0.00	0.00	0.24	1.273	6476.1	66.1	124.1	87.1
12	898	7058.0		40.5	93.3	6.56	0.00	0.00	0.19	1.270	6995.1	52.7	115.1	80.8

Test Set-Up Details	
Test Type:	Bowl
Motor:	11-450HP,8P-AZ
Motor Eff (non-lab):	1.000
Watt Meter Const.	1.000
Flow Meter:	12" Line
Gauge EL:	6.58 ft
Lateral Setting:	0.313 in

Impeller Data									
Model	Number of Stages		Impeller Trim		UF		Material		Kt
NPC	Test	Calc.	Test in	Calc. in	in	Finish	Impeller	Bowl	lb/ft
071-H24LC	2	2	18.130	18.130	3/16"	A	BRZ	CI/COAT	53.80
									0.00
									0.00
									0.00
		RMS Trim	18.130	18.130				AVG Kt	53.80

Pressure Tap Location Dimensions	
Column Diameter:	12.00 in
Shaft Diameter:	1.938 in

Discharge Head Description	
Type	2-Fabricated
Discharge Size	17.25 in

Column Details	
Length	12.04 ft
Diameter	17.25 in
Shaft Diameter	4.000 in

Acceptance Criteria - Primary			
Type	Customer	-	+
Flow		0%	5%
Head		0%	5%
N/A			

Additional Notes:

11-12-13

Performed	
Date:	11/12/2013
By:	Adam Weigel
	Test Technician

Certified	
Date:	11.12.2013
By:	
	DIRECTOR OF ENGINEERING

FRQ-T02.2

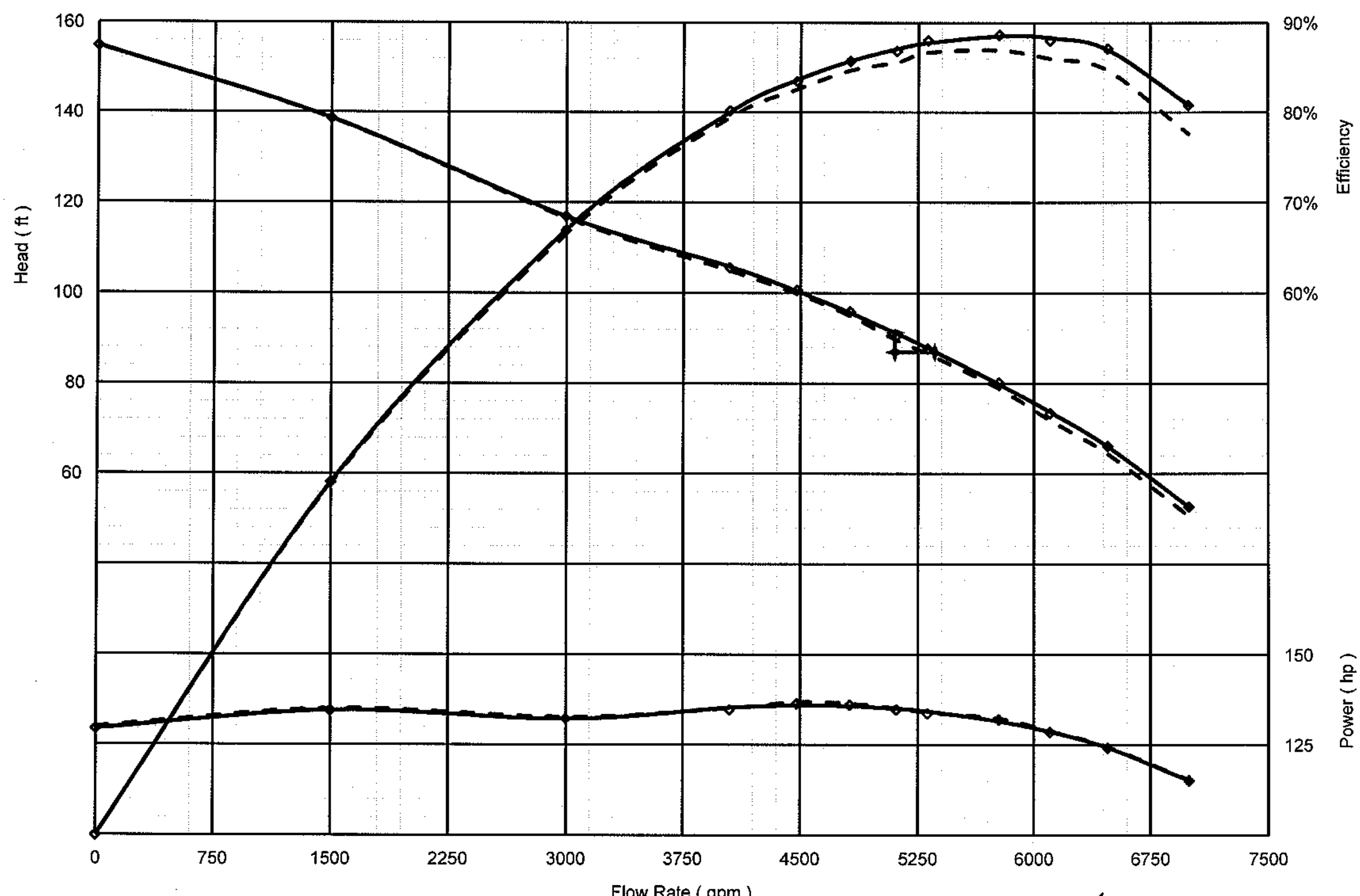
NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information			
Test Number:	TST11654		
Customer Name:	SIERRA MOUNTAIN		
Project Name:	CITY OF TURLOCK		
S/N:	849460A-1	Tag #:	OPS-PUM-100
Model:	Number STG:	Trim:	
H24MC	2	18.130	

Primary Design Condition		
Type	Bowl	
Flow	5100	gpm
Head	87	ft
Min. Eff.	84.0	%
Speed	890	rpm
Spec. Gr.	1.00	



Dash Line - PUMP PERFORMANCE

11.12.2013

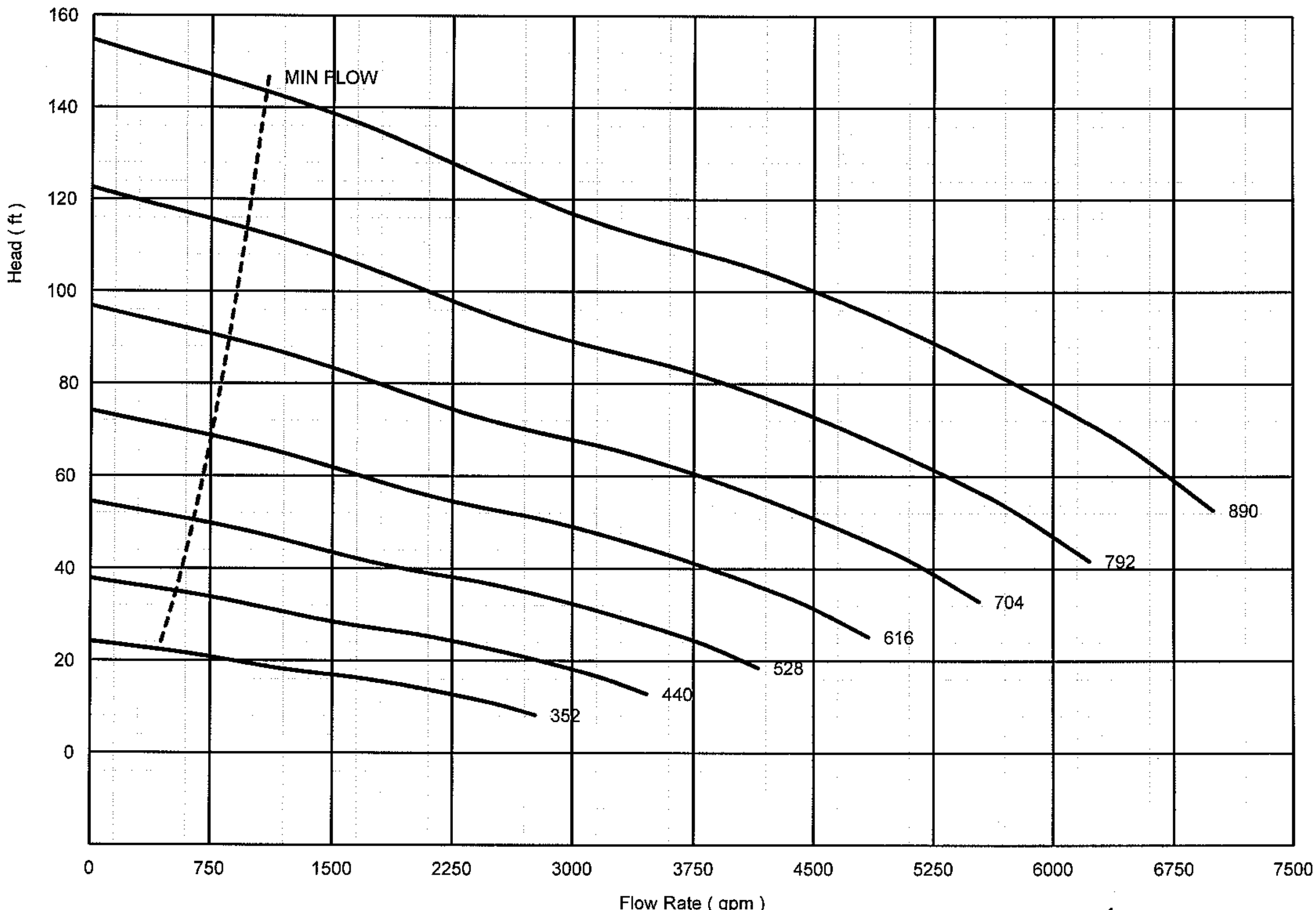
FRQ-T02.2

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information				Rated Conditions	
Test Number:	TST11654			Type	Bowl
Customer Name:	SIERRA MOUNTAIN			Flow	5100 gpm
Project Name:	CITY OF TURLOCK			Head	87 ft
S/N:	849460A-1	Tag #:	OPS-PUM-100	Min. Eff.	84 %
Model:	Number STG:	Trim:		Speed	890 rpm
H24MC	2	18.130		Spec. Gr.	1



Dash Line - PUMP PERFORMANCE

11.12.2013

FRQ-T02.2

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information				Primary Design Condition	
Test Number:	TST11655			Type	Bowl
Customer Name:	SIERRA MOUNTAIN			Flow	5100 gpm
Project Name:	CITY OF TURLOCK			Head	87 ft
S/N:	849460A-2	Tag #:	OPS-PUM-200	Min. Eff.	84.0 %
Model:		Number STG:	Trim:	Speed	890 rpm
H24MC		2	18.130	Spec. Gr.	1.00

Collected Data						Calculated Data					Bowl Performance @ 890 rpm			
Test Point	Speed rpm	Flow gpm	Pressure Gauge ID	Gauge ft	In. Power kW	Vel. Head ft	DH Loss ft	Col Loss ft	BRG Loss hp	Kfactor	Flow gpm	Head ft	Power hp	Efficiency %
1	897	0.0	200FT	152.0	106.3	0.00	0.00	0.00	0.57	1.276	0.0	156.1	132.0	0.0
2	897	1515.0		135.0	108.8	0.30	0.00	0.00	0.51	1.277	1503.2	139.7	135.2	39.2
3	897	3135.0		110.8	107.8	1.29	0.00	0.00	0.43	1.277	3110.5	116.8	134.0	68.4
4	897	4019.0		100.0	108.8	2.13	0.00	0.00	0.39	1.277	3987.6	107.0	135.4	79.6
5	897	4516.0		93.8	110.4	2.69	0.00	0.00	0.37	1.278	4480.8	101.4	137.4	83.5
6	897	4852.0		88.5	110.2	3.10	0.00	0.00	0.36	1.278	4814.1	96.7	137.2	85.6
7	897	5165.0		83.0	109.4	3.51	0.00	0.00	0.34	1.278	5124.7	91.6	136.2	87.1
8	897	5345.0		80.3	108.7	3.76	0.00	0.00	0.33	1.277	5303.3	89.2	135.3	88.3
9	897	5826.0		71.0	107.2	4.47	0.00	0.00	0.30	1.277	5780.5	80.8	133.4	88.4
10	897	6043.0		66.5	105.5	4.81	0.00	0.00	0.28	1.276	5995.8	76.7	131.2	88.5
11	897	6518.0		56.0	102.1	5.60	0.00	0.00	0.25	1.274	6467.1	67.1	126.8	86.4
12	898	7010.0		43.5	94.3	6.47	0.00	0.00	0.20	1.270	6947.6	55.6	116.4	83.7

Test Set-Up Details	
Test Type:	Bowl
Motor:	11-450HP,8P-AZ
Motor Eff (non-lab):	1.000
Watt Meter Const.	1.000
Flow Meter:	12" Line
Gauge EL:	6.58 ft
Lateral Setting:	0.375 in

Impeller Data									
	Number of Stages		Impeller Trim				Material		
Model NPC	Test	Calc.	Test in	Calc. in	UF in	Finish	Impeller	Bowl	Kt lb/ft
071-H24LC	2	2	18.130	18.130	3/16"	A	BRZ	CI/COAT	53.80
									0.00
									0.00
									0.00
RMS Trim			18.130	18.130				AVG Kt	53.80

Pressure Tap Location Dimensions	
Column Diameter:	12.00 in
Shaft Diameter:	1.938 in

Discharge Head Description	
Type	2-Fabricated
Discharge Size	17.25 in

Column Details	
Length	12.04 ft
Diameter	17.25 in
Shaft Diameter	4.000 in

Acceptance Criteria - Primary			
Type	Customer	-	+
Flow		0%	5%
Head		0%	5%
N/A			

Additional Notes:

11-12-13

Performed	
Date:	11/12/2013
By:	Adam Weigel
	Test Technician

Certified	
Date:	11.12.2013
By:	
	DIRECTOR OF ENGINEERING

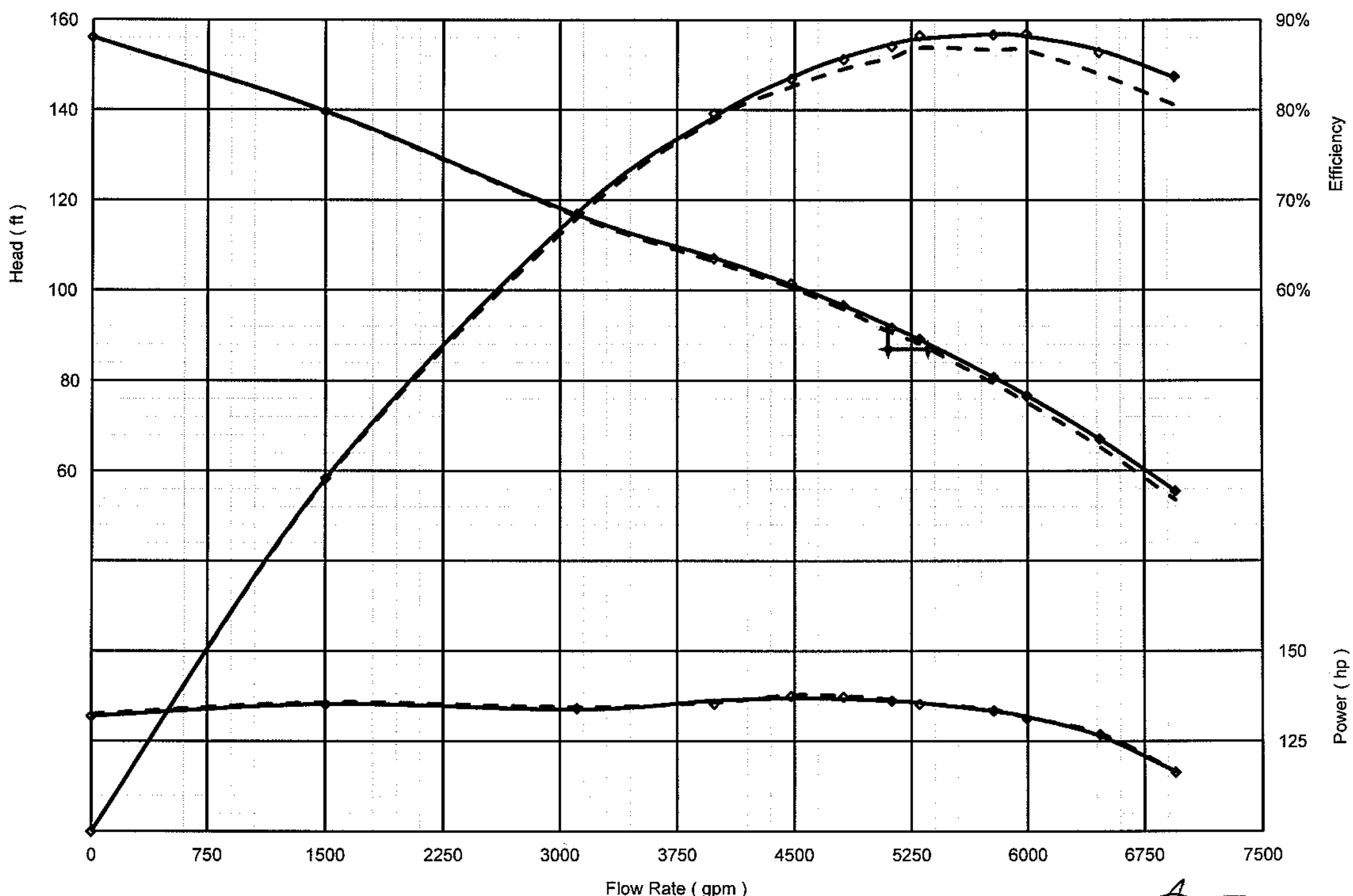
FRQ-T02.2

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information				Primary Design Condition	
Test Number:	TST11655			Type	Bowl
Customer Name:	SIERRA MOUNTAIN			Flow	5100 gpm
Project Name:	CITY OF TURLOCK			Head	87 ft
S/N:	849460A-2	Tag #:	OPS-PUM-200	Min. Eff.	84.0 %
Model:	Number STG:	Trim:		Speed	890 rpm
H24MC	2	18.130		Spec. Gr.	1.00



Dash Line - PUMP PERFORMANCE

11-12-2013

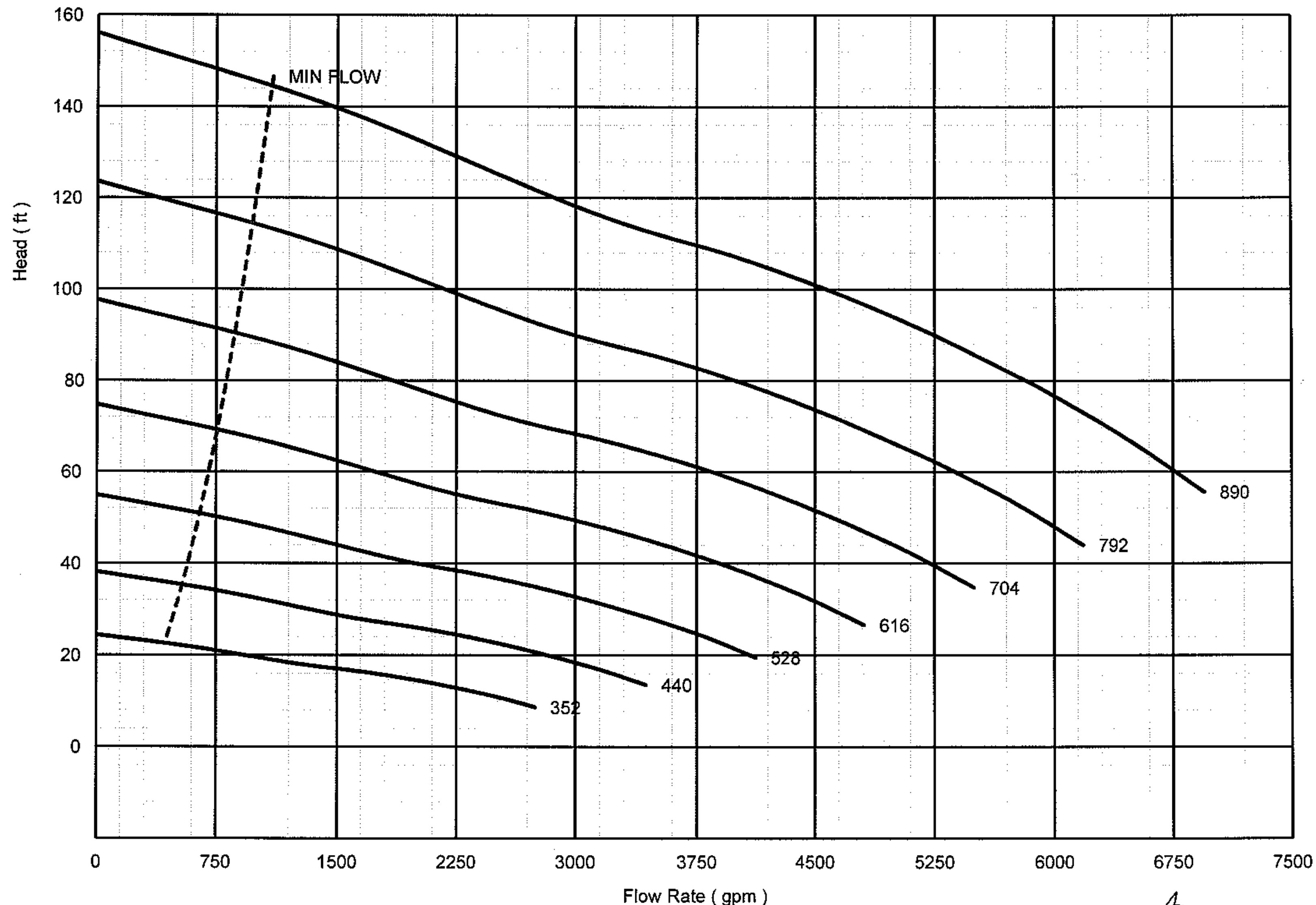
FRQ-T02.2

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information				Rated Conditions	
Test Number:	TST11655			Type	Bowl
Customer Name:	SIERRA MOUNTAIN			Flow	5100 gpm
Project Name:	CITY OF TURLOCK			Head	87 ft
S/N:	849460A-2	Tag #:	OPS-PUM-200	Min. Eff.	84 %
Model:	Number STG:	Trim:		Speed	890 rpm
H24MC	2	18.130		Spec. Gr.	1



11.12.2013

FRQ-T02.2

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information			
Test Number:	TST11656		
Customer Name:	SIERRA MOUNTAIN		
Project Name:	CITY OF TURLOCK		
S/N:	849460A-3	Tag #:	OPS-PUM-300
Model:	Number STG:	Trim:	
H24MC	2	18.130	

Primary Design Condition		
Type	Bowl	
Flow	5100	gpm
Head	87	ft
Min. Eff.	84.0	%
Speed	890	rpm
Spec. Gr.	1.00	

Collected Data						Calculated Data					Bowl Performance @ 890 rpm			
Test Point	Speed rpm	Flow gpm	Pressure Gauge ID	Gauge ft	In. Power kW	Vel. Head ft	DH Loss ft	Col Loss ft	BRG Loss hp	Kfactor	Flow gpm	Head ft	Power hp	Efficiency %
1	897	0.0	200FT	152.0	105.0	0.00	0.00	0.00	0.57	1.276	0.0	156.1	130.3	0.0
2	897	1515.0		134.5	108.2	0.30	0.00	0.00	0.51	1.277	1503.2	139.2	134.5	39.3
3	897	3014.0		112.0	106.4	1.20	0.00	0.00	0.43	1.276	2990.5	117.9	132.2	67.3
4	897	4036.0		99.5	108.4	2.15	0.00	0.00	0.39	1.277	4004.5	106.5	134.8	79.9
5	897	4515.0		93.3	109.4	2.69	0.00	0.00	0.37	1.278	4479.8	100.9	136.2	83.9
6	897	4881.0		87.8	109.2	3.14	0.00	0.00	0.35	1.277	4842.9	96.0	135.9	86.3
7	897	5147.0		83.0	108.0	3.49	0.00	0.00	0.34	1.277	5106.8	91.6	134.4	87.9
8	897	5356.0		79.0	107.7	3.78	0.00	0.00	0.32	1.277	5314.2	88.0	134.0	88.1
9	898	5811.0		70.5	105.5	4.45	0.00	0.00	0.30	1.276	5759.2	80.1	130.8	89.1
10	898	6038.0		65.5	104.4	4.80	0.00	0.00	0.28	1.275	5984.2	75.5	129.4	88.2
11	898	6541.0		53.5	99.8	5.64	0.00	0.00	0.24	1.273	6482.7	64.6	123.5	85.6
12	897	7041.0		40.5	92.2	6.53	0.00	0.00	0.19	1.269	6986.1	52.8	114.1	81.6

Test Set-Up Details	
Test Type:	Bowl
Motor:	11-450HP,8P-AZ
Motor Eff (non-lab):	1.000
Watt Meter Const.	1.000
Flow Meter:	12" Line
Gauge EL:	6.58 ft
Lateral Setting:	0.375 in

Impeller Data									
Model NPC	Number of Stages: Test	Number of Stages: Calc.	Impeller Trim: Test in	Impeller Trim: Calc. in	UF in	Finish	Material: Impeller	Material: Bowl	Kt lb/ft
071-H24LC	2	2	18.130	18.130	3/16"	A	BRZ	CI/COAT	53.80
									0.00
									0.00
									0.00
		RMS Trim	18.130	18.130				AVG Kt	53.80

Pressure Tap Location Dimensions	
Column Diameter:	12.00 in
Shaft Diameter:	1.938 in

Discharge Head Description	
Type	2-Fabricated
Discharge Size	17.25 in

Column Details	
Length	12.04 ft
Diameter	17.25 in
Shaft Diameter	4.000 in

Acceptance Criteria - Primary			
Type	Customer	-	+
Flow		0%	5%
Head		0%	5%
N/A			

Additional Notes:

[signature] 11-12-13

Performed	
Date:	11/12/2013
By:	Adam Weigel
	Test Technician

Certified	
Date:	11.12.20[illegible]
By:	[signature]
	DIRECTOR OF ENGINEERING

FRQ-T02.2

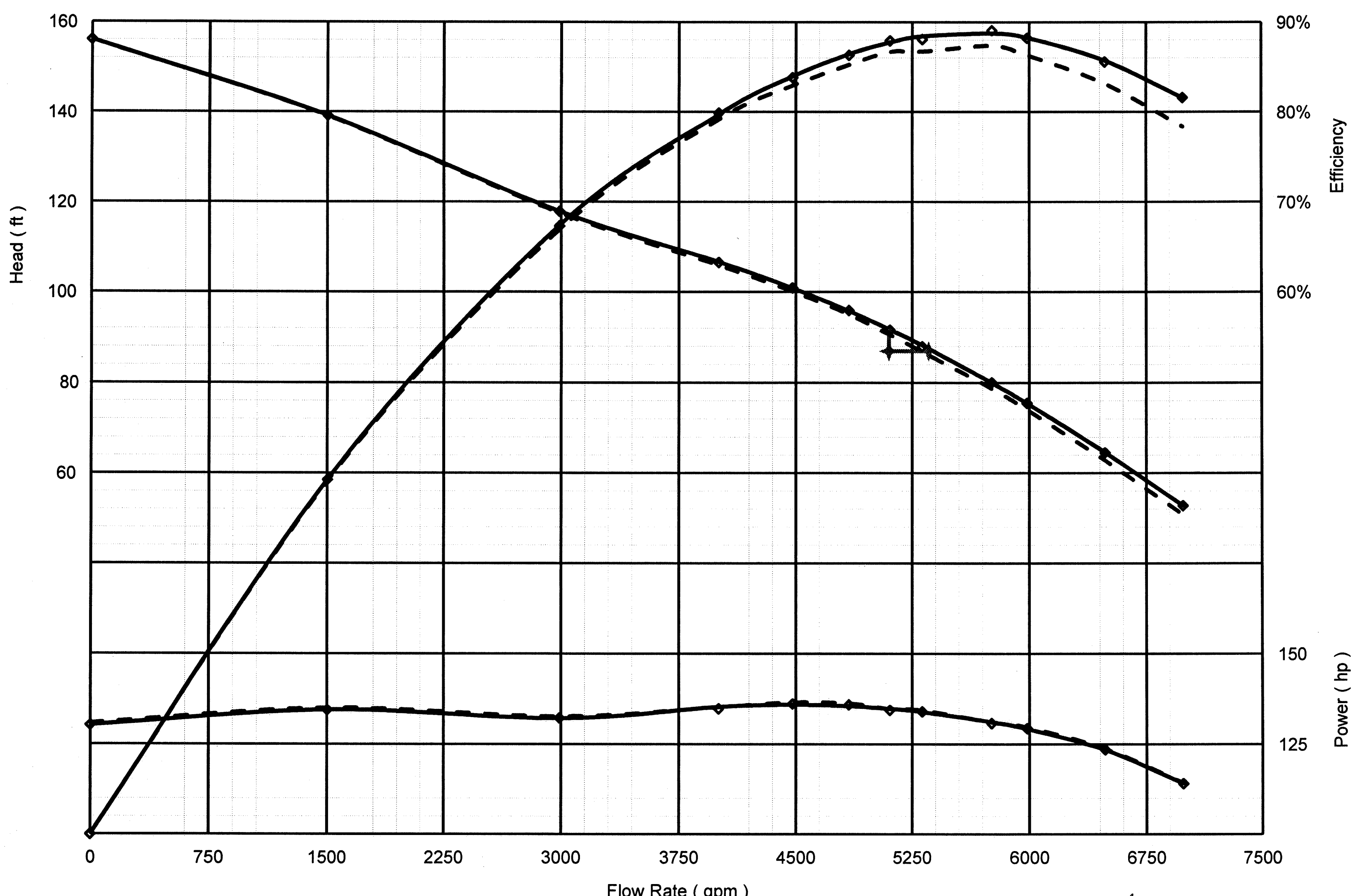
NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information			
Test Number:	TST11656		
Customer Name:	SIERRA MOUNTAIN		
Project Name:	CITY OF TURLOCK		
S/N:	849460A-3	Tag #:	OPS-PUM-300
Model:	Number STG:	Trim:	
H24MC	2	18.130	

Primary Design Condition		
Type	Bowl	
Flow	5100	gpm
Head	87	ft
Min. Eff.	84.0	%
Speed	890	rpm
Spec. Gr.	1.00	



Dash Line - PUMP PERFORMANCE

11.12.2013

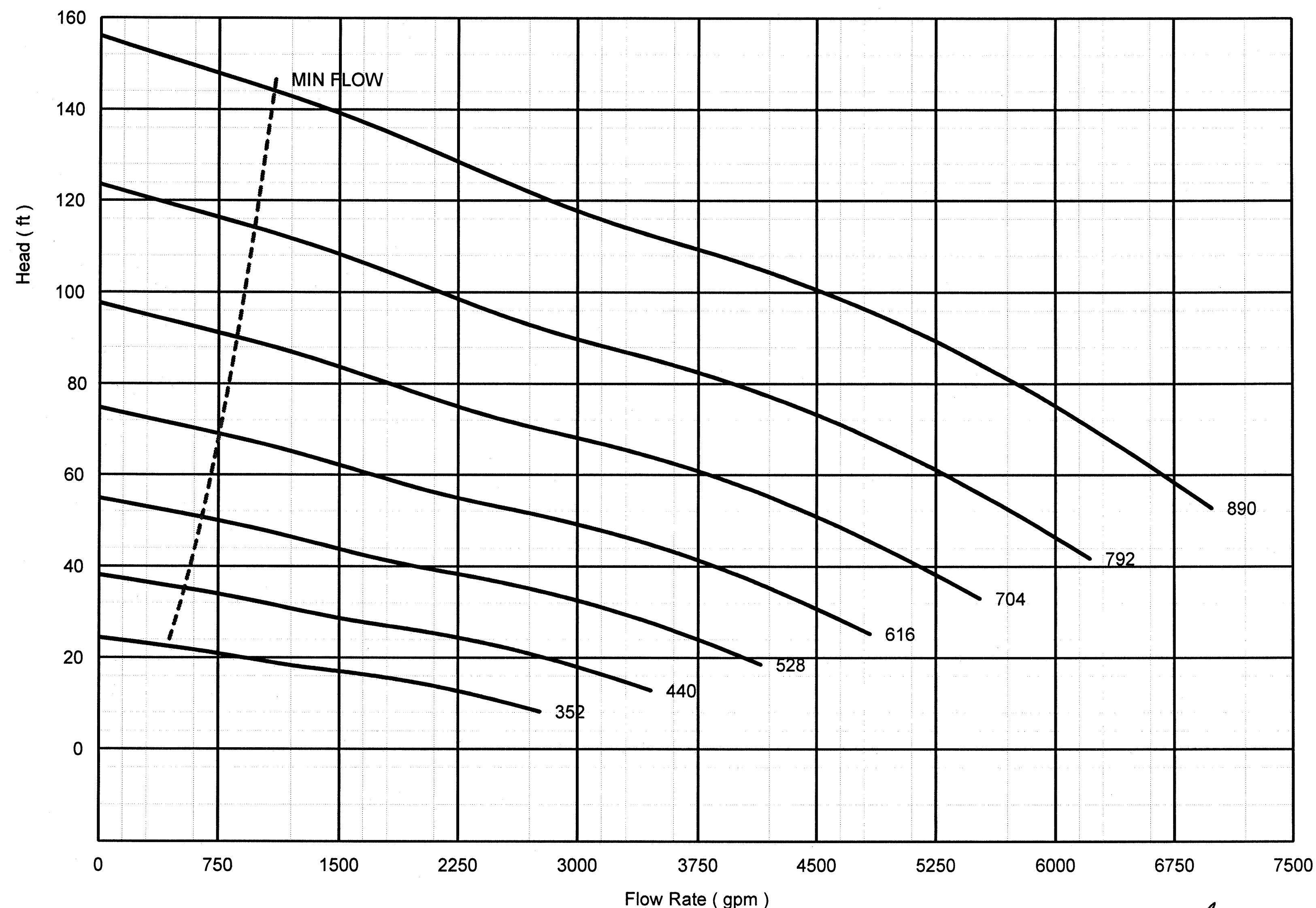
FRQ-T02.2

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

7706 North 71st Ave. Glendale, AZ 85303

PERFORMANCE TEST REPORT

Test Information				Rated Conditions		
Test Number:	TST11656			Type	Bowl	
Customer Name:	SIERRA MOUNTAIN			Flow	5100	gpm
Project Name:	CITY OF TURLOCK			Head	87	ft
S/N:	849460A-3	Tag #:	OPS-PUM-300	Min. Eff.	84	%
Model:	Number STG:	Trim:		Speed	890	rpm
H24MC	2	18.130		Spec. Gr.	1	



11-12-2020

FRQ-T02.2

⚠3 IMPELLER TRIM & MODEL				
STAGE #'S	MODEL	TRIM	# OF VANES	CHK BY
2	H24LC	18.13	5	J.G.

MIN. LATERAL = 0.50

LATERAL = 1 1/8

CHK BY = J.G.

ENGINEERING FINAL CHECK

BY/DATE = [signature] 11-25-2013

ZONE	REV	DESCRIPTION	DATE	APPROVED
	0	INITIAL RELEASE	7/24/2013	GB

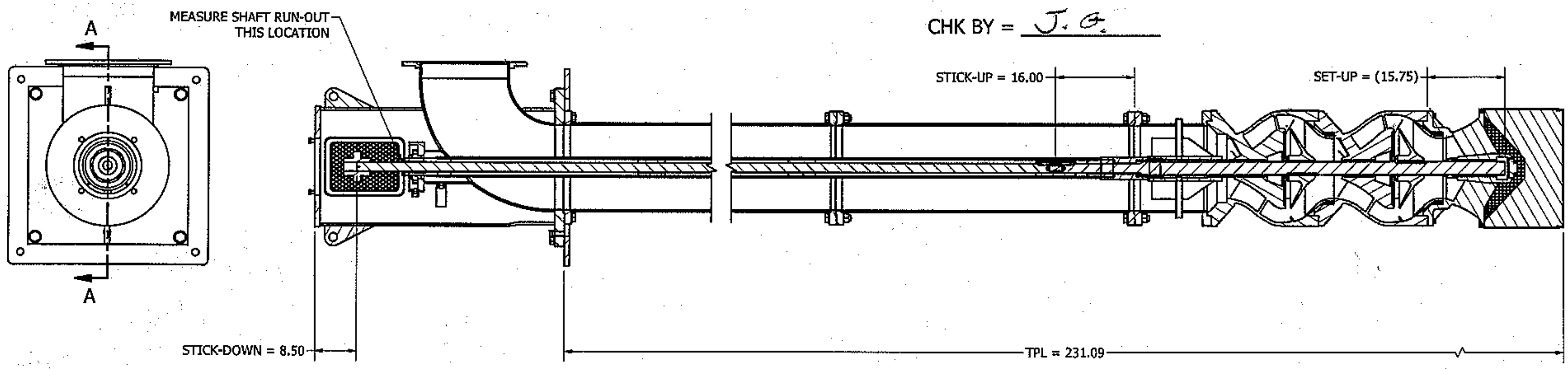
(Revision history)

SHAFT RUN-OUT = .0005

CHK BY = J.G.

STICK-UP = 16"

CHK BY = J.G.



STICK-DOWN = 8 1/2

CHK BY = J.G.

SECTION A-A

TPL = 231

CHK BY = K.T.

NOTES (UNLESS OTHERWISE SPECIFIED):

1. ONE (1) DRAWING TO BE FILLED OUT PER PUMP

2. RECORD EACH DIMENSION TO THE NEAREST 0.06 (1/16)

⚠3. IMPELLER TRIM & MODEL TO BE COMPLETED AFTER TESTING (IF REQUIRED)
STAGE #'S - SPECIFES THE LOCATION (EXAMPLES: "ALL", "1", "2-4" ECT.)

4. STANDARD TOLERANCES ARE AS FOLLOWS:
TPL ±0.25
STICK-UP -0.25/+0.13
STICK-DOWN -0.13/+0.25

5. ENGINEERING MUST REVIEW AND SIGN OFF PRIOR TO SHIPMENT

built by J.G./M.B.

PUMP S/N = 849460A-1

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
DECIMALS .X ±0.1 .XX ±0.03 .XXX ±0.010 ANGLES ±0.5° SURFACE 125
REMOVE ALL BURRS AND SHARP EDGES 0.005-0.010
DO NOT SCALE DRAWING
MATERIAL
WEIGHT

APPROVALS		DATE
DRAWN	ABT	7/20/2013
CHK		
ENGR	GB	7/24/2013

THIRD ANGLE PROJECTION

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY
GLENDALE, AZ U.S.A.

TITLE CHECK-OUT DRAWING: SO#849460A

SIZE C | DWG NO. 849460ACHK | REV. 0
SCALE NTS | UNITS INCHES | SHEET 1 OF 1

FRQ-Q05.1

⚠3 IMPELLER TRIM & MODEL				
STAGE #'S	MODEL	TRIM	# OF VANES	CHK BY
2	4ZYLC	18.13	5	B

MIN. LATERAL = 0.50

LATERAL = 1/8

CHK BY = B

ENGINEERING FINAL CHECK

BY/DATE = A.T. 11.25.2013

ZONE	REV	DESCRIPTION	DATE	APPROVED
	0	INITIAL RELEASE	7/24/2013	GB

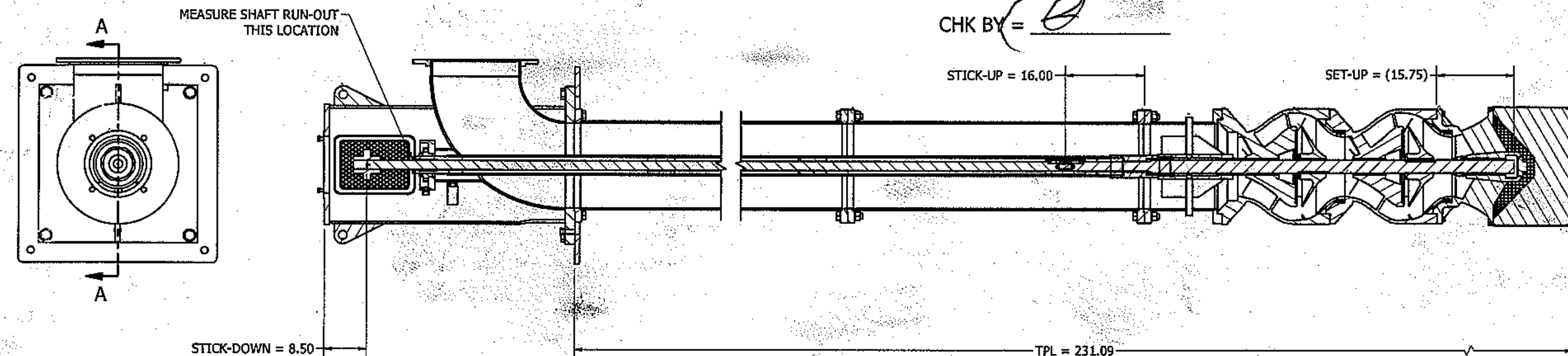
REVISION HISTORY

SHAFT RUN-OUT = 0.0005

CHK BY = B

STICK-UP = 16

CHK BY = B



STICK-DOWN = 8 1/2

CHK BY = B

SECTION A-A

TPL = 231

CHK BY = K.T.

NOTES (UNLESS OTHERWISE SPECIFIED):

1. ONE (1) DRAWING TO BE FILLED OUT PER PUMP
2. RECORD EACH DIMENSION TO THE NEAREST 0.06 (1/16)
3. ⚠ IMPELLER TRIM & MODEL TO BE COMPLETED AFTER TESTING (IF REQUIRED) STAGE #'S - SPECIFES THE LOCATION (EXAMPLES: "ALL", "1", "2-4" ECT.)
4. STANDARD TOLERANCES ARE AS FOLLOWS:
   TPL ±0.25
   STICK-UP -0.25/+0.13
   STICK-DOWN -0.13/+0.25
5. ENGINEERING MUST REVIEW AND SIGN OFF PRIOR TO SHIPMENT

built by J.G./M.B.

PUMP S/N = 849460A-2

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: DECIMALS .X ±0.1 .XX ±0.03 .XXX ±0.010; ANGLES ±0.5°; SURFACE 125; REMOVE ALL BURRS AND SHARP EDGES 0.005-0.010

DO NOT SCALE DRAWING

MATERIAL

WEIGHT

APPROVALS		DATE
DRAWN	ABT	7/20/2013
CHK		
ENGR	GB	7/24/2013

THIRD ANGLE PROJECTION

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY
GLENDALE, AZ U.S.A.

TITLE: CHECK-OUT DRAWING: SO#849460A

SIZE C | DWG NO. 849460ACHK | REV. 0

SCALE NTS | UNITS INCHES | SHEET 1 OF 1

FRQ-Q05.1

3 IMPELLER TRIM & MODEL				
STAGE #'S	MODEL	TRIM	# OF VANES	CHK BY
2	H24LC	18.13	5	MB

MIN. LATERAL = 0.50

LATERAL = 1 1/8

CHK BY = [signature]

ENGINEERING FINAL CHECK

BY/DATE = [signature] 11.25.2017

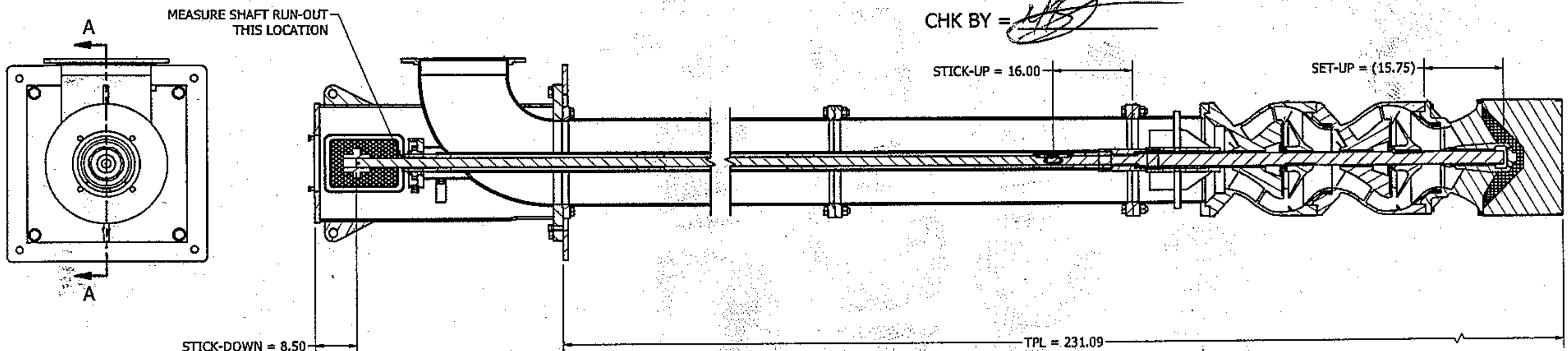
REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	0	INITIAL RELEASE	7/24/2013	GB

SHAFT RUN-OUT = .0025

CHK BY = J.G

STICK-UP = 16

CHK BY = MB



STICK-DOWN = ~~8.005~~ 8 1/2

CHK BY = ~~MB~~ J.G.

SECTION A-A

TPL = 231

CHK BY = K.T

NOTES (UNLESS OTHERWISE SPECIFIED):

1. ONE (1) DRAWING TO BE FILLED OUT PER PUMP
2. RECORD EACH DIMENSION TO THE NEAREST 0.06 (1/16)
3. IMPELLER TRIM & MODEL TO BE COMPLETED AFTER TESTING (IF REQUIRED) STAGE #'S - SPECIFES THE LOCATION (EXAMPLES: "ALL", "1", "2-4" ECT.)
4. STANDARD TOLERANCES ARE AS FOLLOWS:
   TPL ±0.25
   STICK-UP -0.25/+0.13
   STICK-DOWN -0.13/+0.25
5. ENGINEERING MUST REVIEW AND SIGN OFF PRIOR TO SHIPMENT

built by J.G./M.B

PUMP S/N = 849460A-3

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: DECIMALS ANGLES SURFACE .X ±0.1 ±0.5° 125 .XX ±0.03 .XXX ±0.010
REMOVE ALL BURRS AND SHARP EDGES 0.005-0.010
DO NOT SCALE DRAWING
MATERIAL
WEIGHT

APPROVALS		DATE
DRAWN	ABT	7/20/2013
CHK		
ENGR	GB	7/24/2013

THIRD ANGLE PROJECTION

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY
GLENDALE, AZ U.S.A.

TITLE: CHECK-OUT DRAWING: SO#849460A

SIZE: C | DWG NO. 849460ACHK | REV. 0

SCALE NTS | UNITS INCHES | SHEET 1 OF 1

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

PAINT/COATING INSPECTION

CUSTOMER NAME: SIERRA MOUNTAIN CONSTRUCTION
PROJECT NAME: CITY OF TURLOCK
PUMP S/N: 849460A-1
CUSTOMER TAG #: OPS-PUM-100

COMPONENT	SPECIFICATION	COLOR	DFT CHECK (mils)		
			#1	#2	#3
DISCHARGE HEAD OD	PRO-PAI01	RED	N/A	N/A	N/A
DISCHARGE HEAD ID	CUSTOMER (SEE DWG)	OFF-WHITE	15.6	23.7	24.2
COLUMN OD	CUSTOMER (SEE DWG)	OFF-WHITE	24.6	17.4	24.0
COLUMN ID	CUSTOMER (SEE DWG)	OFF-WHITE	23.8	17.7	19.5
ENCLOSING TUBE OD	CUSTOMER (SEE BOM)	OFF-WHITE	11.6	10.9	12.0
BOWL ASSY OD	CUSTOMER (SEE BOM)	OFF-WHITE	15.2	15.5	17.0

NOTES:
ENGINEERING TO CERTIFY.

[signature] PERFORMED BY — DATE: 25NOV13

[signature] CERTIFIED BY — DATE: 11.25.2013

L. [signature] WITNESSED BY — DATE: 25 NOV 13

FRQ-Q12.0

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

PAINT/COATING INSPECTION

CUSTOMER NAME: Sierra Mountain
PROJECT NAME: City of Turlock
PUMP S/N: 849460A-2
CUSTOMER TAG #: OPS-PUM-100

COMPONENT	SPECIFICATION	COLOR	DFT CHECK (mils)		
			#1	#2	#3
DISCHARGE HEAD OD	PRO-PAIO1	RED			
DISCHARGE HEAD ID	CUSTOMER (SEE DWG)	OFF-WHITE	16.2	23.0	23.6
COLUMN OD	CUSTOMER (SEE DWG)	OFF-WHITE	23.8	17.2	26.0
COLUMN ID	CUSTOMER (SEE DWG)	OFF-WHITE	23.6	18.1	18.7
ENCLOSING TUBE OD	CUSTOMER (SEE BOM)	OFF-WHITE	12.0	11.4	12.7
BOWL ASSY OD	CUSTOMER (SEE BOM)	OFF-WHITE	15.5	15.7	18.0

NOTES:

PERFORMED BY — DATE: 27 Nov 13

CERTIFIED BY — DATE: 11.25.2013

WITNESSED BY — DATE: 25 NOV 13

FRQ-Q12.0

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

PAINT/COATING INSPECTION

CUSTOMER NAME: Sierra Mountain
PROJECT NAME: City of Turlock
PUMP S/N: 849460A-3
CUSTOMER TAG #: OPS-PUM-100

COMPONENT	SPECIFICATION	COLOR	DFT CHECK (mils) #1	DFT CHECK (mils) #2	DFT CHECK (mils) #3
DISCHARGE HEAD OD	PRO-PAIO1	RED			
DISCHARGE HEAD ID	CUSTOMER (SEE DWG)	OFF-WHITE	15.8	21.9	22.6
COLUMN OD	CUSTOMER (SEE DWG)	OFF-WHITE	24.1	18.1	24.7
COLUMN ID	CUSTOMER (SEE DWG)	OFF-WHITE	21.7	20.2	17.2
ENCLOSING TUBE OD	CUSTOMER (SEE BOM)	OFF-WHITE	13.1	13.0	13.1
BOWL ASSY OD	CUSTOMER (SEE BOM)	OFF-WHITE	13.8	15.8	16.8

NOTES:

PERFORMED BY — DATE: 25 Nov 13

CERTIFIED BY — DATE: 11.25.2013

WITNESSED BY — DATE: 25 Nov 13

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

FINAL INSPECTION/SHIPMENT APPROVAL

Order Information

Sales Order Number:	849460A	Cust. P.O. No.:	WQCF-6859
Customer Name:	SIERRA MOUNTAIN	Project Name:	CITY OF TURLOCK

☑ Engineered Products ☐ Std Products & Parts Orders

Verify the following documents are complete and accurate	N/A	Yes	Inspected by / Date
Credit Check		☑	
☐ Packing Slip (include copy in shipment) Components Verified to BOM/Sales Order		☑	EJ 11-25-13
Quantity Verified to BOM/Sales Order		☑	" "
Instruction & Operation Manual Included	☑	☐	" "
Paint/Coating Inspection (FRQ-Q12)	☐	☑	
Final "Check-Off Drawing/s" Completed	☐	☑	25 NOV 2013
Production Packet Checklist (FRQ-E09)	☐	☑	22 NOV 2013
Nameplates Verified (FRQ-E06)	☐	☑	25 NOV 2013
Visual Inspection (fasteners tight, coating, etc.)		☑	25 NOV 2013
☐ Other (describe):			
Inspection Test Plan (FRQ-T12)	☑	☐	
Test Requisition (FRQ-T01)	☐	☑	22 NOV 2013
Dynamic Balance Certificate (FRQ-T13)	☐	☑	22 NOV 2013
ENGINEERING SIGN-OFF ON COATING INSPECTION			11.25.2013
Additional documents attached for special requirements to be verified.	☒	☐	

Comments:

QCI Signoff

The above information has been signed by the appropriate authorities and has been verified by the undersigned to be complete and in order file. **Product is authorized for shipment.**

Print Name	Signature	Date
V. LIGHTFOOT	[signature]	25 NOV 2013

FRQ-Q19.3

SECTION 5

INSTRUCTION, OPERATION AND MAINTENANCE MANUAL

NATIONAL PUMP COMPANY

A GORMAN-RUPP COMPANY

FRQ-E15.0

NATIONAL PUMP COMPANY

A GORMAN-RUPP COMPANY

INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS AND PARTS LISTS FOR

VERTICAL TURBINE PUMPS

CUSTOMER:______________________________

PUMP SERIAL NUMBER: ______________________________

DATE SHIPPED:______________________________

DELIVERING VERTICAL TURBINE PUMP RELIABILITY, QUALITY AND SERVICE SINCE 1969.

PERFORMANCE | QUALITY | SERVICE | TRUST

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY
7706 N. 71st Ave., Glendale, AZ 85303 Tel: (623) 979-3560 Fax: (623) 979-2177

February 22nd, 2013

EXTENDED WARRANTY CERTIFICATE

Project:	Sierra Mountain Construction
Purchase Order #:	WQCF-6859
Project Name:	City of Turlock
NPC Sales Order #:	849460

Per specification 11312D section 1.10, specification 15050 requires a one-year warranty. As the proposed equipment being supplied from National Pump Company is an "or equal" on this project, National Pump Company is allowing the Owner a 3 year warranty (1 year standard + 2 years extended) as a special performance guarantee.

National Pump Company's Standard Warranty and Terms and Condition policies are attached, for your convenience.

Should you have any questions or need any further information, please do not hesitate to contact me at kenk@natlpump.com or by telephone at 623-979-3560 ext. 265.

We look forward to working with you on this project.

Sincerely,

Ken Kochamba
V.P. Sales and Marketing

NATIONAL PUMP COMPANY

Subject to the terms and conditions set forth below, NATIONAL PUMP COMPANY ("National") warrants that its manufactured equipment is free from defects in workmanship and materials USING ITS SPECIFICATIONS AS A STANDARD. This warranty does not extend to anyone except the first purchaser to whom the goods are shipped from National.

National's obligation under this warranty is expressly limited to replacing or repairing, free of charge, F.O.B. point of manufacture, any defective part or parts of its manufactured equipment; however, NATIONAL SHALL HAVE NO SUCH LIABILITY EXCEPT WHERE IT IS SHOWN TO THE SATISFACTION OF NATIONAL THAT THE DAMAGE OR CLAIM RESULTED FROM BREACH OF THIS WARRANTY. All parts claimed defective must be delivered to National at its factory or any factory branch, freight or express thereon PREPAID.

Every claim under this warranty SHALL BE DEEMED WAIVED UNLESS MADE IN WRITING AND RECEIVED BY NATIONAL WITHIN THIRTY (30) DAYS OF THE DATE THE DEFECT WAS DISCOVERED OR SHALL HAVE BEEN DISCOVERED, and within one year of the date of installation. The installation date must be within six months of the date the pump was purchased from National.

This Warranty does not cover those parts of the manufactured equipment which are not manufactured by National except to extend to the purchaser the same warranty, if any, which is given to National by the manufacturers of said parts.

National makes no other representation of warranty of any kind, express or implied, in fact or in law, including without limitation, the warranty of merchantability or the warranty of fitness for a particular purchase, other than the limited warranty set forth herein. In no event shall National be liable for any consequential or incidental damages resulting directly or indirectly from the use or loss of use of the manufactured equipment. National shall not be liable for any alleged negligence, breach of warranty, strict liability, or any other theory other than the limited liability set forth herein.

THIS WARRANTY CONTAINS THE ENTIRE WARRANTY RELATING TO THE MANUFACTURED GOODS OF NATIONAL, AND NO CONDUCT, ORAL STATEMENTS OR REPRESENTATIONS NOT CONTAINED IN THIS WARRANTY SHALL HAVE ANY FORCE OR EFFECT OR BE DEEMED A WAIVER THEREOF, THIS WARRANTY SHALL NOT BE MODIFIED IN ANY WAY EXCEPT IF IN WRITING AND SIGNED BY AN AUTHORIZED REPRESENTATIVE OF NATIONAL.

This Warranty, and any liability of National hereunder, shall be governed by, construed, and enforced in accordance with the laws of the State of Ohio.

STANDARD TERMS AND CONDITIONS OF SALE

1. **ACCEPTANCE OF ORDERS:** All orders are subject to acceptance by an Officer of the Company and orders and deliveries are subject to the Company's regular credit policy. The Company reserves the right to refuse any order based on a quotation containing a gross error.

2. **PRICES:** List prices and discount schedules are to be maintained at all times. Prices are for merchandise F.O.B. shipping points, freight collect or prepaid, and added to the invoice. Prices, discounts, quotations, and specifications are subject to change without notice and will be applied as in effect at time of shipment.

3. **TERMS:** Except as otherwise indicated, payment is due 30 days after date of invoices. Interest at the maximum legal rate will be charged on all overdue amounts.

4. **TAXES:** Taxes imposed by any Federal, State, County, or Municipal law on the sale will be added to the invoice, unless a fully executed tax exemption certificate is received with the order.

5. **ORDER CHANGES:** No changes in orders will be accepted from the purchaser except by special written arrangement with the executive office of National.

6. **RETURN OF GOODS:** Written permission from the factory must be obtained before returning any merchandise. All transportation charges must be borne by the Customer. New material of current design accepted by the Company for credit is subject to a restocking charge of at least 15 percent.

7. **CLAIMS:** All goods shall be deemed delivered to purchaser at the time they are placed in the hands of carrier and consigned to purchaser.

8. **ROUTING:** If routing of shipment is specified on Customer's order, it will be followed whenever practical.

9. **SUBSTITUTION:** The Company reserves the right to substitute materials and modify specifications to the extent required in order to comply with any Government law or regulation.

10. **MINIMUM ORDER AMOUNT:** The minimum order amount to be charged on customer account is $50.00. All orders for less than this amount will be billed at the minimum of $50.00 not including tax or freight charges.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS AND CHARTS

SECTION I
GENERAL INFORMATION

I-1. GENERAL INFORMATION

The length of the satisfactory service obtained from the equipment will, in part, depend on proper installation and maintenance. This instruction manual is provided to present the basic information for operating, maintenance and management personnel. Due to the many variations and custom designed units, it is impossible to cover every design variation or contingency which may arise. However, the basic information contained herein will cover most questions.

I-2. IDENTIFICATION

Should questions arise concerning the pump, the factory will require the complete serial number to be of assistance. The serial number is stamped on a metal nameplate affixed to the discharge head assembly and/or bowl assembly. The driver will have a separate nameplate attached to it. When requesting information on the driver both the driver serial number and pump serial number will be required.

I-3. GENERAL DESCRIPTION

The basic components of Close Coupled Pumps are the driver, discharge head assembly, column assembly (when used), and bowl assembly. The pumps are normally shipped assembled and ready for installation. The drivers, couplings and strainers (when used) are shipped unassembled to prevent damage.

I-4. DRIVERS

A variety of drivers may be used, however, electric motors are most common. For the purposes of this manual, all types of drivers can be grouped into two categories:

1. Hollow shaft drivers where the pump shaft extends through a tube in the center of the rotor and is connected to the driver by a clutch assembly at the top of the driver.

2. Solid shaft drivers where the rotor shaft is solid and projects below the driver mounting base. This type of driver requires an adjustable flanged coupling for connecting to the pump.

I-5. DISCHARGE HEAD ASSEMBLY

The discharge head supports the driver and bowl assembly as well as supplying a discharge connection (except for the "NUF" type discharge connection which will be located on one of the column pipe sections below the discharge head). A shaft sealing arrangement is located in the discharge head to seal the shaft where it leaves the liquid chamber. The shaft seal will usually be either a mechanical seal assembly or stuffing box.

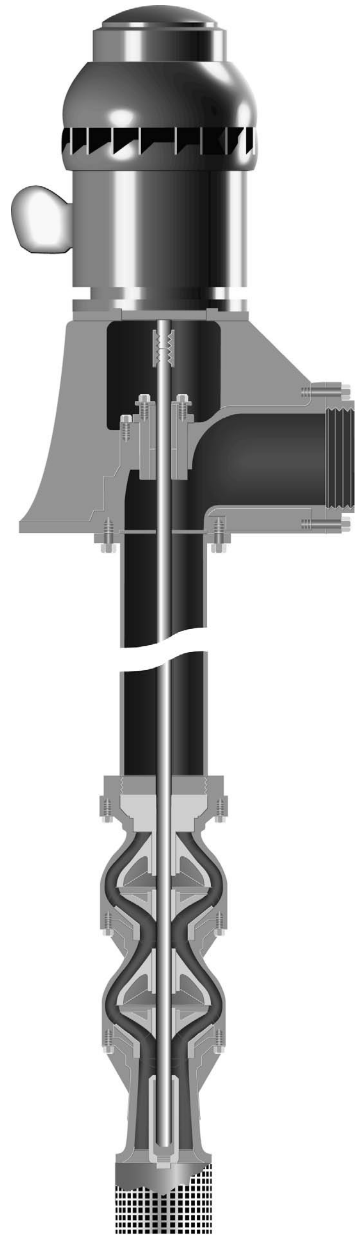


Figure I-1. "N260" Type Unit

I-6. COLUMN ASSEMBLY

Column assembly is of two basic types, either of which may be used:

1. Open lineshaft construction utilizes the fluid being pumped to lubricate the lineshaft bearings.

2. Enclosed lineshaft construction has an enclosing tube around the lineshaft and utilizes oil, grease or injected liquid (usually clean water) to lubricate the lineshaft bearings.

Column assembly will consist of: 1) column pipe, which connects the bowl assembly to the discharge head, 2) shaft, connecting the bowl shaft to the driver and, 3) may contain bearings, if required, for the particular unit. Column pipe may be either threaded or flanged.

Note: Some units will not require column assembly, having the bowl assembly connected directly to the discharge head instead.

I-7. BOWL ASSEMBLIES

The bowl consists of: 1) impellers rigidly mounted on the bowl shaft which rotate and impart energy to the fluid, 2) bowls to contain the increased pressure and direct the fluid, 3) suction bell or case which directs the fluid into the first impeller, and 4) bearings located in the suction bell (or case) and in each bowl.

SECTION II
PRE-INSTALLATION

II-1. RECEIVING

When shipment is received extreme care should be exercised when unloading. Heavy parts should be carefully skidded to the ground if lifting equipment is not available. Do not drop the unit, or any parts, as damage may cause trouble in assembly and operation of the units.

Inspect unit for signs of transit damage before beginning to uncrate or put into storage. If damage is evident the local transporting company agent should be notified before uncrating and a claim filed with the agent.

II-2. STORAGE

If the unit is to be stored prior to installation, carefully select a storage space so the unit will not be subjected to excess moisture, extreme weather conditions, corrosive fumes, or other harmful conditions. Carefully inspect the unit and clean any rust spots on machined surfaces with fine emery cloth or scotchbrite pad and coat with a rust preventive. If the unit is stored for a long period it should be inspected from time to time, cleaned, and shafting rotated as required.

II-3. UNCRATING & CLEANING

If unit appears undamaged proceed to uncrate. The pump is shipped as a unit from the factory and is advisable to lift into the vertical position before uncrating. If this is not possible the longer units must be supported at more than one place to avoid putting undue strain on the unit when raising to the vertical position.

Clean all parts of all dirt, packing materials and other foreign matter. Flush the pump inside and outside with clean water. Clean all machined surfaces. These are coated with a rust preventive before shipment which must be removed. Remove any rust spots found on the machined surfaces with a fine emery cloth or scotchbrite pad. Clean all threaded connections and any accessory equipment.

NOTE: Parts and accessories may be placed inside shipping containers or attached to skids in individual packages. Inspect all containers, crates and skids for attached parts before discarding.

II-4. EQUIPMENT AND TOOLS

No installation should be attempted without equipment adequate for the job. The following list covers the principal items required for an installation.

1. Mobile crane capable of hoisting and lowering the weight of the pump or motor.
2. Cable sling for attaching to the pump and motor lifting eyes.
3. Ordinary hand tools—end wrenches, socket set, screw drivers, allen wrenches, collet hammer, etc.
4. Wire brush, scraper and fine emery cloth or scotchbrite pad.
5. Thread compound and light machinery oil.

II-5. PRE-INSTALLATION CHECK LIST

The following checks should be made before starting actual installation to assure proper installation and prevent delays:

1. Where more than one unit is received, check the pump serial number against the packing slip to be sure the correct unit is being installed.
2. Check the driver horsepower and speed indicated on the driver nameplate, and the horsepower and speed indicated on the pump nameplate (located on the discharge head) to be sure they agree.

NOTE: A slight difference between the speeds (RPM) shown on the driver and pump nameplates is O.K., however, the difference should not be more than 2%.

3. With motor driven units be sure the voltage and frequency on the motor nameplate agree with the service available. Also make sure the horsepower and voltage rating of the control box or starter agree with the horsepower and voltage rating of the motor.
4. Check the depth of the sump against the pump length to be sure there will be no interference.

5. Check the proposed liquid level in the sump against the pump length. The bottom stage of the pump must be submerged at all times.

6. Clean the sump and piping system before installing the pump.

7. Check the installation equipment to be sure it will safely handle the equipment.

8. Check all pump connections (bolts, nuts, etc.) for tightness. These have been properly tightened before leaving the factory, however, some connections may have worked loose in transit.

9. On the hollow shaft drivers, check the clutch size and drive key against the shaft size which must go through the clutch. Sometimes the shaft size coming through the discharge head is different from the shaft size going through the driver. Be sure you check against the shaft which will go through the driver.

10. On solid shaft drivers check the motor shaft size against the coupling bore size.

SECTION III
INSTALLATION

III-1. GENERAL

This is a precision piece of equipment and should be treated as such. Proper installation is necessary to provide maximum service from the pump. To insure proper alignment three items are very important during installation:

1. All machined mating surfaces (such as the mating flanges of pump and driver) must be clean and free of burrs and nicks. These surfaces should be cleaned thoroughly with a scraper, wire brush and emery cloth if necessary and any nicks or burrs removed with a fine file.

2. Exterior strain must not be transmitted to the pump. The most common cause of trouble in this respect is forcing the piping to mate with the pump. It is recommended that flexible connectors be installed in the piping adjacent to the pump. This is especially critical on "NUF" type units where the discharge may be several feet below the supporting structure, and a relatively small strain can cause misalignment.

3. All threads should be checked for damage and repaired if necessary. If filing is necessary, remove the part from the pump if possible, or arrange a rag to catch all filings so they do not fall into other parts of the pump. Clean all threads with wire brush and cleaning solvent. Ends of shafts must be cleaned and any burrs removed since alignment depends on the shaft ends butting squarely. Lubricate all screwed connections with a thread lubricant – an anti-galling threading compound such as "Never-Seez" should be used on stainless and monel mating threads.

CAUTION: Apply thread lubricant sparingly to male shaft threads only when making up shaft connection. Excess lubricant should not be allowed to get between the ends of the shaft.

III-2. FOUNDATION

The foundation may consist of any material that will afford permanent, rigid support to the discharge head and will absorb expected stresses that may be encountered in service.

Concrete foundations should have anchor bolts installed in sleeves twice the diameter of the bolt to allow alignment with the holes in the mounting plate as illustrated in Figure III-1.

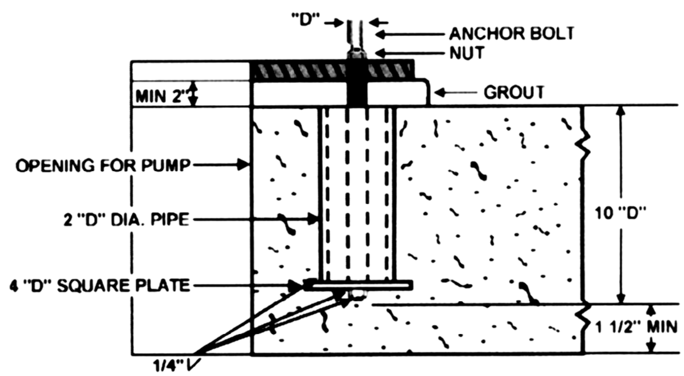


Figure III-1. Recommended Anchor Bolt Arrangement

III-3. INSTALLING PUMP

1. Position lifting equipment so it will center over the foundation opening.

NOTE: Sump and piping should be thoroughly cleaned of all loose debris before starting installation.

2. If a base plate is used, level the mounting surface grout and anchor in place.

3. Clean pump discharge flange.

NOTE: All machined surfaces are coated with rust preventive prior to shipment. This must be completely removed along with any paint overspray

or rust which might be on the machined faces. The surfaces should be scraped and wire brushed and then a fine emery cloth used to remove any stubborn spots.

4. Lift pump, mount strainer if required, and lower slowly into sump. Hand guide the pump as it is lowered and watch for any obstructions or binding of the pump which can be felt through the hands. Stop lowering unit when still a few inches off foundation.

NOTE: Be particularly careful not to damage any piping which may extend down along the column and/or bowl assembly. This piping (when used) must remain open. Should it be damaged, it should be removed and replaced.

5. Rotate pump until discharge flange faces proper direction for alignment with piping, and align anchor bolt holes.

6. Slowly lower pump onto foundation.

7. Install anchor bolts or nuts, but do not tighten.

8. Shift the pump slightly on the foundation, if required, to facilitate alignment.

9. Check level of discharge head once sitting on grout plate.

CAUTION: Exterior stresses should not be transferred to the pump. All piping must be carefully aligned and supported to prevent this.

NOTE: It is strongly recommended that flexible connectors (Dresser Couplings, or equal) be installed in the piping immediately adjacent to the pump.

10. Tighten discharge flange bolting using proper torque sequence. Be sure the flanges mate without forcing.

11. Tighten anchor bolting.

12. Mechanical seal should be installed at this time if the pump is so equipped. If the mechanical seal was shipped not installed, see paragraph III-9 for further details.

III-4. INSTALLING HOLLOWSHAFT DRIVE

1. Clean the driver mounting flange on the discharge head and flange. Check for burrs or nicks on the register and mounting face. Oil lightly.

2. Remove driver clutch.

3. Lift the driver and clean the mounting flange, checking for burrs and nicks.

4. Some electric motors will be supplied with a "lowerguide bushing" (steady bushing) which is installed at the bottom of the motor to stabilize the shaft at this point. Some motor manufacturers mount this guide bushing before shipping while others will ship the guide bushing with instructions for field mounting. Check the packing slip to see if a guide bushing is required. If so, determine if the bushing is already mounted or not and proceed accordingly. See Fig. III-2.

5. Raise and center driver over pump.

6. Lower carefully until about 1/4" above mounting flange. Rotate driver until junction box on motor or input shaft on gear drive is in correct position. Align bolt holes and insert bolts.

7. Lower carefully into place making certain that the female register on the driver mates over the male register on the pump.

8. Tighten mounting bolts.

9. Check driver manufacturer's instruction manual for special instructions including lubrication instructions and follow all "start up" directions.

10. Electric drivers should be checked for rotation at this time. Make electrical connections and jog motor momentarily to check rotation. DRIVER MUST ROTATE COUNTER-CLOCKWISE when looking down at top end of motor. To change the direction of rotation on a three-phase motor, interchange any two line leads. To change direction of rotation on a two-phase motor, interchange the leads of either phase.

CAUTION: Reverse rotation with the pump connected can cause extensive damage to the pump – ALWAYS check rotation before connecting driver to pump.

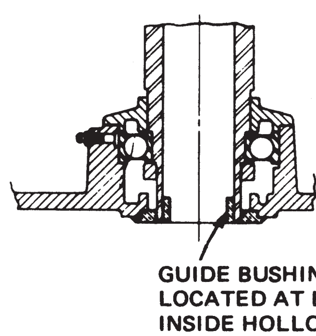


Figure III-2. Motor Guide Bushing Location

NOTE: On units equipped with one piece headshaft (no lineshaft coupling between driver and pump) Steps 11, 12 and 13 will not be applicable.

11. Clean all shaft threads (both ends of head shaft and on top shaft). Try the lineshaft coupling and headshaft nut on their respective threads. These should thread on by hand. If not, clean up threads with fine three cornered file. Check ends of shaft where they will butt inside lineshaft coupling. Ends must be square and clean. Fit gib key so it slides smoothly.

12. Lubricate top shaft threads and thread (LEFT OR RIGHT HAND threads) headshaft nut half way onto top shaft.

CAUTION: Apply thread lubricant only to male shaft threads. Apply sparingly to avoid build-up between ends of shaft which could cause misalignment.

13. Lower headshaft carefully down through driver. Clean and lubricate threads and thread into lineshaft coupling. Shafts must butt against each other.

NOTE: Headshaft should stand centered (long shafts may lean slightly from own weight, however, they can be centered without effort) in the driver hollow shaft. If not, check driver mounting flange for improper mounting and re-clean ends of shaft where coupled inside discharge head.

14. Remove headshaft nut and install clutch on driver being careful that it fits down properly.

15. Install gib key in clutch and shaft. Gib key should be a slip fit. Do not force.

16. Thread adjusting nut down (RIGHT OR LEFT HAND threads) on shaft until it bears against clutch.

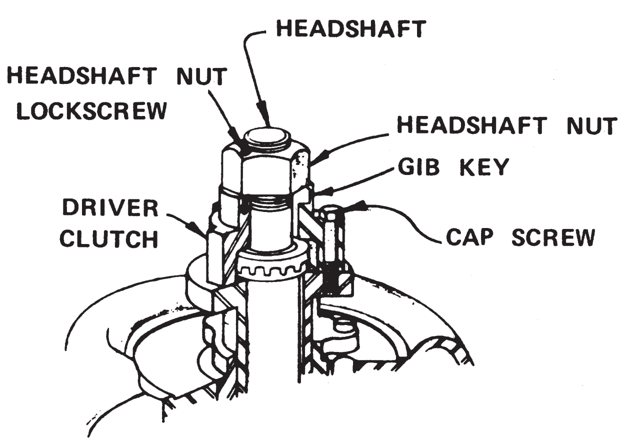


Figure III-3. Hollow Shaft Driver Clutch

17. See paragraph III-6 for impeller adjustment.

18. Adjust mechanical seal AFTER adjusting impellers.

III-5 INSTALLING SOLID SHAFT DRIVER

1. Clean driver mounting flange on discharge head and check for burrs or nicks on the register and mounting face.

2. Clean pump half of AFS coupling and fit key to shaft, and install. Clean headshaft threads. Lubricate and try adjusting nut. The adjusting nut should run down on the threads by hand, until flush with top of threads on headshaft.

3. Lift driver and clean mounting flange, checking for burrs and nicks.

4. Install driver half-coupling on driver shaft (See Figure III-4 and III-6 for coupling illustrations):

   a. Place straight key into keyway, be sure the key is up far enough to clear the groove cut around the shaft near the end.

   b. Slide driver half-coupling onto shaft far enough to insert the circular thrust rings into the shaft groove.

   c. Install circular thrust ring in shaft groove. When properly positioned, the half-coupling will slip down over the circular key and hold it in position (see Figure III-4.)

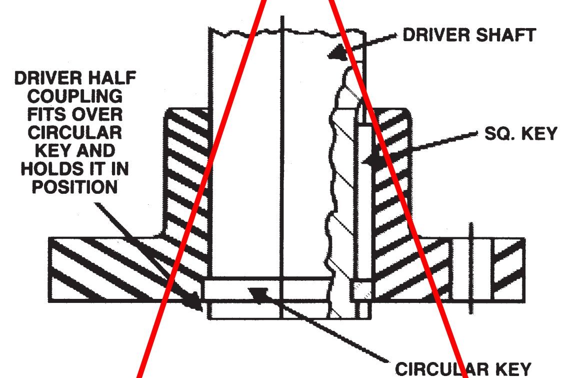


Figure III-4. Driver Half-Coupling Correctly Positioned

5. Mechanical seal should be installed at this time if the pump is so equipped. If the mechanical seal was shipped not installed, see paragraph III-9 for further details.

6. Install pump half-coupling on head shaft:

   a. Slide pump half-coupling onto shaft.

   b. Install key and push down to clear threads.

c. Thread adjusting nut (RIGHT OR LEFT HAND threads) onto shaft until end of shaft is even with top of adjusting nut.

7. Center motor over pump and rotate to align mounting holes.

   Electric Motors — rotate junction box into desired position.

   Gear Drives — rotate input shaft into desired position.

8. Lower driver carefully into place making certain that the female register on the driver mates over the male register on the discharge head.

9. Bolt driver to discharge head.

10. Check driver manufacturer's instructions for special instructions including lubrication instructions and follow all "start up" instructions.

11. Electric drivers should be checked for rotation at this time. Make electrical connections and jog motor briefly to check rotation. **DRIVER MUST ROTATE COUNTERCLOCKWISE** when looking down at the top end of motor. To change the direction of rotation on a three-phase motor, interchange any two line leads. To change direction of rotation on a two-phase motor, interchange the leads of either phase.

CAUTION: Before jogging the motor make sure the coupling halves are not touching and that the driver can rotate freely without rotating the pump. Driver half-coupling must be in proper position as shown in Figure III-4 so the circular thrust ring will not come out.

CAUTION: Reverse rotation with the pump connected can cause extensive damage to the pump. ALWAYS check rotation before connecting driver pump.

12. On pumps using the spacer-type coupling, bolt the spacer to the driver half-coupling.

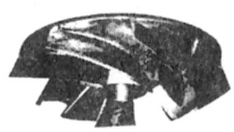
13. On adjustable flanged couplings — thread the adjusting nut up the shaft until there is a proper gap between nut and spacer or driver half-coupling. (See paragraph III-6 for impeller adjustment.)

NOTE: Adjusting Nuts on all sizes have drilled holes inside inserting handle of hex wrench or round bar to facilitate adjustment.

14. Adjust mechanical seal AFTER adjusting impellers.

III-6. IMPELLER ADJUSTMENT – GENERAL

Proper impeller adjustment positions the impeller inside the bowl assembly for maximum performance. The impellers must be raised slightly to prevent dragging on the bowls. Impellers are of two basic types: "enclosed" and "semi-open" (sometimes called "semi-enclosed"). The type of impeller will determine proper adjustment. The type of impellers installed in the pump can be determined from the pump nameplate or packing slip. The second letter of the pump type indicated enclosed impellers by "C" and semi-open "O", thus "MO" would indicate semi-open impellers while "MC" would indicate enclosed impellers.



Semi-Open Type Impeller

Enclosed Type Impeller

Figure III-5. Types of Impellers

ENCLOSED IMPELLERS — Enclosed impellers should be raised 1-1/2 to 2 turns of the adjusting nut or approximately 1/8".

SEMI-OPEN IMPELLERS — The adjustment of semi-open impellers is more critical than for enclosed impellers. The performance of the pump will vary considerably (see Figure V-2) for a small change in the impeller setting. For maximum performance, the impeller must run within a few thousandths of the bowl seat — exact shaft adjustment will vary according to variables of each installation; however, for close-coupled units as covered by this manual a general rule of .015" plus .005" for each 100 feet of discharge head produced by the pump plus .005" for each 10 feet of column assembly will provide near ideal adjustment. The highest discharge head the unit will be expected to operate against should be used for this adjustment. As an example – a pump designed to operate at 400' discharge head but will also be operated against a closed valve for short period at which time it will produce 500', therefore 5 x .005" = .025". If the unit has 20' of column assembly — 2 x .005" = .010". The initial adjustment would be .025" + .010" + .015" = .050".

CAUTION: The impellers must be down against the bowl seat when starting impeller adjustment. All dimensions and instructions given above assume the impellers are initially all the way down. When pumps are subjected to suction pressure the pressure acting against the shaft ends, raise them. If the suction pressure is great enough it can raise the shaft. Make sure the shaft is down when starting to adjust the impellers.

If, after making the above adjustment, the pump does not deliver its rated capacity, the impellers can be lowered one step at a time until the lowest possible adjustment is achieved without the impellers dragging. On the other hand, if the impellers appear to be dragging after the initial adjustment, the unit should be stopped and the impellers raised one step. Dragging impellers will increase the load markedly and can usually be heard and felt as increased vibration.

NOTE: If semi-open impellers are raised and then adjusted down, a slight increase in power required will be noted due to the increased delivery of the pump. Do not confuse this with the marked increase when the impellers are lowered enough to drag.

III-7 IMPELLER ADJUSTMENT – HOLLOW SHAFT DRIVER

Impeller adjustment, when using a hollow shaft driver is accomplished at the top of the driver by the following procedure. The driver canopy will have to be removed before beginning.

1. Install headshaft as outlined in paragraph III-4 if not already in place.
2. Install driver clutch in accordance with the driver instruction manual and bolt into place.
3. Install gib key, making sure top of gib key slides easily down below top of clutch.
4. Check shaft position — raise shaft slightly by hand and lower until there is a definite feel of metal contacting metal. This indicates the impellers are "on bottom" and is the correct starting position for impeller adjustment.
5. Thread headshaft nut down (RIGHT OR LEFT HAND threads) until impellers are just lifted off their seat and the shaft will rotate freely. When semi-open impellers are used the correct determination of the point where the impellers just barely clear their seat is very important for proper adjustment.
6. Adjust impellers as outlined in paragraph III-6.
7. Lock the headshaft nut with lockscrews inserted down through holes in headshaft nut and threaded into driver clutch.

CAUTION: Always lock headshaft nut before starting driver. Failure to do so could result in damage to the pump and driver.

III-8. IMPELLER ADJUSTMENT – SOLID SHAFT DRIVER

Impeller adjustment when using solid shaft drivers is accomplished in the adjustable flanged coupling located below the driver.

III-8a. ADJUSTABLE FLANGED SPACER COUPLINGS

1. Assemble coupling on pump and driver as outlined in paragraph III-5.
2. Rotate adjusting nut up shaft (threads are RIGHT OR LEFT HAND) until the nut bears firmly against spacer or driver shaft and headshaft will not move down. This will insure that the impellers are all the way down against their seat and in proper position for adjustment.
3. Thread adjusting nut down until the proper impeller adjustment as outlined in paragraph III-6 can be measured between the adjusting nut and spacer or driver half-coupling as shown in Figure III-6.

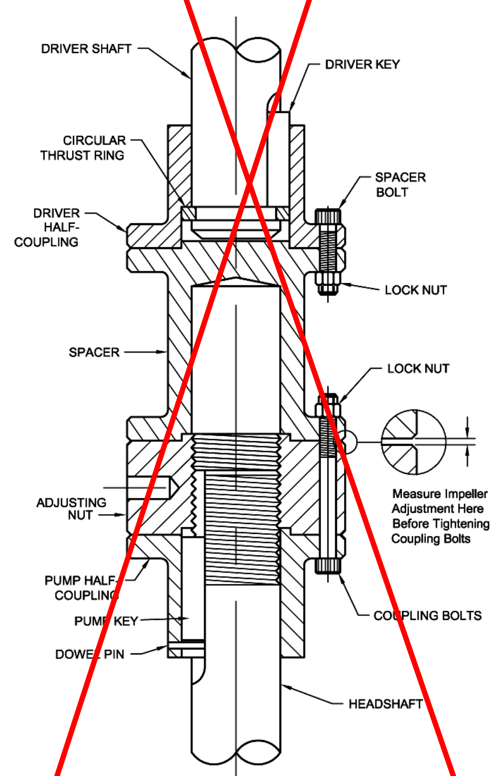


Figure III-6. Adjustable Flanged Coupling (Illustrated with Spacer)

4. Slide pump half-coupling up shaft and align adjusting nut bolt holes with those in pump half-coupling. Rotate driver shaft until bolts can be inserted and tightened.
5. Tighten all bolts which will raise impellers to correct for any operating position.

III-9. MECHANICAL SEAL

Because of the numerous mechanical seal arrangements available, separate instruction manuals are written covering installation and operation of these seals. There are, however, comments which apply to all seals.

1. The seal cavity must be clean before installing seal.
2. The faces and register of the seal housing and gland plate or cap must be clean and free of burrs.
3. The shaft seal is a precision product. Treat it with care. Take particular care not to scratch or chip the lapped faces of the runner or seat.
4. Circulation lines must remain in place and open. Do not remove.
5. Impeller adjustment must be made PRIOR to seal adjustment.

READ THE MECHANICAL SEAL INSTRUCTION MANUAL FURNISHED WITH THIS UNIT.

III-10. STUFFING BOXES

Stuffing boxes are pre-packed at the factory and will be factory installed. Do not tighten the packing gland. See Section V for further information.

III-11. ENCLOSING TUBE TENSION

The enclosing tube (enclosed lineshaft design) tension is pre-adjusted at the factory before shipping on short set pumps: additional adjustment will not be required. See assembly instructions (Section VI) if assembly or adjustment is required for any reason.

SECTION IV
OPERATION

IV-1. PRE-STARTING CHECKS

Before starting the pump, the following checks should be made:

1. Rotate the pump shaft by hand to make sure the pump is free and the impellers are correctly positioned.
2. Is the head shaft adjusting nut properly locked into position?
3. Has the driver been properly lubricated in accordance with the instructions furnished with the driver?
4. Has the driver been checked for proper rotation? If not, the pump must be disconnected from the driver before checking. The driver must rotate COUNTER CLOCKWISE when looking down at the top of the driver.
5. Check all connections to the driver and control equipment.
6. Check that all piping connections are tight.
7. Check all anchor bolts for tightness.
8. Check all bolting and tubing connections for tightness (driver mounting bolts, flanged coupling bolts, gland plate bolts, seal piping, etc.).
9. On pumps equipped with stuffing box, make sure the gland nuts are only finger tight — DO NOT TIGHTEN packing gland before starting.
10. On pumps equipped with mechanical seals, clean fluid should be put into the seal chamber. With pumps under suction pressure this can be accomplished by bleeding all air and vapor out of the seal chamber and allowing the fluid to enter. With pumps not under suction pressure, the seal chamber should be flushed liberally with clean fluid to provide initial lubrication. Make sure the mechanical seal is properly adjusted and locked into place.

NOTE: After initial start-up, pre-lubrication of the mechanical seal will usually not be required as enough liquid will remain in the seal chamber for subsequent start-up lubrication.

11. On pumps equipped with enclosed lineshaft, lubricating liquid must be available and should be allowed to run into the enclosing tube in sufficient quantity to thoroughly lubricate all lineshaft bearings.

IV-2. INITIAL STARTING

1. If the discharge line has a valve in it, it should be partially open for initial starting — Min. 10%.
2. Start lubrication liquid flow on enclosed lineshaft units.
3. Start the pump and observe the operation. If there is any difficulty, excess noise or vibration, stop the pump immediately and refer to Section V for probable cause.
4. Open the discharge valve as desired.

5. Check complete pump and driver for leaks, loose connections or improper operation.

6. If possible, the pump should be left running for approximately ½ hour on the initial start-up. This will allow the bearings, packing or seals, and other parts to "run-in" and reduce the possibility of trouble on future starts.

NOTE: If abrasives or debris are present upon start-up, the pump should be allowed to run until the pumpage is clean. Stopping the pump when handling large amounts of abrasives (as sometimes present on initial starting) may lock the pump and cause more damage then if the pump is allowed to continue operation.

CAUTION: Every effort should be made to keep abrasives out of lines, sumps, etc. so that abrasives will not enter the pump.

IV-3. STUFFING BOX ADJUSTMENT

On the initial starting it is very important that the packing gland not be tightened too much. New packing must be "run in" properly to prevent damage to the shaft and shortening of the packing life. See paragraph V-3c, page 10 for further information.

The stuffing box must be allowed to leak for proper operation. The proper amount of leakage can be determined by checking the temperature of the leakage, this should be cool or just lukewarm — NOT HOT.

When adjusting the packing gland bring both nuts down evenly and in small steps until the leakage is reduced as required. The nuts should only be tightened about ½ turn at a time at 20 to 30 minute intervals to allow the packing to "run in".

Under proper operation, a set of packing will last a long time. Occasionally a new ring of packing will need to be added to keep the box full. After adding two or three rings of packing, or when proper adjustment cannot be achieved, the stuffing box should be cleaned completely of all old packing and re-packed.

IV-4. LINESHAFT LUBRICATION

Open lineshaft bearings are lubricated by the pumped fluid and on close coupled units (less than 30' long) will usually not require pre or post lubrication.

Enclosed lineshaft bearings are lubricated by extraneous liquid (usually oil or clean water) which is fed to the tension nut by either a gravity flow system or pressure injection system. The gravity flow system utilizing oil is the most common arrangement. The oil reservoir must be kept filled with a good quality light turbine oil (about 150 SSU at operating temperature) and adjusted to feed 10 to 12 drops per minute plus one (1) drop per 100' of setting.

Injection systems are designed for each installation — injection pressure and quantity of lubricating liquid will vary. Refer to packing slip or separate instruction sheet for requirements when unit is designed for injection lubrication.

The following oils can be recommended for Enclosed Lineshaft Bearing Lubrication under normal operating conditions.

MANUFACTURER	TRADE NAME OF OIL
Continental Oil Company	Conoco Turbine Oil, Light
Exxon Company	Teresstic - 32
Mobil Oil Company	Mobile DTE - 797
Shell Oil Company	Tellus 32
Standard Oil Co. of Calif.	Chevron OC Turbine 9
Texaco, Inc.	Texaco Regal 32 R & O

If none of the above oils is available, an oil with the following specifications should be obtained: Turbine type oil with rust and oxidation inhibitors added. Viscosity 145-175 SUS at 100°F with a 90 minimum viscosity index.

It is recommended that detergent type oils not be used.

Figure IV-1. Recommended Lineshaft Oil

SECTION V
MAINTENANCE

V-1. GENERAL

A periodic inspection is recommended as the best means of preventing breakdown and keeping maintenance costs to a minimum. Maintenance personnel should look over the whole installation with a critical eye each time the pump is inspected — a change in noise level, amplitude or vibration, or performance can be an indication of impending trouble.

Any deviation in performance or operation from what is expected can be traced to some specific cause. Determination of the cause of any misperformance or improper operation is essential to the correction of the trouble — whether the correction is done by the user, the dealer or reported back to the factory.

Variances from initial performance will indicate changing system conditions or wear or impending breakdown of unit.

V-2. PERIODIC INSPECTION

A periodic, once-a-month inspection is suggested for all units. During this inspection, the pump and driver should be checked for performance and change in noise or vibration level, loose bolts or piping, dirt and corrosion. Clean and re-paint all areas that are rusted or corroded.

V-3. STUFFING BOX MAINTENANCE

Maintenance of the stuffing box will consist of greasing the box when required, tightening the packing gland occasionally as the leakage becomes excessive, and installing new packing rings or sets as required.

V-3a. GREASING THE STUFFING BOX

Under ordinary operation, once-a-month greasing of the stuffing box will be adequate. A good grade of grease such as Standard of California No. TB-medium or Texaco Multi-fax No. 2-medium should be used.

V-3b. REPLACING PACKING

Remove gland and all old packing. If the box contains a lantern ring remove this and all packing below it. Inspect shaft or sleeve for score marks or rough spot. Be sure by-pass holes (if required) are not plugged. Repair or replace badly worn shaft or sleeve. If wear is minor, dress down until smooth and concentric. Clean box bore.

Oil inside and outside of replacement rings lightly and install box, staggering joints 90 degrees. Be sure to replace lantern ring in proper position when used.

Replace gland and tighten nuts, making sure gland enters box squarely. Keep the packing under moderate pressure for one minute to allow it to cold flow and adjust itself. Back off on the gland until loose before starting the pump.

V-3c. START UP WITH NEW PACKING

Check that the bypass line (if used) is connected and packing gland nuts are finger tight only. Start pump and allow to run for 20 to 30 minutes. Do not tighten the gland during this "run-in" period even if leakage is excessive. If the leakage continues to be more than normal, adjust as outlined in paragraph IV-3. Should the new packing cause excess heating during "run-in," flush the shaft and packing box area with cold water or shut the pump down and allow to cool if necessary.

V-3d. AUXILIARY STUFFING BOX MAINTENANCE

Pumps equipped with mechanical seals may also be provided with an auxiliary stuffing box to restrict leakage should the mechanical seal fail. This packing gland must be left loose since, under normal operation, the packing will not be cooled and lubricated by the pumpage. This

"N-260" TYPE				
SHAFT SIZE	NO. OF PACKING RINGS	PACKING RING SIZE	DEPTH OF BOX	BORE OF BOX
1	5	1/4	1-1/2	1-1/2
1-1/4	5	1/4	1-1/2	1-3/4
1-1/2	5	1/4	1-1/2	2
1-11/16	5	1/4	1-1/2	2-3/16

ALL DIMENSIONS ARE IN INCHES

"HI-PRO" TYPE				
SHAFT SIZE	NO. OF PACKING RINGS	PACKING RING SIZE	DEPTH OF BOX	BORE OF BOX
1	6	1/2	3-1/4	2
1-1/4	6	1/2	3-1/4	2-1/4
1-1/2	6	1/2	3-1/4	2-1/2
1-11/16	6	1/2	3-1/4	2-11/16
1-15/16	6	1/2	3-1/4	2-15/16
2-3/16	6	1/2	3-1/4	3-3/16

Figure V-1. Standard Packing Dimensions

stuffing box arrangement is designed to help contain leakage past the mechanical seal. It is not designed as a primary seal and should not be used as such.

V-4. MECHANICAL SEAL MAINTENANCE

Mechanical seals should not be readjusted unless there is a reason. Best results will be obtained if the seal is properly set on start-up and left that way. If the seal starts to leak after an extended operating period, some extra service may be obtained by readjusting. However, it is usually best to plan on replacing the seal at the next maintenance period.

After impeller readjustment, seal leakage may occur due to improper seal adjustment or improper seating of the seal parts. If readjustment of the seal will not correct the problem, refer to the Mechanical Seal Instruction Manual for further information.

V-5. IMPELLER RE-ADJUSTMENT

Ordinarily, impellers will not require readjustment if properly set at initial installation. Almost no change in performance can be obtained by minor adjustment of enclosed impellers. However, the positioning of semi-open impellers has a definite effect on the performance of the pump. This fact is sometimes used to adjust the output of the pump without valving. Figure V-2 illustrates the general effect of raising semi-open impellers.

After extended operation under abrasive conditions the sealing faces between semi-open impellers and the bowl will wear, causing a reduction in performance. The pump performance can be brought back up to almost “as new” by proper readjustment of the impellers. See paragraph III-6 for proper adjustment procedure.

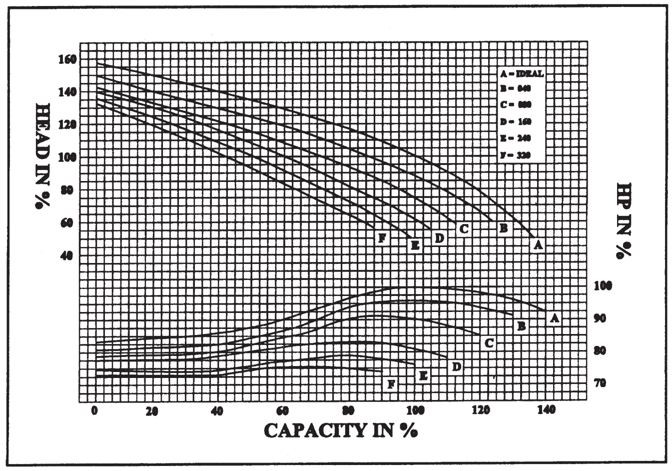
NOTE: All adjustments of the impellers will change the mechanical seal setting. Unless the adjustment is to be very minor, it is recommended that the seal be loosened from the shaft until the adjustment is complete and then reset.

V-6. PUMP LUBRICATION

Other than the stuffing box lubrication outlined in paragraph V-3a and lineshaft lubrication outlined in paragraph IV-4, the pump will not requite further periodic lubrication. The suction bearing on the bowl assembly should be repacked when repairs are made. However, no attempt should be made to repack until repairs to the bowl assembly are necessary.

V-7. DRIVER LUBRICATION

Drivers will require periodic attention. Refer to the driver instruction manual for recommendations.



THE ABOVE CHART INDICATES THE APPROXIMATE EFFECT OF RAISING SEMI-OPEN IMPELLERS FROM THEIR IDEAL (A) OPERATING POSITION. RAISING THE IMPELLERS INCREASES THE CLEARANCE BETWEEN IMPELLER AND BOWL SEAT AND REDUCES THE PERFORMANCE ACCORDINGLY. THE CHART IS GENERAL AND WILL NOT BE EXACTLY CORRECT FOR ANY PARTICULAR PUMP MODEL SINCE EACH MODEL WILL REACT DIFFERENTLY. 100% HEAD AND CAPACITY ARE TO BE TAKEN AS THE HEAD AND CAPACITY OF THE PUMP AT PEAK EFFICIENCY. EXAMPLE: IF A PARTICULAR PUMP DELIVERS 250 GPM AT 50’ HEAD AT PEAK EFFICIENCY WHEN THE IMPELLERS ARE PROPERLY ADJUSTED, RAISING THE IMPELLERS .080: WOULD REDUCE THE CAPACITY TO APPROXIMATELY 181 GPM (72 1/2% OF 250 GPM) WHILE MAINTAINING THE 50’ HEAD OR CONVERSELY, THE PUMP WOULD DELIVER 250 GPM @ 37 1/2’ HEAD (75% OF 50’). THE HORSEPOWER WOULD BE ABOUT 91 1/2% OF THE PREVIOUS HORSEPOWER

Figure V-2. Effect of Raising Semi-Open Impellers

V-8. TROUBLESHOOTING

CONDITION	PROBABLE CAUSE	REMEDY
Pump Will Not Run	1. Motor overload protection contacts open. a. Incorrect control box. b. Incorrect connections. c. Faulty overloads. d. Low voltage. e. Ambient temperature of control box or starter too high. 2. Blown fuse, broken or loose electric connections. 3. Defective motor. 4. Faulty control equipment. 5. Faulty switch. 6. Pump binding.	1. a. Check nameplate for HP and voltage. b. Check wiring diagram furnished with starter. c. Replace. d. Check voltage at pump side of control box. e. Use ambient compensated relays. 2. Check fuses, relays or heater elements for correct size and all electrical connections. 3. Repair or replace. 4. Check all circuits and repair. 5. Repair or replace. 6. Pull master switch, rotate pump by hand to check. Check impeller adjustment or disassemble unit to determine cause.
Pump Runs but No Water Delivered	1. Line check valve backward. 2. Line check valve stuck. 3. Unit running backwards. 4. Lift too high for pump. 5. Pump not submerged. 6. Excessive amounts of air or gas. 7. Intake strainer or impeller plugged, or pump in mud or sand. 8. Impeller loose on shaft.	1. Reverse check valve. 2. Free the valve. 3. See Section III. 4. Check with performance curve. 5. Lower pump if possible or add fluid to system. 6. Correct conditions. 7. Start & stop pump several times or use the line pressure if available to back flush. Pull pump and clean. 8. Pull unit and repair.
Reduced Capacity	1. Bypass open. 2. Lift too high for pump. 3. Motor not coming up to speed. 4. Strainer or impellers partly plugged. 5. Scaled or corroded discharge pipe or leaks anywhere in system. 6. Excessive amounts of air or gas. 7. Excessive water due to abrasives. 8. Impellers not properly adjusted. 9. Impeller loose on shaft.	1. Check bypass valving. 2. Check performance curve. 3. Check voltage while unit is running. 4. Start & stop pump several times or use line pressure if available to back flush. Pull pump and clean. 5. Replace pipe or repair leaks. 6. Correct conditions. 7. Replace worn parts. 8. See Section III. 9. Pull unit and repair.
Motor Over-loaded	1. Line voltage not correct. 2. Faulty equipment used to check. 3. Specific gravity higher than design. 4. Operation at point on pump curve other than design. 5. Motor speed too high. 6. Impellers dragging. 7. Pump in bind.	1. Check and correct. 2. Check equipment. 3. Correct specific gravity or re-evaluate system. 4. Check performance curve. 5. Line voltage too high or incorrect frequency. 6. Re-adjust. 7. Pull master switch, rotate pump by hand to check. Disassemble unit to determine cause.
Pump Noisy and Vibrating Excess-ively	1. Unit running backwards. 2. Pump breaking suction and pumping air. 3. Loose fasteners. 4. Badly worn motor or pump bearings. 5. Impeller loose on shaft. 6. Pump & motor shafts misaligned. 7. Stress due to piping misalignment.	1. See "Initial Starting of Unit" 2. Lower pump or reduce capacity. 3. Check all bolts, nuts, etc. 4. Pull unit and repair. 5. Pull unit and repair. 6. Pull unit and repair. 7. Correct.
Excess Wear	1. Abrasives. 2. Pump in bind. 3. Vibration.	1. Clean System. 2. Pull master switch, rotate pump by hand to check. Disassemble unit to determine cause. 3. Determine cause and correct.
Corrosion	1. Impurities. 2. Corrosive Liquid.	1. Analyze fluid. 2. Change to corrosion resistant materials.

Fig. V-3 Troubleshooting Chart

SECTION VI
REPAIRS

VI-1. GENERAL

It must be borne in mind that eventually repairs have to made, either to the pump or to the motor. When regular maintenance checks indicate that an overhaul is required, it should not be delayed.

Repairs will consist of removal of the unit and disassembly to the point necessary for replacement of worn parts.

Disassembly should be performed in a clean area with sufficient space to lay out the parts in order of disassembly. Cleanliness throughout repairs is important. Remember this is a close toleranced, high speed machine and should be handled as such.

CAUTION: Protect machined surfaces from burrs and scrapes which will cause mis-alignment on reassembly.

VI-2. EQUIPMENT AND TOOLS

Required equipment and tools will be listed in Section II of this manual.

CAUTION: Always pull and lock the driver master switch before doing any work on the pump or driver.

VI-3. STUFFING BOX REPAIRS

Stuffing box repairs can be affected without removing the complete unit. Packing replacement, as outlined in Section V, can be accomplished without disturbing the pump driver. The stuffing box bearing can be replaced if necessary by removing the driver and sliding the stuffing box off the shaft.

VI-4. MECHANICAL SEAL REPAIRS

Mechanical seal repairs can be affected without removing the complete unit. The mechanical seal assembly can be replaced by removing the spacer and lowering half coupling on solid shaft units. On hollow shaft units, the driver shaft and shaft coupling inside the discharge head must be removed or lifted out of the way. Replacement of the bearing located at the bottom of the seal housing will usually require removal of the driver in order to obtain sufficient headroom.

VI-5. DISASSEMBLY

NOTE: Refer to Section VII for parts drawings and identification.

1. Disconnect electrical leads from motor.
2. Loosen mechanical seal from shaft.
3. Disconnect pumpshaft from driver:
   a. Hollow Shaft—Remove headshaft nut lockscrew (132), headshaft nut (131), gib key (133) and driver clutch. Unscrew headshaft (130) from shaft coupling (270) inside discharge head and remove.
   b. Solid Shaft—Lower shaft and unbolt driver half coupling.
4. Remove bolts (123) which attach driver to discharge head.
5. Lift driver off pump and set on wooden supports. With solid shaft drivers be sure supports are high enough to clear shaft and coupling half.
6. Disconnect discharge piping from pump.
7. Remove anchor bolts (or nuts).
8. Lift pump vertically until pump suction clears foundation or base plate.
9. Cover opening in foundation.
10. Lower pump into a horizontal position on suitable support and in a suitable are for disassembly.

NOTE: If more than minor repairs are anticipated it is recommended that the unit be taken to a shop or other clear area with a smooth floor and overhead lifting equipment.

11a. Stuffing box construction — remove slinger (199) and packing gland (185).

11b. Mechanical seal construction — loosen seal cover cap screws (156) and remove gland plate (151).

NOTE: With sleeve mounted mechanical seals the seal and sleeve assembly should be removed with the gland plate. See Seal Instruction Manual for further details.

11c. Enclosed lineshaft construction – remove lockscrew (173) and lubrication line (149) and unscrew tension nut assembly (171). Threads are **LEFT HAND.**

12. Remove cap screws (178) which attach the stuffing box, tube adapter or seal housing to discharge head.
13. Remove stuffing box (175), tube adapter (170) or seal housing (150).

NOTE: If non-sleeve mounted mechanical seal is used the set screws which lock the seal assembly to the shaft must be loosened before removing seal housing.

NOTE: Before proceeding further, make sure the discharge head and bowl assembly are supported independently of each other.

14. Disconnect bowl assembly or top column from discharge head. This connection may be flanged or the column pipe or bowl assembly may be threaded into the discharge head. If threaded, the threads will be **RIGHT HAND**.

15. Remove discharge (101) being careful not to damage or bend shaft.

16. Disconnect column pipe (251) (if present) at first joint below top and remove from shaft.

17. (a) Open Lineshaft Construction — Each time a lineshaft coupling (270) is exposed by removing length of column pipe the lineshaft (272) and coupling should be removed by holding the lower lineshaft and turning the coupling in a **RIGHT HAND** direction (lineshaft threads are **LEFT HAND**). Bearing retainers (280) should be removed after the lineshaft coupling. Before lifting the bearing retainer out of the pipe coupling or register in flanged column — any nicks or burrs on the shaft should be removed.

CAUTION: When using wrenches on shafting always place the wrenches on the same side of the shaft to avoid excess side strain on the shafting. Care should always be taken so that exposed lengths of shafting are not damaged or bent.

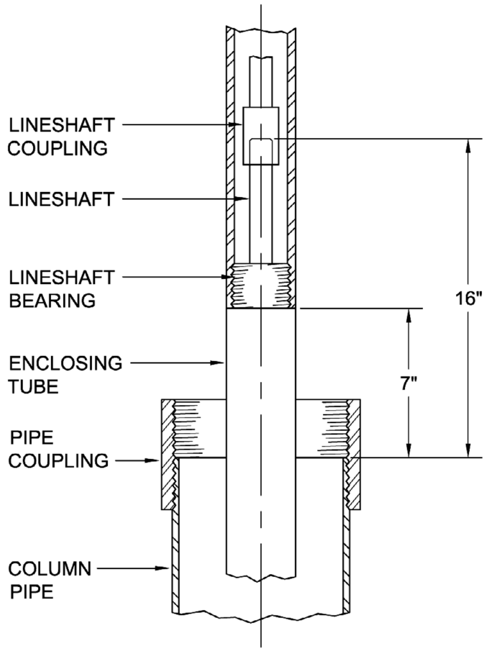


Figure VI-1. Standard Enclosing Tube and Lineshaft Projection

17. (b) Enclosed lineshaft construction — Each time a length of column pipe is removed the enclosing tube (241) and lineshaft (235) must also be disassembled. Locate the joint (See Figure VI-2) and unscrew (RIGH OR LEFT HAND threads) the enclosing tube (241) from the lineshaft bearing (240) (which acts as a bearing for the shaft and also as and enclosing tube coupling). Leave the lineshaft bearing threaded into the enclosing tube not being removed (to support the lineshaft). Slide the enclosing tube up to expose the lineshaft coupling and uncouple as outlined in step 17(a) above.

18. Disconnect each section of column pipe one at a time and remove along with shaft and enclosing tube as applicable until all are removed.

19. Remove bowl assembly to clear area and continue disassembly.

VI-6 INSPECTION AND CLEANING

After disassembly, all components should be thoroughly cleaned and examined for physical defects, wear, corrosion and damage.

Check all bearings for total clearance over the shaft diameter. It is recommended that all bearings indicating wear be replaced. The following indicates the maximum allowable diametrical clearance over existing shaft diameter:

1” through 1-3/4” shaft — .020” clearance.
1-15/16” through 2-7/16” shaft — .025” clearance.
2-11/16” through 3-15/16” shaft — .030” clearance.

All bearings are pressed into their respective bores and can be either pressed out or machined on the inside diameter until the wall is thin enough to collapse.

VI-7. REPLACEMENT PARTS

Parts showing signs of damage, cracks or excessive wear should be replaced.

CAUTION: When repairing a pump that has been in service for several years, the physical condition or strength of all parts such as cap screws, bowls, threads, etc., must be carefully checked to be sure that these parts can continue to perform their function without failure.

VI-8. LUBRICATION

Lubricate all bearings and impeller skirts with clean grease or oil. Thoroughly clean all threaded connections and flanges and paint with threading compound and oil or pipe joint compound.

VI-9. ASSEMBLY

Assembly of the unit is basically the reverse of disassembly. Before proceeding with assembly, clean thoroughly and check all threads, registers and mating faces for burrs. Clean up with file where required. Lubricate as outlined above. Oil all shafts lightly.

Proceed with assembly in reverse order of disassembly as outlined in paragraph VI-5 above. Figure VI-2 indicates recommended torque values for standard fasteners.

Fastener Size	1/4	5/16	3/8	7/6	1/2	9/16	5/8	3/4
Torque (Ft.- Lb.)	5.4	10	17	27	40	60	84	135

Torque values shown are standard fasteners lubricated with a high stress lubricant (graphite and oil, monlydisulphite, white lead, etc.)

Figure VI-2. Torque Values for Standard Fasteners

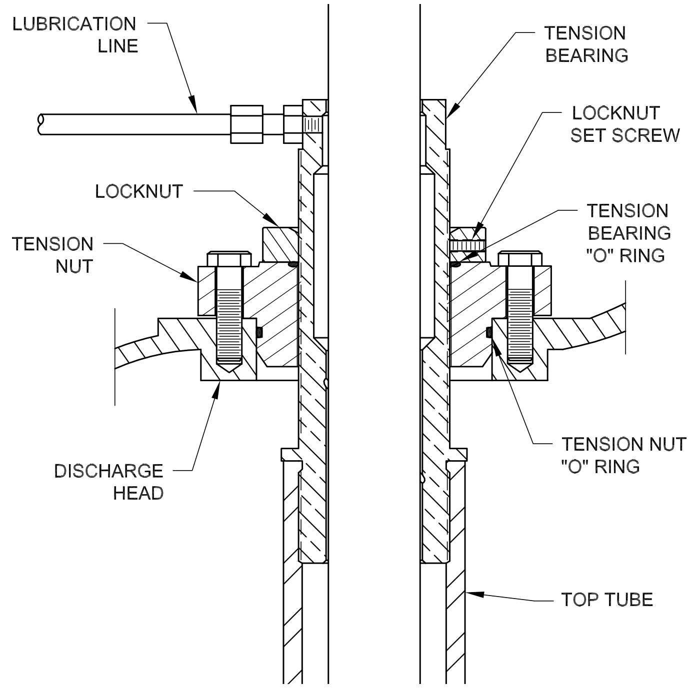


Figure VI-3. Tube Adapter Assembly "N260" & "Hi-Pro Type Unit

CAUTION: Cleanliness and proper lubrication are very important since one small chip, burr or one dry bearing can be a cause for re-doing the whole job.

VI-10. TENSION NUT ASSEMBLY AND ADJUSTMENT

Enclosed lineshaft (oil lubricated) units use a tube tension assembly which must be properly tightened for proper operation. General construction is shown in Figure VI-3.

1. Clean all machined surfaces thoroughly before assembly.
2. Assemble tube tension bearing into top tube and tighten properly before placing discharge head on top column nipple.
3. Thread discharge head with top column flange on to top column nipple.
4. Place "O" ring on tension nut and thread tension nut on to tube tension bearing until nut is snug against discharge head. Continue to tighten tension nut until bolt holes in discharge head line up with tension nut holes (1/4 – 1/2 turn should be sufficient). Install four (4) tension nut capscrews.

CAUTION: It is necessary that the enclosing tube have tension on it which is accomplished by tightening the tension nut. However, excess tightening will distort or break the tube tension bearing. Do not tighten more than 1-1/4 turns on close-coupled pumps.

5. Place "O" ring over tube tension bearing and proceed to thread lock nut onto the tube tension bearing. Tighten as required.
6. Install lock nut set, screw, and tighten.
7. Install lubrication line and fittings as shown in Figure VI-3.
8. Proceed with remainder of installation.

VII
PARTS LIST

VII-1. ORDERING PARTS

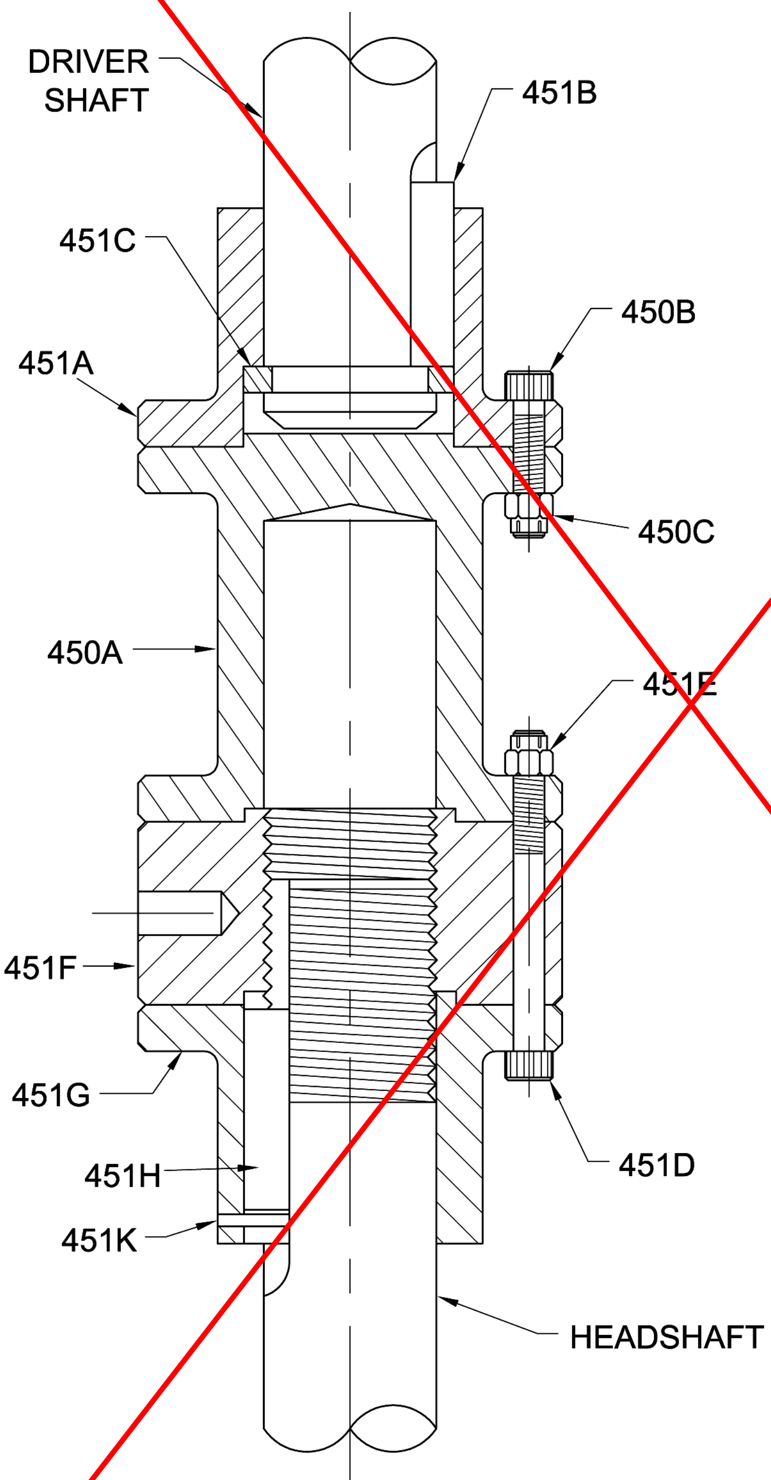
When ordering spare or replacement parts the pump serial number and size and type of pump must be given. This can be found on the nameplate furnished with the unit. Give the complete name and reference number of each part as indicated on the applicable sectional drawing (Fig. VII-2 or VII-3) and the quantity required.

VII-2. STOCKING SPARE PARTS

Spare parts to be kept in inventory will vary according to service, field maintenance anticipated, allowable down time and number of units. A minimum inventory of one complete set of bearings, gaskets, "O" rings, and packing (or mechanical seal) and one spare of each moving part is suggested.

PARTS LIST

Illustrated with Spacer

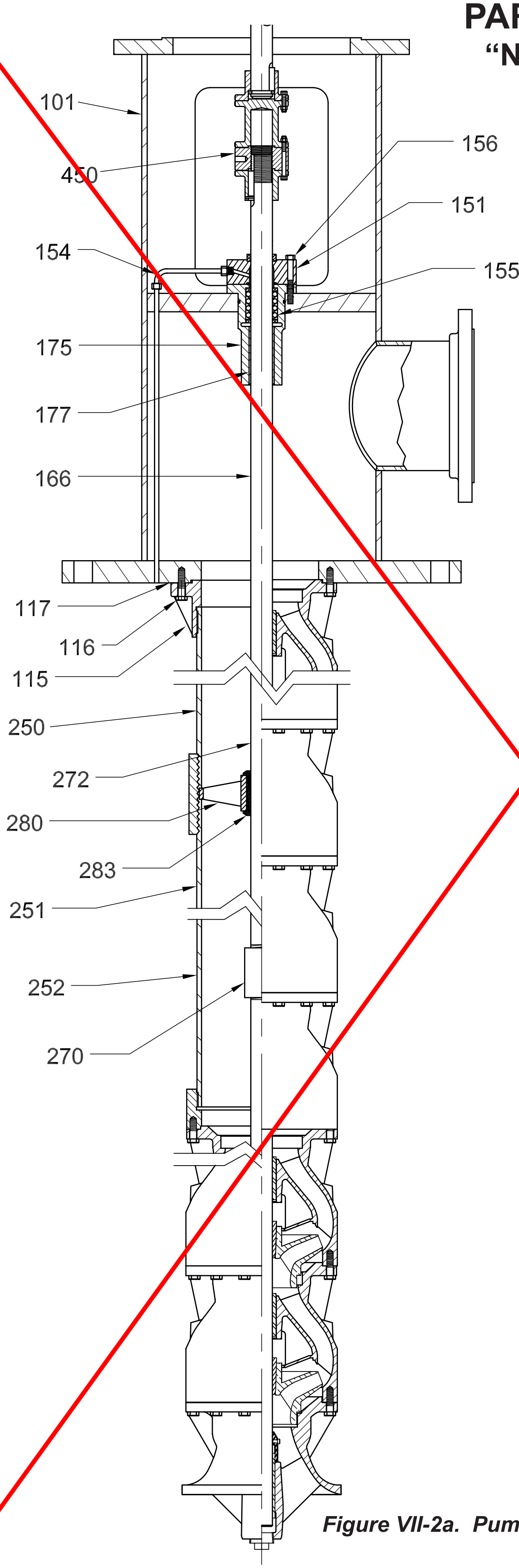


REF. NO.	DESCRIPTION
450	Assembly - With Spacer
451*	Assembly - Less Spacer
450A	Spacer
450B	Spacer Bolts
450C	Lock Nuts
451A	Driver - Half Coupling
451B	Driver Key
451C	Split Thrust Ring
451D	Coupling Bolts
451E	Lock Nuts
451F	Adjusting Nut
451G	Pump Half Coupling
451H	Pump Key
451K	Dowel Pin

*Construction for coupling assembly less spacer will be identical to that shown, except parts 450A, 450B and 450C will be omitted.

Figure VII-1. Adjustable Flanged Coupling Parts List

PARTS LIST
"NF" TYPE



ILLUSTRATED WITH MECHANICAL SEAL

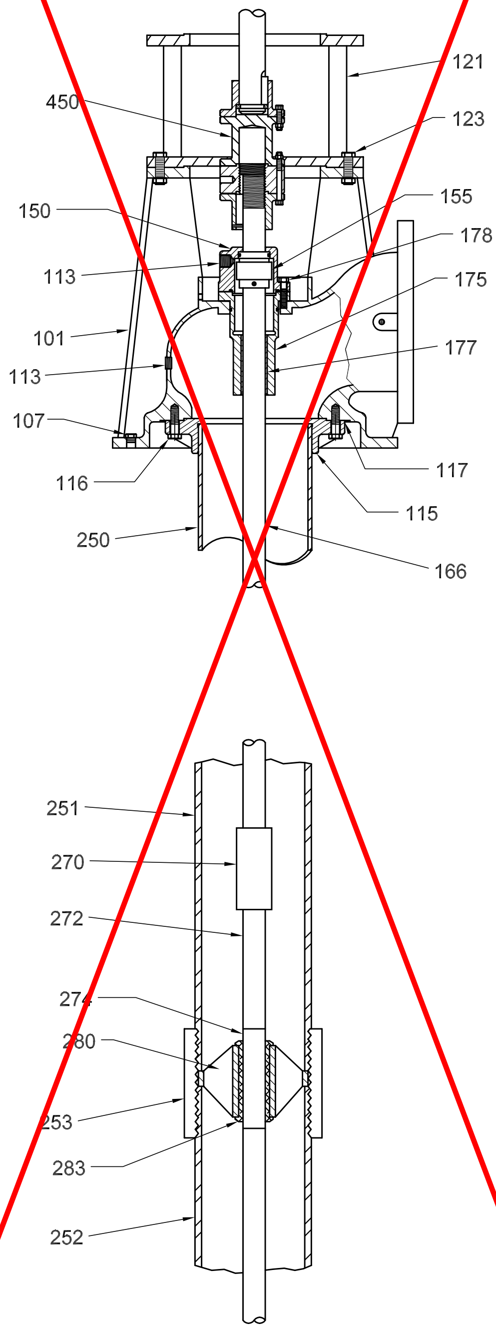
REF. NO.	DESCRIPTION
101	Discharge Head
116	Top Column Flange Capscrews
117	Top Column Flange Gasket
151	Gland Plate
154	By-pass Line with Fittings
155	Mechanical Seal Assembly
156	Packing Gland Capscrews
166	Top Lineshaft
175	Stuffing Box
177	Stuffing Box Bearings
250	Top Column Pipe
251	Intermediate Column Pipe
252	Bottom Column Pipe
270	Shaft Coupling
272	Intermediate Lineshaft
280	Bearing Retainer
283	Open Lineshaft Bearing
450	See Figure VII-1

Figure VII-2a. Pump Parts List

PARTS LIST

"HI-PRO" AND "N260" TYPE

Illustrated with adjustable flanged spacer coupling, motor stand and mechanical seal.



Note: Lineshaft sleeve (274) may be omitted when special material is used for lineshaft bearings (283) and/or lineshafts (272).

"HI-PRO" AND "N260" TYPE

Illustrated with solenoid operated lubricator assembly for enclosed lineshaft.

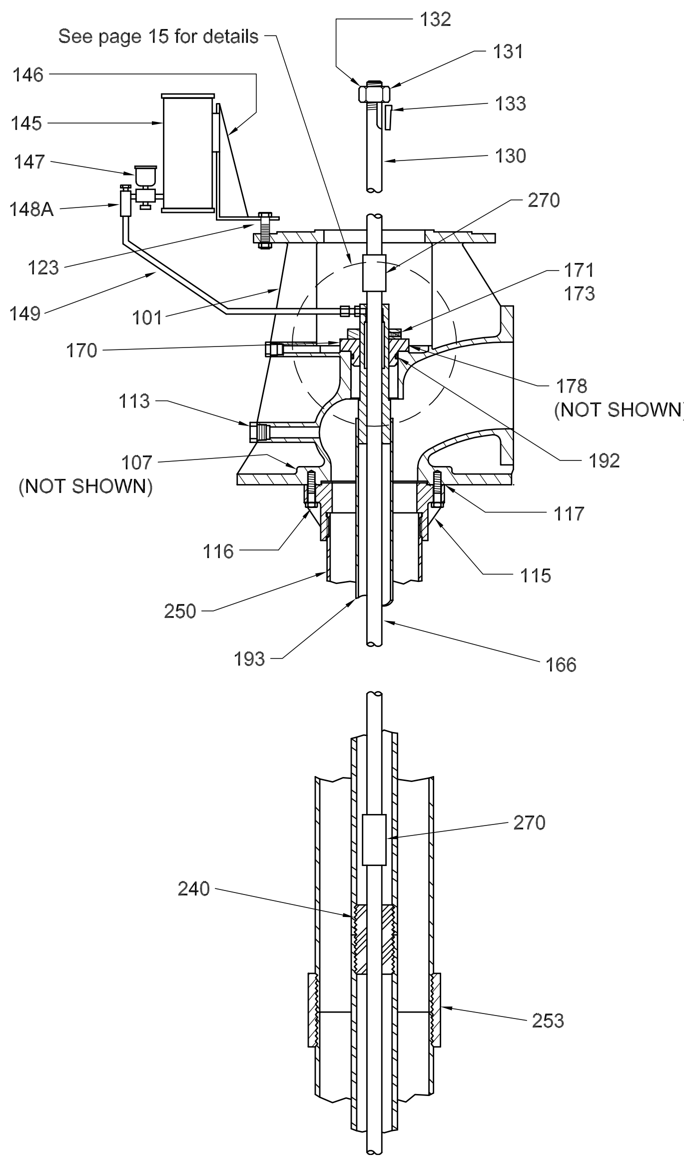
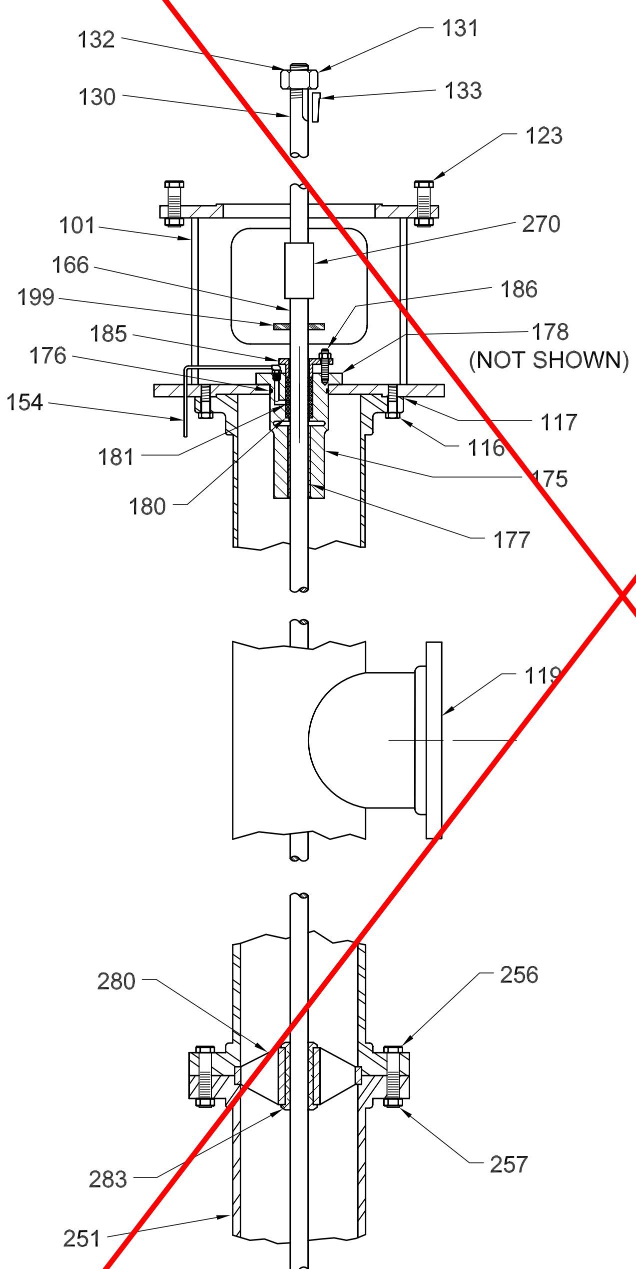


Fig. VII-2b. Pump Parts List

PARTS LIST

"NUF" TYPE

Illustrated with hi-pressure stuffing box and flanged column pipe.



Note: Complete pump description with serial number must be supplied when ordering parts.

REF. NO.	DESCRIPTION
101	Discharge Head
107	Snap Plug
113	Pipe Plug
115	Top Column Flange
116	Top Column Flange Capscrews
117	Top Column Flange Gasket
119	Underground Discharge Assembly
121	Motor Stand
123	Driver Bolts and Nuts
130	Headshaft
131	Headshaft Nut
132	Headshaft Nut Lock Screw
133	Gib Key
145	Lubricator Assembly
146	Lubricator Mounting Bracket
147	Solenoid Valve
148A	Sight Feed Valve (Auto)
148M	Sight Feed Valve (Man) - not shown
149	Lubrication Line with Fittings
150	Gland Cap
154	By-Pass with Fittings
155	Mechanical Seal Assembly
166	Top Line Shaft
170	Tube Tension Nut
171	Lock Nut
173	Lock Nut Set Screw
175	Stuffing Box
176	Stuffing Box "O" Ring
177	Stuffing Box Bearing
178	Stuffing Box Cap Screws
180	Packing Rings
181	Lantern Rings
185	Packing Gland
186	Pacing Gland Studs & Nuts
192	Tension Nut "O" Rings
193	Top Tube
199	Slinger
240	Lineshaft Bearing
250	Top Column Pipe
251	Intermediate Column Pipe
252	Bottom Column Pipe
253	Column Pipe Coupling
256	Column Flange Bolts
257	Column Flange Nuts
270	Shaft Coupling
272	Intermediate Lineshaft
274	Lineshaft Sleeve
280	Bearing Retainer
283	Open Lineshaft Bearing
450	See Fig. VII-1

Fig. VII-2c. Pump Parts List

PARTS LIST

BOWL ASSEMBLY

BRONZE BEARING OIL LUBRICATED (BZL) ENCLOSED LINESHAFT CONSTRUCTION

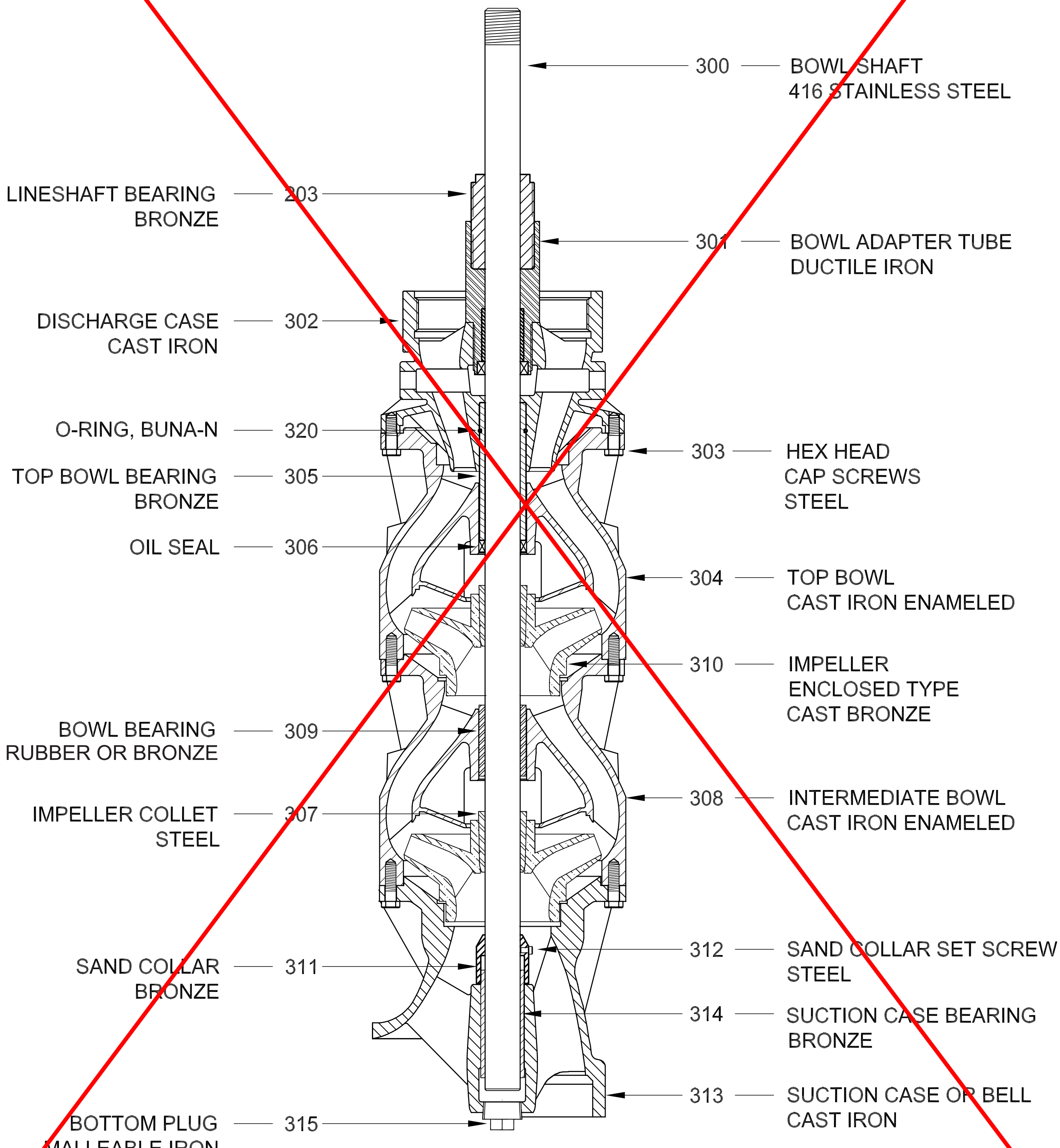


Figure VII-3a.

ALTERNATE MATERIALS AVAILABLE UPON REQUEST

PARTS LIST

BOWL ASSEMBLY

PRODUCT LUBRICATED (PRL)
OPEN LINESHAFT CONSTRUCTION

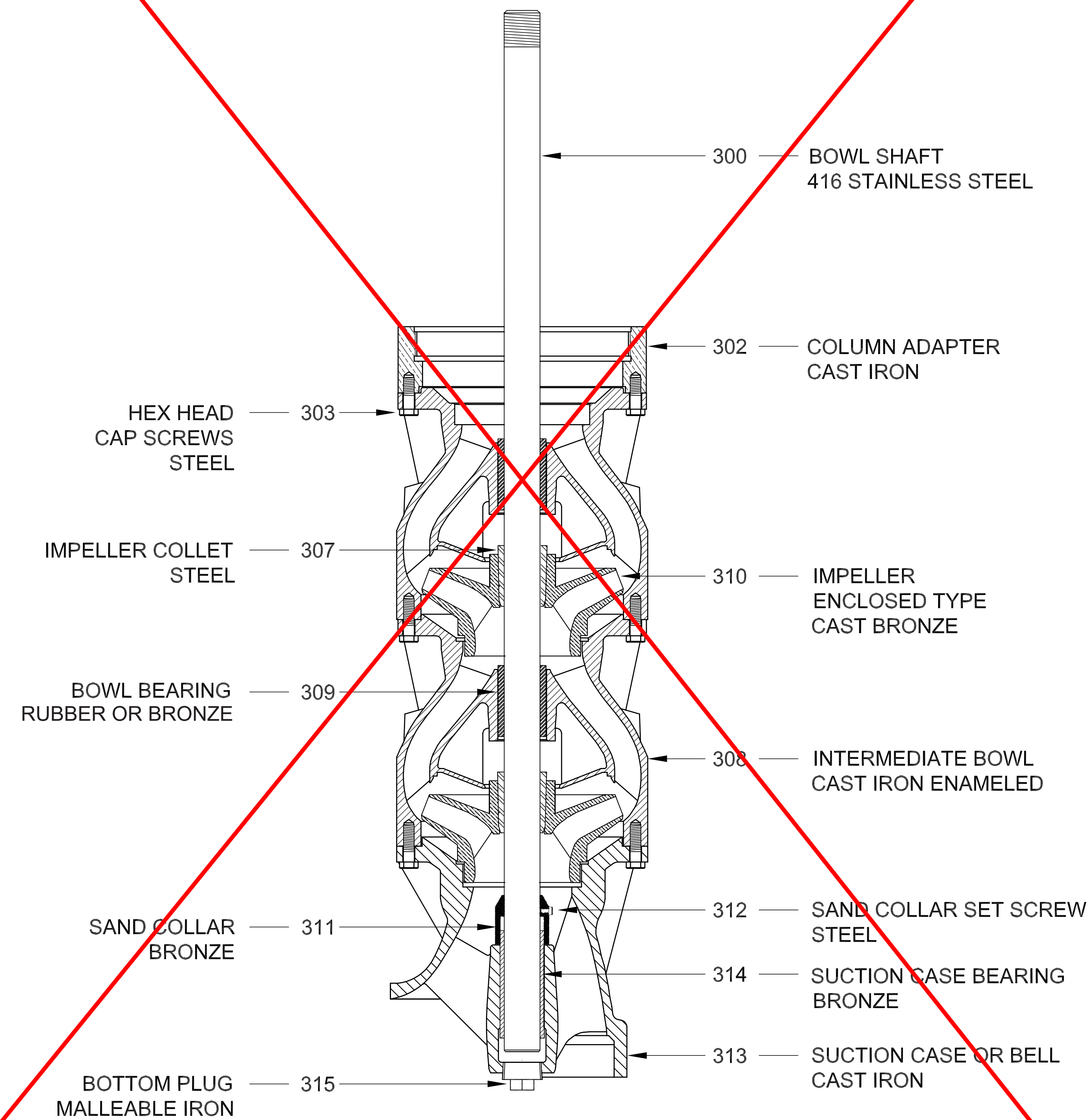


Figure VII-3b.

ALTERNATE MATERIALS AVAILABLE UPON REQUEST

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

NOTES

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

MAIN OFFICE

ARIZONA
7706 N. 71st Avenue
Glendale, AZ 85303-1703
(623) 979-3560 • Fax (623) 979-2177
(800) 966-5240

nqa. ISO 9001 Registered

FACTORY BRANCH LOCATIONS

CALIFORNIA
2790 S. Railroad Avenue
Fresno, CA 93725
(559) 497-5071 • Fax (559) 497-8816
(800) 868-9755

FLORIDA
195 E. 3rd Street
Zolfo Springs, FL 33890
(863) 735-8222 • Fax (863) 735-8202
(800) 994-3045

GEORGIA
902 East Union Street
Vienna, GA 31092
(229) 268-2921 • Fax (229) 268-7136
(800) 741-2921

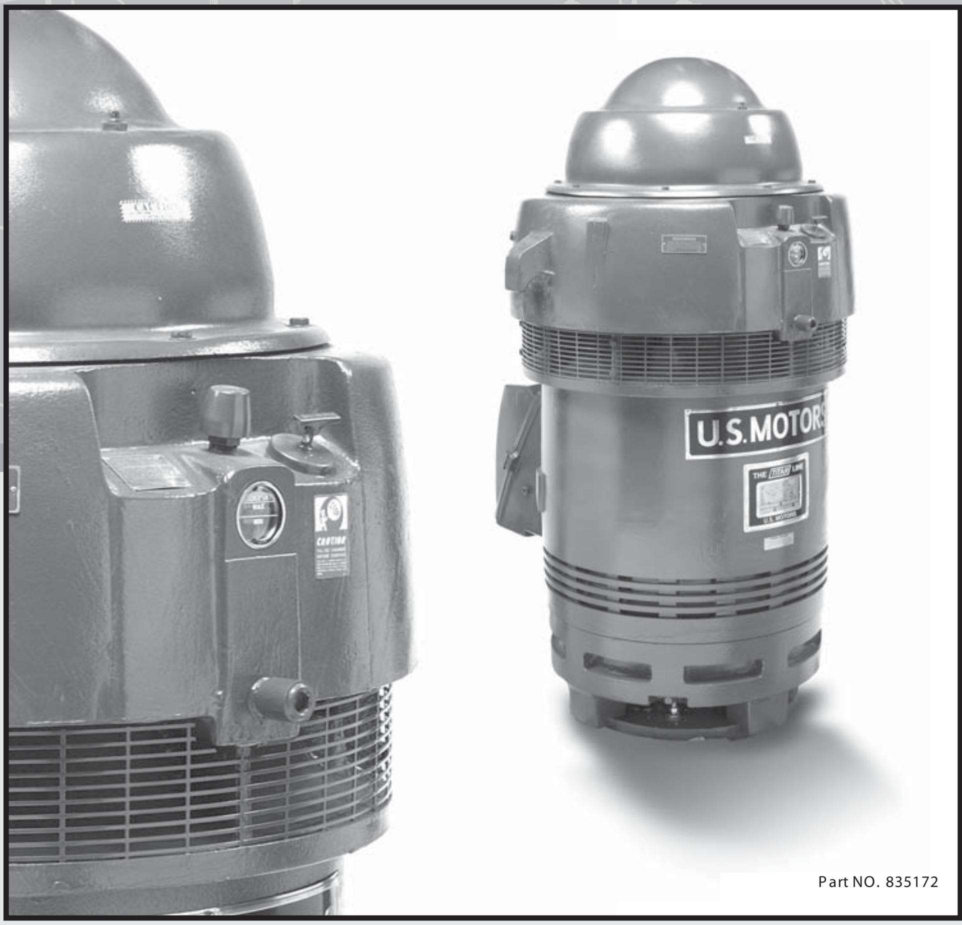
MISSISSIPPI
11176 Green Valley Drive
Olive Branch, MS 38654
(662) 895-1110 • Fax (662) 895-5083
(866) 668-4914

TEXAS
3107 Slaton Highway
Lubbock, TX 79404
(806) 745-5396 • Fax (806) 745-6668
(800) 745-5393

Email: info@natlpump.com

www.nationalpumpcompany.com

Vertical High Thrust Motors



Installation, Operation, and Maintenance

MOTORS

EMERSON™
Motor Technologies

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SAFETY FIRST!

High voltage and rotating parts can cause serious injury or loss of life. Installation, operation, and maintenance must be performed by qualified personnel. Familiarization with and adherence to NEMA MG2, the National Electrical Code, and local codes is recommended. It is important to observe safety precautions to protect personnel from possible injury. Personnel should be instructed to:

1. Disconnect all power to motor and accessories prior to initiating any installation, maintenance, or repairs. Also ensure that driven equipment connected to the motor shaft will not cause the motor to rotate (windmilling of fans, water flowing back through pump, etc.).

2. Avoid contact with rotating parts.

3. Act with care in accordance with this manual's prescribed procedures in handling and installing this equipment.

4. Be sure unit and accessories are electrically grounded and proper electrical installation wiring and controls are used in accordance with local and national electrical codes. Refer to "National Electrical Code Handbook" - NFPA No. 70. Employ qualified electricians.

5. Be sure equipment is properly enclosed to prevent access by children or other unauthorized personnel in order to prevent possible accidents.

6. Be sure shaft key is fully captive before unit is energized.

7. Provide proper safeguards for personnel against rotating parts and applications involving high inertia loads which can cause overspeed.

8. Avoid extended exposure to equipment with high noise levels.

9. Observe good safety habits at all times and use care to avoid injury to yourself or damage to equipment.

10. Be familiar with the equipment and read all instructions thoroughly before installing or working on equipment.

11. Observe all special instructions attached to the equipment. Remove shipping fixtures if so equipped before energizing unit.

12. Check motor and driven equipment for proper rotation and phase sequence prior to coupling. Also check if a unidirectional motor is supplied and note proper rotation.

13. Electric motors can retain a lethal charge even after being shut off. Certain accessories (space heaters, etc.) are normally energized when the motor is turned off. Other accessories such as power factor correction capacitors, surge capacitors, etc. can retain an electrical charge after being shut off and disconnected.

14. Do not apply power correction capacitors to motors rated for operation with variable frequency drives. Serious damage to the drive will result if capacitors are placed between the motor and drive. Consult drive supplier for further information.

INSTALLATION AND MAINTENANCE

Table of Contents

INSTALLATION AND MAINTENANCE

Shipment, Handling & Storage

I. SHIPMENT

Prior to shipment, all motors undergo extensive mechanical and electrical testing, and are thoroughly inspected. Upon receipt of the motor, carefully inspect the unit for any signs of damage that may have occurred during shipment. Should such damage be evident, unpack the motor at once in the presence of a claims adjuster and immediately report all damage and breakage to the transportation company.

When contacting Emerson Motor Co. concerning the motor, be sure to include the complete motor identification number, frame, and type which appear on the nameplate.

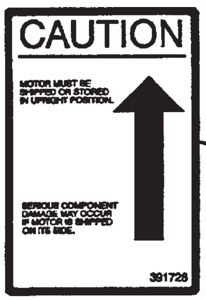
II. HANDLING

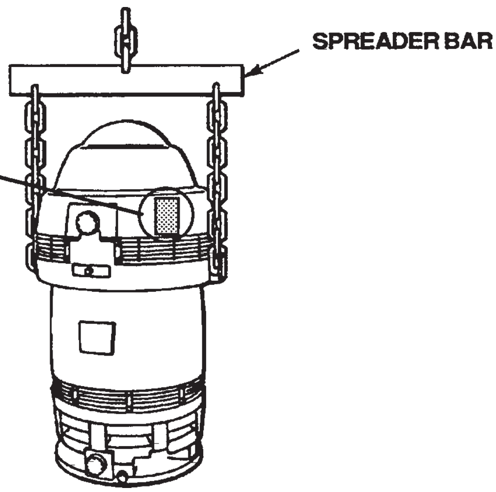
The equipment needed to handle the motor includes a hoist and spreader bar arrangement (see Figure 1) of sufficient strength to lift the motor safely. The spreader bar should have the lifting rings or hooks positioned to equal the span of the lifting lugs or eyebolts. The lifting lugs or eyebolts are intended to lift the motor weight only.

> ⚠ ***WARNING***
> ***Lifting the motor by other means may result In damage to the motor or injury to personnel.***

> ⚠ ***CAUTION***
> ***Do not move motor with oil sumps filled. Sloshing action of oil in sumps can result in oil leaks and motor damage.***

FIGURE 1





III. STORAGE

1. When To Put A Motor In Storage.

   If a motor is not put into immediate service (one month or less), or if it is taken out of service for a prolonged period, special storage precautions should be taken to prevent damage. The following schedule is recommended as a guide to determine storage needs.

A. Out of service or in storage less than one month - no special precautions except that space heaters, if supplied, must be energized at any time the motor is not running.

B. Out of service or in storage for more than one month but less than six months - store per items 2A, B, C, D, E, F(2), and G, items 3A, B, and C, and item 4.

C. Out of service or in storage for six months or more - all recommendations.

2. Storage Preparation.

A. Where possible, motors should be stored indoors in a clean, dry area.

B. When indoor storage is not possible, the motors must be covered with a tarpaulin. This cover should extend to the ground; however, it should not tightly wrap the motor. This will allow the captive air space to breathe, minimizing formation of condensation. Care must also be taken to protect the motor from flooding or from harmful chemical vapors.

⚠ *CAUTION*

Immediately remove any shrink wrap used during shipping. Never wrap any motor in plastic for storage. This can turn the motor into a moisture trap causing severe, non-warranty damage.

C. Whether indoors or out, the area of storage should be free from excessive ambient vibration which can cause bearing damage.

D. Precautions should be taken to prevent rodents, snakes, birds, or other small animals from nesting inside the motors. In areas where they are prevalent, precautions must be taken to prevent insects, such as dauber wasps, from gaining access to the interior of the motor.

E. Inspect the rust preventative coating on all external machined surfaces, including shaft extensions. If necessary, re-coat the surfaces with a rust preventative material, such as Rust Veto No. 342 (manufactured by E.F. Houghton Co.) or an equivalent. The condition of the coating should be checked periodically and surfaces re-coated as needed.

F. Bearings:

(1) When storage time is 6 months or more, grease lubricated cavities must be completely filled with lubricant. Remove the drain plug and fill cavity with grease until grease begins to purge from drain opening. Refer to section **IX. "LUBRICATION"** and/or review motor's lubrication nameplate for correct lubricant.

⚠ *CAUTION*

Do not re-grease bearings with drain closed or with unit running.

(2) Oil lubricated motors are shipped without oil. When storage time exceeds one (1) month, the oil sumps must be filled to the maximum capacity as indicated on the oil chamber sight gauge window. Refer to motor lubrication nameplate or Section **IX "Lubrication"** for proper oil.

NOTE: Motor must not be moved with oil in reservoir. Drain oil before moving to prevent sloshing and possible damage. With a clean cloth, wipe any excess oil from the threads of the drain plug and the inside of the drain hole. Apply Gasoila P/N SS08 or equivalent thread sealant to the threads of the drain plug and replace the plug in the oil drain hole. Refill oil when motor has been moved to the new location.

G. To prevent moisture accumulation, some form of heating must be utilized. This heating should maintain the winding temperature at a minimum of 5° above ambient. If space heaters are supplied, they should be energized. If none are available, single phase or "trickle" heating may be utilized by energizing one phase of the motor's winding with a low voltage. Request the required voltage and transformer capacity from Emerson Motor Co. A third option is to use an auxiliary heat source and keep the winding warm by either convection or blowing filtered warm air into the motor.

3. Periodic Maintenance.

A. Oil should be inspected monthly for evidence of moisture or oxidation. The oil must be replaced whenever contamination is noted or every twelve months; which ever occurs first. It is important to wipe excess oil from the threads of the drain plug and the drain hole and to coat the plug threads with Gasoila P/N SS08 or equivalent thread sealant before replacing the drain plug.

B. Grease lubricated bearings must be inspected once a month for moisture and oxidation by purging a small quantity of grease through the drain. If any contamination is present, the grease must be completely removed and replaced.

C. All motors must have the shaft rotated once a month to maintain a lubricant film on the bearing races and journals.

D. Insulation History:

The only accurate way to evaluate the condition of the winding insulation is to maintain a history of the insulation readings. Over a period of months or years these readings will tend to indicate a trend. If a downward trend develops, or if the resistance drops too low, thoroughly clean and dry the windings, retreating if necessary, by an authorized electrical apparatus service shop.

The recommended insulation resistance test is as follows:

(1) Using a megohm meter, with winding at ambient temperature, apply DC voltage (noted below) for sixty seconds and take reading.

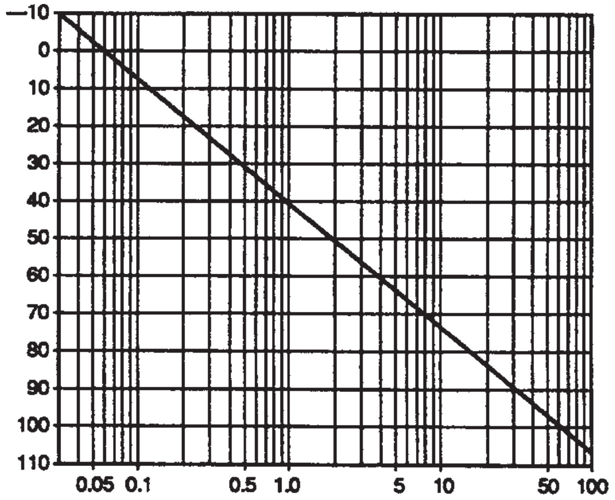
Rated Motor Voltage	Recommended DC Test Voltage
Up to 600 (inclusive)	500 VDC
601 to 1000 (inclusive)	500 to 1000 VDC
1001 and up	500 to 2500 VDC (2500 VDC optimum)

(2) For comparison, the reading should be corrected to a 40°C base temperature. This may be done by utilizing the following formula:

$$R_{40C} = K_t \times R_t$$

Where:
R_{40C} = insulation resistance (in megohms) corrected to 40°C
R_t = measured insulation resistance (in megohms)
K_t = temperature coefficient (from Graph 1)

GRAPH 1



INSULATION RESISTANCE TEMPERATURE COEFFICIENT (K_t)

(3) Insulation resistance readings must not drop below the value indicated by the following formula:

$$R_m = Kv + 1$$

Where:
R_m = minimum insulation (in megohms) at 40°C
Kv = rated motor voltage in kilovolts

(4) Dielectric absorption ratio:

In addition to the individual test reading, a dielectric absorption ratio may be required. The dielectric absorption ratio is obtained by taking megohm meter readings at a one minute and ten minute interval, or when hand powered megohm meters are used, at a thirty second and sixty second interval. The voltage should be the same as outlined in part 1 of this procedure.

The ratio is obtained by dividing the second reading by the first reading and is based on a good insulation system increasing its resistance when subjected to a test voltage for a period of time.

10 Minute: 1 Minute		60 Second: 30 Second	
Dangerous	= Less than 1.0	Poor	= Less than 1.1
Poor	= 1.0 to 1.4	Questionable	= 1.1 to 1.24
Questionable	= 1.5 to 1.9	Fair	= 1.25 to 1.3
Fair	= 2.0 to 2.9	Good	= 1.4 to 1.6
Good	= 3.0 to 4.0	Excellent	= Over 1.6
Excellent	= Over 4.0		

If a low insulation resistance reading is obtained in either the individual test or dielectric absorption ratio test, thoroughly clean and dry the windings. Recheck insulation resistance and dielectric absorption ratio.

NOTE: Slightly lower dielectric absorption ratios may be acceptable when high initial insulation resistance readings are obtained (1000 + megohms). Refer any questions to Emerson Motor Co. Product Service Department.

For additional information on insulation testing, refer to IEEE Transaction No. 43.

4. Start-up Preparations After Storage.

   A. Motor should be thoroughly inspected and cleaned to restore to an “As Shipped" condition.

   B. Motors which have been subjected to vibration must be disassembled and each bearing inspected for damage.

   C. When storage time has been six (6) months or more, oil and/or grease must be completely changed using lubricants and methods recommended on the motor’s lubrication plate, or in Section **IX - "LUBRICATION."**

   D. The winding must be tested to obtain insulation resistance and dielectric absorption ratio as described in Section **III., item 3**.

   E. Contact Emerson Motor Co. Product Service Department prior to start-up if storage time has exceeded one year.

IV. INSTALLATION LOCATION

When selecting a location for the motor and driven unit, keep the following items in mind:

1. The location should be clean, dry, well ventilated, properly drained, and provide accessibility for inspection, lubrication, and maintenance. Outdoor installations on open dripproof motors require protection from the elements.

2. The location should provide adequate space for motor removal without shifting the driven unit.

3. Temperature rise of a standard motor is based upon operation at an altitude not exceeding 3300 feet (1000 meters) above sea level unless specified otherwise on nameplate.

4. To avoid condensation inside the motor, it should not be stored or operated in areas subject to rapid temperature changes unless it is energized or protected by space heaters.

5. The motor should not be installed in close proximity to any combustible material or where flammable gases may be present, unless it is specifically built for that environment and is U.L. labeled accordingly.

6. Oil lubricated motors must be mounted within one degree of true vertical. Failure to do so will result in oil leakage and possibly bearing failure.

V. INITIAL INSTALLATION

1. General

Reliable, trouble free operation of a motor and driven unit depends on a properly designed foundation and base plus good alignment. If the motor and driven unit are not installed properly, the following may result:

* Noisy operation
* Bearing damage or failure
* Excessive vibration
* Motor failure

2. Shaft Alignment

On Holloshaft motors, the pump shaft and motor coupling must be aligned within .003" TIR. On Solidshaft motors, the motor and pump shafts must be aligned within .002" TIR.

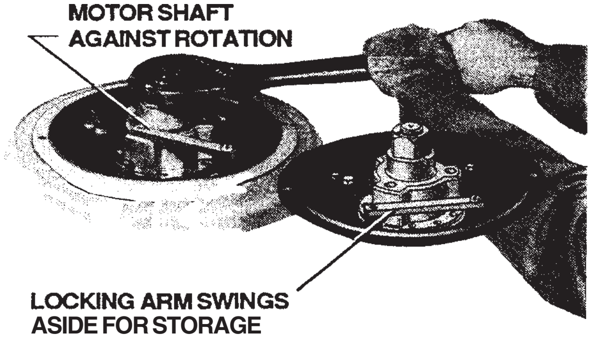
3. Pump Shaft Adjustment (Holloshaft motors only)

To facilitate axial pump shaft adjustment, a locking feature is provided to lock the motor shaft against rotation. The two types of locking features are as follows:

A. Locking arm (Figure 2) -The locking arm is bolted to a stationary part and is pinned (for best results use arm in tension) or interferes with a rotating part (when locking arm is not in use it should be moved out of the way and bolted in place). A non-reverse ratchet functions as a locking device. Motors supplied with non-reverse ratchets are not equipped with a locking arm.

B. Pinning through mating holes-Holes are provided in both a stationary and rotating part which line up allowing insertion of a pin.

FIGURE 2



⚠ WARNING

Locking device must be disengaged prior to starting motor or motor damage and/or injury to personnel may result.

⚠ CAUTION

Care should be exercised when lowering the motor over the pump shaft so that the oil retaining tube in the lower bracket is not damaged (applies only to motors with oil lubricated lower bearing).

4. Drive Coupling (Holloshaft units only).

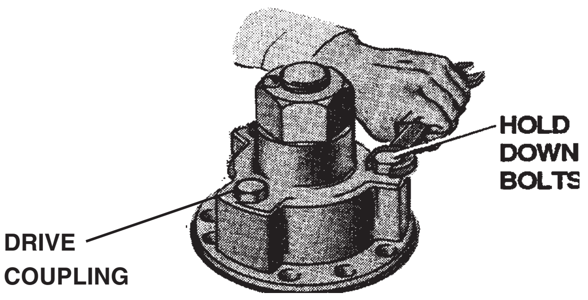
   The drive coupling may be utilized in one of two ways:

   A. Bolted type (Figure 3) - Hold down bolts are installed (some motors require removal of driving pins to allow installation of hold down bolts) in the drive coupling to prevent upward movement of the pump shaft. This will allow momentary upthrust from the pump to be taken by the motor's guide bearing.

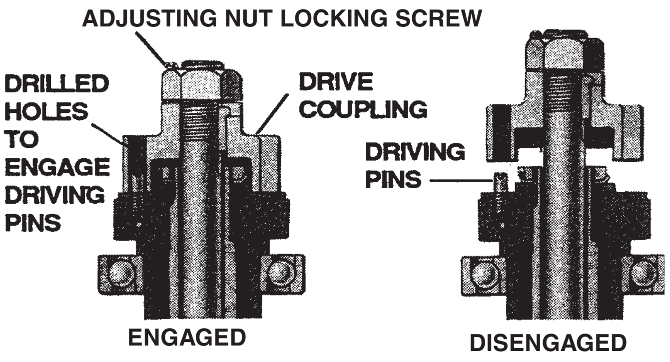
⚠ WARNING

Failure to tighten coupling and non-reverse ratchet bolts to required torque values may cause bolts to break, resulting in equipment damage or injury to personnel.

BOLTED COUPLING
FIGURE 3



SELF RELEASE COUPLING
FIGURE 4



   B. Self-release type (Figure 4) - Driving pins are used to engage the drive coupling with the rotor. A power reversal may unscrew the joints of the pump shafting, causing the shafting to lengthen and buckle or break if the shafting is restrained. The self-release coupling will lift out of engagement with partial unscrewing of the shafting, thus stopping further rotation of the pump. The following items must be followed for proper functioning of the self-release coupling:

   - The pump shaft adjusting nut must be properly secured to the drive coupling with a locking screw.
   - The drive coupling should not bind on the driving pins.
   - The drive coupling must not be bolted down.
   - The pump shaft must be concentric to the motor shaft to prevent rubbing of the pump shaft inside the motor shaft.
   - There must be no potential for upthrust in the application.
   - Do not use the self-release feature in conjunction with a lower steady bushing, as friction between the parts can damage the line shafting and/or bushing.
   - Due to the possibility of sparking as the parts separate, the self-release feature must not be used in an environment where explosive gases or dust may be present.

⚠ WARNING

Should a motor supplied with a self-release coupling become uncoupled, the motor and pump must be stationary and all power locked out before manually re-coupling.

5. Water Cooling For Bearing Oil Reservoir.

   If the motor is equipped with cooling coils in the oil reservoir, a minimum water supply of 4 GPM must be maintained at a maximum of 125 PSI with a 32°C (90°F) maximum inlet temperature. External water connections must be self draining to prevent cooling coil rupture at freezing temperatures. Use clean, noncorrosive water only. If corrosive conditions exist and are specified at time of motor order, special corrosion resistant fittings can be supplied.

6. Electrical Connection.

   Refer to the motor nameplate for power supply requirements and to the connection diagram on the motor. Be sure connections are tight. Check carefully and assure that they agree with the connection diagram, then carefully tape all connections with electrical tape to be sure that they will not short against each other or to ground. Be sure the motor is grounded to guard against possible electrical shock. Refer to the National Electrical Code Handbook (NFPA No. 70) and to local electrical codes for proper wiring, protection, and wire sizing. Be sure proper starting equipment and protective devices are used for every motor. For assistance contact the local sales office of the motor starter manufacturer for the particular brand of equipment you are using.

   Part Winding Starters: Part winding starters used with part winding start motors should have the timer set at a minimum time consistent with the power company requirements. The recommended maximum time on part winding is two seconds. Setting the timer for longer periods can cause permanent damage to the motor and may void the warranty. Note that motor may or may not start on part winding start connection.

7. Direction Of Rotation.

   As a standard, motors that are equipped with a non-reverse ratchet are designed to operate in a counter-clockwise direction as viewed from the top of the motor. Also, some high speed motors have unidirectional ventilating fans. When the motor has a unidirectional ventilating fan, the direction of rotation is indicated by an arrow mounted on the motor and by a warning plate mounted near the main nameplate.

⚠ CAUTION

Apply power momentarily to observe the direction of rotation for which the leads are connected. Motor damage may occur if power is applied for more than ten seconds while rotation is locked against the non-reverse ratchet. The motor should be uncoupled from the driven equipment during this procedure to assure driven equipment is not damaged by reverse rotation. Couplings (if installed) should be properly secured.

For a 3 phase motor, to reverse the direction of rotation (if the motor is not operating in the correct direction), interchange any two of the three power leads on the motor. For a 1 phase motor, if the motor is not operating in the correct direction, follow the instructions on the connection plate attached to the motor in order to reverse the direction of rotation. For both 1 and 3 phase motors, be sure that the power is off and steps are taken to prevent accidental starting of the motor before attempting to change electrical connection.

8. Spring-Preloaded Thrust Bearings.

Motors built with spherical roller thrust bearings (bearing number 29xxx) at any speed or tandem angular contact thrust bearings (bearing number 7xxx) on large 3600 or 3000 RPM (2-pole) motors have preload springs which maintain a minimum thrust load at all times to prevent bearing skidding. These motors require a minimum external thrust load sufficient to compress the springs to properly seat the thrust bearing and to relieve the lower guide bearing of axial spring thrust. Refer to motor's minimum thrust nameplate for required thrust.

> ⚠ ***CAUTION***
> ***Do not run a motor which has bearing preload springs without thrust load for more than fifteen (15) minutes as bearing damage may result.***

9. Initial Start.

After installation is completed, but before motor is put into regular service, make an initial start as follows:

A. Ensure that motor and control device connections agree with wiring diagrams.

B. Ensure that voltage, phase, and frequency of line circuit (power supply) agree with motor nameplate.

C. Check insulation resistance according to Section **III "STORAGE"** item 3.

D. Check all foundation, base, non-reverse ratchet (if applicable), and coupling bolts (if applicable) to ensure they are tight.

E. If motor has been in storage, either before or after installation, refer to Section **III "STORAGE"** item 4 for preparations.

F. Check oil lubricated units to be certain that bearing housings have been filled to between the "MAX" and "MIN" levels on the sight gauge windows with the correct lubricant. Refer to Section **IX "LUBRICATION"** for proper oils.

G. Check for proper or desired rotation. See item 7 of this section for details.

H. Ensure that all protective devices are connected and operating properly, and that all outlet accessory, and access covers have been returned to their original intended position.

I. Start motor at lowest possible load and monitor to be sure that no unusual condition develops.

> ⚠ ***WARNING***
> ***All loosened or removed parts must be reassembled and tightened to original specifications. Keep all tools, chains, equipment, etc. clear of unit before energizing motor.***

J. When checks are satisfactory to this point, increase load slowly up to rated load and monitor unit for satisfactory operation.

VI. NORMAL OPERATION

Start the motor in accordance with standard instructions for the starting equipment used.

1. General Maintenance.

   Regular, routine maintenance is the best assurance of trouble-free, long-life motor operation. It prevents costly shutdown and repairs. Major elements of a controlled maintenance program are:

   A. Trained personnel who have a working knowledge of rotational equipment and have read this manual.

   B. Systematic records which contain at least the following:

      1. Complete nameplate data.
      2. Prints (wiring diagrams, certified outline dimensions).
      3. Alignment data.
      4. Results of regular inspection, including vibration and bearing temperature data, as applicable.
      5. Documentation of any repairs.
      6. Lubrication data:
         - Method of application
         - Types of lubricants for wet, dry, hot, or adverse locations
         - Maintenance cycle by location (some require more frequent lubrication)

2. Inspection and Cleaning

   Stop the motor before cleaning. ***CAUTION: Assure against accidental starting of the motor.*** Clean the motor inside and out regularly. The frequency of cleaning depends upon actual conditions existing around the motor. Use the following procedures as they apply:

   A. Wipe off dirt, dust, oil, water, or other liquids from external surfaces of motor. These materials can work into or be carried into the motor windings and may cause overheating or insulation breakdown.

   B. Remove dirt, dust, or debris from ventilating air inlets. Never allow dirt to accumulate near air inlets. Never operate motor with air passages blocked.

   C. Clean motors internally by blowing with clean, dry, compressed air at 40 to 60 PSI. If conditions warrant, use a vacuum cleaner.

⚠ *CAUTION*
When using compressed air, always use proper eye protection to prevent accidental eye injury.

   D. When dirt and dust are solidly packed, or windings are coated with oil or greasy grime, disassemble the motor and clean with solvent. Use only high-flash naphtha, mineral spirits, or Stoddard solvent. Wipe with solvent dampened cloth, or use suitable soft bristled brush. ***DO NOT SOAK***. Oven dry (150 – 175°F) solvent cleaned windings thoroughly before reassembly.

   E. After cleaning and drying the windings, check the insulation resistance per Section **III, Item 3**.

VII. NON-REVERSE RATCHET

Units featuring non-reverse ratchets are refine-balanced by attaching weights to the rotating ratchet. If the ratchet is removed it should be marked and reassembled in the same position to retain proper balance.

VIII. ENDPLAY ADJUSTMENT

The term *endplay* is defined as the total axial float of the rotor. Should the motor be disassembled for any reason, the rotor endplay must be adjusted. Care must be taken to ensure that end play is within the proper range. Use one of the following procedures, depending upon the type of thrust bearing to set end play:

⚠ *CAUTION*

Excessive endplay can allow the thrust bearing to separate when units are run with zero thrust or momentary up thrust, resulting in thrust bearing failure. Insufficient endplay may cause the bearings to load against each other, resulting in extreme heat and rapid failure of both the guide and thrust bearings.

1. Spherical Roller Thrust Bearings and Angular Contact Bearings (With Springs).

   Setting the correct end play on units with spring-preloaded spherical roller or angular contact thrust bearings requires a controlled assembly method, due to various deflections internal to the motor and friction of locknut threads from spring force. An end play setting of .005 to .008 inches is required to allow the lower guide bearing to return to an unloaded position when external thrust is applied to the motor (see Figure 5). End play can be properly adjusted by the following recommended procedure:

   A. Place spring retainer (without springs) and lower thrust washer of bearing into upper bearing bore.

   B. Using a depth micrometer, measure the distance between the top of the lower thrust washer and the faced surface on top of the bearing housing (see Figure 5). Record dimension to three decimals.

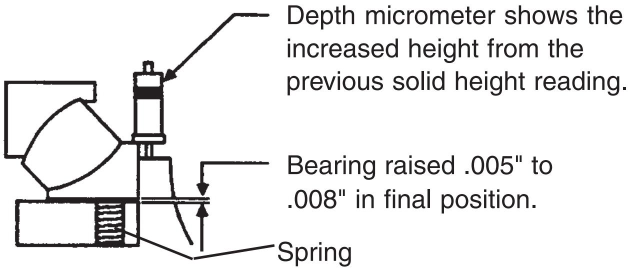
   C. Add .005 to .008 inches to the recorded dimension to obtain the correct endplay range for the unit.

   D. Reassemble bearing with springs. Motor is now ready to set end play. Several acceptable methods for setting endplay are following.

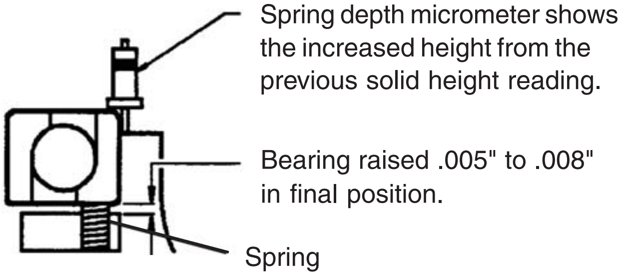
   NOTE: Certain motor builds require removal of the fabricated steel or cast aluminum oil baffle to provide access for depth micrometer measurements.

FIGURE 5

SPHERICAL ROLLER THRUST BEARING



ANGULAR CONTACT BEARING



2. Angular Contact Ball Bearings (Without Springs)

   A. No preliminary measurements are required to set end play. End play may be set by any of the following methods described in this section.

   B. To correctly adjust the endplay setting, a dial indicator should be positioned to read the shaft axial movement. (See figure 7 for location of dial indicator). The rotor adjusting lock nut should be turned until no further upward movement of the shaft is indicated. The locknut is then loosened until .005 to .008" endplay is obtained. Lock the locknut with lock washer.

⚠ CAUTION

Care should be taken to ensure that the locknut is not over-tightened, as this can lead to an erroneous end play setting (due to deflection of parts) and bearing damage may result.

   C. Motors that have two opposed angular contact bearings that are locked for up and downthrust do not require endplay adjustment. The shaft, however, must be set to the original 'AH' (shaft extension length) to prevent the guide bearing from taking thrust.

ENDPLAY ADJUSTMENT METHODS

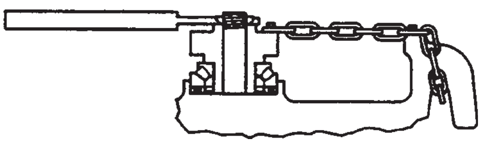
1. Method 1 (refer to Figures 6 & 7)

   This method requires the user to install a bolted chain from the bearing mount back to a lifting lug. Rotate the locknut with a spanner wrench (and bar extension) until dial indicator shows no movement on end of shaft. The locknut should then be loosened until proper endplay is obtained, lock the locknut with lock washer. (See figure 7 for location of dial indicator.)

   NOTE: This is the lowest cost of the three methods and requires the least amount of equipment. This method, however, may be less desirable than Method 2 as considerable locknut torque may be encountered on units with bearing preload springs.

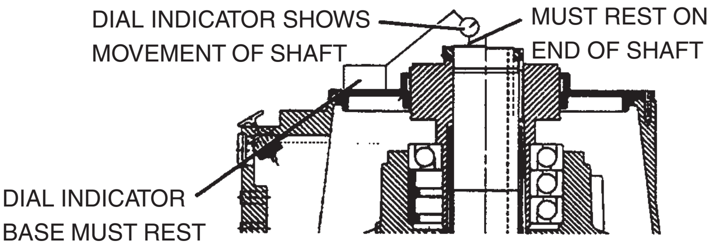
   Special equipment required:
   - Locking bolts
   - 3/4" chain
   - Spanner wrench with extension
   - Dial indicator
   - Depth micrometer

FIGURE 6 (METHOD 1)



MOUNTING SPRINGS ARE COMPRESSED AND ROTOR IS LIFTED BY LOCKNUT

FIGURE 7 (METHOD 1 & 3)



2. Method 2 (refer to Figure 8 - Utilized on Spring Loaded Bearings Only)

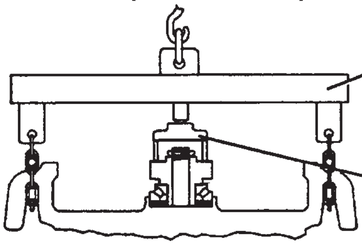
   This method utilizes a spreader bar and chains to wrap around lifting lugs, a hydraulic jack (five ton), and crane to lift the spreader bar. The hydraulic jack is supported by two steel blocks of equal thickness on top of the bearing mounting with the jack pushing against the spreader bar. On large motors, the rotor can be lifted by placing a second jack below the motor shaft to allow the locknut to be turned easily.

   NOTE: This method utilizes typical shop equipment and tools. Endplay settings can be checked quickly on larger vertical motor products. The locknut lifts rotor weight only.

   Equipment required:
   - Large spreader bar with chains and locking bolts
   - Overhead crane
   - Depth micrometer
   - Spanner wrench
   - Metal blocks
   - 5-ton hydraulic jack
   - Dial indicator

FIGURE 8 (METHOD 2)

MOUNTING SPRINGS ARE COMPRESSED – ONLY THE ROTOR IS LIFTED BY THE LOCKNUT.



3. Method 3 (refer to Figure 9)

   This method uses a one inch thick steel disc with a center hole for the shaft end bolt and two threaded hydraulic jacks connected to a single pump. Apply load to hydraulic jacks until dial indicator shows no movement on end of shaft. (See figure 7 for location of dial indicator). The shaft locknut should be positioned and the pressure from hydraulic jack relieved until proper endplay is obtained.

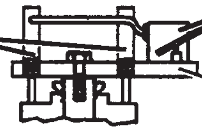
> ⚠ ***CAUTION***
> ***Use of excessive hydraulic pressure can damage bearings.***

   NOTE: This method is directly usable on solid shaft motors and can be used on most HOLLOSHAFT motors with the use of a long threaded rod and plate. It is easy to apply and settings can be checked quickly, especially in field service. The locknut does not see any force and can be turned easily.

   Equipment required:
   - Fixture with hydraulic jacks
   - Dial indicator
   - Spanner wrench

MOUNTING SPRINGS ARE COMPRESSED AND ROTOR IS LIFTED BY THE FIXTURE. THE LOCKNUT IS TURNED FOR ADJUSTMENT.

FIGURE 9 (METHOD 3)



> ⚠ ***CAUTION***
> ***After setting endplay, run unit for three to five minutes, then stop and verify the endplay setting. Readjust as necessary. All loosened or removed parts must be reassembled and tightened to original specifications. Keep all tools, chains, equipment, etc. clear of unit before energizing motor.***

IX. LUBRICATION

Motor must be at rest and electrical controls should be locked open to prevent energizing while being serviced. If motor is being taken out of storage refer to Section **III "STORAGE"**, item 4 for instructions.

1. Oil Lubricated Bearings.

   Change oil once per year with normal service conditions. Frequent starting and stopping, damp or dusty environment, extreme temperature, or any other severe service conditions will warrant more frequent oil changes. If there is any question, consult Emerson Motor Co. Product Service Department for recommended oil change intervals regarding your particular situation.

   Determine required oil ISO Viscosity Grade (VG) and base oil type from Table 3, then see Table 4 for approved oils. Add oil into oil fill hole at each bearing housing until the oil level reaches between minimum and maximum marks located on the sight gauge window. It is important to wipe excess oil from the threads of the drain hole and to coat the plug threads with Gasoila P/N SS08, manufactured by Federal Process Corporation or equivalent thread sealant before replacing the drain plug. Plug should be tightened to a minimum of 20 lb.-ft. using a torque wrench. See the motor nameplate or Table 5 for the approximate quantity of oil required.

2. Grease Lubricated Bearings.

   A. Relubrication of Units in Service

   Grease lubricated bearings are pre-lubricated at the factory and normally do not require initial lubrication. Relubricating interval depends upon speed, type of bearing and service. Refer to Table 1 for suggested regreasing intervals and quantities. Note that operating environment and application may dictate more frequent lubrication.

   To relubricate bearings, remove the drain plug. Inspect grease drain and remove any blockage (caked grease or foreign particles) with a mechanical probe, taking care not to damage bearing.

⚠ *WARNING*
Under NO circumstances should a mechanical probe be used while the motor is in operation.

   Add new grease at the grease inlet. New grease must be compatible with the grease already in the motor (refer to table 2 for compatible greases).

⚠ *CAUTION*
Greases of different bases (lithium, polyurea, clay, etc.) may not be compatible when mixed. Mixing such greases can result in reduced lubricant life and premature bearing failure. Prevent such intermixing by disassembling motor, removing all old grease and repacking with new grease per item B of this section. Refer to Table 2 for recommended greases.

   Run the motor for 15 to 30 minutes with the drain plug removed to allow purging of any excess grease. Shut off unit and replace the drain plug. Return motor to service.

⚠ *CAUTION*
Overgreasing can cause excessive bearing temperatures, premature lubricant breakdown and bearing failure. Care should be exercised against overgreasing.

B. Change of Lubricant

Motor must be disassembled as necessary to gain full access to bearing housing(s).

Remove all old grease from bearings and housings (including all grease fill and drain holes). Inspect and replace damaged bearings. Fill bearing housings both inboard and outboard of bearing approximately 30 percent full of new grease. Grease fill ports must be completely charged with new grease. Inject new grease into bearing between rolling elements to fill bearing. Remove excess grease extending beyond the edges of the bearing races and retainers.

Table 1
Recommended Grease Replenishment Quantities & Lubrication Intervals

Bearing Number		Grease Replenishment Quantity (Fl. Oz.)	Lubrication Interval		
62xx, 72xx	63xx, 73xx		1801 thru 3600 RPM	1201 thru 1800 RPM	1200 RPM and slower
03 thru 07	03 thru 06	0.2	1 Year	2 Years	2 Years
08 thru 12	07 thru 09	0.4	6 Months	1 Year	1 Year
13 thru 15	10 thru 11	0.6	6 Months	1 Year	1 Year
16 thru 20	12 thru 15	1.0	3 Months	6 Months	6 Months
21 thru 28	16 thru 20	1.8	3 Months	6 Months	6 Months

Refer to motor nameplate for bearings provided on a specific motor.

For bearings not listed in Table 1, the amount of grease required may be calculated by the formula:

$G = 0.11 \times D \times B$

Where: G = Quantity of grease in fluid ounces.
D = Outside diameter of bearing in inches.
B = Width of bearing in inches.

Table 2
Recommended Greases

Motor Frame Size	Motor Enclosure	Grease Manufacturer	Grease (NLGI Grade 2)
All Thru 447	All	Chevron USA, Inc. Exxon Mobil	Grease No. 83343 SRI No. 2 Polyrex-EM
449 and Up	Open Dripproof		
449 and Up	TEFC and Explosionproof	Exxon Mobil	Grease No. 974420 Mobilith SHC-100

The above greases are interchangeable with the grease provided in units supplied from the factory (unless stated otherwise on motor lubrication nameplate).

Table 3
Emersom Motor Co. Recommended Oil Viscosities

Angular Contact Thrust Bearing (7XXX Series)

Motor Enclosure	Frame Size	Speed (RPM)	Ambient Temperature	ISO VG	Base Oil Type
Open Dripproof or Weather Protected	324 and Larger	All	-15C thru 40C (5-104F)	32	Mineral or Synthetic
			41C thru 50C (105-122F)	68	Synthetic Only
Totally Enclosed or Explosionproof	404 thru 447		-15C thru 40C (5-104F)	32	Mineral or Synthetic
			41C thru 50C (105-122F)	68	Synthetic Only
	449 thru 5811	1801 - 3600	-15C thru 40C (104F)	32	Synthetic Only
		1800 & Below		68	Synthetic Only
		All	41C thru 50C (105-122F)	Refer to Office	

Spherical Roller Thrust Bearing (29XXX Series)

Motor Enclosure	Frame Size	Speed (RPM)	Ambient Temperature	ISO VG	Base Oil Type
Open Dripproof or Weather Protected	444 and Larger	1800 and Below	-15C thru 25C (5-77F)	68	Mineral or Synthetic
			6C thru 40C (42-104F)	150	
			41C thru 50C (105-122F)		Synthetic Only
Totally Enclosed or Explosionproof	449 and Larger		-15C thru 25C (5-77F)	68	Mineral or Synthetic
			6C thru 40C (42-104F)	150	Synthetic Only
			41C thru 50C (105-122F)	Refer to Office	

Notes:
1. If lower guide bearing is oil lubricated, it should use the same oil as the thrust bearing.
2. If lower guide bearing is grease-lubricated, refer to TABLE 2 for recommended greases.
3. Refer to Emerson Motor Co. for ambient temperatures other than those listed.

Table 4
Emerson Motor Co. Approved Oil Specifications For Use With Anti-Friction Bearings

Oil Manufacturer	ISO VG 32		ISO VG 68		ISO VG 150	
	Viscosity: 130-165 SSU @ 100F		Viscosity: 284-347 SSU @ 100F		Viscosity: 620-765 SSU @ 100F	
	Mineral Base Oil	Synthetic Base Oil	Mineral Base Oil	Synthetic Base Oil	Mineral Base Oil	Synthetic Base Oil
Chevron USA, Inc	GST Turbine Oil 32	Tegra 32	GST Turbine Oil 68	Tegra 68	R&O Machine Oil 150	Tegra 150
Conoco Oil Co.	Hydroclear Turbine Oil 32	Syncon 32	Hydroclear Turbine Oil 68	Syncon 68	Hydroclear AW Hyd. Fluid 150	N/A
ExxonMobil	Teresstic 32	Synnestic 32	Teresstic 68	Synnestic 68	Teresstic 150	Synnestic 150
ExxonMobil	DTE Oil Light	SHC 624	DTE Oil Heavy Medium	SHC 626	DTE Oil Extra Heavy	SHC 629
Pennzoil Co., Inc	Pennzbell TO 32	Pennzbell SHD 32	Pennzbell TO 68	Pennzbell SHD 68	Pennzbell TO 150	Pennzbell SHD 150
Phillips Petroleum Co.	Magnus 32	Syndustrial "E" 32	Magnus 68	Syndustrial "E" 68	Magnus 150	N/A
Shell Oil Co.	Tellus 32	Tellus HD Oil AW SHF 32	Tellus 68	Tellus HD Oil AW SHF 68	Tellus 150	N/A
Texaco Lubricants Co.	Regal 32	Cetus PAO 32	Regal 68	Cetus PAO 68	Regal 150	N/A

Table 5
Approximate Oil Sump Capacities

Frame Size	Motor Type Designation (See Motor Nameplate)	Oil Capacity (Quarts)	
		Upper Bearing	Lower Bearing
180 - 280	AU, AV-4	Grease	Grease
180 - 280	AV		
320 - 440	RV		
320 - 360	RV-4, RU	3	
400	RV-4, RU	5	
440	RV-4 (2 pole)	17	
	RV-4, RU (4 pole & slower, w/ ang contact thrust brg.)	6	
	(4 pole & slower, w/ spherical thrust brg.)	4	
180 - 440	TV-9, TV, LV-9, LV	Grease	
180 -360	TV-4, TU, LV-4, LU		
400	TV-4, TU, LV-4, LU	6	
440	TV-4, TU, LV-4, LU	5	
449	JU, JV-4	22	
	HU, HV-4	12	
	JV-3, JV, HV	Grease	
5000	HV, EV, JV, RV	Grease	
	RU, RV-4	30	
	HU, HV-4 (4 pole & slower)	12	
	HV-4 (2 pole only)	20	
	EU, JU, EV-4, JV-4	22	5
5800	HU, HV-4	24	3
	EU, JU, EV-4, JV-4	37	4
6800	HU, HV-4	70	3
	HV (Bow Thruster)	Grease	Grease
	HV (Other Than Bow Thruster)	70	3
8000	RU, RV-4	70	6
	RV	Grease	Grease
9600	RU, RV-4	64	13
	RV	Grease	Grease

X. FUNDAMENTAL TROUBLESHOOTING - PROBLEM ANALYSIS

This chart can reduce work and time spent on motor analysis. Always check the chart first before starting motor disassembly, as what appears to be a motor problem may often be located elsewhere. For additional information, consult our website at www.usmotors.com.

SYMPTOM	PROBABLE CAUSE	ANALYSIS
Motor fails to start	Defective power supply	Check voltage across all phases above disconnect switch.
	Blown or defective primary fuses	
	Blown or defective secondary fuses	Check voltage below fuses (all phases) with disconnect closed.
	Open control circuit	Push reset button.
	Overload trips are open	
	Defective holding coil in magnetic switch	Push start button and allow sufficient time for operation of time delay, if used, then check voltage across magnetic holding coil. If correct voltage is measured, coil is defective. If no voltage is measured, control circuit is open.
	Loose or poor connections in control circuits.	Make visual inspection of all connections in control switch.
	Magnetic switch closes	Open manual disconnect switch, close magnetic by hand, and examine contractors and springs.
	Poor switch contact	
	Open circuit in control panel	Check voltage at Tl, T2, & T3
	Open circuit in leads to motor	Check voltage at leads in outlet box
	Leads improperly connected	Check lead numbers and connections.
Motor fails to come up to speed	Low or incorrect voltage	Check voltage at Tl, T2, & T3 in control panel and at motor leads in outlet box.
	Incorrect connection at motor	Check for proper lead connections at motor and compare with connection diagram on motor.
	Overload - mechanical	Check impeller setting. Check for a tight or locked shaft.
	Overload - hydraulic	Check impeller setting. Check GPM against pump capacity and head.
Motor Vibrates	Headshaft misaligned	Remove top drive coupling and check alignment of motor to pump.
	Worn line shaft bearings or bent line shaft	Disconnect motor from pump and run motor only to determine source of vibration.
	Hydraulic disturbance in discharge piping	Check isolation joint in discharge piping near pump head.
	Ambient Vibration	Check base vibration level with motor stopped.
	System Natural Frequency (Resonance)	Revise rigidity of support structure.
Motor noisy	Worn thrust bearing	Remove dust cover, rotate rotor by hand, and make visual examination of balls and races. Bearing noise is commonly accompanied by a high frequency vibration and/or increased temp.
	Electrical noise	Most motors are electrically noisy during the starting period. This noise should diminish as motor reaches full speed.

SYMPTOM	PROBABLE CAUSE	ANALYSIS
Motor overheating (Check with thermocouple or by resistance methods. Do not depend on hand.)	Overload	Measure load and compare to nameplate rating. Check for excessive friction in motor or in complete drive. Reduce load or replace motor with greater capacity motor. Refer to Appendix C.
	Motor intake or exhaust blocked or clogged.	Clean motor intake and exhaust areas. Clean filters or screens if motor is so equipped.
	Unbalanced voltage	Check voltage to all phases. Refer to Appendix A.
	Open stator windings	Disconnect motor from load. Check idle amps for balance in all three phases. Check stator resistance in all three phases.
	Over / Under Voltage	Check voltage and compare to nameplate voltage.
	Ground	Locate with test lamp or insulation tester and repair.
	Improper Connections.	Recheck connections.
Bearing Overheating	Misalignment	Check alignment.
	Incorrect oil, or oil level too high or too low.	Refill with proper oil. Verify oil level is correct.
Generally, bearing tempatures (as measured by a tipsensitive RTD or thermocouple touching the bearing outer race) should not exceed 90°C when using mineral-based lubricants or 120°C when using synthetic-based lubricants.	Excessive thrust.	Reduce thrust from driven machine.
	Bearing over-greased.	Relieve bearing cavity of grease to level specified in lubrication section.
	Motor overloaded	Measure load and compare to nameplate rating. Check for excessive friction in motor or in complete drive. Reduce load or replace motor with greater capacity motor. Refer to Appendix C.
	Motor intake or exhaust blocked or clogged.	Clean motor intake and exhaust areas. Clean filters or screens if motor is so equipped.
Bearing oil leaking around the drain plug.	Insufficient sealant applied to drain plug threads.	Remove drain plug and drain existing oil from sump. With a clean cloth, wipe excess oil from the plug threads and the threads in the drain hole. Apply Gasoila Thread Sealant P/N SS08 to the threads of the plug and replace. Fill sump with new oil to the proper level.

XI. SPARE PARTS

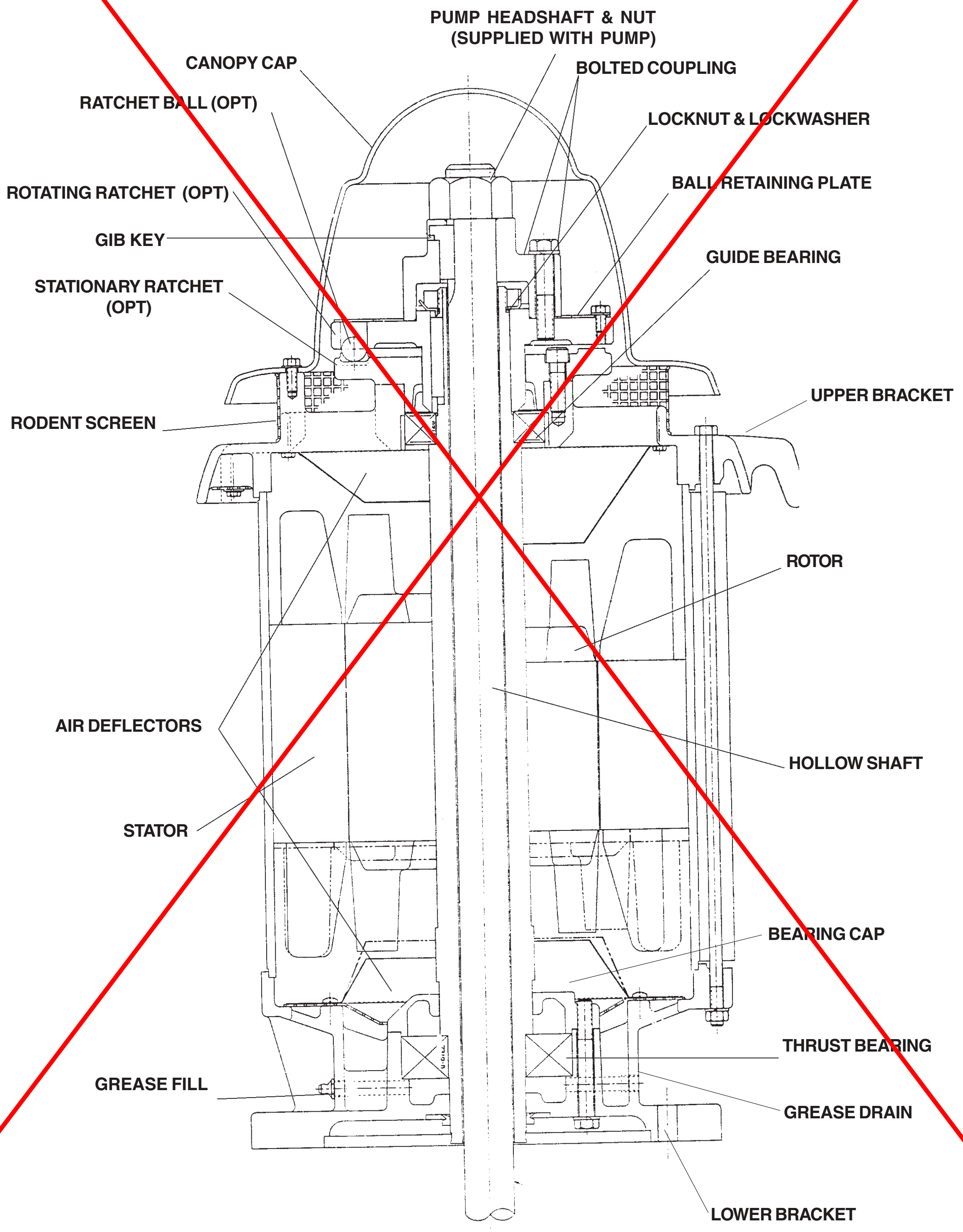
A parts list is available for your unit and will be furnished upon request. Parts may be obtained from local Emerson Motor Co. distributors and authorized service shops, or through Emerson Motor Co. distribution center.

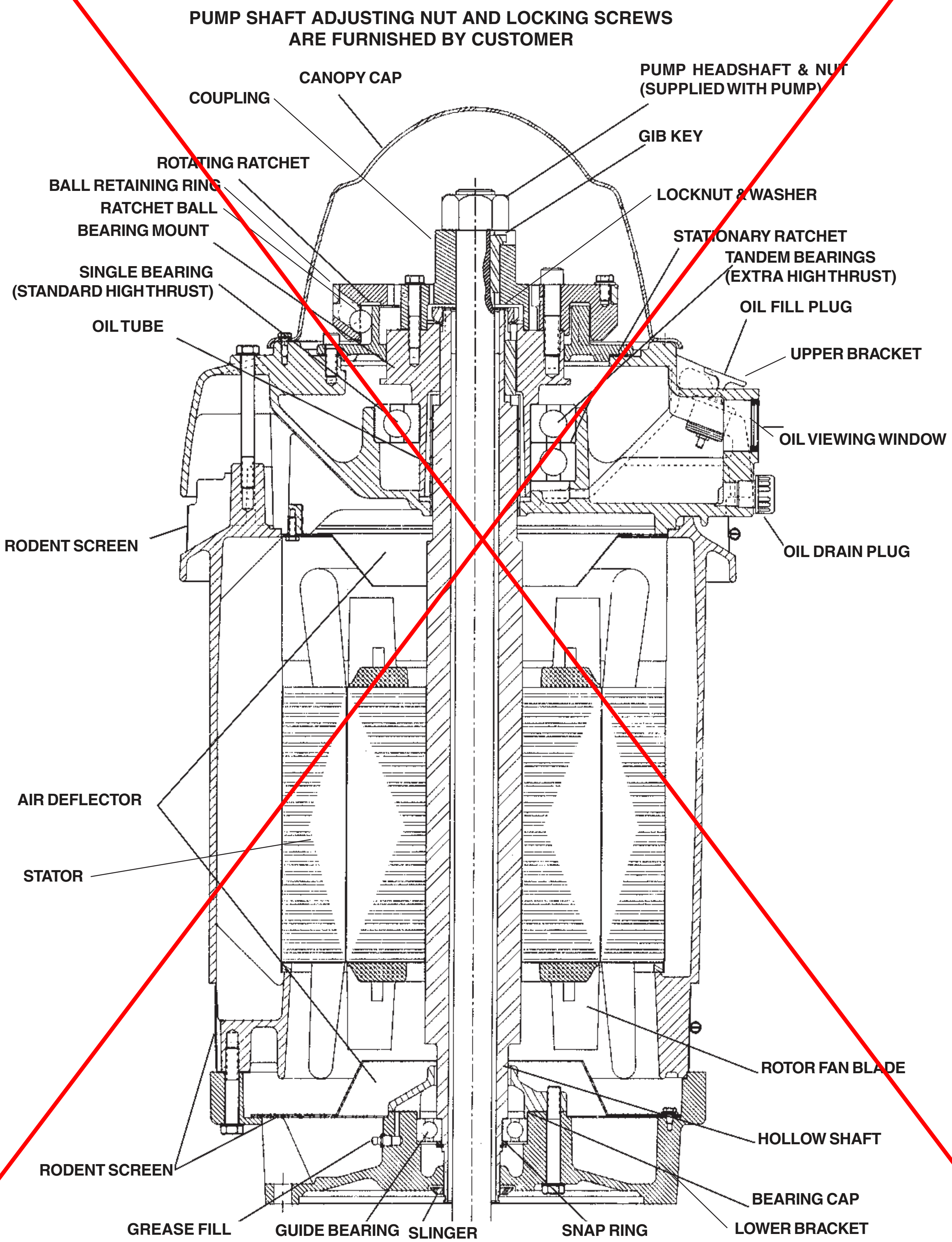
Emerson Motor Co.
710 Venture Drive
Suite 100
Southaven, MS 38672
Phone (662) 342-6910
Fax (662) 342-7350

Drawings for many standard designs are supplied on the following pages. Most of the parts should be easy to identify. If however, there is some deviation from your machine, consult the factory for assistance.

Spare Parts

250 and 280 Frames
Type AU HIGH THRUST

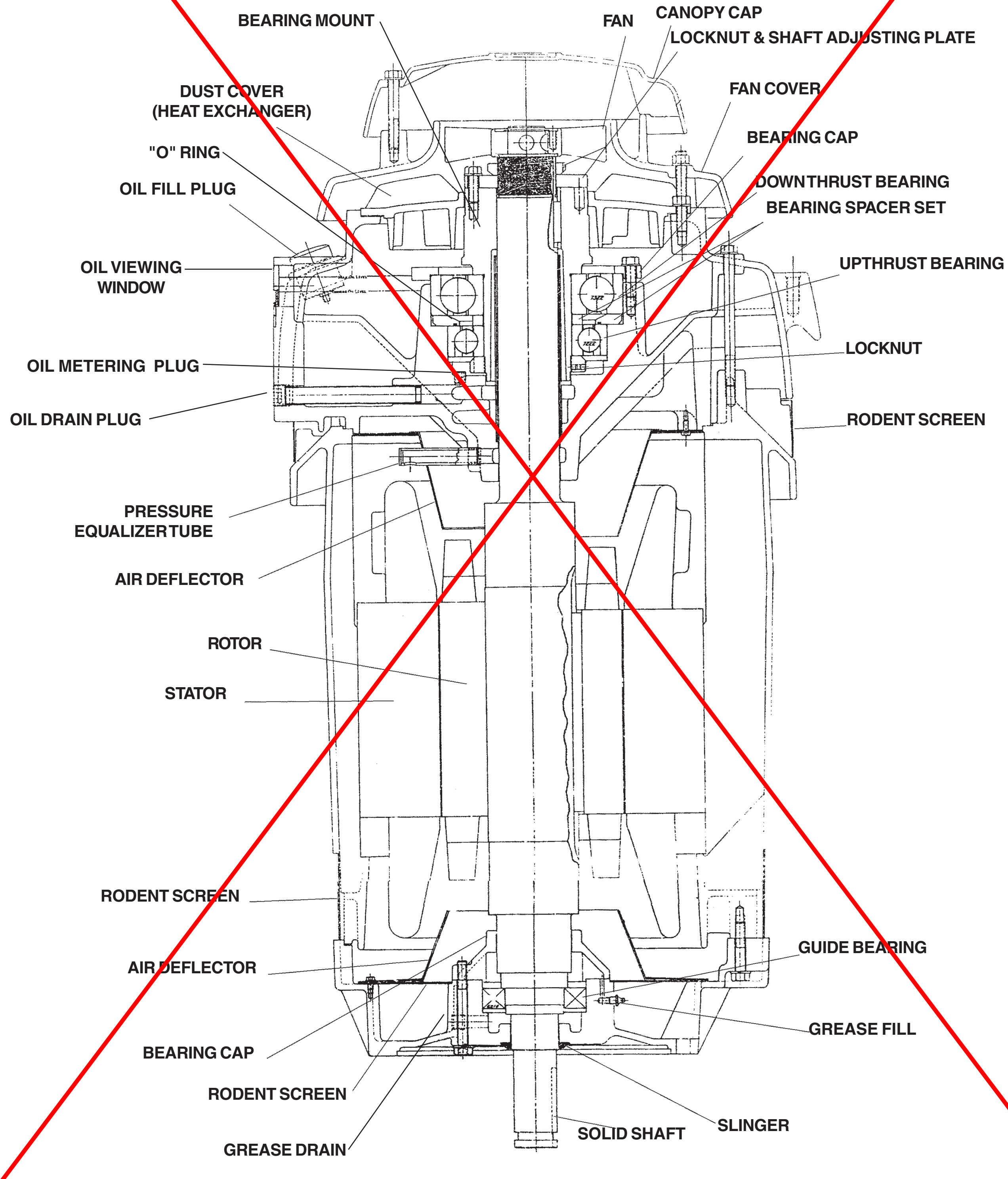




PUMP SHAFT ADJUSTING NUT AND LOCKING SCREWS
ARE FURNISHED BY CUSTOMER
CANOPY CAP
COUPLING
PUMP HEADSHAFT & NUT
(SUPPLIED WITH PUMP)
GIB KEY
ROTATING RATCHET
BALL RETAINING RING
RATCHET BALL
BEARING MOUNT
LOCKNUT & WASHER
STATIONARY RATCHET
TANDEM BEARINGS
(EXTRA HIGH THRUST)
SINGLE BEARING
(STANDARD HIGH THRUST)
OIL FILL PLUG
OIL TUBE
UPPER BRACKET
OIL VIEWING WINDOW
RODENT SCREEN
OIL DRAIN PLUG
AIR DEFLECTOR
STATOR
ROTOR FAN BLADE
HOLLOW SHAFT
RODENT SCREEN
BEARING CAP
LOWER BRACKET
GREASE FILL
GUIDE BEARING
SLINGER
SNAP RING

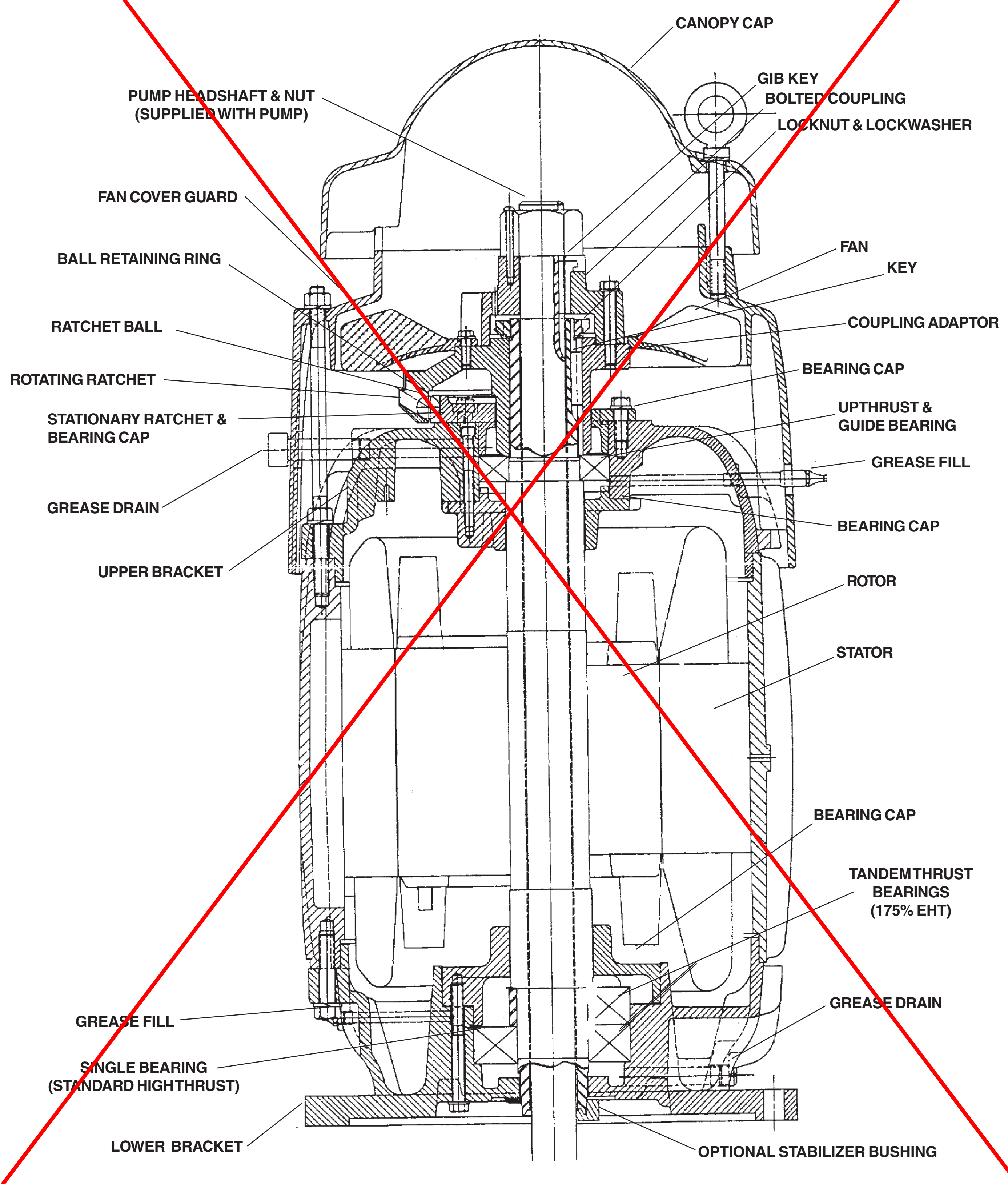
Spare Parts

440 Frame, Type RV-4 (2 Pole)



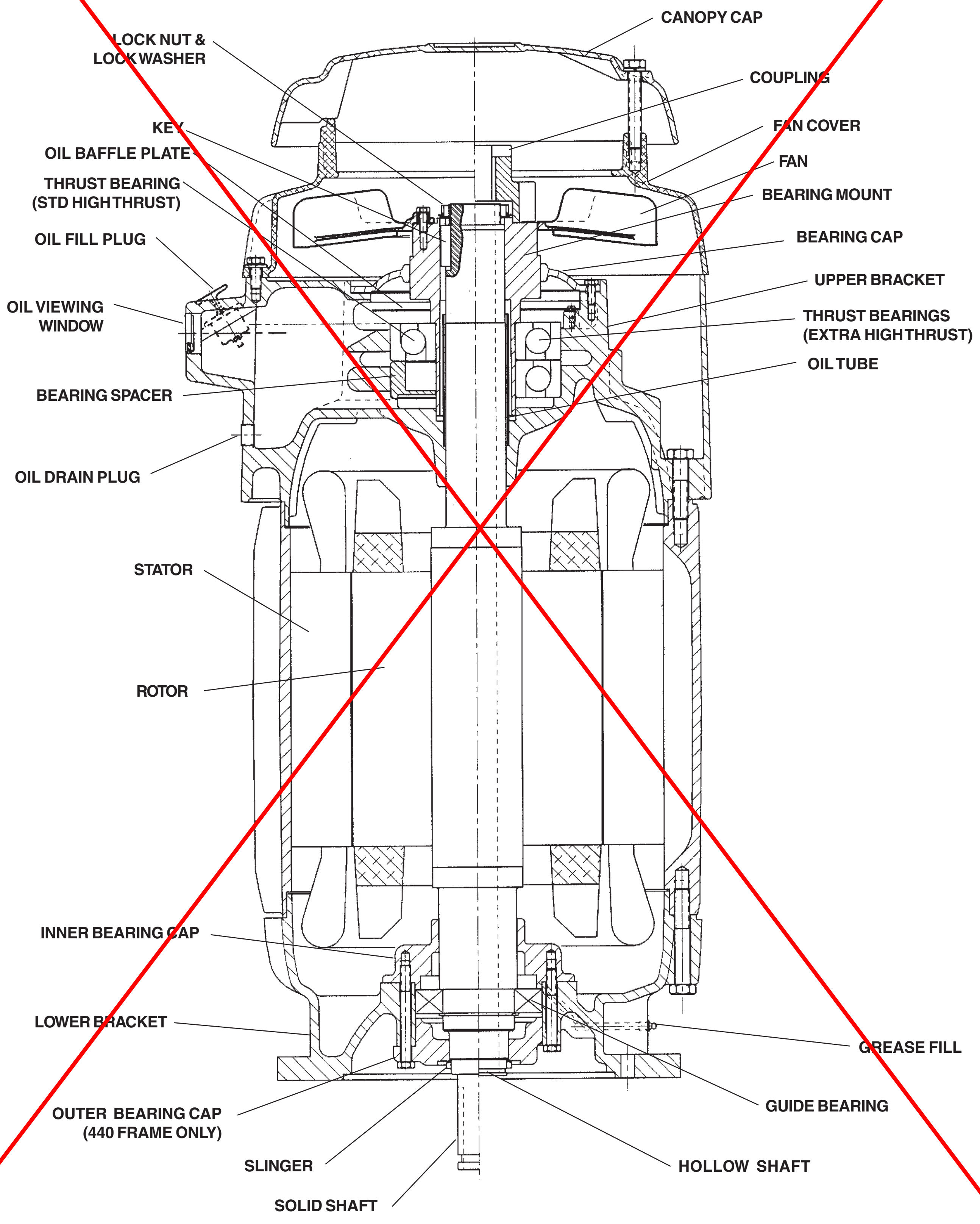
Spare Parts

280, 320, 360 FRAMES, TYPE LU
320, 360 FRAMES TYPE TU



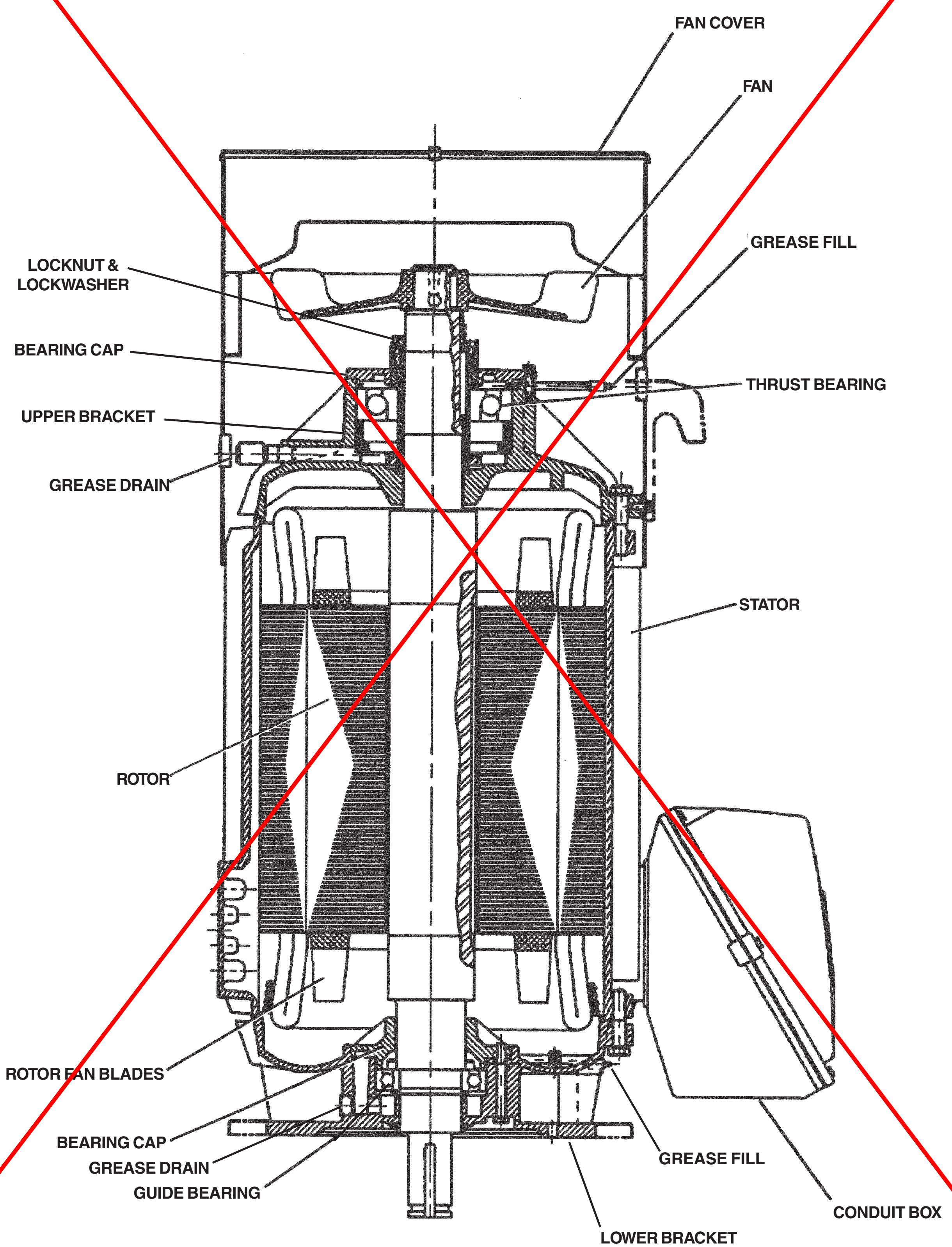
Spare Parts

400 Thru 440 Frame Types TU, LU, TV-4 and LV-4 High Thrust



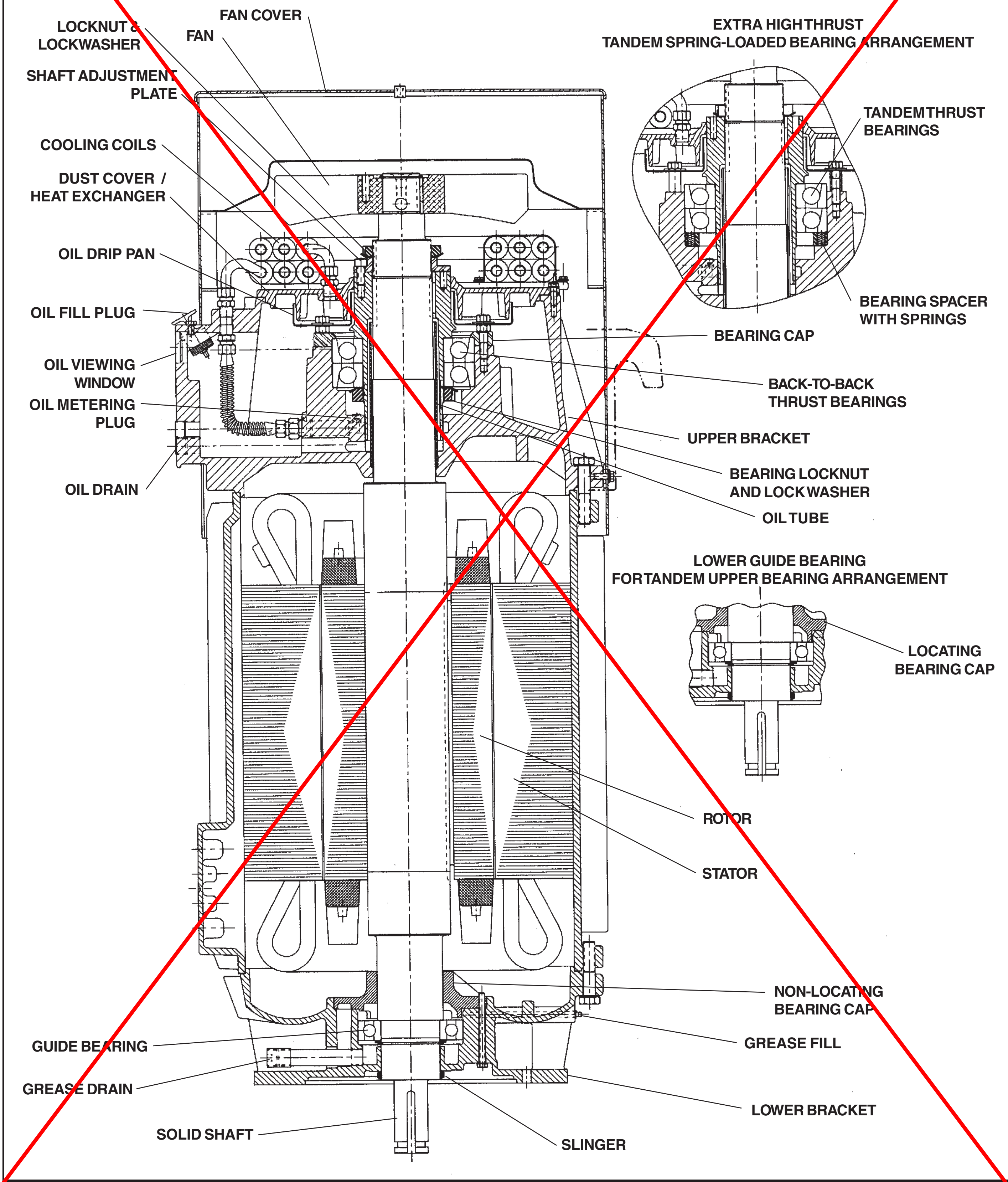
Spare Parts

449 Frame
Types JV & JV-3



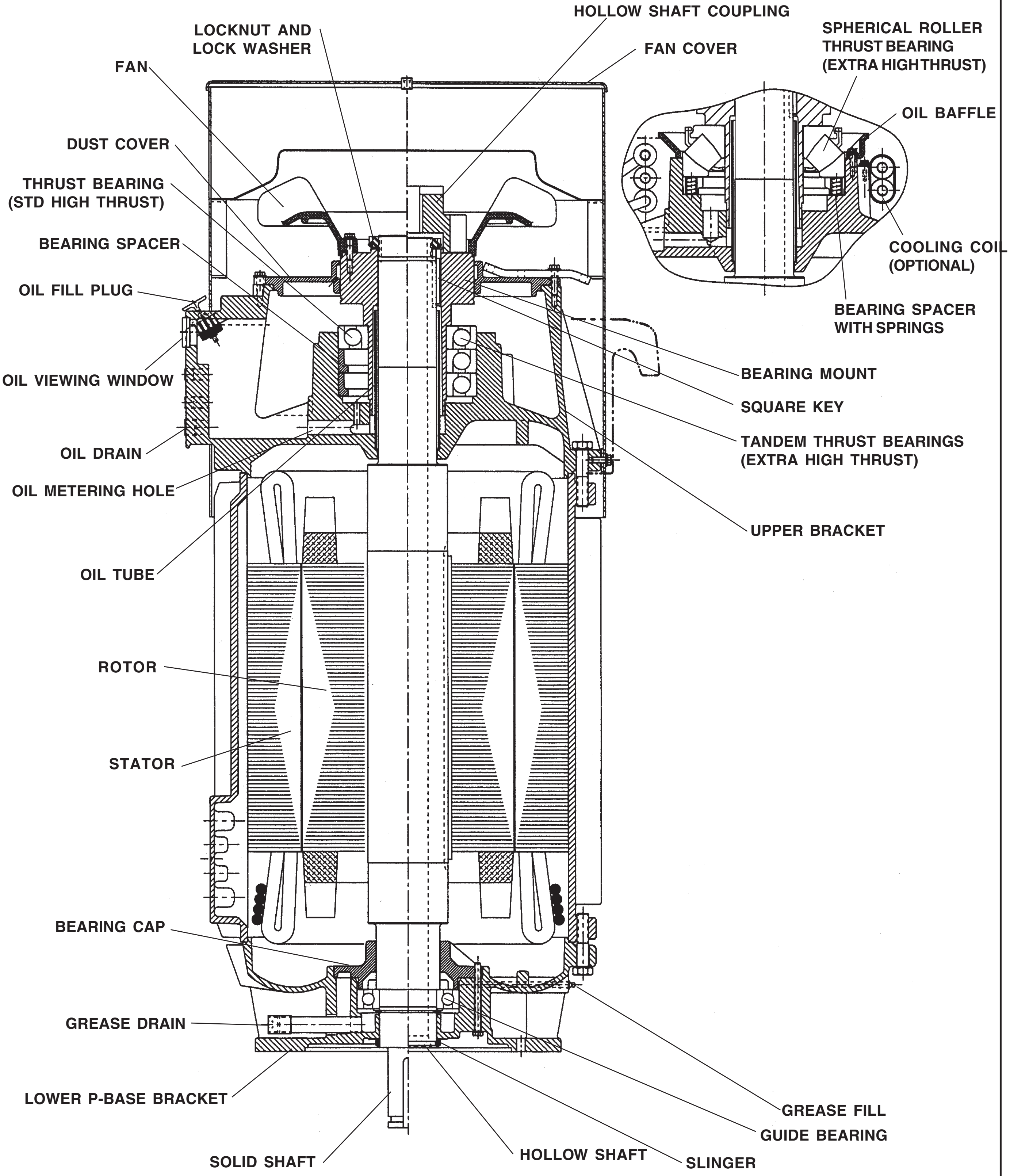
INSTALLATION AND MAINTENANCE

Spare Parts
449 Frame
Type JV-4 (2 Pole)



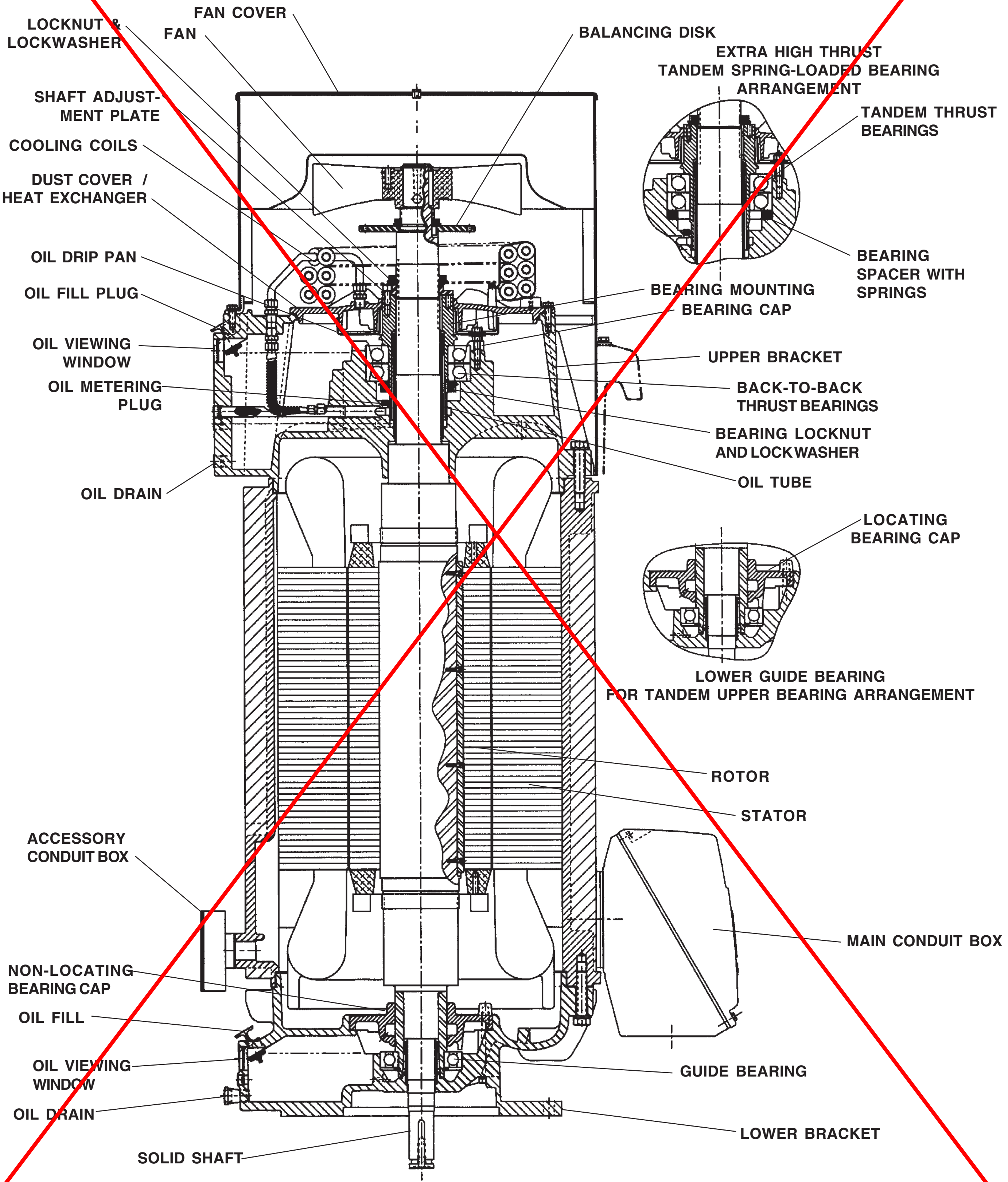
Spare Parts

449 Frame
Types JU and JV-4
(4 Pole & Slower)



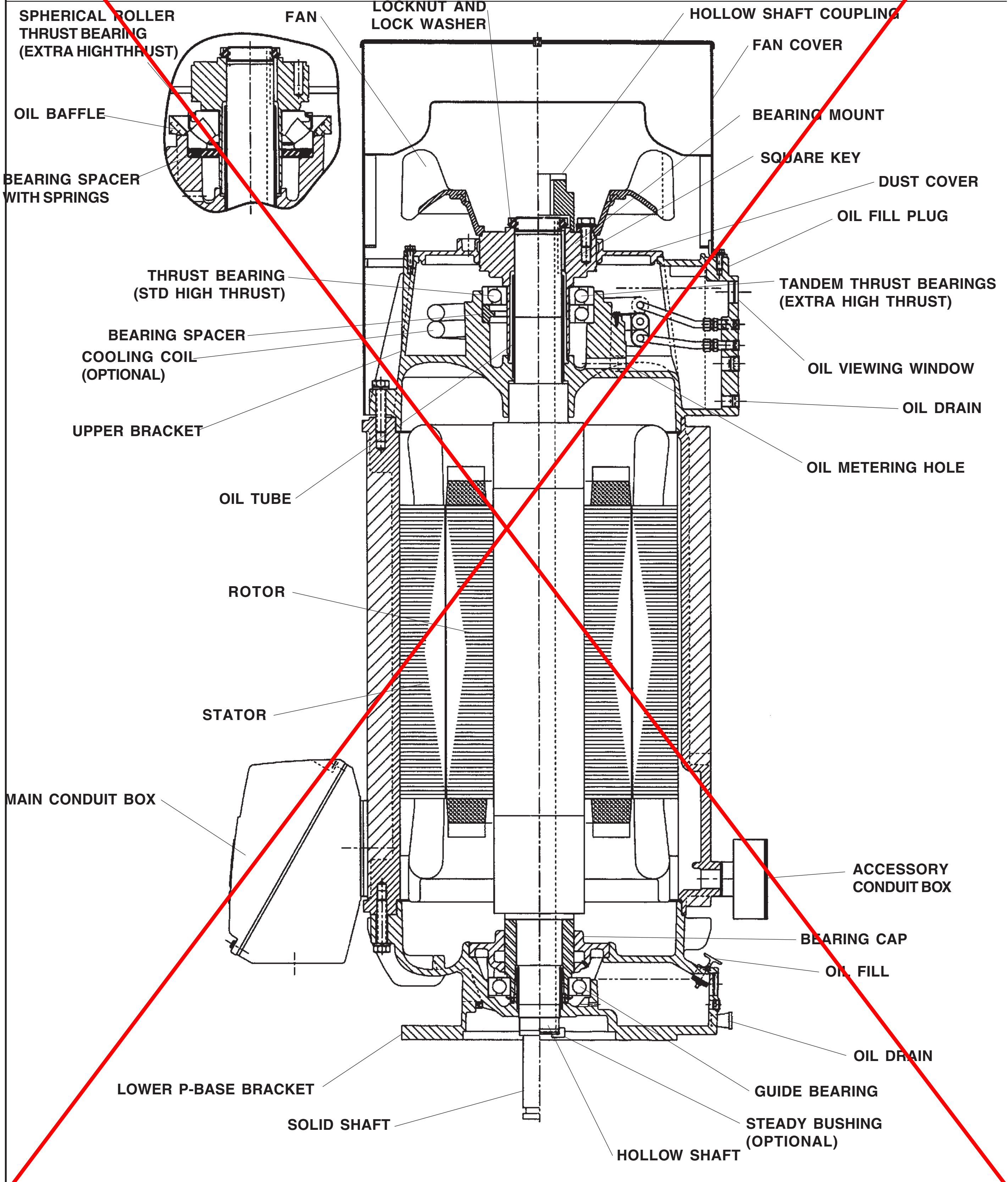
INSTALLATION AND MAINTENANCE

Spare Parts
5800 Frame
Type JV-4 & EV-4 (2 Pole)

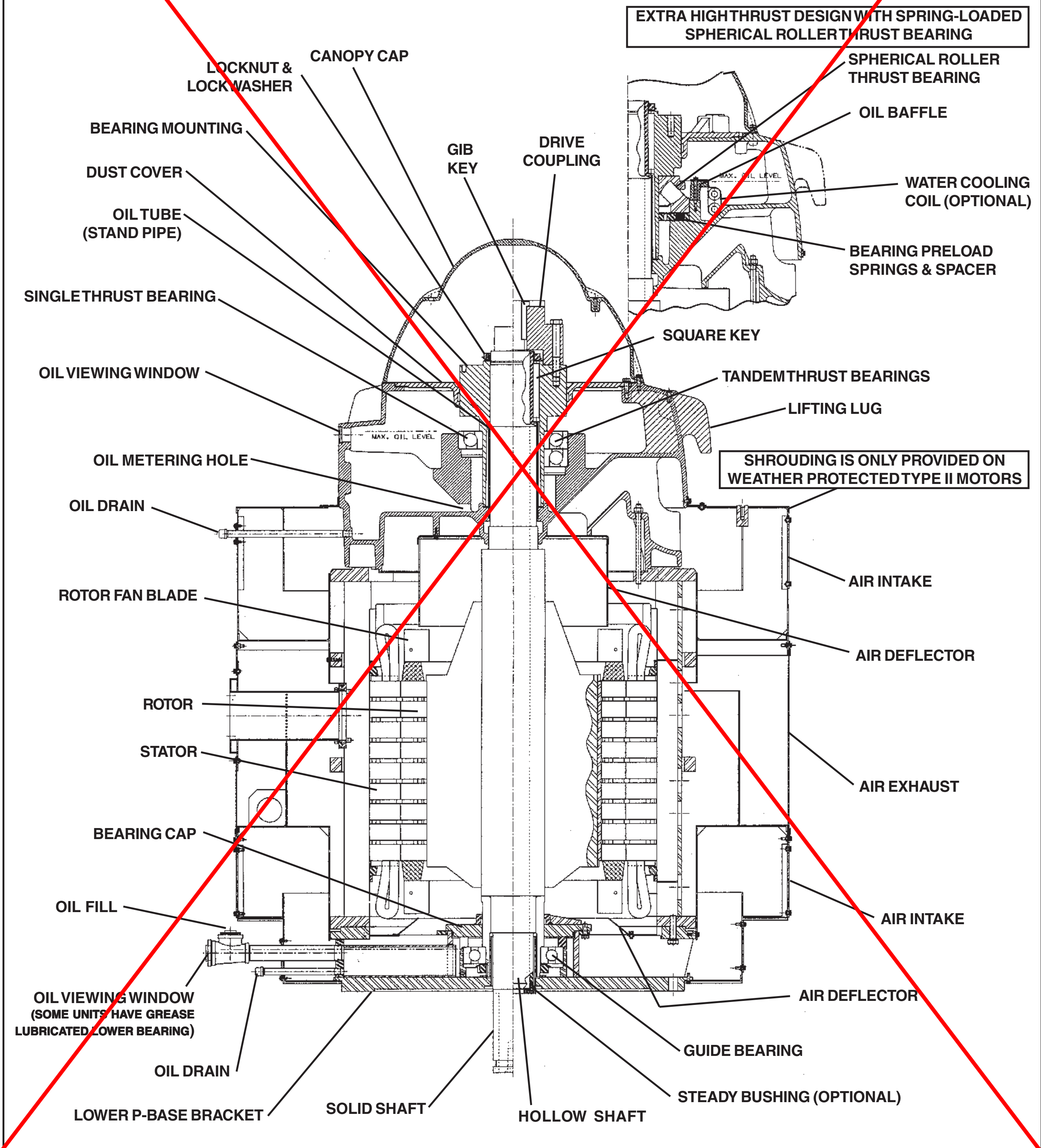


Spare Parts

5800 Frame
Types JU, JV-4, EU, EV-4
(4 Pole & Slower)

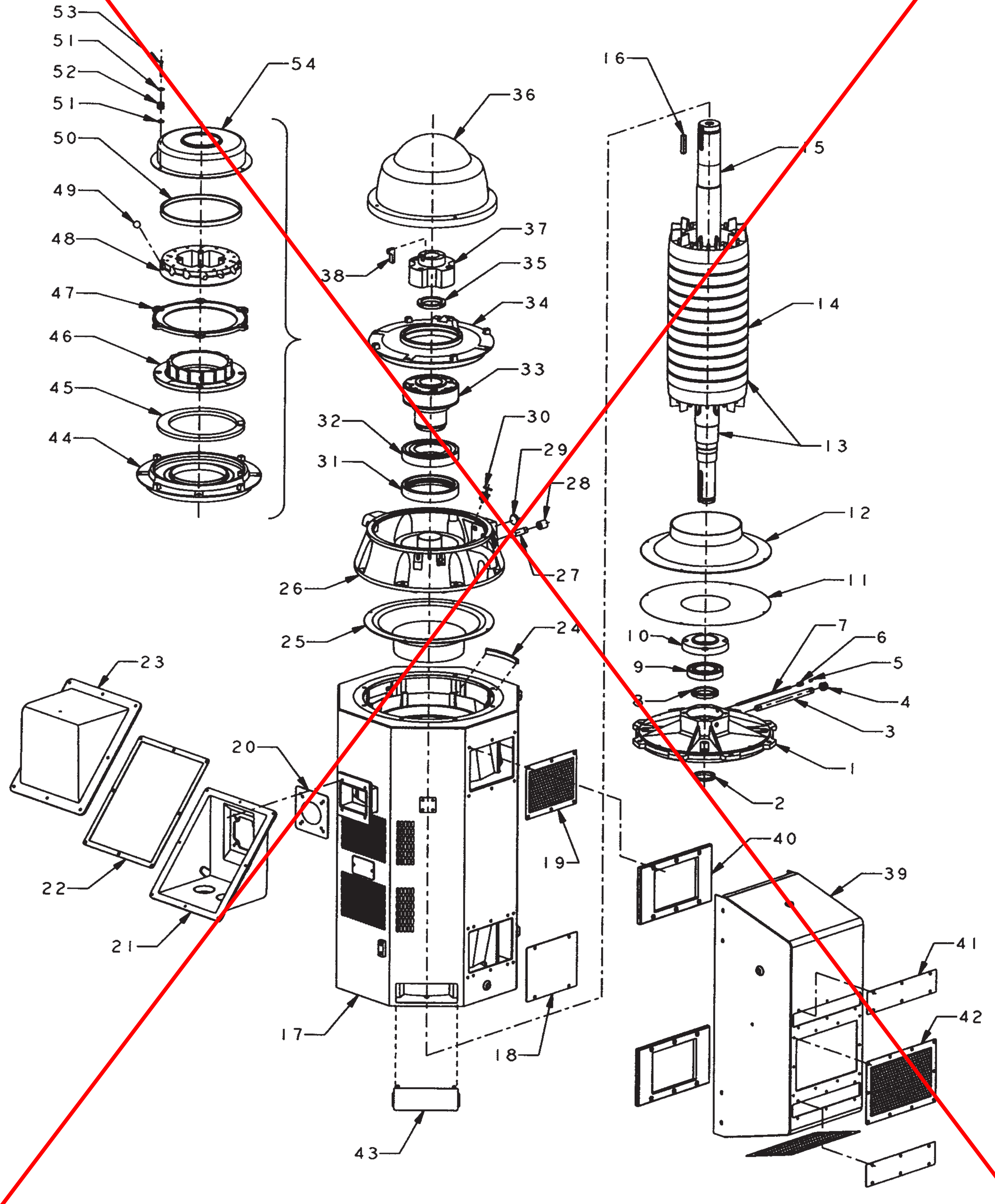


PUMP SHAFT, ADJUSTING NUT, AND LOCKING SCREWS ARE FURNISHED BY CUSTOMER



Spare Parts

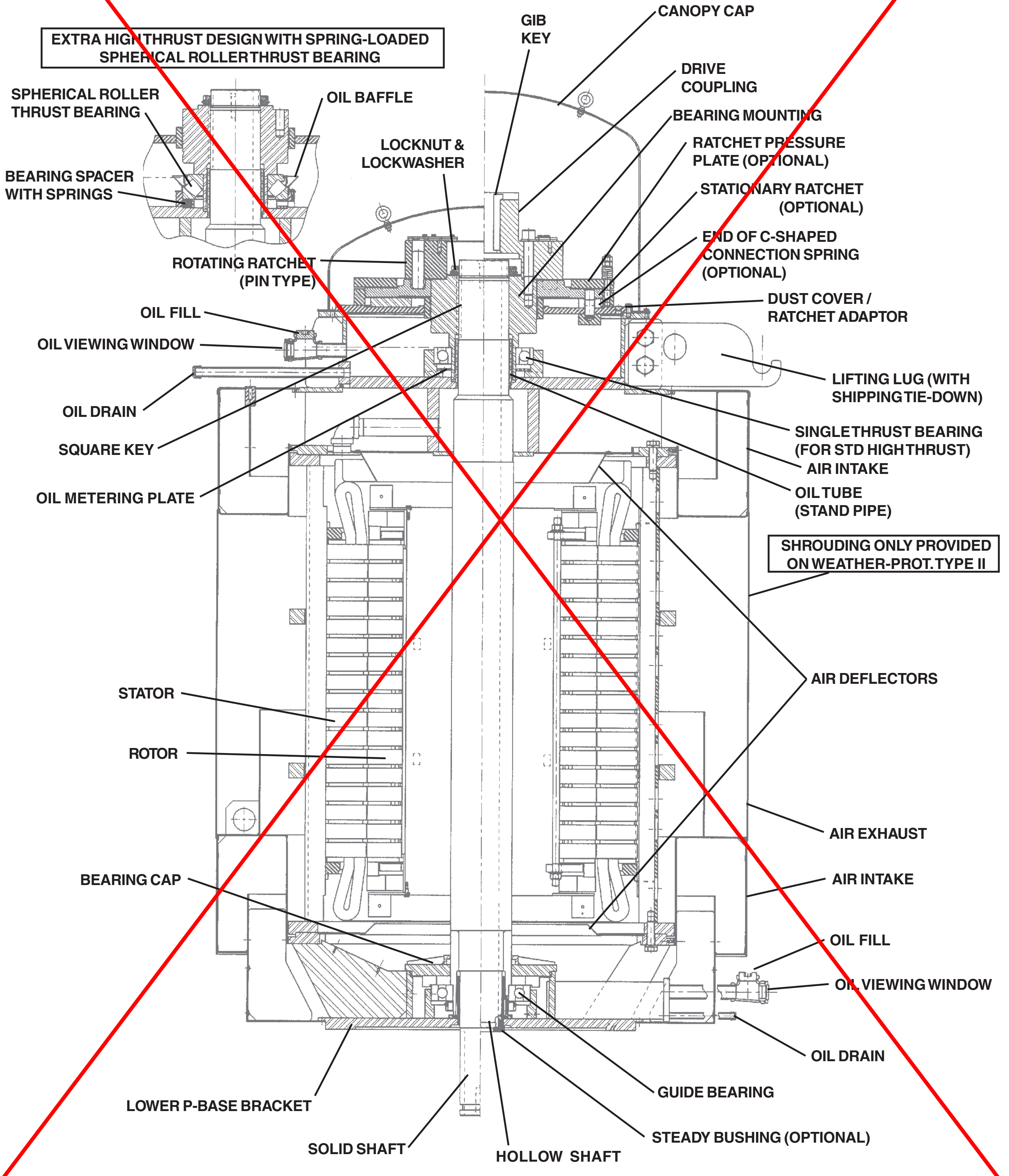
5000 Frame
Types RU and RV-4



Item No.	Quantity	Name of Part	Remarks / Limitations
1	1	Lower Bracket	All Motors
2	1	Shaft Water Slinger	All Motors
3	1	Pipe Nipple (Lower Grease Drain)	All Motors
4	1	Pipe Cap (Lower Grease Drain)	All Motors
5	1	Grease Zerk Fitting	All Motors
6	1	Pipe Coupling (Lower Grease Fill)	All Motors
7	1	Pipe Nipple (Lower Grease Fill)	All Motors
8	1	Locknut and Lockwasher (Lower Bearing)	All Motors
9	1	Lower Bearing	All Motors
10	1	Lower Bearing Cap	All Motors
11	1	Lower Intake Screen	Only on WP-1
12	1	Lower Air Deflector	All Motors
13	1	Rotor Assembly	All Motors
14	1	Rotor Core	All Motors
15	1	Rotor Shaft	All Motors
16	1	Square Key (Bearing Mounting to Shaft)	All Motors
17	1	Stator Assembly	All Motors
18	2	Lower Air Intake Cover	Only on WP-1
19	2	Upper Air Intake Screen	Only on WP-1
20	1	Gasket (Outlet Box Base to Stator)	All Motors
21	1	Outlet Box Base	All Motors
22	1	Gasket (Outlet Box Cover to Base)	All Motors
23	1	Outlet Box Cover	All Motors
24	16	Grommet (Air Deflector to Frame Baffle)	All Motors - 8 on each end
25	1	Upper Air Deflector	All Motors
26	1	Upper Bracket	All Motors
27	1	Pipe Nipple (Oil Drain)	All Motors
28	1	Pipe Cap (Oil Drain)	All Motors
29	1	Oil Sight Gauge Window	All Motors
30	1	Oil Fill Plug (Expanding)	All Motors
31	1	Bearing Spacer (or Tandem Thrust Bearing)	All Motors
32	1	Upper Thrust Bearing	All Motors
33	1	Bearing Mounting	All Motors
34	1	Dust Cover	Only on Units Without Ratchet
35	1	Locknut and Lockwasher (Brg Mtg to Shaft)	All Motors
36	1	Canopy Cap	All Motors
37	1	Thrust Coupling	Only on Hollowshaft
38	1	Gib Key	Only on Hollowshaft
39	2	WP2 Intake Box	Only on WP-2
40	4	Adapter Flange	Only on WP-2
41	4	Filter Access Cover	Only on WP-2
42	4	Intake Screen	Only on WP-2
43	4	Cover (Flange Access)	Only on WP-2
44	1	Ratchet Adaptor	Only on Units With Ratchet
45	1	Connection Spring	Only on Units With Ratchet
46	1	Stationary Ratchet	Only on Units With Ratchet
47	1	Pressure Plate	Only on Units With Ratchet
48	1	Rotating Ratchet	Only on Units With Ratchet
49	12 (5008), 14 (5012)	Ratchet Ball	Only on Units With Ratchet
50	1	Ball Retaining Ring	Only on Units With Ratchet
51	4 (5008), 12 (5012)	Plain Washer	Only on Units With Ratchet
52	4 (5008), 6 (5012)	Die Spring	Only on Units With Ratchet
53	4 (5008), 6 (5012)	Screw	Only on Units With Ratchet
54	1	Pressurization Baffle	All Motors

Spare Parts

9600 Frame
Types RU and RV-4



Installation Record

NAMEPLATE AND INSTALLATION INFORMATION

SERIAL NUMBER OR MODEL NUMBER .... ______________________
HORSEPOWER .... ______________________
MOTOR RPM .... ______________________
PHASE .... ______________________
FREQUENCY .... ______________________
AMPS .... __________ AT ______________________ VOLTS
DESIGN .... ______________________
FRAME .... ______________________
TYPE .... ______________________
DATE PURCHASED .... __________ P.O. NUMBER ______________________
DATE INSTALLED .... ______________________
LOCATION OF JOB SITE .... ______________________
MACHINE OR INSTALLATION NUMBER .... ______________________
PURCHASED FROM .... ______________________
MOTOR RESISTANCE LINE TO LINE AT TIME OF INSTALLATION .... ______________________

INSULATION TO GROUND READING AT TIME OF INSTALLATION .... ______________________

RECORD OF MAINTENANCE

GRADE AND TYPE OF LUBRICANT USED .... ______________________

DATE OF LAST RELUBRICATION	INSULATION RESISTANCE		OVERHAUL OR REPAIR	
	DATE	MEGOHMS	DATE	ACTION

Table 6

Threaded Fastener Torque Requirements

All threaded fasteners used for rigid joints (cast iron and low carbon steel) in products of Emerson Motor Co., are to be tightened to the torque values listed in the following tabulation. Values are based upon dry assembly.

Diameter of Fastener	Number of Threads Per Inch	Grade5 Fasteners	Grade 2 Fasteners
#6	32	16 lb.-in.	10 lb.-in
	40	18	12
#8	32	30	19
	36	31	20
#10	24	43	27
	32	49	31
#12	24	66	37
	28	72	40
1/4"	20	96	66
	28	120	76
5/16"	18	16 lb.-ft.	11 lb.-ft.
	24	18	12
3/8"	16	29	20
	24	34	23
7/16"	14	46	30
	20	52	35
1/2"	13	70	50
	20	71	55
9/16"	12	102	
	18	117	
5/8"	11	140	
	18	165	
3/4"	10	249	
	16	284	
7/8"	9	401	
	14	446	
1"	8	601	
	14	666	
1-1/8"	7	742	
	12	860	
1-1/4"	7	1046	
	12	1196	
1-3/8"	6	1371	
	12	1611	
1-1/2	6	1820	
	12	2110	

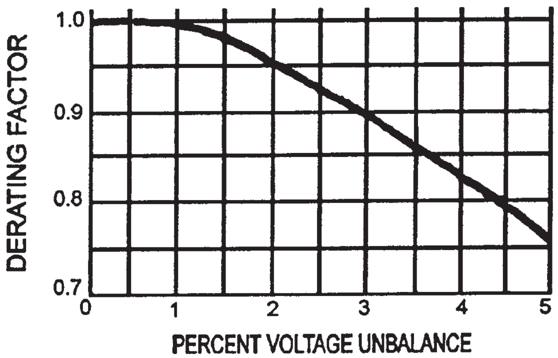
The above torque limits are not to be used when a drawing or specification lists a specific torque.

Effects of Unbalanced Line Voltage.

A potential cause of premature motor failure is unbalanced line (supply) voltage. Three phase motors produce useful work when they efficiently convert electrical energy into mechanical energy. This is accomplished when each phase of the supply voltage is of equal strength and works in harmony to produce a rotating magnetic field within the motor.

When the value of supply voltage leg to leg is not equal (e.g. 460-460-460), the risk of unbalanced line voltage is present. If this voltage unbalance exceeds about 1%, excessive temperature rise will result. Unless the motor HP capacity is derated to compensate, the motor will run hot resulting in degradation of the insulation system and bearing lubricant.

From NEMA MG-1, 14.36: Derating factors due to unbalanced line voltage



Example: Field ratings of Phase A - 480 v, Phase B = 460 v, Phase C = 450 v

As a rule of thumb, the percentage increase in temperature rise will be about two times the square of the percentage voltage unbalance. In this case the average voltage (480 + 460 + 450) is equal to 463 volts. The maximum deviation between legs is 17 volts (480 - 463 volts).

The Percentage voltage unbalance is determined as follows: 17 / 463 x 100 = 3.7%. The temperature rise will then increase $(3.7)^2$ x 2 = 27%. This condition will reduce the typical life of your motor to less than 25% of its design life. Should this condition be present, call your electric utility and resolve your unbalanced supply condition.

Other areas of motor performance will also be effected - e.g., loss of torque capacity, change in full load RPM, greatly unbalanced current draw at normal operating speed. Refer to NEMA MG-1 section 14.36 for details.

Motors Applied to Variable Frequency Drives (VFD's).

Electric motors can be detrimentally affected when applied with variable frequency drives (VFD's). The non-sinusoidal waveforms of VFD's have harmonic content which causes additional motor heating; and high voltage peaks and short rise times, which result in increased insulation stress, especially when long power cable lengths are used. Other affects of VFD's on motor performance include reduced efficiency, increased load current, vibration and noise. Standard motors utilized with VFD's must be limited to those application considerations defined in NEMA MG-1 Part 30.

NEMA MG-1 Part 31 defines performance and application considerations for Definite-Purpose Inverter Fed motors. To insure satisfactory performance and reliability, Emerson Motor Co. offers and recommends nameplated inverter duty motor products which meet the requirements of NEMA MG-1 Part 31. The use of non-inverter duty motors may result in unsatisfactory performance or premature failure, which may not be warrantable under the Terms and Conditions of Sale. Contact your Emerson Motor Co. Field Sales Engineer for technical assistance in motor selection, application and warranty details.

ELECTRIC MOTOR LOAD TEST USING THE WATT HOUR METER

In the analysis of electric motors it is sometimes desirable to conduct an accurate load check on a particular installation to determine whether the motor is operating within the rating and horsepower for which it was designed. Since most pump installations have their own watt hour power meters, accurate readings will permit a load check via the following formula:

K = Disc constant (watts per revolution of disc per hour). This is typically found on the meter face.

R = Revolutions of disc in watt meter within the time of the test.

T = Time of test, in seconds.

Transformer ratio = Stated on meter face. Must be included where current transformers are used with watt meters.

To obtain input kilowatts:

$$\text{Input KW} = \frac{K \times R \times 3.6}{T}$$

To obtain input horsepower:

$$\text{Input HP} = \frac{K \times R \times 4.83 \times \text{Transformer Ratio}}{T}$$

The watt hour meter measures power consumed over a period of time. It is necessary to establish the rate at which power is being consumed by the work being done. We establish this rate by counting the revolutions of the disc in a given time. Here is a typical example of a load check:

GIVEN

- Pump motor to be load checked is rated 100 HP, 1800 RPM, 3-phase, 60 Hz, 1.15 service factor, 91.0 Percent Efficiency.
- Disc constant (K) found on face of meter = 40.
- Transformer ratio found on face of meter = 3.

DATA FOUND FROM TESTS
With stop watch, disc was observed to revolve 10 times in exactly 49 seconds. Therefore, R = 10; T = 49.

THUS

$$\text{Input HP} = \frac{40 \times 10 \times 4.83 \times 3}{49} = 118.29$$

Output HP = Input HP x Motor Efficiency
Output HP = 118.29 x 91% = 107.54

CONCLUSION
The output HP (107.54) is greater than output HP shown on nameplate (100 HP), but is well within the 1.15 service factor which applies to this motor.

EMERSON
Motor Technologies

SECTION 6

SUPPLEMENTARY DOCUMENTS

7706 N 71ST Street
Glendale, AZ 85303
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F. 623.979.2177
W. www.nationalpumpcompany.com

From the office of:
Marco Porras
P. 623.979.3560 ext 212
E. marcop@natlpump.com

NATIONAL PUMP COMPANY
A GORMAN-RUPP COMPANY

ANALYSIS REPORT

Reed Critical Frequency Analysis
H24LC (2) STAGE

Prepared by: Marco Porras
Project Engineer, National Pump Company

Approved by: A. Bruce Ticknor III, P.E.
Manager of Engineering, National Pump Company

REGISTERED PROFESSIONAL ENGINEER
ALBERT BRUCE TICKNOR III
No. M 34118
EXP 06.30.2014
MECHANICAL
STATE OF CALIFORNIA

02.20.2013

Customer:	Sierra Mountain
Customer PO:	WQCF-6859
Customer Tag:	OPS-PUM-100,-200,-300
Sales Order:	849460
Release Date:	17-DEC-2012
Revision:	0
Revision Date:	17-DEC-2012
File Name:	849460A_RCF_REV0

Summary

A reed critical frequency (RCF) analysis was performed to satisfy the analysis requirement for National Pump Company sales order 832520. The pump will operate at a variable speed of 40%-100% of 890 rpm with a required separation margin of 25% above and 25% below the pump operating speed. This results in a range of interest from 267 cpm to 1113 cpm.

The discharge head and motor were modeled as solids and meshed using solid tetragonal elements in Autodesk Inventor and with simulation. A modal analysis was performed to verify there were no natural frequencies within the range of interest.

No natural frequencies were found within the range of interest. The pump is acceptable to operate at a range of 356-890 rpm with respect to structural resonant response.

Release Date:	17-DEC-2012
Revision:	0
Revision Date:	
File Name:	849460A_RCF_REV0

1. Introduction

1.1. A reed critical frequency (RCF) analysis was performed to satisfy the analysis requirement for National Pump Company sales order 832520. The pump will operate at a variable speed of 40%-100% of 890 rpm with a required separation margin of 25% above and 25% below the operating speed of the pump. This results in a range of interest from 267 cpm to 1113 cpm.

2. Assumptions

2.1. Motor data provided by the manufacturer is accurate.
2.2. The pump is mounted on a level and ridged foundation.
2.3. There are no restraints or forces applied on the discharge flange.
2.4. The effects of the pump column mass, stiffness and hydraulic interactions are insignificant.
2.5. Welds and weld material have no significant effect on the analysis results.
2.6. The coupling, seal, shaft and bolts have no significant effect on the analysis results.

3. Modeling

3.1. The discharge head was modeled as a single solid using Autodesk Inventor. Items such as the registers, bolt holes, guards, and vents may not have been modeled to simplify meshing. A detailed drawing and material properties are presented in appendix A1.

3.2. The motor was modeled as a hollow cylinder. The cylinder's outside diameter was modeled as the motor's base diameter (BD). The cylinder's inside diameter was modeled as the motor's register diameter. The cylinder's height was modeled as two times the motor's center of gravity. The modulus of elasticity was tuned such that the natural frequency of the cylinder matches the motor's specified RCF. The density was tuned such that the weight of the cylinder matches the motor's specified weight. The tuned material properties and manufacturer supplied motor data is detailed in appendix A2.

3.3. The model was meshed with solid tetragonal elements and a modal analysis was solved using Autodesk Inventor with simulation. The base was retrained in three translational degrees of freedom.

4. Analysis

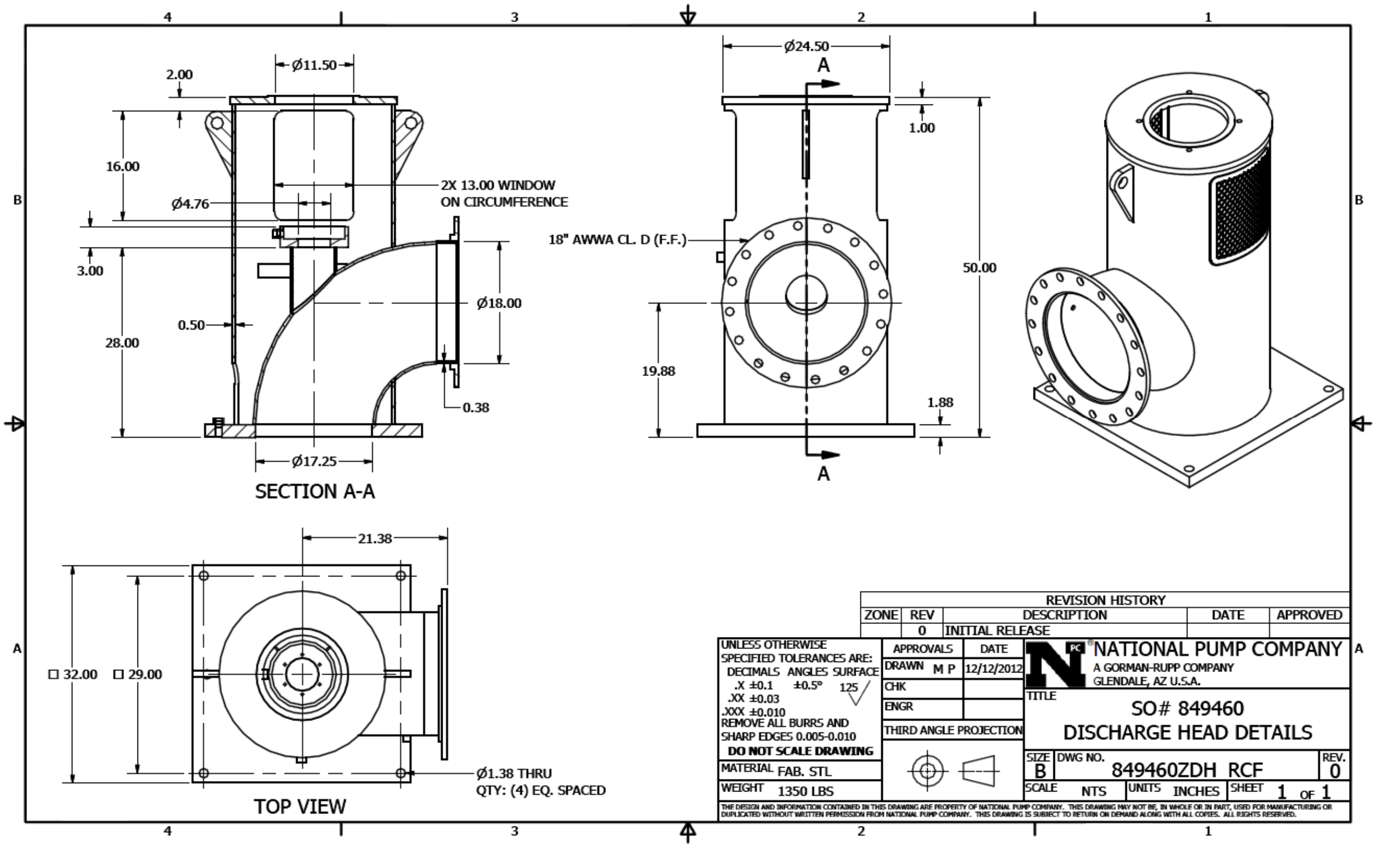
4.1. The 1st inline frequency was 18.62 Hz (1117 cpm). The 1st transverse natural frequency was 20.55 Hz (1233 cpm). Each of these mode shapes are presented in appendix A3. Since both of these 1st natural frequencies are above the range of interest, the 2nd inline and transverse natural frequencies present no problem.

5. Conclusion

5.1. Since the 1st and 2nd natural frequencies are not in the range of interest, the 2-stage H24LC for National Pump Company sales order number 849460A is acceptable in terms of structural resonant response to operate at a variable speed of 356-890 rpm.

Appendix

A1. Discharge Head Details



Discharge Head Material Properties

Modulus of Elasticity	3.048e7	psi
Poisson's Ratio	0.30	
Density	0.283	lb/in3

Release Date:	17-DEC-2012
Revision:	0
Revision Date:	
File Name:	849460A_RCF_REV0

A2. Motor Details

TYPICAL REED CRITICAL FREQUENCY DATA

USEM MODEL NO: NA
USEM CATALOG NO: NA

Frame: 449TP Type: JUEI

REED CRITICAL FREQUENCY:	31	HZ
CENTER OF GRAVITY:	26	IN
DEFLECTION @ CENTER OF GRAVITY:	0.0102	IN
UNIT WEIGHT:	3300	LBS.
BASE DIAMETER:	24.5	IN.
MAXIMUM MOTOR DIAMETER:	26.25	IN.
DATE:	12/5/2012	

Motor Data Provided by Manufacturer

Tuned Motor Material Properties

Modulus of Elasticity	3.19e5	psi
Poisson's Ratio	0.30	
Density	0.193	lb/in3

A3.Analysis Results

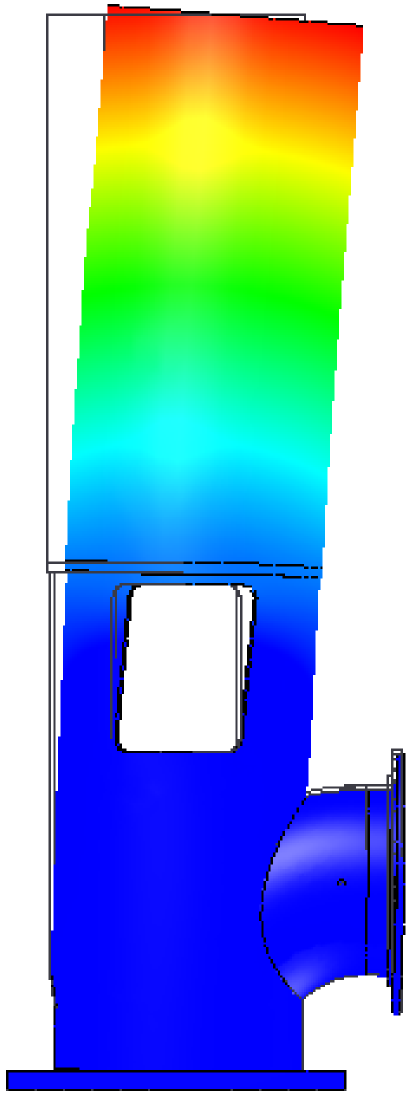


Figure: 1st Inline Natural Frequency 19.17 Hz (1150 cpm)

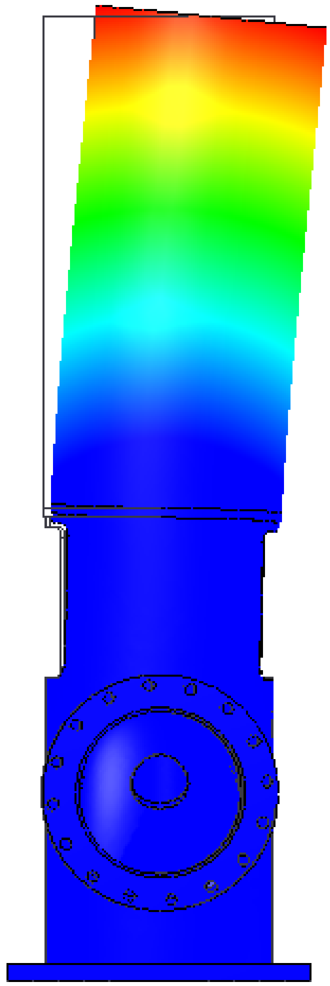


Figure: 1st Transverse Natural Frequency 21.19 Hz (1271 cpm)

Revision History

Level	Description	Date	By	Approved
0	Initial Release	17-DEC-2012	MP	ABT

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P. 623.979.3560 ext 223
E. brucet@natlpump.com

ANALYSIS REPORT

Lateral and Torsional Rotordynamic Analysis
H24LC-2 STAGE

Prepared by: A. Bruce Ticknor III, P.E.
Director of Engineering, National Pump Company

Checked by: Gary Brooks
Senior Project Engineer, National Pump Company

Customer:	Sierra Mountain Construction
Customer PO:	WQCF-6859
Customer Tag:	OPS-PUM-100, -200, -300
Sales Order:	849460A
Release Date:	05.20.2013
Revision:	0
Revision Date:	05.20.2013
File Name:	849460A_RDA_rev0.docx

Summary

A lateral and torsional rotordynamic analysis was performed to satisfy the analysis requirement for National Pump Company sales order 849460A. The pump will operate on a variable frequency drive (VFD) between 356 rpm (40%) and 890 rpm with a required separation margin of ±20% for both the lateral and torsional analysis. This results in a range of interest from 285 rpm to 1068 rpm.

The pump was modeled as a rotor assembly using discrete idealized shaft elements, lumped parameter disks and bearings in DyRoBeS. A damped natural frequency analysis was performed to verify that there were no lateral critical speeds. A torsional natural frequency analysis was performed to verify that there were no torsional critical speeds.

No critical speeds were found within the range of interest. The pump has been found acceptable in terms of lateral and torsional resonant response to operate within the speed range of 356 rpm to 890 rpm.

Table of Contents

Release Date:	05.20.2013
Revision:	0
Revision Date:	05.20.2013
File Name:	849460A_RDA_rev0.docx

1. Introduction

1.1. A lateral and torsional rotordynamic analysis was performed to satisfy the analysis requirement for National Pump Company sales order 849460A. The pump will operate on a variable frequency drive (VFD) between 356 rpm (40%) and 890 rpm with a required separation margin of ±20% for both the lateral and torsional analysis. This results in a range of interest from 285 rpm to 1068 rpm.

2. Assumptions

2.1. Motor data provided by the manufacturer is accurate.
2.2. The motor rotor does not add or detract from the system stiffness.
2.3. Roller element bearings have no damping.
2.4. Mass diametrical moment of inertia for the impellers was assumed to be 0.6 times the mass polar moment of inertia supplied by National Pump Company Engineering Catalog.
2.5. The stiffness of bearing support structures were considered to be rigid.
2.6. Modal damping was assumed to be 1% at each node.
2.7. Torque excitations were assumed to be 1% of rated torque.

3. Modeling

3.1. The pump was modeled as a rotor assembly using DyRoBeS. The shaft elements were discrete idealized Timoshenko elements. The disks were lumped parameter disks containing four degrees of freedom. The bearings' stiffness and dampening factors were calculated using the DyRoBeS BePerf module. Two models were created, one for the lateral analysis and one for the torsional analysis.

3.2. Motor Model

3.2.1. Lateral Analysis
3.2.1.1. The motor was modeled as a stepped shaft with a single discrete disk element using data provided by Nidec Motor Corporation detailed in appendix A4.

3.2.2. Torsional Analysis
3.2.2.1. The motor was modeled as a dummy shaft with a single discreet disk element. A torsional link was connected between the dummy shaft nodes using the torsional spring stiffness provided by Nidec Motor Corporation detailed in appendix A4.

3.3. The impellers and shaft couplings were modeled as discrete disk elements. The disks are defined by the mass, mass diametrical moment of inertia (J_d) and mass polar moment of inertia (J_p). The disks lengths, outside diameters and inside diameters are for appearance only and have no effect on the analysis. The impeller J_p was determined from the National Pump Company Engineering Catalog. The impeller J_d was calculated as 0.6 times the J_p (see assumption 2.4). The J_p and J_d for the line shaft couplings where calculated based on National Pump Company drawings and material properties. The J_p and J_d for the ridged flange coupling was calculated based on a 3D model. Disk details are presented in appendix A5.

3.4. The enclosing tube was modeled as a shaft with zero rotational speed. A infinitely stiff bearing was used to represent the ridged mounting of the enclosing at the discharge head and discharge case. The line shaft bearings were then connected between the shaft and enclosing tube.

3.5. The tension, line shaft, bowl adapter tube, top bowl, bowl and suction bell bearing coefficients were determined using DyRoBeS BePerf module. This was done using the fixed-lobed, plain cylindrical journal with constant viscosity and dimensions from National Pump Company drawings which are presented in appendix A6. The bearing coefficients were calculated throughout the speed range being analyzed and are available upon request in electronic format (.txt) due to their excessive length.

3.6. The annular seal effects of the impeller and bowl skirt/wear rings were also included. This was done by specifying dimensions and the per-stage differential pressure from National Pump Company drawings and performance data. Annular seal details are presented in appendix A6.

3.7. Axial loads, rated torque and unbalance loads were applied to the model. The axial thrust load was applied between the upper motor bearing and first stage. The rated motor torque was applied between the rotor core center and the first stage impeller. All of the motor unbalance was applied to center of the motor core. The impeller unbalance was applied at the impeller. The calculations and values are detailed in appendix A7.

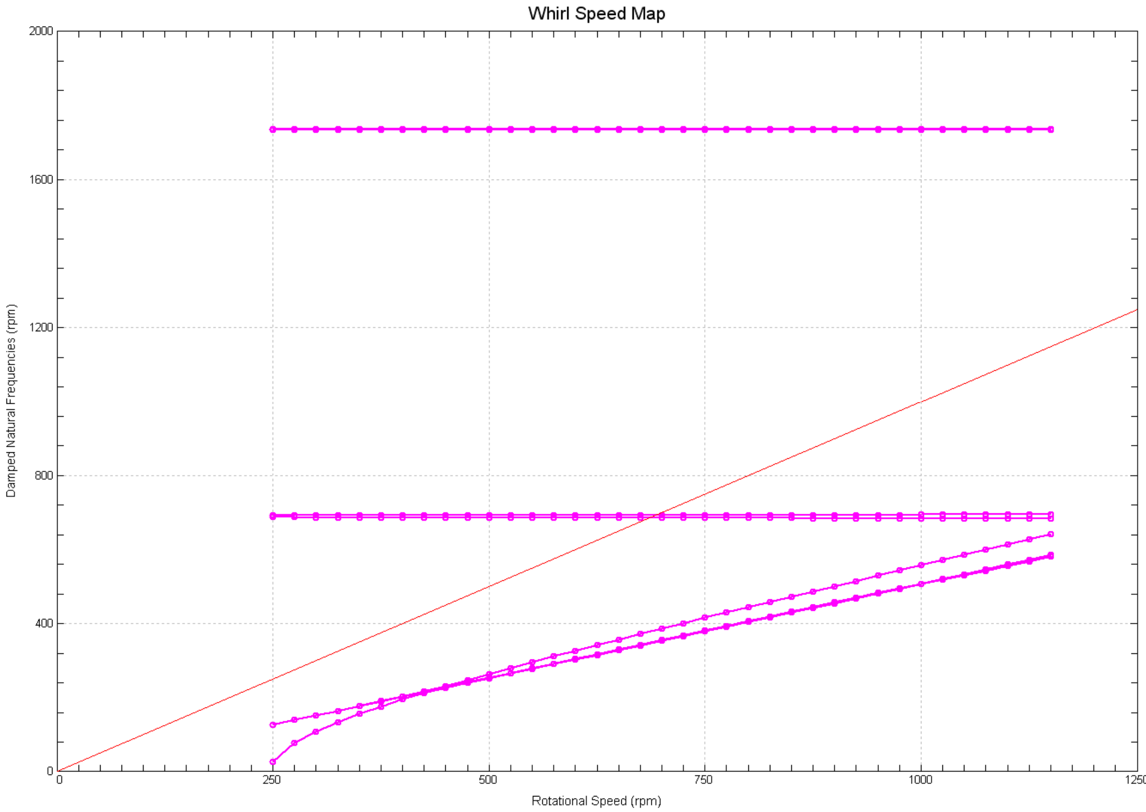
3.8.The complete rotordynamic model is depicted in appendix A8. The lateral model summary generated by DyRoBeS is presented in appendix A9. The torsional model summary generated by DyRoBeS is presented in appendix A10.

4. Analysis

4.1. Lateral Analysis

4.1.1. A damped natural frequency analysis was performed to identify possible lateral critical speed within the range of interest. Figure 4.1.1.1 shows the lateral interference diagram with a half and 1st order excitation line. Table 4.1.1.2 thru 4.1.1.5 detail the mode, damped natural frequency, log decrement, damping factor and ratio to operating speed. A selection of mode shapes are depicted in appendix A11, additional modes shapes can be provided upon request. Figure 4.1.1.6 shows the damping factor versus the frequency ratio with the API 610 limits at four (4) speeds within the operating range.

4.1.1.1. Figure: Whirl Speed Map



4.1.1.2. Table: Damped Lateral Natural Frequencies at 900 rpm

Mode	Type	Damped Natural Frequency (cpm)	Log Decrement	Damping Factor	Ratio of Damped Natural Frequency to Running Speed
1	Forward	454	0.543	0.086	0.505
2	Forward	457	0.764	0.121	0.508
3	Forward	457	0.745	0.118	0.508
4	Forward	457	0.812	0.128	0.508
5	Forward	457	0.923	0.145	0.508
6	Forward	501	4.220	0.558	0.556
7	Forward	684	0.073	0.012	0.760
8	Mixed	693	0.169	0.027	0.770
9	Mixed	1735	0.034	0.005	1.928

4.1.1.3.Table: Damped Lateral Natural Frequencies at 700 rpm

Mode	Type	Damped Natural Frequency (cpm)	Log Decrement	Damping Factor	Ratio of Damped Natural Frequency to Running Speed
1	Forward	355	0.697	0.11	0.507
2	Forward	355	0.773	0.122	0.508
3	Forward	355	0.751	0.119	0.508
4	Forward	356	0.834	0.132	0.508
5	Forward	356	0.976	0.154	0.508
6	Forward	387	5.480	0.658	0.552
7	Forward	685	0.082	0.013	0.979
8	Mixed	692	0.164	0.026	0.989
9	Mixed	1735	0.035	0.005	2.479

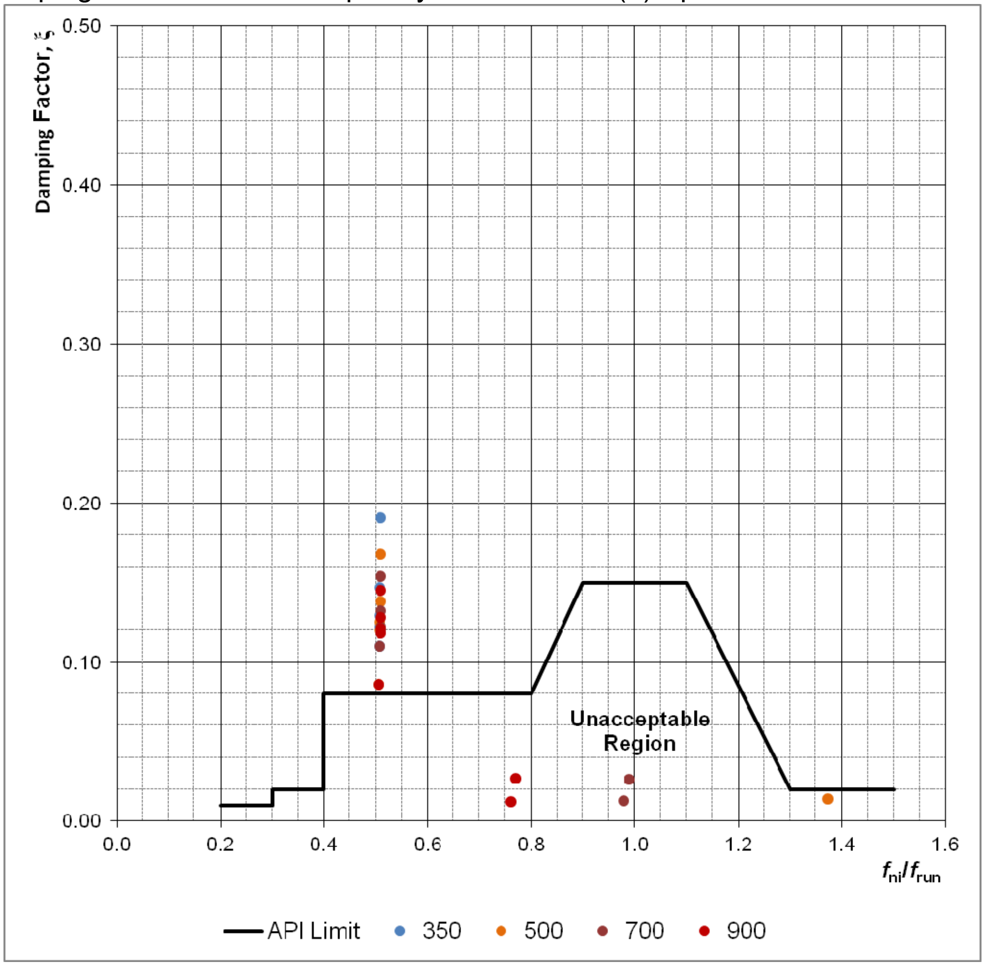
4.1.1.4.Table: Damped Lateral Natural Frequencies at 500 rpm

Mode	Type	Damped Natural Frequency (cpm)	Log Decrement	Damping Factor	Ratio of Damped Natural Frequency to Running Speed
1	Forward	252	0.543	0.086	0.505
2	Forward	254	0.789	0.125	0.508
3	Forward	254	0.761	0.120	0.508
4	Forward	254	0.874	0.138	0.508
5	Forward	254	1.070	0.168	0.508
6	Forward	264	8.180	0.793	0.529
7	Forward	686	0.090	0.014	1.372

4.1.1.5.Table: Damped Lateral Natural Frequencies at 350 rpm

Mode	Type	Damped Natural Frequency (cpm)	Log Decrement	Damping Factor	Ratio of Damped Natural Frequency to Running Speed
1	Forward	156	14.200	0.914	0.445
2	Forward	177	0.697	0.110	0.507
3	Forward	178	0.937	0.147	0.508
4	Forward	178	0.815	0.129	0.508
5	Forward	178	0.774	0.122	0.508
6	Forward	178	1.220	0.191	0.508
7	Forward	686	0.098	0.016	1.961

4.1.1.6. Figure: Damping Factor Versus Frequency Ratio at Four (4) Speeds



4.1.2. A steady-state damped unbalance response analysis was performed with four times the permissible unbalance. Table 4.1.2.1 details the displacements at each node being investigated, the type, the maximum peak-peak displacement and the percentage of diametrical clearance with a balance grade of 16W/N. Appendix A12 shows the mode shapes at 900 rpm and the bode plots at each location of interest throughout the range of interest.

4.1.2.1. Table: Steady-State Damped Unbalanced Response Results at 16W/N

Node	Type	Diametrical Clearance (in)	Max. Peak-Peak Displacement (in)	Percentage of Diametrical Clearance
17/40	Tension BRG	0.010	0.0000	0.5%
19/43	Line Shaft BRG	0.010	0.0000	0.1%
22/46	Line Shaft BRG	0.010	0.0000	0.3%
25/49	Line Shaft BRG	0.010	0.0001	0.8%
27/52	BAT BRG	0.014	0.0015	10.9%
28	Top Bowl BRG	0.014	0.0024	18.1%
30	Wear Ring	0.032	0.0027	8.4%
31	Bowl BRG	0.014	0.0024	18.0%
33	Wear Ring	0.032	0.0009	2.9%
34	Suction BRG	0.014	0.0000	0.1%

4.1.3. Since no peak-peak displacement was found greater than 35% of the diametrical clearance, there are no lateral critical speeds within the range of interest.

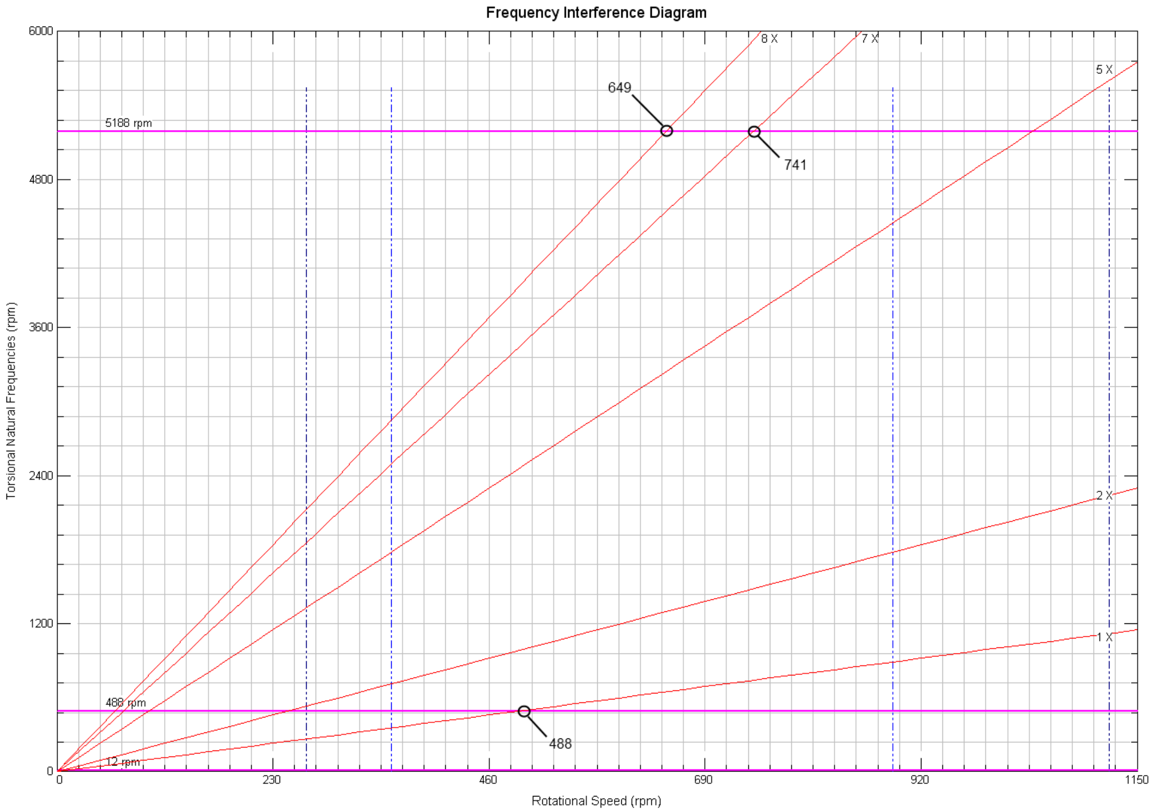
4.2. Torsional Analysis

4.2.1. A torsional natural frequency analysis was performed to identify possible torsional critical speeds within the range of interest. The mode shapes are depicted in appendix A13. Table 4.2.1.1 details the modes and natural frequencies. Figure 4.2.1.2 shows a torsional interference diagram which was constructed using the torsional natural frequencies and overlaying the generic 1st and 2nd excitations, 5th order excitation for the for the impeller vanes, 7th order excitation for the bowl vanes and 8th order excitation for the motor slip frequency.

4.2.1.1. Table: Torsional Natural Frequencies

Mode	Natural Frequency (Hz)	Natural Frequency (cpm)
1	0.20	12
2	8.14	488
3	86.46	5188

4.2.1.2.Figure: Torsional Interference Diagram

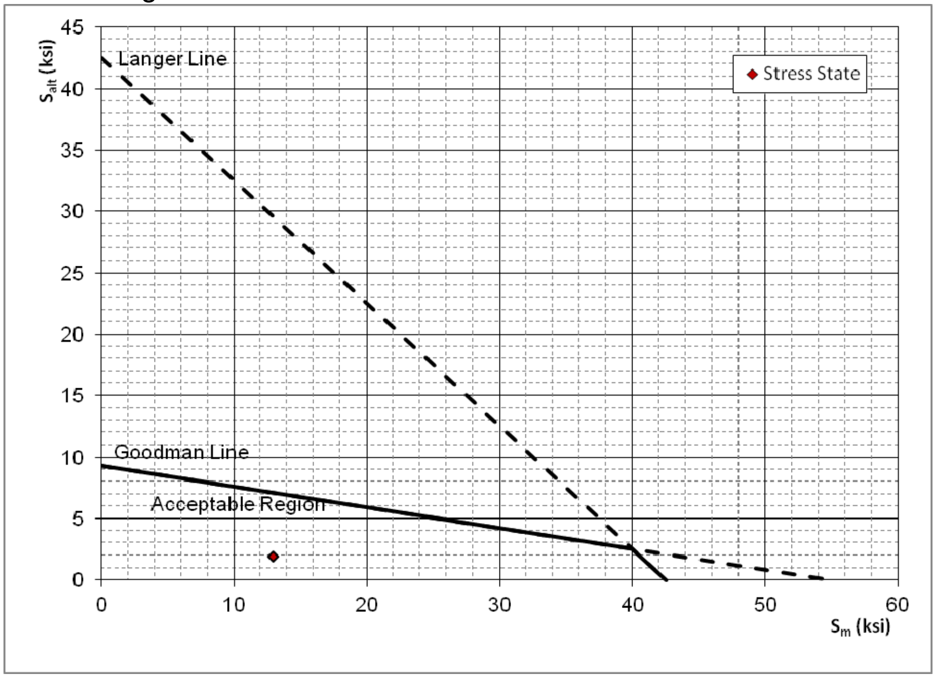


4.2.2. Figure 4.2.1.2 shows three (3) interferences within the range of interest. Additional analysis was performed to determine if the interferences were in fact critical speeds.

4.2.3. Interference at 488 rpm

4.2.3.1. This interference was due to the generic 1st order exciting the 2nd torsional mode. The 1st torsional mode shape depicted in appendix A13 shows displacement at the bowl and motor, thus a steady-state forced response analysis was required. The resulting maximum steady state alternating stress was determined to be 1086 psi within the line shaft assembly shown in appendix A14. A fatigue calculation was performed and is detailed in appendix A15. Since the fatigue calculations determined the shaft has infinite life, this interference was ruled a non-critical speed.

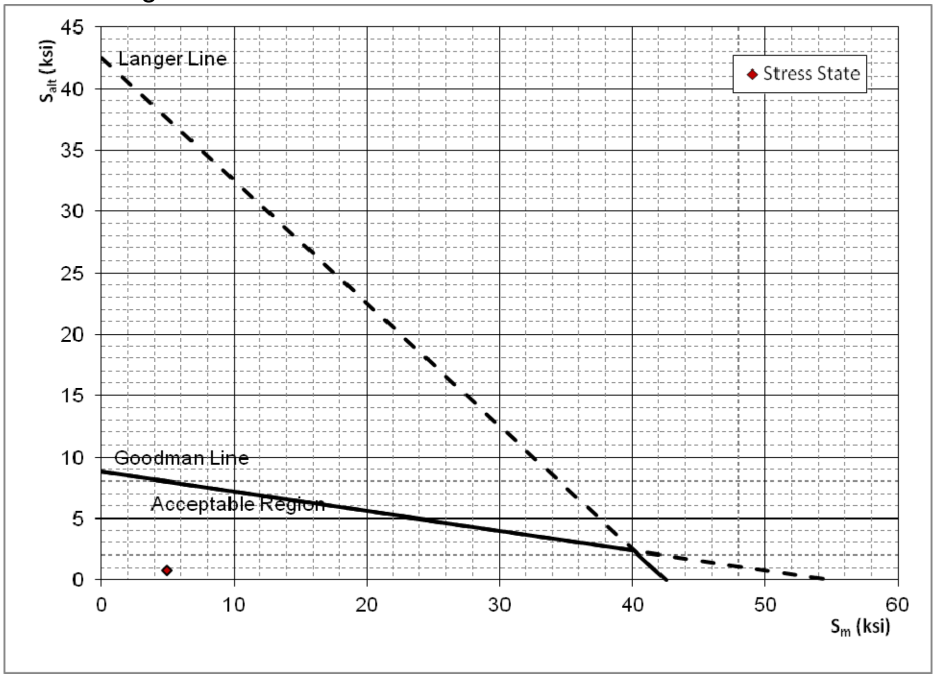
4.2.3.2. Figure: Line Shaft Fatigue Calculation



4.2.4. Interference at 741 rpm

4.2.4.1. This interference was due to the 7th order bowl vane exciting the 3rd torsional mode. The 3rd torsional mode shape depicted in appendix A13 shows displacement at the bowl, thus a steady-state forced response analysis was required. The resulting maximum steady state alternating stress was determined to be 480 psi within the bowl shaft assembly shown in appendix A14. A fatigue calculation was performed and is detailed in appendix A15. Since the fatigue calculations determined the shaft has infinite life, this interference was ruled a non-critical speed.

4.2.4.2.Figure: Bowl Shaft Fatigue Calculation



4.2.5. Interference at 649 rpm

4.2.5.1. This interference was due to the 8th order motor slip exciting the 3rd torsional mode. The 3rd torsional mode shape depicted in appendix A13 shows no displacement at the motor, thus this mode cannot be excited. This interference was ruled a non-critical speed.

4.2.6. Since all three (3) interferences were determined to be non-critical speeds, there are no torsional critical speeds within the range of interest.

5. Conclusion

5.1. The two (2) stage H24LC pump for National Pump Company sales order number 849460A has been found acceptable in terms of lateral and torsional resonant response to operate within the speed range of 356 rpm to 890 rpm.

Appendix

A1. References

1. API Standard 610, Tenth Edition, 2004, “Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries,” American Petroleum Institute, Washington DC
2. Chen, W. J. & Gunter, E. J., First Edition, 2005, “Introduction to Dynamics of Rotor-Bearing Systems,” Trafford Publishing, Victoria, British Columbia, Canada
3. Corbo, M. A.& Melanoski, S. B., 1996, “Practical Design Against Torsional Vibration,” *Twenty-Fifth International Turbomachinery Symposium*, Texas A&M University, College Station, Texas
4. IRD Balancing Technical Paper 1, 2007, “Balance Quality Requirements of Rigid Rotors – The Practical Application of ISO 1940/1,” Entek IRD Balancing, Columbus, Ohio
5. Kaiser, T.E., Osman, R. H. & Dickau, R. O., 2008, “Analysis Guide for Variable Frequency Drive Operated Centrifugal Pumps,” *Twenty-Fourth International Pump Users Symposium*, Turbomachinery Laboratory, Texas A&M University, College Station, Texas
6. Leader, M.E., “A Machinery User’s Guide to Practical Lateral Rotordynamics,” Applied Machinery Dynamics Company, Dickinson, Texas
7. Leader, M. E., “Practical Implementation of Torsional Analysis,” Applied Machinery Dynamics Company, Dickinson, Texas
8. Lindeburg, M. R., Twelfth Edition, First Printing, 2006, “Mechanical Engineering Reference Manual for the PE Exam,” Professional Publications, Inc., Belmont, California
9. National Pump Company, 2009, “Engineering Catalog,” Glendale, Arizona
10. Shigley, J. E., Mischke, C. R. & Budynas, R. G., Seventh Edition, 2004, “Mechanical Engineering Design,” McGraw-Hill, New York, New York

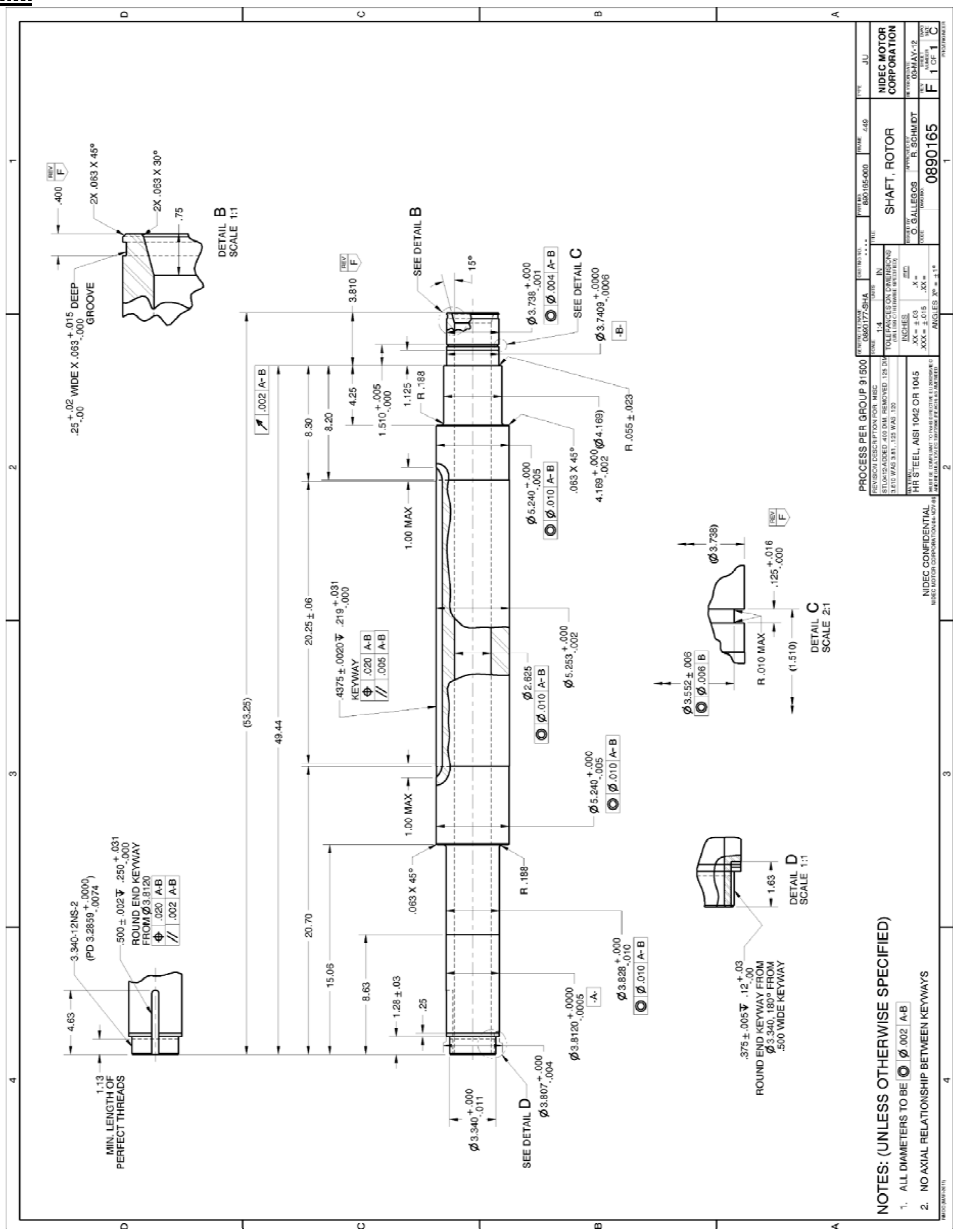
A2. Definitions

Bode Plot: plot of amplitude and phase verses operating speed
Critical Speed: a speed at which the rotating equipment excites a natural frequency and produces damage
Lateral – this occurs when the dampening factor is below that specified by API 610 Figure I.1 and a steady-state damped unbalance response analysis results in a peak-to-peak displacement exceeding 35% of the bearing clearance with four times the permissible unbalance applied
Torsional – this occurs when there is an interference within the range of interest and a steady-state force response analysis results in a stress state outside the acceptable region of the fatigue diagram
Damping Factor (ξ): ratio of damping to critical damping
Damped Natural Frequency: the frequency at which a structure vibrates in the presence of damping
Fatigue Diagram (Goodman): diagram showing the stress state of a component and the allowable stress envelope of the material in cyclic stress and mean stress
Logarithmic Decrement (σ): the natural logarithm of the ratio of two successive amplitudes
Mode Shape: characteristic shape of a structure when vibrating at a particular natural frequency, also referred to as a precessional mode in lateral rotordynamic analysis
Order of Excitation: the number of oscillations of per shaft revolution
Range of Interest: the operating range with the separation margins
Torsional Interference Diagram (Campbell): diagram showing the operating speed, natural frequencies and excitation lines, locations where an excitation line crosses and natural frequency line is known as an interference, if this falls within the range of interest a steady state analysis must be performed
Whirl Speed Map: diagram showing the damped lateral natural frequencies versus the operating speed

A3. About the Author

A. Bruce Ticknor III graduated from Washington State University in Pullman Washington in 2005 with a bachelor of science in mechanical engineering. He is a registered professional engineer in Arizona, California and Washington. He has been specializing in design and analysis of vertical turbine pumps for over six years. He has completed over 30 hours of specialized training in rotordynamic analysis from Dr. Edgar J. Gunter, Jr., Ph.D., Fellow ASME (Rotor-Bearing Dynamics Using DyRoBeS) and Malcolm E. Leader, P.E. (Rotordynamics). He is an active participant in the Hydraulic Institute (HI) chairing the 2.1-2.2 Nomenclature and Definition committee, committee member multiple sections including Vibration Dynamics. In 2013, he was awarded the “Future Engineering of the Year” by HI. He currently is working for National Pump Company as the Director of Engineering.

A4. Motor Data



Release Date:	05.20.2013
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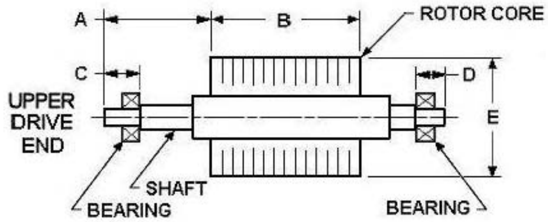
Revision Date:	05.20.2013
File Name:	849460A_RDA_rev0.docx

LATERAL CRITICAL SPEED ANALYSIS DATA

ORDER NO: 20121843-100

FRAME SIZE 449TP, JU



ROTOR DATA (dimensions in inches)			
A - ROTOR CORE LOCATION	**B - ROTOR CORE LENGTH**	**C - OPPOSITE DRIVE END BRG.**	**D - DRIVE END BRG. LOCATION**
21.00	20.00	7.47	3.81
E - ROTOR CORE DIAMETER	**SHAFT LENGTH END TO END**	**ROTOR CORE WEIGHT (lbs)**	**ROTOR ASSEMBLY WEIGHT (lbs)**
15.00	53.25	841	1026
ROTOR INERTIA POLAR (lb-ft^2)	**ROTOR INERTIA TRANSVERSE (lb-ft^2)**		**SHAFT/ROTOR ASM BALANCE**
177	88.5		ISO 1940 G 2.5

BEARING DATA			
UPPER END BEARING		**LOWER END BEARING**	
NUMBER	**STIFFNESS (lb/in)**	**NUMBER**	**STIFFNESS (lb/in)**
7226 BCB	1.44 X 10^6	6219 J/C3	1.03 X 10^6

SHAFT DATA			
DRAWING NO.	**MATERIAL**	**DENSITY**	**YIELD**
0890165	AISI 1040 –1045 HR	.283 LBS/IN^3	45,000 psi
TENSILE	**YOUNG'S MODULUS**	**SHEAR MODULUS**	
82,000 psi	30.0 x10^6 psi	12.0 x 10^6 psi	

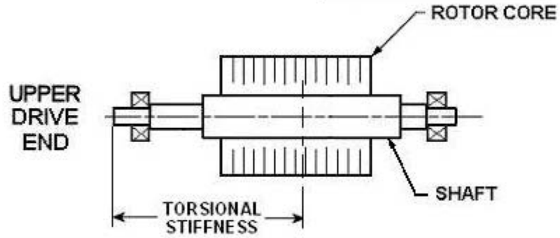
NIDEC MOTOR CORPORATION

ST. LOUIS, MISSOURI **4/30/2013**

TORSIONAL ANALYSIS DATA

ORDER NO: 20121843-100

FRAME SIZE 449TP, JU



SHAFT DATA			
DRAWING NO.	**MATERIAL**	**DENSITY**	**YIELD**
0890165	AISI 1040 –1045 HR	.283 LBS/IN^3	45,000 psi
TENSILE	**YOUNG'S MODULUS**	**SHEAR MODULUS**	
82,000 psi	30 x10^6 psi	12 x 10^6 psi	

MOMENT OF INERTIA - ROTOR ASSEMBLY:

WR^2 = 177 LB-FT^2

SHAFT TORSIONAL STIFFNESS:

7.88 X 10^6 LB-IN/RADIAN

Torsional stiffness is the spring rate or constant which allows a user to determine the amount of twist or angular deflection in a shaft based on the amount of torque applied. The portion of the shaft for which the shaft stiffness has been calculated from 1/3 the length of the rotor core to the end of the drive end connection. It is the users responsibility to correct for coupling mounting effects.

NIDEC MOTOR CORPORATION
ST. LOUIS, MISSOURI **4/30/2013**

Release Date:	05.20.2013
Revision:	0
Revision Date:	05.20.2013
File Name:	849460A_RDA_rev0.docx

A5. Impeller and Shaft Coupling Data

Impeller Data

Impeller Model	H24LC	
Number of Impeller Vanes	5	
Number of Bowl Vanes	7	
Number of Stages	2	
Location	ALL	
Mass (M)	120.0	lb
Mass Polar Moment of Inertia (J_p or WR^2)	51.1	lb-ft^2
Mass Diametrical Moment of Inertia (J_d)	30.66	lb-ft^2

Head Shaft Coupling

Head Shaft Coupling Type	RF	
Number of Couplings	1	
Material	STEEL	
Density (ρ)	Not Required	lb/in3
Outside Diameter (D_o)	4.00	in
Inside Diameter (D_i)	1.94	in
Length (L)	5.38	in
Mass (M)	19.40	lb (per 3D model)
Mass Polar Moment of Inertia (J_p or WR^2)	71.01	lb-in^2 (per 3D model)
Mass Diametrical Moment of Inertia (J_d)	65.19	lb-in^2 (per 3D model)

Shaft Couplings

Line Shaft Coupling Type	KEYED	
Number of Couplings	1	
Material	416SS	
Density (ρ)	0.292	lb/in3
Outside Diameter (D_o)	3.25	in
Inside Diameter (D_i)	1.94	in
Length (L)	8.00	in
Mass (M)	12.47	lb
Mass Polar Moment of Inertia (J_p or WR^2)	22.33	lb-in^2
Mass Diametrical Moment of Inertia (J_d)	77.67	lb-in^2

Equations:

$$M = \rho * V = \rho * \frac{\pi}{4} * \left(D_o^2 - D_i^2\right) * L = lb$$

$$J_p = \frac{M * (D_o^2 + D_i^2)}{8} = lb - in^2$$

Used for coupling

$$J_d = \left(\frac{M}{12}\right) * \left(3 * \left(\frac{D_o}{2}\right)^2 + 3 * \left(\frac{D_i}{2}\right)^2 + L^2\right) = lb - in^2$$

A6. Bearing Geometry and Annular Seal Data

Shaft Diameters

Line Shaft	1.9375	in
Bowl Shaft	2.6875	in

Bearing Geometry

		Inside Diameter		Length	Radial Clearance	
					As-New	2X As-New
	P/N	in	in	in	in	in
Tension	849460ZBRGT	1.9480	1.9460	6.25	0.0048	0.0095
Line Shaft	849460ZBRGLS	1.9480	1.9460	6.25	0.0048	0.0095
Bowl Adapter Tube	849460ZBRGBAT	2.7020	2.7000	5.00	0.0068	0.0135
Top Bowl	849460ZBRGTB	2.7020	2.7000	12.00	0.0068	0.0135
Bowl	02X0090005	2.7020	2.7000	6.69	0.0068	0.0135
Suction Bell/Case	02X0090105	2.7020	2.7000	8.00	0.0068	0.0135

Bearing Load Calculation

Impeller Grade Specified	16W/N	
Impeller Grade Calculated	16W/N	
Balance Constant (K)	16	
Impeller Mass (W)	120	lb
Rated Speed (n)	890	rpm
Permissible Unbalance (U_{per})	2.16	oz-in
Radial Force (F_c)	3.02	lbf

Bearing Lubricant Properties

		Dynamic Viscosity		Density	
	Type	cP	Reyn	Spec. Gr.	lbm/in^3
Tension	Oil	30.1	4.365E-06	0.852	0.031
Line Shaft	Oil	30.1	4.365E-06	0.852	0.031
Bowl Adapter Tube	Water	1.1	1.602E-07	0.998	0.036
Top Bowl	Water	1.105	1.602E-07	0.998	0.036
Bowl	Water	1.105	1.602E-07	0.998	0.036
Suction Bell/Case	Grease	533	7.729E-05	0.930	0.034

Annular Seal Data

Seal Length	1.73	in
Impeller Seal Diameter	13.8810	in
Bowl Seal Diameter	13.9130	in
Radial Clearance	0.0160	in
Fluid Density	0.036	lbm/in^3
Dynamic Viscosity	1.602E-07	Reyn
Differential Pressure per Stage	19.4	psi

Equations:

$$U_{per} = \frac{KW}{n} = oz - in$$

$$F_c = 1.77 * \left(\frac{n}{1000}\right)^2 * U_{per} = lb$$

A7. Axial, Torque & Unbalance Loads

Impeller Weight

Model	H24LC	
Number of Stages	2	
Impeller Weight	120	lb
Total Impeller Weight	240	lb

Hydraulic Thrust

Rated Head (H)	87	ft
Thrust Factor (Kt)	53	lb/ft
Specific Gravity (SG)	1	
Hydraulic Thrust (T_{tot})	4611	lb

Line Shaft Weight

Line Shaft Diameter	1.94	in
Line Shaft Material	416SS	
Line Shaft Length (L)	231.38	in
Line Shaft Weight per Foot (w/l)	10.22	lb/ft
Line Shaft Weight (W_L)	197	lb

Bowl Shaft Weight

Bowl Shaft Diameter	2.69	in
Bowl Shaft Material	416SS	
Bowl Shaft Length (L)	94	in
Bowl Shaft Weight per Foot (w/l)	19.8	lb/ft
Bowl Shaft Weight (W_B)	155	lb

Total Axial Load = 5203 lb

Rated Torque

Motor Horsepower (P)	150	HP
Rated Speed (n)	890	rpm
Rated Torque (T)	10622	lb-in

Motor Unbalance

Rotor Assy. Weight (W)	1026	lb
Rotor Balance Spec.	ISO 1940 G 2.5	
Rated Speed (n)	890	rpm
Permissible Unbalance (U_{per})	8.67	oz-in

Impeller Unbalance

Permissible Unbalance (U_{per})	2.16	oz-in (see appendix A6)

Equations:

$$T_{tot} = SG * Kt * H = lb$$

$$T = \frac{63025 * P}{n} = lb - in$$

$$U_{per} = \frac{G * 6.015 * \frac{W}{2}}{n} = oz - in$$

G = grade number

Release Date:	05.20.2013
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File Name:	849460A_RDA_rev0.docx

A8. Rotordynamic Model Figure

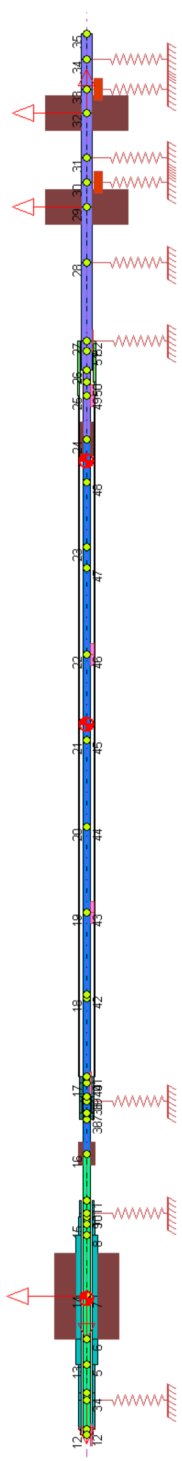

Figure: Lateral Rotordynamic Model

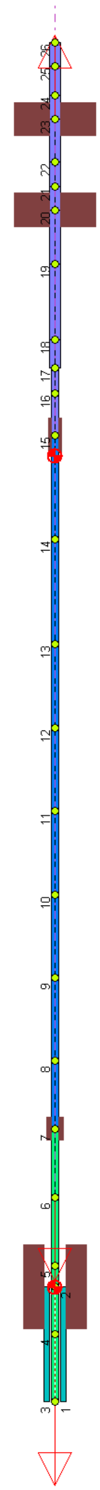

Figure: Torsional Rotordynamic Model

A9. Lateral Model Summary

```
   DyRoBeS-Rotor Ver 16.23, W. J. Chen, All Rights Reserved.
   Time: 08:56:06.30 am   Date: 05-15-2013
   FileName: 849460A_LAT.rot
                    *************************************
                    **           Summary               **
                    **             of                  **
                    **          input data             **
                    **             and                 **
                    **       system parameters         **
                    *************************************
                        ***** Unit System = 2 *****
                  Engineering English Units (s, in, Lbf, Lbm)
                        ***** Analysis Required *****
                            Model Summary
 **************************** System Parameters ******************************
                               3  Shafts
                              49  Elements
                              49  SubElements
                               9  Materials
                               3  Unbalances
                                  3  Mass Unbalances (mew^2)
                               5  Rigid Disks (4 dof)
                               0  Flexible Disks (6 dof)

                              14  Linear Bearings
                                  2  Liquid Annular Seals
                               0  NonLinear Bearings
                               0  Flexible Supports

                               2  Axial Loads
                               0  Static Loads
                               0  Time Forcing Functions
                               0  S.S. Harmonic Excitation

                               0  Natural Boundary Conditions
                               0  Geometric Boundary Conditions
                               0  Constraints

                              52  Stations
                             208  Degrees of Freedom
 **************************** Description Headers ****************************
  SALES ORDER# 849460A
  CUSTOMER NAME: SIERRA MOUNTAIN
  PROJECT NAME: CITY OF TURLOCK
  BY: A. BRUCE TICKNOR III, P.E.
 **************************** Material Properties ****************************
```

Property no	Mass Density (Lbm/in^3)	Elastic Modulus (Lbf/in^2)	Shear Modulus (Lbf/in^2)
1	.28300	.30000E+08	.12000E+08
2	.28200	.29000E+08	.12000E+08
3	.28200	.29000E+08	.12000E+08
4	.28200	.29000E+08	.12000E+08
5	.31400	.13000E+08	.52000E+07
6	.28400	.30000E+08	.12000E+08
7	.28400	.30000E+08	.12000E+08
8	.28400	.30000E+08	.12000E+08
9	.25000	.25000E+08	.95000E+07

```
****************************** Shaft Elements ******************************
     Sub   Left                 ------ Mass ------     --- Stiffness ----
 Ele Ele   End                   Inner     Outer       Inner     Outer   Material
  no  no   Loc      Length      Diameter  Diameter    Diameter  Diameter    no
                     (in)             (in)                  (in)

   1
     1      .000    1.2800    2.6250    3.3400      2.6250    3.3400     1
   2
     1     1.280    6.7700    2.6250    3.8120      2.6250    3.8120     1
   3
     1     8.050    1.8600    2.6250    3.8120      2.6250    3.8120     1
   4
     1     9.910    6.4300    2.6250    3.8280      2.6250    3.8280     1
   5
     1    16.340    5.9400    2.6250    5.2530      2.6250    5.2530     1
   6
     1    22.280   10.0000    2.6250    5.2530      2.6250    5.2530     1
   7
     1    32.280   14.1900    2.6250    5.2530      2.6250    5.2530     1
   8
     1    46.470    4.2500    2.6250    4.1690      2.6250    4.1690     1
   9
     1    50.720     .7550    2.6250    3.7410      2.6250    3.7410     1
  10
     1    51.475    3.0600    2.6250    3.7410      2.6250    3.7410     1
 -------
  12
     1      .000   16.3450     .0000    1.9375       .0000    1.9375     2
  13
     1    16.345   16.3450     .0000    1.9375       .0000    1.9375     2
  14
     1    32.690   16.3450     .0000    1.9375       .0000    1.9375     2
  15
     1    49.035   16.3450     .0000    1.9375       .0000    1.9375     2
  16
     1    65.380   16.3800     .0000    1.9375       .0000    1.9375     3
  17
     1    81.760   19.8150     .0000    1.9375       .0000    1.9375     3
  18
     1   101.575   19.8150     .0000    1.9375       .0000    1.9375     3
  19
     1   121.390   20.0000     .0000    1.9375       .0000    1.9375     3
  20
     1   141.390   20.0000     .0000    1.9375       .0000    1.9375     3
  21
     1   161.390   20.0000     .0000    1.9375       .0000    1.9375     3
  22
     1   181.390   25.0000     .0000    1.9375       .0000    1.9375     3
  23
     1   206.390   25.0000     .0000    1.9375       .0000    1.9375     3
  24
     1   231.390   10.0000     .0000    1.9375       .0000    1.9375     4
  25
     1   241.390    6.0000     .0000    1.9375       .0000    1.9375     4
  26
     1   247.390    6.8500     .0000    2.6875       .0000    2.6875     4
  27
     1   254.240   18.0800     .0000    2.6875       .0000    2.6875     4
  28
     1   272.320   12.9600     .0000    2.6875       .0000    2.6875     4
  29
     1   285.280    5.6200     .0000    2.6875       .0000    2.6875     4
  30
     1   290.900    5.8200     .0000    2.6875       .0000    2.6875     4
  31
     1   296.720   10.3100     .0000    2.6875       .0000    2.6875     4
```

32								
	1	307.030	5.6200	.0000	2.6875	.0000	2.6875	4
33								
	1	312.650	6.9900	.0000	2.6875	.0000	2.6875	4
34								
	1	319.640	5.7500	.0000	2.6875	.0000	2.6875	4

36								
	1	73.380	1.5000	1.9500	3.5000	1.9500	3.5000	5
37								
	1	74.880	2.6100	2.2500	3.5000	2.2500	3.5000	5
38								
	1	77.490	1.1400	2.2500	3.5000	2.2500	3.5000	5
39								
	1	78.630	3.1300	1.9375	3.5000	1.9375	3.5000	5
40								
	1	81.760	1.6300	1.9375	3.5000	1.9375	3.5000	5
41								
	1	83.390	19.0000	3.5000	4.0000	3.5000	4.0000	6
42								
	1	102.390	19.0000	3.5000	4.0000	3.5000	4.0000	6
43								
	1	121.390	20.0000	3.5000	4.0000	3.5000	4.0000	7
44								
	1	141.390	20.0000	3.5000	4.0000	3.5000	4.0000	7
45								
	1	161.390	20.0000	3.5000	4.0000	3.5000	4.0000	7
46								
	1	181.390	20.0000	3.5000	4.0000	3.5000	4.0000	8
47								
	1	201.390	20.0000	3.5000	4.0000	3.5000	4.0000	8
48								
	1	221.390	20.0000	3.5000	4.0000	3.5000	4.0000	8
49								
	1	241.390	3.2500	3.5000	4.5000	3.5000	4.5000	9
50								
	1	244.640	7.1000	3.0000	4.5000	3.0000	4.5000	9
51								
	1	251.740	2.5000	3.3800	4.5000	3.3800	4.5000	9

**************************** Rigid/Flexible Disks ****************************

Stn no	Mass (Lbm)	Diametral Inertia (Lbm-in^2)	Polar Inertia (Lbm-in^2)	Skew X (deg.)	Skew Y (deg.)	Offset (in)
7	841.00	12744.	25488.	.0000	.0000	.0000
16	19.400	65.190	71.010	.0000	.0000	.0000
24	12.470	77.670	23.330	.0000	.0000	.0000
29	120.00	4415.0	7358.0	.0000	.0000	.0000
32	120.00	4415.0	7358.0	.0000	.0000	.0000

******************* Rotor Equivalent Rigid Body Properties *******************

Rotor no	Left End Location (in)	Length (in)	C.M. Location (in)	Mass (Lbm)	Diametral Inertia (Lbm-in^2)	Polar Inertia (Lbm-in^2)	Speed Ratio
1	.000	54.535	31.811	1022.5	.4448E+05	26203.3	1.0000
2	.000	325.390	226.466	602.33	.5440E+07	15019.5	1.0000
3	73.380	180.860	165.175	177.03	.5973E+06	602.528	.0000
--- Sum ---		325.390	109.982	1801.9	.2104E+08	41825.3	

**************************** Bearing Coefficients ****************************

Available upon request in .txt format

************************* Bearing Location and Span *************************

No.	Station	Location	Span	Distance Between Stations
1	3	8.05000	8.05000	1 - 3
2	10	51.47500	43.42500	3 - 10
3	38	77.49000	26.01500	10 - 38
4	17	81.76000	4.27000	38 - 17
5	19	121.39000	39.63000	17 - 19

```
    6       22       181.39000        60.00000             19 - 22
    7       25       241.39000        60.00000             22 - 25
    8       27       254.24000        12.85000             25 - 27
    9       52       254.24000          .00000             27 - 52
   10       28       272.32000        18.08000             52 - 28
   11       30       290.90000        18.58000             28 - 30
   12       31       296.72000         5.82000             30 - 31
   13       33       312.65000        15.93000             31 - 33
   14       34       319.64000         6.99000             33 - 34
 ************************** Mass Unbalance (M x Ecc) **************************
     Ele   SubEle     ----- Left End -----        ----- Right End -----
      no      no       Magnitude      Angle        Magnitude      Angle
                        (oz-in)      (degree)       (oz-in)      (degree)
       7       1        8.6700          .00        .00000          .00
      29       1        2.1600          .00        .00000          .00
      32       1        2.1600          .00        .00000          .00
 ************************** Axial Forces and Torques **************************
                Element          Force            Torque
                                 (Lbf)           (Lbf-in)
                   3             5203.0           .00000
                   7             5203.0           10622.
                  31             5203.0           10622.
 *********************** Gravity Constant (g) (in/s^2) ************************
   X direction = .000000     Y direction = -386.088     Z direction =  .000000
 ******************************************************************************
   Time: 08:56:09.57 am   Date: 05-15-2013
```

A10. Torsional Model Summary

```
   DyRoBeS-Twist/Axial Ver 16.30, W. J. Chen, All Rights Reserved.
   Time: 09:55:56.56 am   Date: 05-15-2013
   FileName: 849460A_TOR.rot
                    *************************************
                    **           Summary               **
                    **             of                  **
                    **          input data             **
                    **             and                 **
                    **       system parameters         **
                    *************************************
                        ***** Unit System = 2 *****
                  Engineering English Units (s, in, Lbf, Lbm)
                          Torsional Model Summary
                       Modal Damping: Included
                     Viscous Damping: NOT Included
                     Dynamic Damping: NOT Included
 **************************** System Parameters ****************************
                               2  Shafts
                              24  Elements
                              24  SubElements
                               9  Materials
                               5  Disks
                               1  Linear Springs (K,C)

                              26  Stations
                               0  Constraints
                              26  Degrees of Freedom
 *************************** Description Headers ***************************
  SALES ORDER# 849460A
  CUSTOMER NAME: SIERRA MOUNTAIN
  PROJECT NAME: CITY OF TURLOCK
  BY: A. BRUCE TICKNOR III, P.E.
 *************************** Material Properties ***************************
          Property       Mass          Elastic         Shear
             no         Density        Modulus        Modulus
                       (Lbm/in^3)     (Lbf/in^2)     (Lbf/in^2)

             1         .00001         .10000E-03     .10000E-08
             2         .28200         .29000E+08     .12000E+08
             3         .28200         .29000E+08     .12000E+08
****************************** Shaft Elements ******************************
       Sub   Left              ------ Mass ------    ------ Stiffness ------
   Ele Ele   End              Inner     Outer         Axial        Torsional
    no  no   Loc    Length   Diameter  Diameter       EA/L           GIp/L
                     (in)          (in)             (Lbf/in)    (Lbf-in/rad)
    1
      1      .000   27.6700    2.6250    5.2500     .17603E+08    .30324E+08
  -------
    3
      1      .000   16.3450     .0000    1.9375     .52310E+07    .10157E+07
    4
      1    16.345   16.3450     .0000    1.9375     .52310E+07    .10157E+07
    5
      1    32.690   16.3450     .0000    1.9375     .52310E+07    .10157E+07
    6
      1    49.035   16.3450     .0000    1.9375     .52310E+07    .10157E+07
    7
      1    65.380   16.3800     .0000    1.9375     .52198E+07    .10135E+07
    8
      1    81.760   19.8150     .0000    1.9375     .43150E+07    .83783E+06
    9
      1   101.575   19.8150     .0000    1.9375     .43150E+07    .83783E+06
   10
      1   121.390   20.0000     .0000    1.9375     .42751E+07    .83008E+06
   11
```

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```
     1   141.390   20.0000     .0000    1.9375     .42751E+07   .83008E+06
  12
     1   161.390   20.0000     .0000    1.9375     .42751E+07   .83008E+06
  13
     1   181.390   25.0000     .0000    1.9375     .34200E+07   .66406E+06
  14
     1   206.390   25.0000     .0000    1.9375     .34200E+07   .66406E+06
  15
     1   231.390   10.0000     .0000    1.9375     .85501E+07   .16602E+07
  16
     1   241.390    6.0000     .0000    1.9375     .14250E+08   .27669E+07
  17
     1   247.390    6.8500     .0000    2.6875     .24016E+08   .89719E+07
  18
     1   254.240   18.0800     .0000    2.6875     .90988E+07   .33992E+07
  19
     1   272.320   12.9600     .0000    2.6875     .12693E+08   .47421E+07
  20
     1   285.280    5.6200     .0000    2.6875     .29272E+08   .10936E+08
  21
     1   290.900    5.8200     .0000    2.6875     .28266E+08   .10560E+08
  22
     1   296.720   10.3100     .0000    2.6875     .15956E+08   .59610E+07
  23
     1   307.030    5.6200     .0000    2.6875     .29272E+08   .10936E+08
  24
     1   312.650    6.9900     .0000    2.6875     .23535E+08   .87922E+07
  25
     1   319.640    5.7500     .0000    2.6875     .28610E+08   .10688E+08
********************************** Disks **********************************
        Stn                          Diametral        Polar
         no          Mass             Inertia         Inertia       Offset
                     (Lbm)           (Lbm-in^2)      (Lbm-in^2)
          2         841.00           12744.          25488.          .00000
          7         19.400           65.190          71.010          .00000
         15         12.470           77.670          23.330          .00000
         20         120.00           4415.0          7358.0          .00000
         23         120.00           4415.0          7358.0          .00000
**************** Rotor Equivalent Rigid Body Properties *****************
 Rotor  Left End         C.M.               Diametral     Polar      Speed
  no    Location  Length  Location    Mass    Inertia     Inertia    Ratio
           (in)     (in)     (in)     (Lbm)   (Lbm-in^2)  (Lbm-in^2)

  1       .000    27.670    25.853  968.14      .4227E+05  26035.5     1.000
  2       .000   325.390   226.466  602.33      .5440E+07  15019.5     1.000

  --- Sum ---    325.390   102.796  1570.5      .2043E+08  41055.0
*************************** Linear Connections *****************************
                     Stn    Stn         Spring        Damping
                      I      J         Constant        Coeff.
                                     (Lbf-in/rad) (Lbf-in-s/rad)
                      2      3       .78800E+07      .00000
*************************** Modal Damping Factor ***************************
                                Mode     % Damping
                                 all     1.00000000
**************** Element Equivalent Stiffness and Damping,*****************
                   Element          Stiffness      Damping
                                  (Lbf-in/rad) (Lbf-in-s/rad)
                      1           .30324E+08      .00000
  -------
                      3           .10157E+07      .00000
                      4           .10157E+07      .00000
                      5           .10157E+07      .00000
                      6           .10157E+07      .00000
                      7           .10135E+07      .00000
                      8           .83783E+06      .00000
                      9           .83783E+06      .00000
```

```
                    10          .83008E+06     .00000
                    11          .83008E+06     .00000
                    12          .83008E+06     .00000
                    13          .66406E+06     .00000
                    14          .66406E+06     .00000
                    15          .16602E+07     .00000
                    16          .27669E+07     .00000
                    17          .89719E+07     .00000
                    18          .33992E+07     .00000
                    19          .47421E+07     .00000
                    20          .10936E+08     .00000
                    21          .10560E+08     .00000
                    22          .59610E+07     .00000
                    23          .10936E+08     .00000
                    24          .87922E+07     .00000
                    25          .10688E+08     .00000
                  Station       Inertia
                     1          .70907
                     2          66.725
 -------
                     3          .82582E-02
                     4          .16516E-01
                     5          .16516E-01
                     6          .16516E-01
                     7          .20046
                     8          .18287E-01
                     9          .20023E-01
                    10          .20116E-01
                    11          .20210E-01
                    12          .20210E-01
                    13          .22736E-01
                    14          .25262E-01
                    15          .78110E-01
                    16          .80839E-02
                    17          .15843E-01
                    18          .46628E-01
                    19          .58056E-01
                    20          19.093
                    21          .21397E-01
                    22          .30169E-01
                    23          19.088
                    24          .23585E-01
                    25          .23828E-01
                    26          .10755E-01
****************************************************************************
  Time: 09:55:56.61 am   Date: 05-15-2013
```


A11. Lateral Damped Natural Frequency Mode Shapes

Mode shapes shown at 900 rpm only. Additional mode shapes available at other speeds as requested.

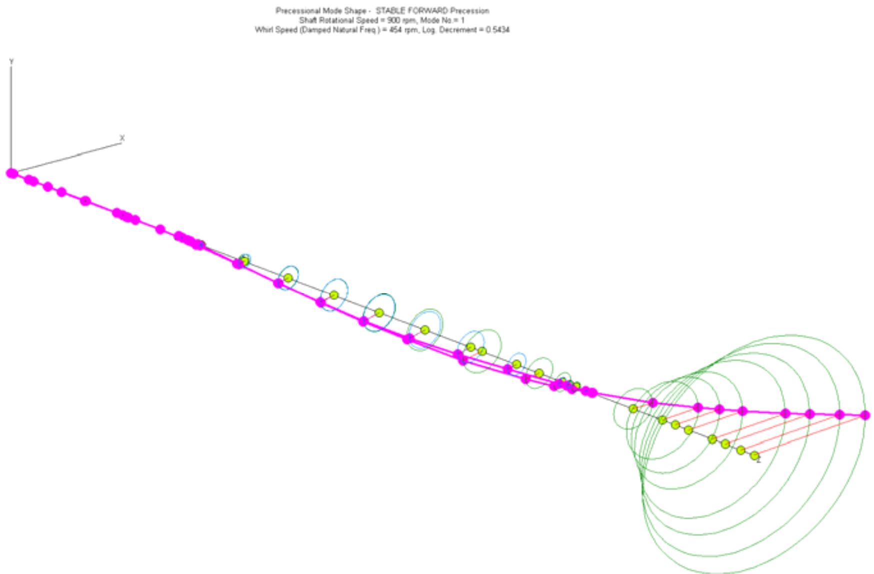

Figure: 1st Damped Lateral Mode Shape

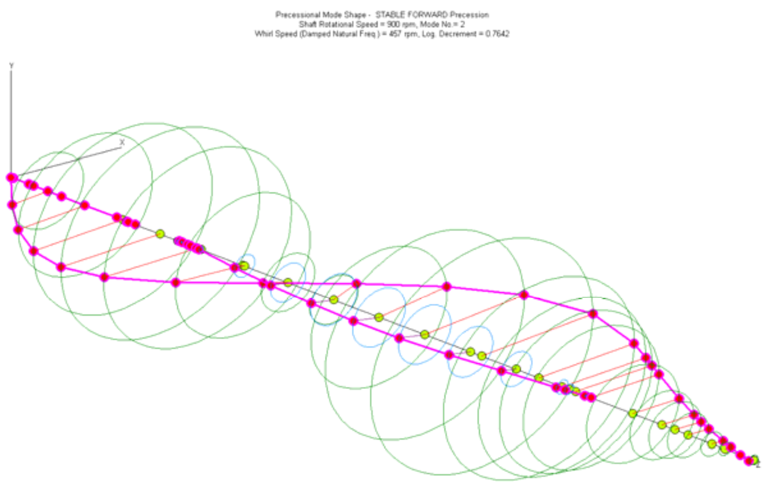

Figure: 2nd Damped Lateral Mode Shape

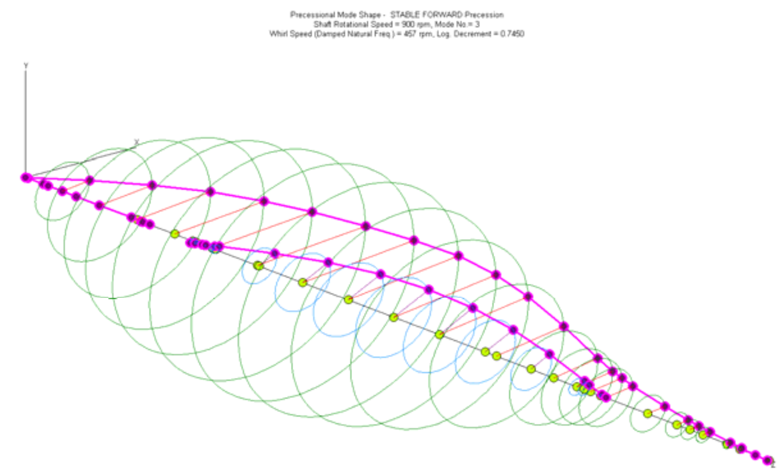

Figure: 3rd Damped Lateral Mode Shape

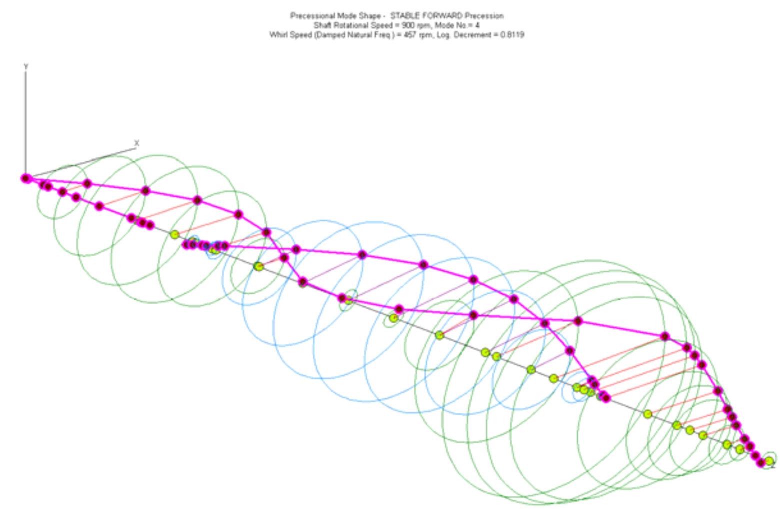

Figure: 4th Damped Lateral Mode Shape

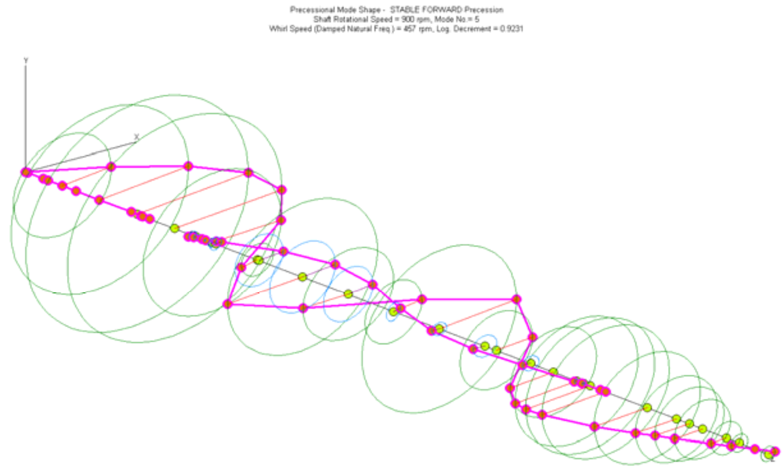

Figure: 5th Damped Lateral Mode Shape

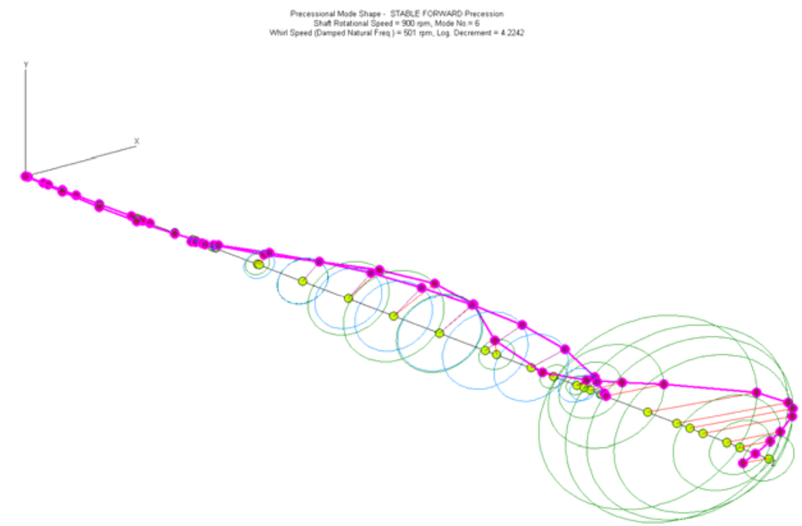

Figure: 6th Damped Lateral Mode Shape

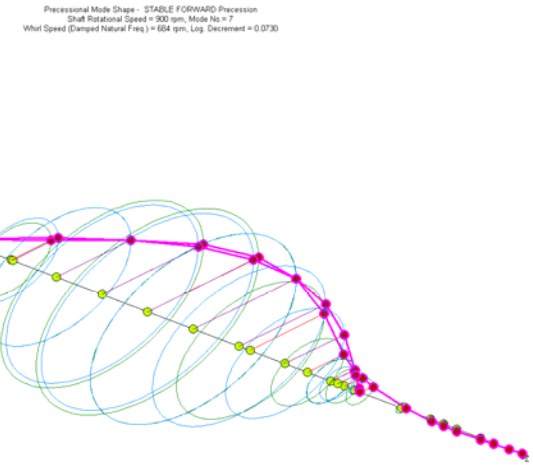

Figure: 7th Damped Lateral Mode Shape

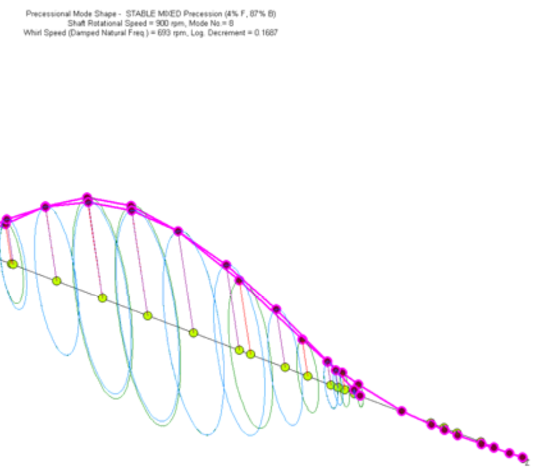

Figure: 8th Damped Lateral Mode Shape

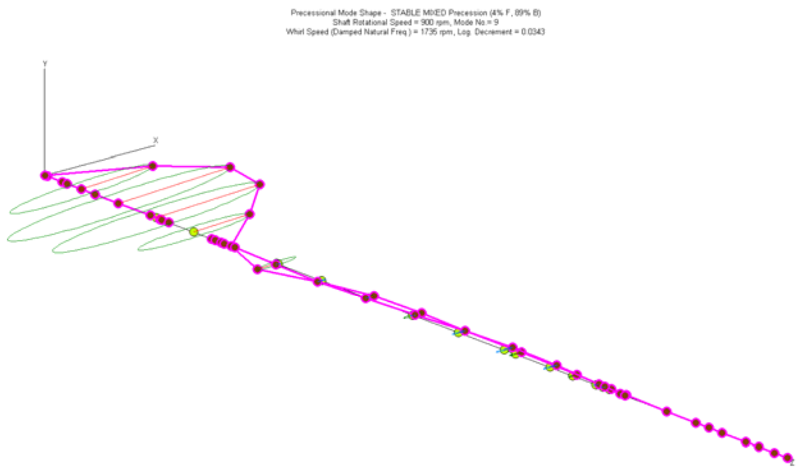

Figure: 9th Damped Lateral Mode Shape

A12. Steady-State Damped Unbalanced Response Analysis

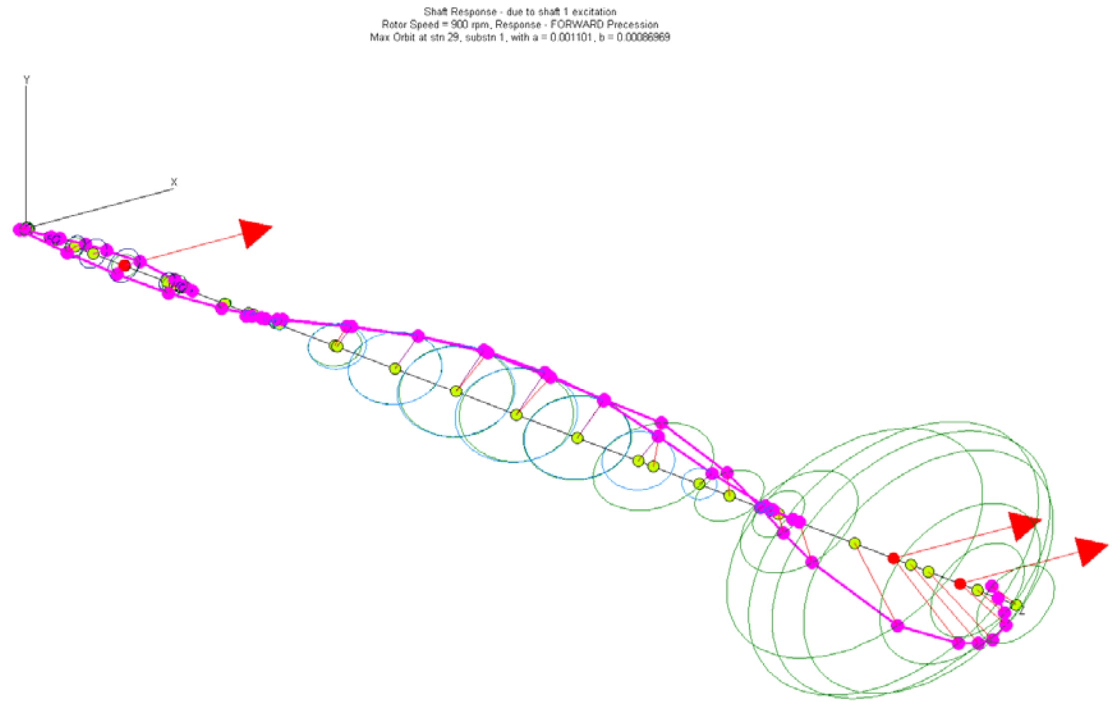

Figure: Steady-State Unbalanced Response at 900 rpm

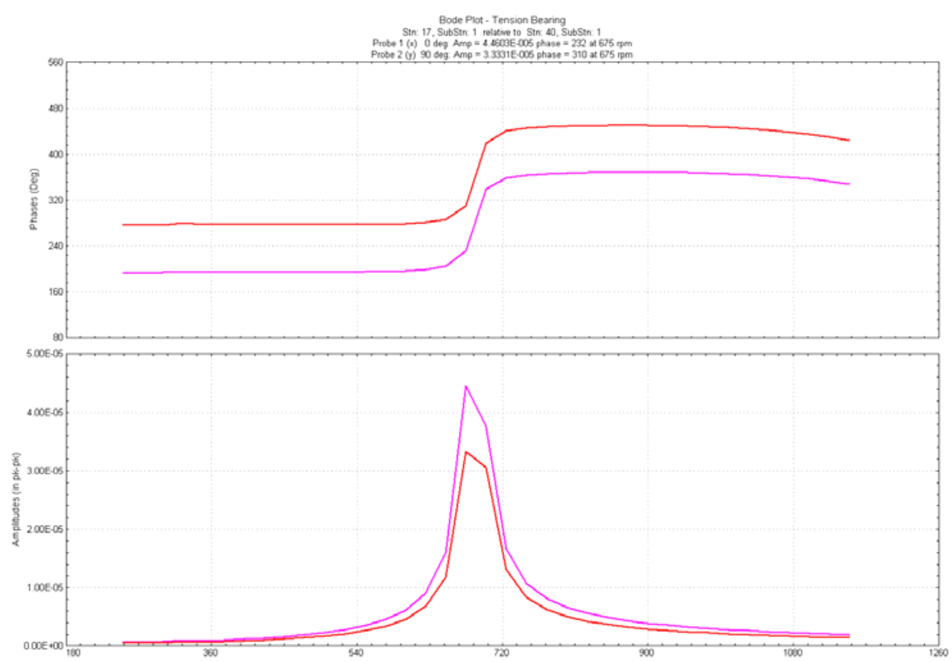

Figure: Bode Plot at Station 17/40, Tensions Bearing

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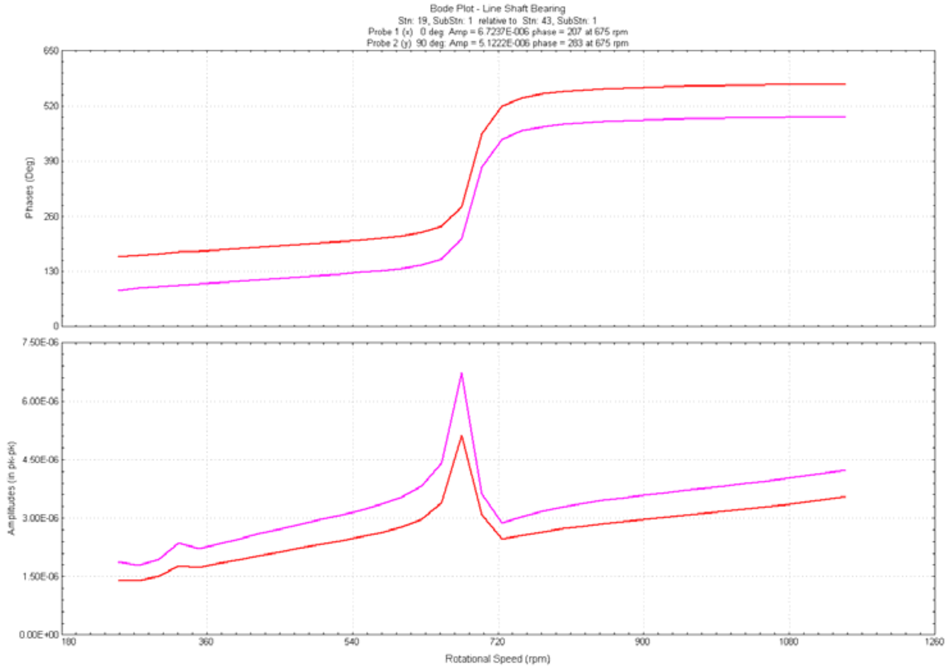

Figure: Bode Plot at Stations 19/43, Line Shaft Bearing

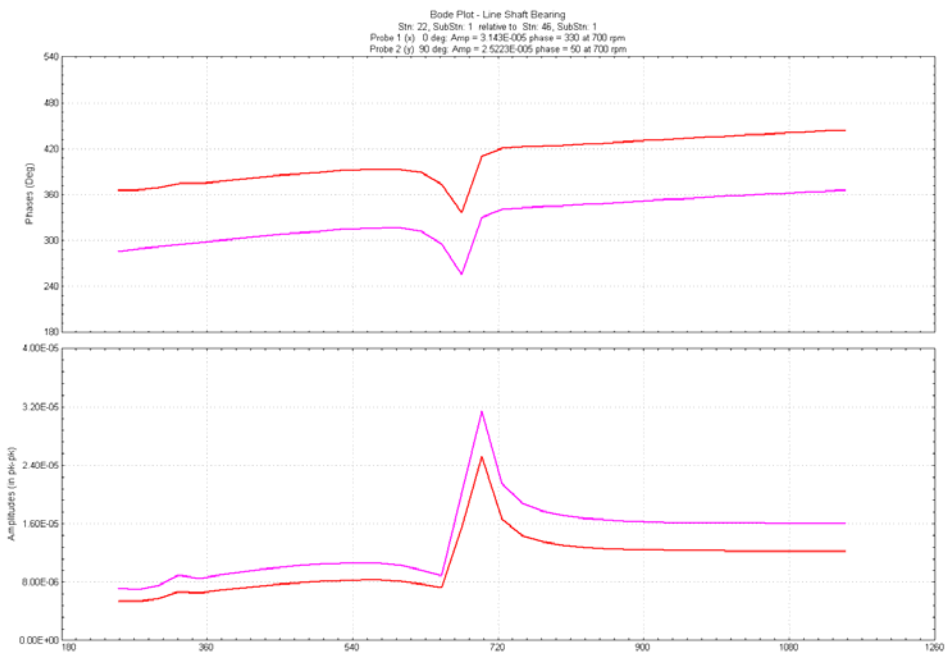

Figure: Bode Plot at Stations 22/46, Line Shaft Bearing

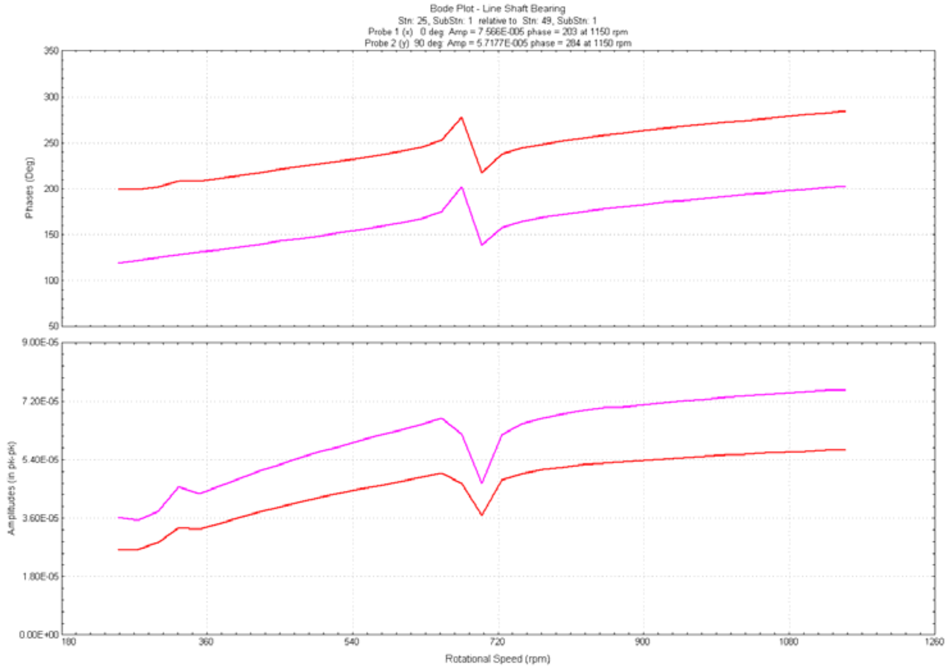

Figure: Bode Plot at Stations 25/49, Line Shaft Bearing

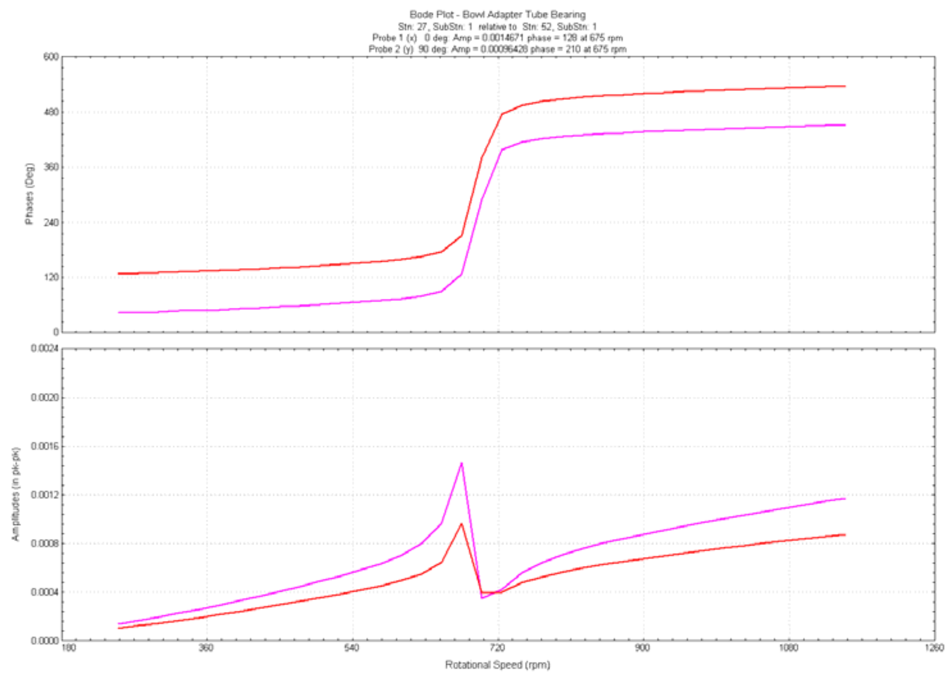

Figure: Bode Plot at Stations 27/52, Bowl Adapter Tube Bearing

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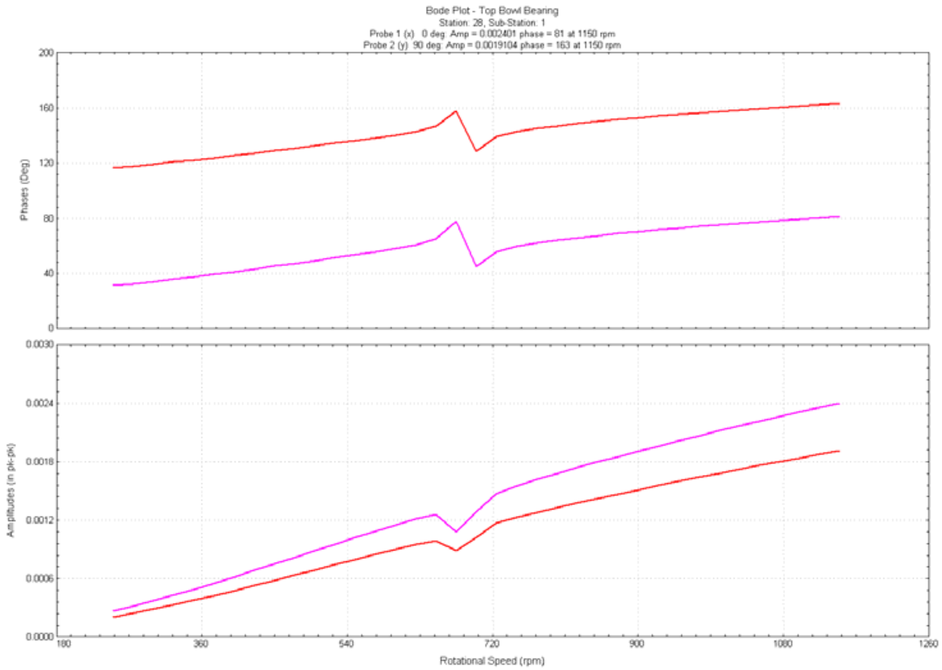

Figure: Bode Plot at Stations 28, Top Bowl Bearing

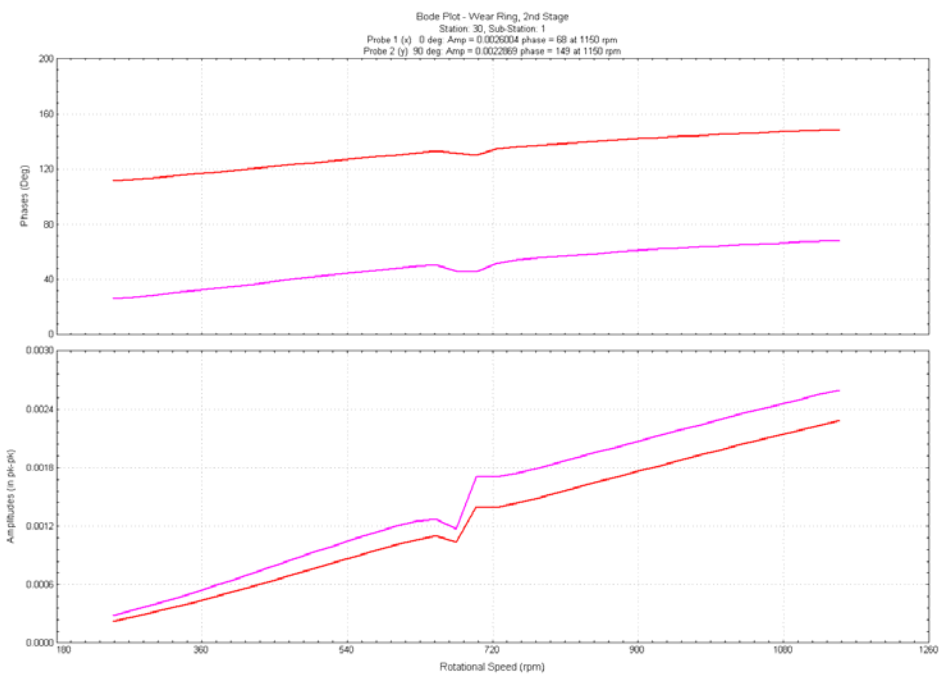

Figure: Bode Plot at Stations 30, 2nd Stage Wear Ring

Release Date:	05.20.2013
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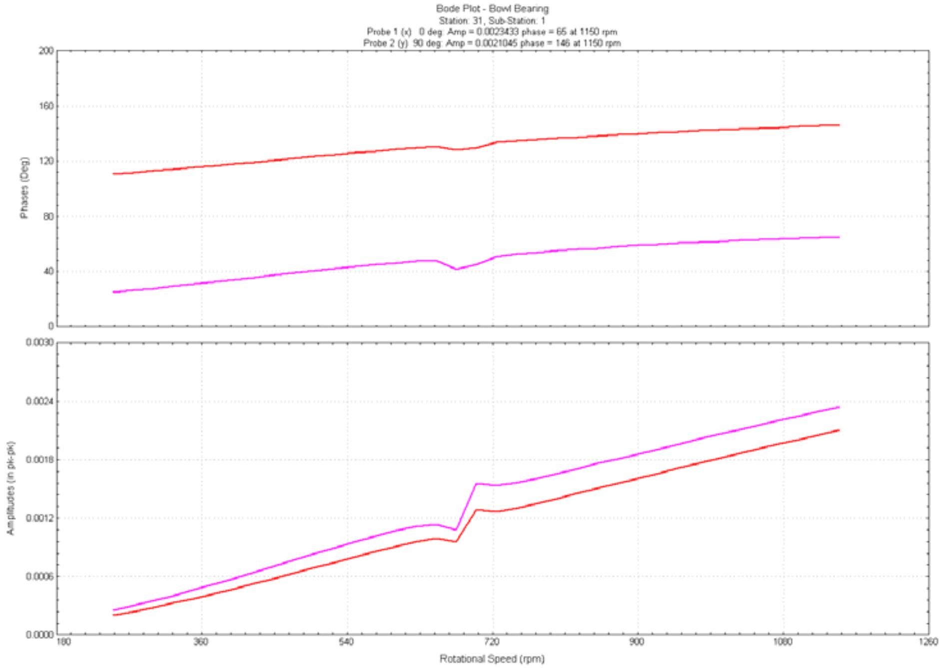

Figure: Bode Plot at Stations 31, Bowl Bearing

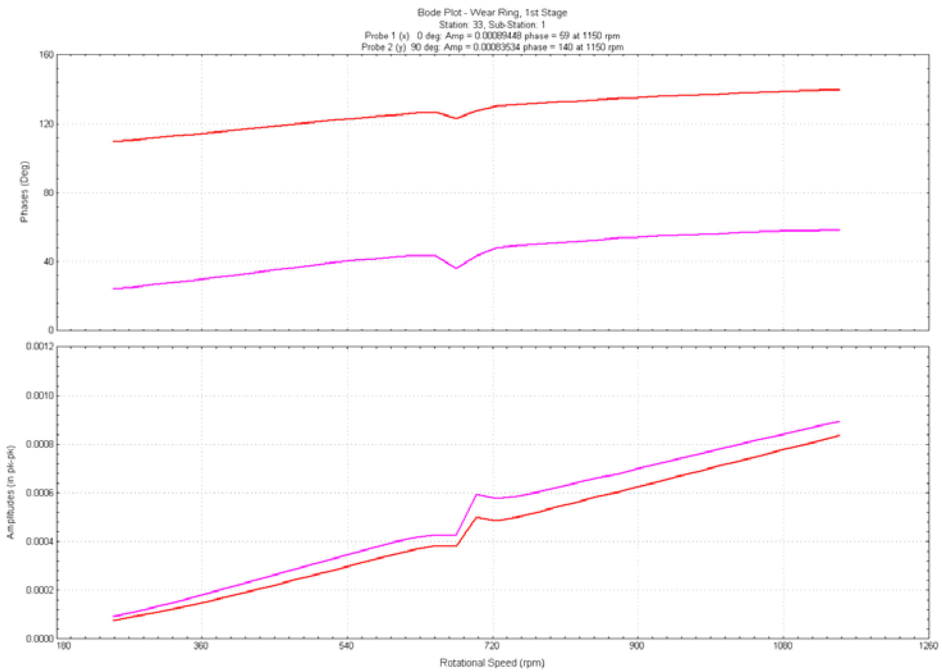

Figure: Bode Plot at Stations 33, 1st Stage Wear Ring

Release Date:	05.20.2013
Revision:	0
Revision Date:	05.20.2013
File Name:	849460A_RDA_rev0.docx

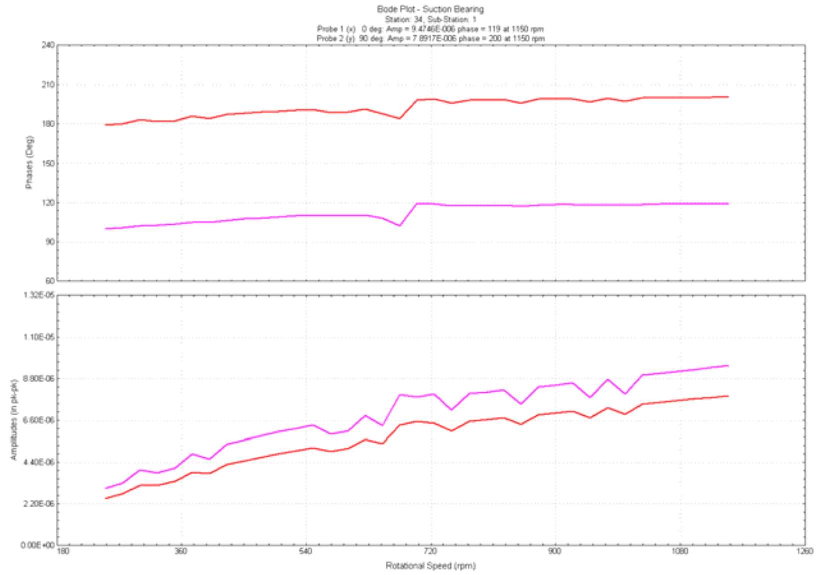

Figure: Bode Plot at Stations 34, Suction Bearing

A13. Torsional Natural Frequency Mode Shapes

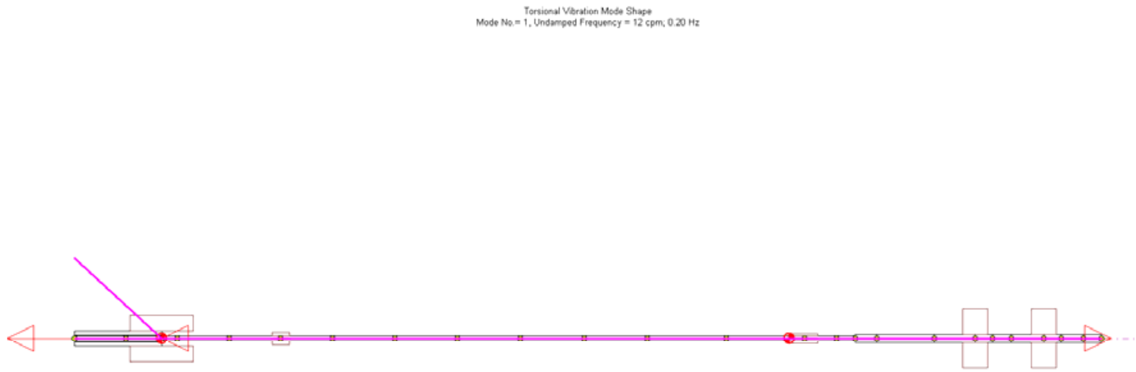

Figure: 1st Torsional Mode Shape

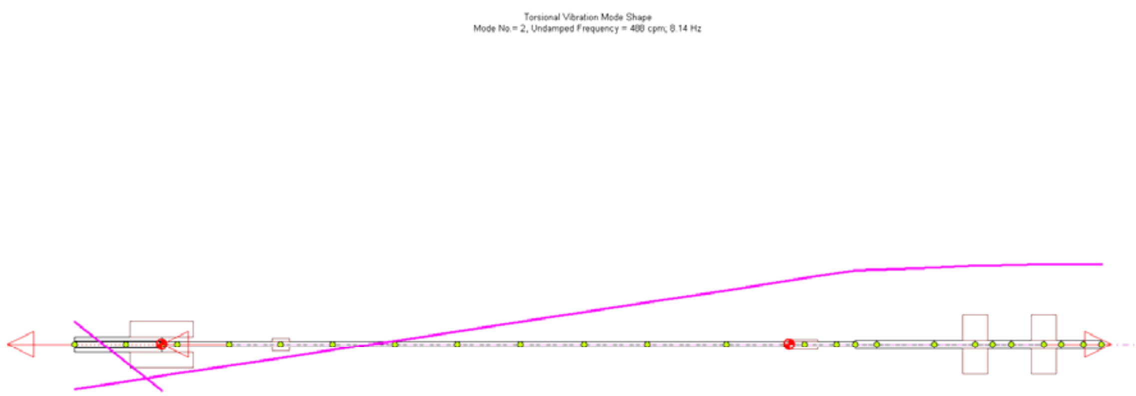

Figure: 2nd Torsional Mode Shape

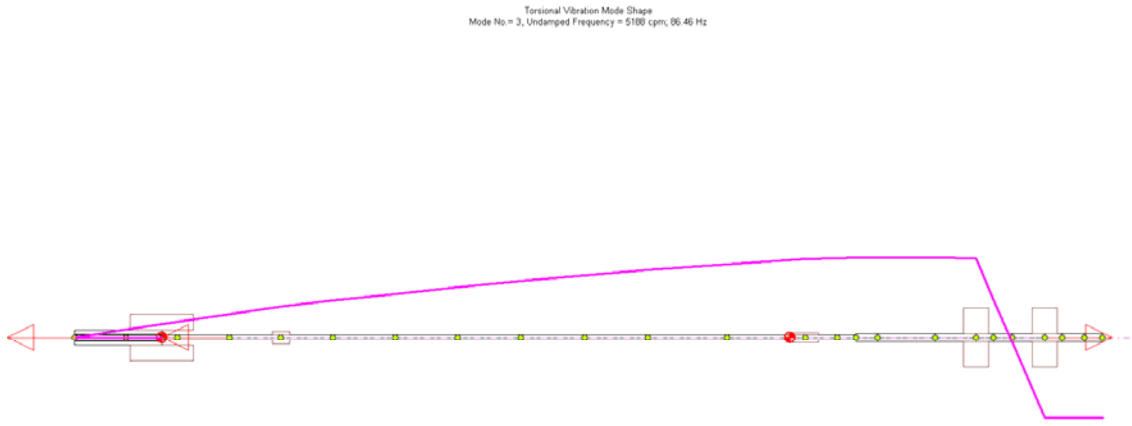

Figure: 3rd Torsional Mode Shape

A14. Steady-State Forced Reponses Analysis

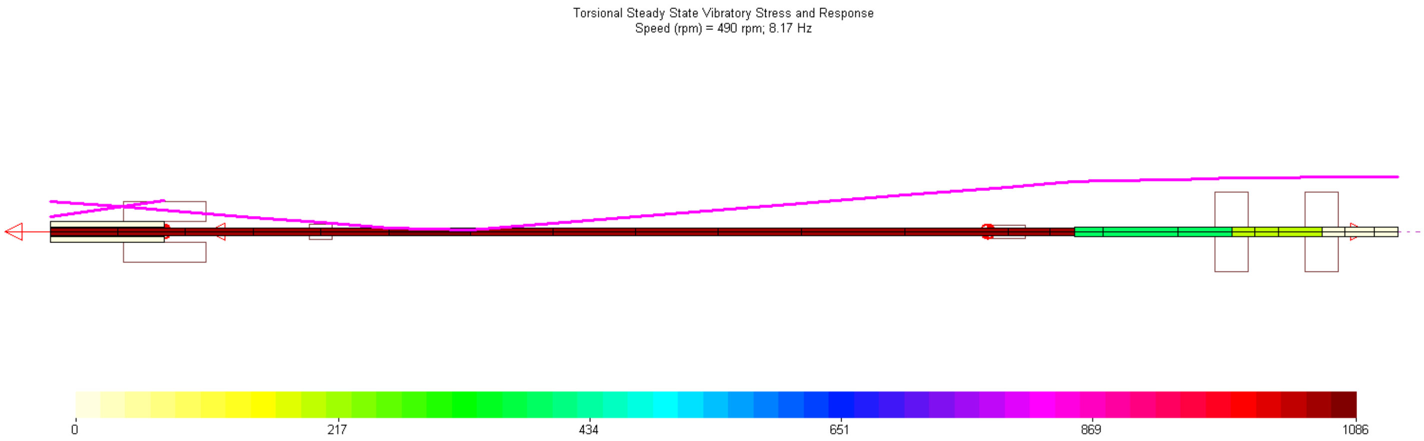

Figure: Vibratory Stress at 488 rpm

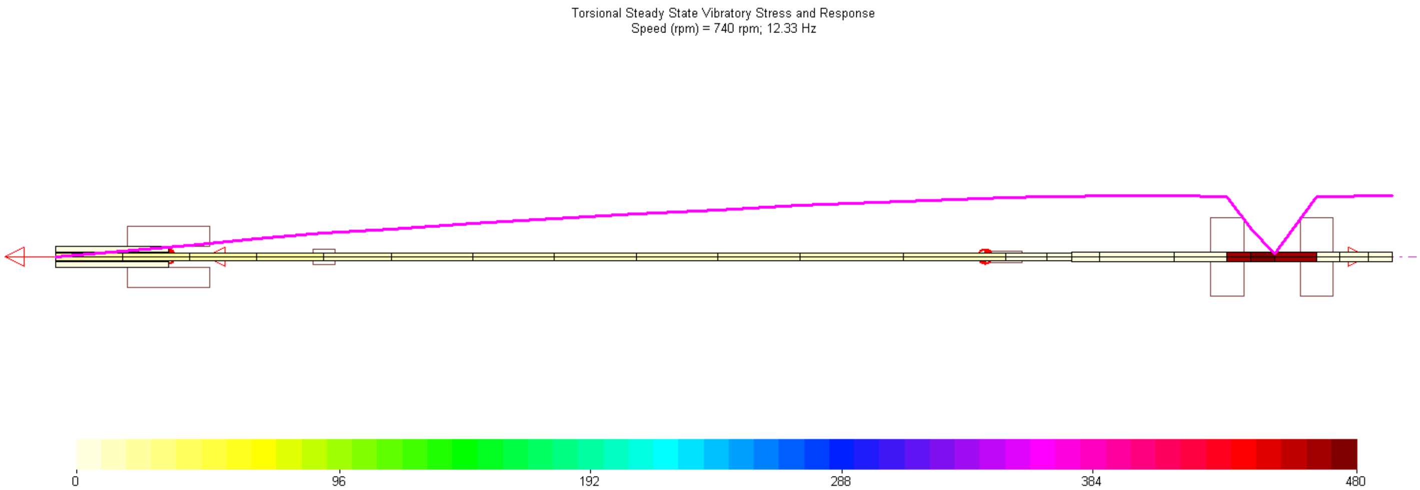

Figure: Vibratory Stress at 741 rpm

A15. Fatigue Calculation

Line Shaft Calculation

Shaft Properties		
Diameter (D)	1.94	in
Material Type	A276 Type 416	
Ultimate Tensile Strength (S_{uts})	110000	psi
Yield Strength (S_y)	85000	psi
Endurance Limit Calculation		
Endurance Limit (S'_e)	55000	psi
Surface Factor		
Surface Finish	Machined or Cold-Drawn	
a	2.70	
b	-0.265	
k_a	0.78	
Size Factor		
k_b	0.83	
Load Factor		
Type	Torsional	
k_c	0.59	
Temperature Factor		
k_d	1.00	
Reliability Factor		
Reliability	90%	
z	1.28	
k_e	0.90	
Estimated Endurance Limit (S_e)	18806	psi
Factor of Safety (FOS)	2	
Fatigue Calculation		
Motor Torque (T)	10622	lb-in
Axial Load (F)	5203	lb
Steady-State Von Mises Stress (S_m)	12953	psi
Alternating Shear Stress (τ_{alt})	1086	psi
Equivalent Alternating Von Mises Stress (S_{alt})	1881	psi

Bowl Shaft Calculation

Shaft Properties		
Diameter (D)	2.69	in
Material Type	A276 Type 416	
Ultimate Tensile Strength (S_{uts})	110000	psi
Yield Strength (S_y)	85000	psi
Endurance Limit Calculation		
Endurance Limit (S'_e)	55000	psi
Surface Factor		
Surface Finish	Machined or Cold-Drawn	
a	2.70	
b	-0.265	
k_a	0.78	
Size Factor		
k_b	0.80	
Load Factor		
Type	Torsional	
k_c	0.59	
Temperature Factor		
k_d	1.00	
Reliability Factor		
Reliability	90%	
z	1.28	
k_e	0.90	
Estimated Endurance Limit (S_e)	18206	psi
Factor of Safety (FOS)	2	
Fatigue Calculation		
Motor Torque (T)	10622	lb-in
Axial Load (F)	5203	lb
Steady-State Von Mises Stress (S_m)	4900	psi
Alternating Shear Stress (τ_{alt})	480	psi
Equivalent Alternating Von Mises Stress (S_{alt})	831	psi

Equations:

$$S'_e = 0.5 * S_{uts} = psi$$

$$k_a = a * S_{uts}^b$$

where S_{uts} is in ksi

$$k_b = \begin{cases} \left(\frac{D}{0.3}\right)^{-0.107} & 0.11 \leq D \leq 2.00\ in \\ 0.91 * D^{-0.157} & 2.00 < D \leq 10.00\ in \end{cases}$$

$$k_e = 1 - 0.08 * z$$

$$S_e = k_a * k_b * k_c * k_d * k_e * S'_e = psi$$

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0	Initial Release	05.20.2013	ABT	GB

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