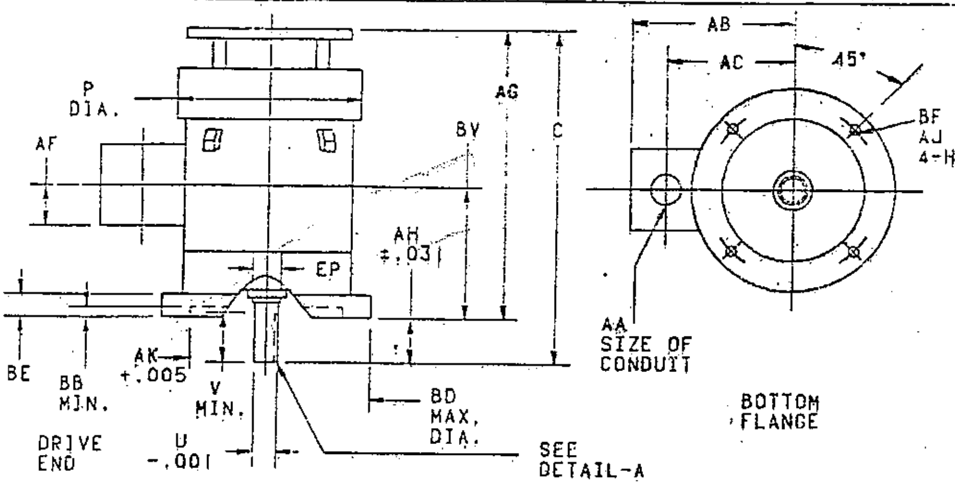
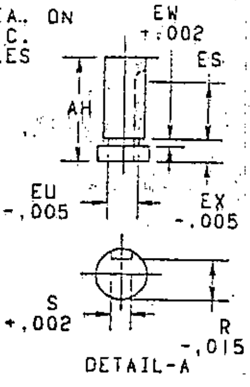
OUTLINE DRAWING | T.E.F.C. EXPL. PRF. CHEM. PROCESS IN-LINE PUMP MOTOR

14 CP
3-144265
E-130034-0002

FACE RUNOUT	ECC. MTG. RABBET	SHAFT RUNOUT
.004	.004	.001



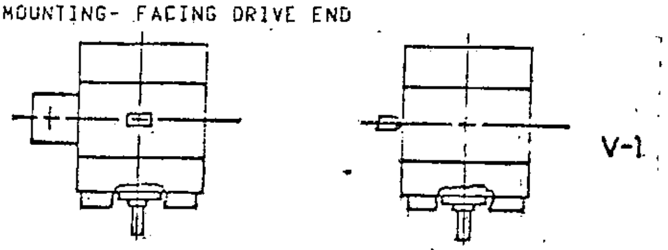


REVISION LTR.	DATE APPR
A	10-19-79
B	1-7-80
C	2-25-80
D	4-14-80
E	2-27-81
F	10-21-81
G	8-2-82
H	9-21-82

FRAME	P	AA	AB	AC	AF	AG	EP	ES	EU	EW	EX
365 LP	18.50	3	14.94	11.75	6.66	36.75	2.25	3.03	1.750	.375	.750
405 LP	20.80	4	17.69	13.50	7.50	39.93	2.25	3.03	1.750	.375	.750
445 LP	24.00	4	19.66	15.49	7.50	44.09	2.25	3.03	1.750	.375	.750

		DRIVE END EXTENSION										
FRAME	C	R	S	U	V	AH	AJ	AK	BB	BD	BE	BF	BV
365 LP	41.25	1.845	.500	2.125	4.00	4.500	14.75	13.500	.25	16.50	1.00	.688	16.37
405 LP	44.43	1.845	.500	2.125	4.00	4.500	14.75	13.500	.25	16.50	1.00	.688	17.25
445 LP	48.59	1.845	.500	2.125	4.00	4.500	14.75	13.500	.25	16.50	1.00	.688	18.90

MOUNTING- FACING DRIVE END



V-1

NOTES
1-CONDUIT BOX OUTLET MAY BE TURNED TO ANY ONE OF 4 POSITIONS.
2-TOTAL AXIAL ENDPLAY OF .002 MAX. UNDER 50 LBS. REVERSING STATIC LOAD WITH MOTOR AT AMBIENT TEMPERATURE.
3-RADIAL DISPLACEMENT AT END OF MOTOR SHAFT IS .001 MAX. AT AMBIENT TEMP WITH ZERO AXIAL LOAD AND A 25 LB. FORCE APPLIED AT THE PUMP END OF MOTOR SHAFT.

CERTIFICATION OF A.C. EXPLOSION PROOF MOTORS
CERTIFIED FOR OIL PRODUCTS PIPELINE LTD.
M.A.NO 3-144265 ORDER NO. EC-9-2796-B
TYPE CESB FRAME 445LP H.P. 100
R.P.M. 1480 VOLTS 380 PHASE 3
HERTZ 50 AMPS 142 CODE E
OPRG.TEMP.CODE T2D CL.I GR. D CL.II GR. —
BASE — QUANTITY TWO
REMARKS SPACE HEATER 230VOLTS, 99WATTS 3THERMISTORS; GROUND IN COND.BOX
APPROVED BY R.R.H. DATE 10/25/82

ORIGINAL ISSUE
PREPARED BY L.L.S.
APPROVED BY
DATE 8-2-82

REV.
SHT.

LOUIS ALLIS
Litton Milwaukee, WI. 53201

CODE ID.NO.	DRAWING NO.	REV.
01425	E-130034-0002	H
SCALE NONE	90000	SHEET 1 OF 1

ESF 171C 4/82 PRODUCED ON LOUIS ALLIS CAD-CAM SYSTEM

REPORT OF ROUTINE TESTS
INDUCTION MOTOR

PURCHASER Oil Products Pipeline Ltd.

DATE OF TEST 2/7/83-1/19/83
MANUFACTURERS ORDER NO. 3-144265
PURCHASERS ORDER NO. EG-9-2796-B

NAMEPLATE DATA

TYPE	FRAME	RATED H.P.	R.P.M.	VOLTS	SERV.FACT.
CE5B	445LP	100	1480	380	1.00

PHASE	HERTZ	AMPERES	LOCKED KVA/H.P.	AMBIENT TEMP.	INSUL. CLASS	DESIGN LETTER	TIME RATING	TEMP. RISE BY RESISTANCE
3	50	142	E	45°C	F	-	CONT.	100°C

TEST CHARACTERISTICS

SERIAL NO.	NO LOAD					STATOR WDG. RES. BETWEEN TERMINALS	
	VOLTS	HZ	SPEED	AMP	WATTS	OHMS	TEMP.°C
3144265-001	380	50	1500	34.7	1800	.0432	23
	135	50	1500	11.8	1136		
	460	60	1800	36.1	3000	-	-
	160	60	1800	13.6	2140		
3144265-002	460	60	1800	36.9	3100	.0429	23
	160	60	1800	14.4	2360		

SERIAL NO.	LOCKED ROTOR (1) PHASE				HIGH POTENTIAL TEST VOLTAGE (A)	WOUND ROTOR OPEN-CIRCUIT VOLTAGE	
	VOLTS	HZ	AMP	WATTS			
3144265-001	160	50	250.4	20,000	2500	--	--
	160	60	184	7,800	--	--	--
3144265-002	160	60	188	8,000	2500	--	--

NOTES:
1-DATA ON TEST FROM these MOTOR(S)
(THIS OR DUPLICATE)

(A) ☒ 1 SECOND
☐ 1 MINUTE

2-IN ACCORDANCE WITH NEMA PUB. NO. MG 1-1978 PAR. 12.51,12.54 & IEEE 112-1978 FORM A-1

~~THIS DATA FOR REFERENCE ONLY UNLESS OTHERWISE SPECIFIED~~

PREPARED BY
APPROVED BY M. Beiman
DATE 4/5/83

Litton LOUIS ALLIS Milwaukee, Wisconsin 53201

F44BJ4-100-K60-RO

SHEET 1 OF 1

M 3166 2/82

TYPICAL INDUCTION MOTOR DATA

MANUFACTURERS ORDER NO. 3-144265

PURCHASER Oil Products Pipeline Ltd.

PURCHASERS ORDER NO. EG. 9-2796-B

TYPE CE5B FRAME 445LP H.P. 100 SYN.SPEED 1500

VOLTAGE 380 PHASE/HERTZ 3/50 AMBIENT 45°C SERVICE FACTOR 1.00

INSULATION CLASS F DUTY CONT. ENCLOSURE TEXP MOUNTING V-1 (Vert.)

EFFICIENCY		POWER FACTOR	
1/2 LOAD	.926	1/2 LOAD	.811
3/4 LOAD	.933	3/4 LOAD	.856
FULL LOAD	.930	FULL LOAD	.861
FULL LOAD R.P.M.	1480	OUTLINE DWG. NO.	E-130034-0003
FULL LOAD AMPS	142	TOTAL APPROX. WGT.	2050 LBS.
LOCKED ROTOR AMPS	715	BEARINGS	Ball Anti-Friction
LOCKED ROTOR TORQUE	125 %	D.E. **	OPP. D.E. *
BREAKDOWN TORQUE	210 %	LUBRICATION	Grease

REMARKS: ** Bearings D.E. 80BC03XPX3 USA

* Bearings opposite D.E. 90BT03XXX00X USA

3/4 Load Amps - 106.5; 1/2 Load Amps - 75.5

No Load Amps - 33; Locked Rotor Power Factor - .29

94 DBA @ 3 Ft.

M 3187 2/82

THIS DATA FOR REFERENCE ONLY UNLESS OTHERWISE SPECIFIED

PREPARED BY Razia Dada
APPROVED BY
DATE 11/12/82

Litton LOUIS ALLIS Milwaukee, Wisconsin 53201

F44BJ4-100-K60-DO

SHEET 1 OF 1

DATE OF TEST ---

MANUFACTURERS ORDER NO. 3-144265

SPEED-TORQUE & CURRENT CURVE

PURCHASERS ORDER NO. EG-9-2796-B

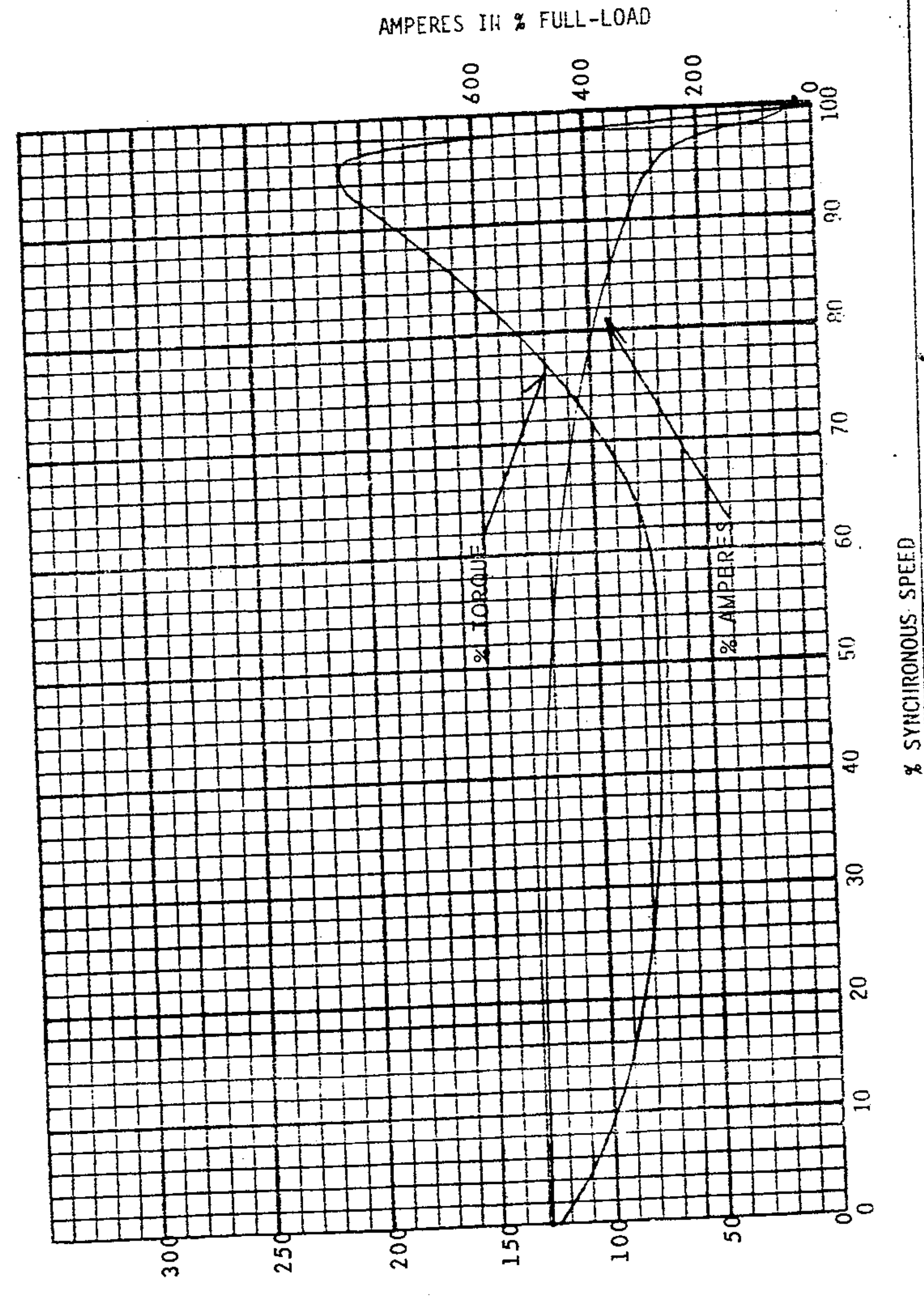
PURCHASER Oil Products Pipeline Ltd.

TYPE CE5B FRAME 445LP HP 100 F.L. RPM 1480

VOLTAGE 380 PHASE/HERTZ 3/60 AMBIENT 45°C SERVICE FACTOR 1.00

F.L. AMPS 142 F.L. TORQUE 355 LBS. FT.

INSULATION CLASS F DUTY CONT. ENCLOSURE TEXP MOUNTING V-1 (Vert.)



M 3184 2/82

THIS DATA FOR REFERENCE ONLY UNLESS OTHERWISE SPECIFIED

PREPARED BY Razia Dada

APPROVED BY

DATE 11/2/82

Litton LOUIS ALLIS Milwaukee Wisconsin 53201

F44BJ4-100-K60-SO

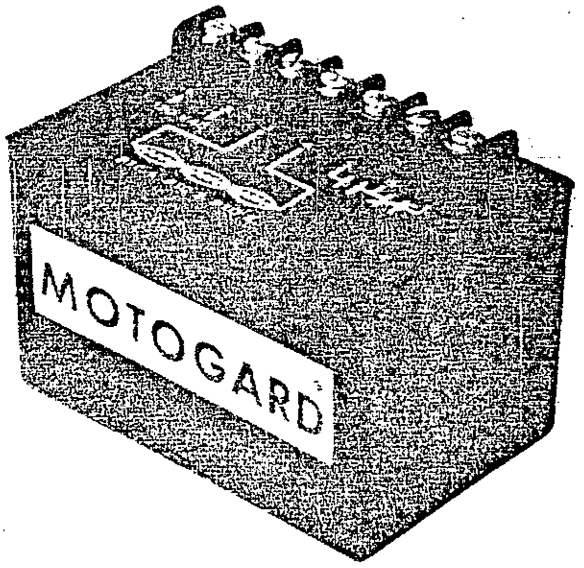
SHEET 1 OF 1

POWER CONTROL CORPORATION

Series 150 MOTOGARD®

OVERTEMPERATURE PROTECTION SYSTEMS

Compact single input for the economical protection of low horsepower motors



The new Series 150 "Motogard" Overtemperature Protection System provides immediate, reliable protection against motor overheating regardless of cause.

In the case of high temperature, the motor may either be disconnected from its supply and/or a warning signal activated by reason of:

- Single phasing
- Frequently repeated overloads
- Phase voltage unbalance
- Too frequent starting
- Locked rotor or bearing seizure.
- Heavy plugging or reversing duty
- Ventilation failures

The Series 150 "Motogard" is designed to operate from the Power Control Corporation's Type 8000 or Type 9000 Positive Temperature Coefficient (PTC) thermistors. These rugged, industrially designed sensors are placed in the windings of the motor, normally one for each phase. If the temperature of the winding reaches the switch point of the thermistor, the resistance of the thermistor sharply increases tripping the controller output electro-mechanical relay through a printed circuit board solid state network. Resetting of the output may be automatic (standard) when the temperature of the motor drops several degrees below its switch point or by a remote manual reset (optional).

To insure reliable operation, the output relay is energized under normal motor run conditions. Loss of power to the relay, break of the input sensors leads, or short circuit of the sensor input (less than 100 ohms) causes the output relay to remove the motor from the line and/or trip the warning circuit.

SERIES 150 "MOTOGARD" KEY FEATURES

- Single Sensor Input—Designed for 3 PTC thermistor sensors connected in series to minimize the number of motor to controller sensor wires.
- Isolation—Output "load" circuit electrically isolated from both controller excitation and sensor inputs.
- Output Rating—Form C relay (rated for direct control of 120V, Size 5 contactor coils).
- Dual Fault Operation—Controller cannot be damaged by grounding of any two of the sensor, output or controller excitation terminals.
- Compact controller design potted in high impact strength phenolic enclosure for industrial applications.
- No adjustments required. Module independent of motor horsepower.
- Sensors continuously monitor motor temperature, operating only when required and eliminate the nuisance trips of current sensing overloads.

APPLICATIONS

Other applications of the Series 150 "Motogard" include overtemperature protection of:

- Equipment enclosures
- Sleeve bearings
- Semiconductor heat sinks
- Transformer windings
- Electromagnets
- Compressor oil sumps
- Process vats, furnaces and ovens

OPTIONS

- Special resistance inputs
- Manual reset

SERIES 150 CONTROLLER

Excitation: 120V, 50/60 Hz

S... Input: Three Style 8000 or 9000 thermistors connected in series. Controller off at 3500 ohms or greater with 10% resistance hysteresis to prevent chatter.

Relay Output: Form C (Rated 120 VAC for Size 5 contactor coil).

Isolation: Output load circuit isolated from excitation and sensor inputs.

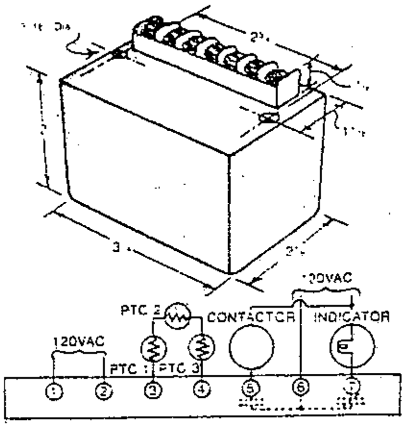
Fail Safe: Under normal conditions, the output relay is energized and de-energizes on sensor lead break or short circuit, or loss of excitation voltage.

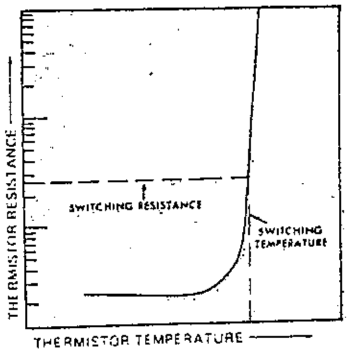
Dual Fault Operation: Controller cannot be damaged by short circuiting of any two of its terminals.

Reset: Automatic.

Ambient Temperature: −20° to +50° C.

Construction: Potted in high impact strength phenolic enclosure.

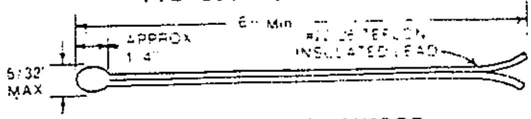




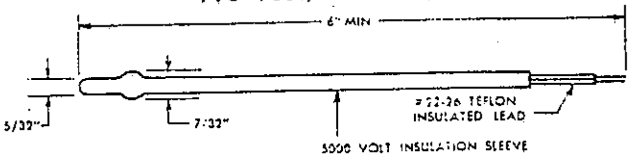
The temperature sensors used with MOTOGARD® Controllers are positive temperature coefficient thermistors of the switching type. The PTC switching thermistor, unlike other thermistors, increases its resistance sharply upon reaching its switch point temperature. This provides snap-action response and allows remote location from the controller without any change in switch point calibration.

PTC "8000" and "9000" thermistors are encapsulated in a special epoxy for rugged mechanical properties and good thermal conductivity. They are well suited for use in severe industrial environments. Both use identical sensor pellets.

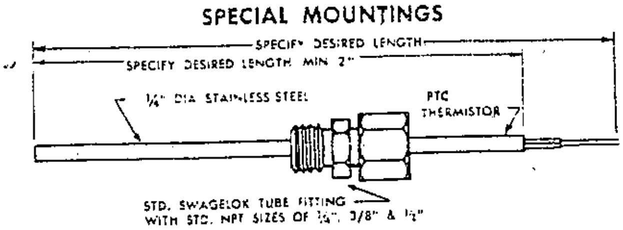
PTC "8000" THERMISTOR

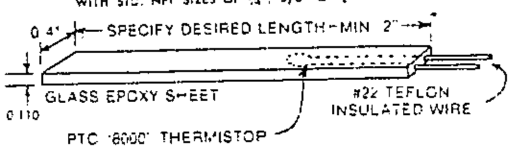


PTC "9000" THERMISTOR



SPECIAL MOUNTINGS





*Additional lead lengths available

PTC "9000" thermistors have an additional silicone rubber, glass braid, 5000 volt insulation sleeve over the teflon insulated leads. Specially mounted units are also available for slot and bearing probe applications as shown. The switching temperatures listed are standard. Thermistors with other switching temperatures within the range of 5° to 195°C can be supplied at extra charge.

Switching Temperature (Nominal)

Type No.	T8005 T9005	T8015 T9015	T8025 T9025	T8035 T9035	T8055 T9055	T8065 T9065	T8085 T9085	T8105 T9105	T8115 T9115	T8135 T9135	T8155 T9155	T8175 T9175	T8195 T9195
Centigrade °C±5°	5	15	25	35	55	65	85	105	115	135	155	175	195
Fahrenheit °F±9°	41	59	77	95	131	149	185	221	239	275	311	347	383

FOR SERIES "150" MOTOGARD USE TYPE "8000" OR "9000" PTC THERMISTORS

The PCC engineering staff is available for recommendations or custom modifications of MOTOGARD systems for your special requirements.

POWER CONTROL CORPORATION

RIDC INDUSTRIAL PARK, 122 GAMMA DR., PITTSBURGH, PA. 15238 PHONE (412) 782-3120

BULLETIN 8115

OPERATING and LUBRICATING INSTRUCTIONS

LOUIS ALLIS *PACEMAKER*®

P9211

VERTICAL SOLID SHAFT – NORMAL THRUST "P" BASE

TOTALLY ENCLOSED FAN COOLED
FRAMES 143 LP / HP through 445 LP / HP

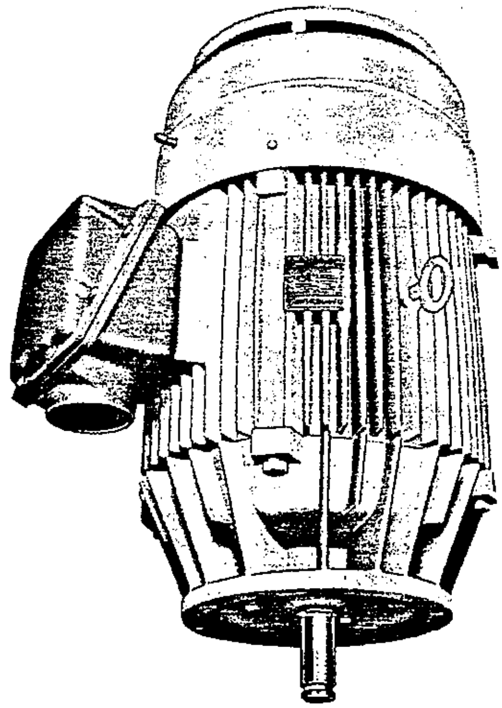


Figure 1

INTRODUCTION

Totally enclosed fan cooled motors covered by this instruction booklet are designed to give long periods of trouble-free service when properly installed and maintained. Figure 1 shows a typical totally enclosed fan cooled vertical P-base motor.

The arrangement of the thrust bearing of the normal thrust unit has been designed to accept the pumps developed load. Overloading will greatly reduce the motor's bearing life; therefore, the amount of thrust load applied to the motor should not exceed the published values.

Proper maintenance of the pump will help to assure successful operation of the motors driving the pumps. Care in maintaining the packing gland in pumps utilizing this sealing method will prevent liquid from entering the motor at the lower bearing bracket. Additional protection against liquids can be provided by mounting a shaft slinger on the pump shaft. Motors driving pumps in pressure systems where the pressure is maintained after shutdown should be protected by check valves in the system arranged to prohibit back pressure on the pump during shutdown.

RECEIPT OF SHIPMENT

Upon arrival, the motors should be checked immediately to see that all components have been received and that there is no evidence of damage in shipment.

In the event the complete assembly has not been received or arrives in a damaged condition, you should, without delay, notify the carrier who handled the shipment and the nearest Louis Allis District Sales Office.

STORAGE

If the equipment is not put into immediate use it should be stored in a clean, dry location. For long periods of storage, especially where moisture or dust is prevalent, the equipment should be covered to protect it from corrosion. If the motor is to be stored over three months, the shaft should be rotated about ten revolutions at least once a month.

® PACEMAKER is a trademark of Litton Industrial Products, Inc.

PRICES AND OTHER DATA SUBJECT TO
CHANGE WITHOUT NOTICE.

Litton LOUIS ALLIS Milwaukee Wisconsin 53201

INSTALLATION

In selecting a location for the unit, two primary considerations should be made: First-consideration should be given to ventilation and Second-consideration should be given to accessibility. It should be far enough from walls or other objects so as to permit free passage of air and allow easy access for maintenance and repairs.

Be sure that the mounting surfaces are clean and the pump flange is rigid enough to prevent excessive vibration of the unit. When aligning, shim the pump base with a small number of large shims instead of a large number of small shims.

The motor should never be placed in a room with a hazardous process or where flammable gases or combustible material may be present unless it is specifically designed for this service.

INSTALLATION OF COUPLINGS

The flexible coupling should be heated in oil before installation and slid into position on the shaft or installed with a pushing device.

WARNING: DO NOT DRIVE OR FORCE COUPLINGS ONTO THE SHAFT. DAMAGE TO BEARINGS MAY RESULT. REFER TO THE COUPLING MANUFACTURER'S INSTRUCTIONS FOR THE PROPER INSTALLATION PROCEDURE.

ALIGNMENT (DIRECT CONNECTED)

Angular misalignment and runout between direct connected shafts will cause increased bearing loads and vibration even when the connection is made by means of a flexible coupling.

To check for angular misalignment, clamp a dial indicator to one coupling hub and place the finger or button of the indicator against the finished face of the other hub, as shown in Figure 2.

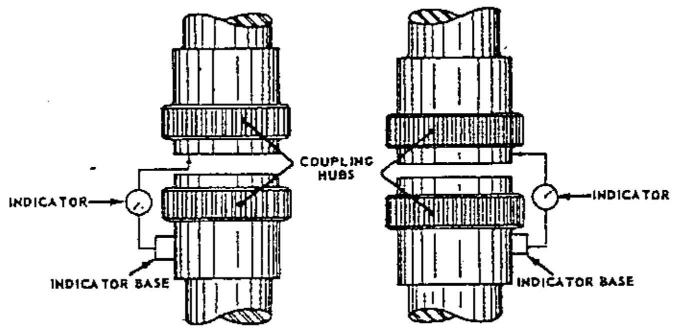


Figure 2 Figure 3

Rotate both shafts simultaneously keeping the indicator button at the reference mark on the coupling hub, and note the reading on the indicator dial at each one-quarter revolution.

ANGULAR MISALIGNMENT OF SHAFTS MUST NOT EXCEED A TOTAL INDICATOR READING OF .001 INCH FOR EACH INCH OF RADIUS OF THE COUPLING HUB.

After the shafts have been checked for angular misalignment and are parallel within the limits specified in the preceding paragraph, check the shaft for RUN-OUT to insure concentricity of the shafts. Clamp the indicator to one coupling hub and place the indicator button on the machined diameter of the other hub, as shown in Figure 3.

Rotate both shafts simultaneously, keeping the indicator button at the reference mark on the hub and note the reading on the indicator dial at each one-quarter revolution.

TOTAL RUN-OUT BETWEEN THE HUBS SHOULD NOT EXCEED .002 INCH. NEVER ATTEMPT TO MEASURE THE TEMPERATURE RISE OF A MOTOR BY HAND.

Temperature rise of a motor may be measured by a thermometer, resistance, or by an embedded detector or thermocouples.

ELECTRICAL CONNECTIONS

Before starting the motor, check the nameplate to insure that the correct power supply (voltage, hertz, frequency, and phase) is being used and that the motor is connected according to the connection diagram on the nameplate. Be sure that the motor is connected for the correct rotation. Before connecting the driven machine, energize the motor and check the rotation.

OPERATION

Alternating current motors shall operate successfully at rated load and frequency with voltage variations not more than 10% above or below nameplate ratings. Motors shall operate successfully at rated load and voltage with frequency variations not more than 5% above or below the rated frequency. Motors shall also operate successfully at rated loads with combined variations in voltage and frequency not more than 10% above the rated voltage and frequency provided the frequency variation does not exceed 5%. Performance within these variations will not necessarily be in accordance with the standards established for operation at rated frequency and voltage.

LUBRICATION

Ball bearing motors are properly lubricated at the factory and it is not necessary to lubricate before using. In the event a motor is not put into service for six months or longer, regreasing is required. When regreasing, the following steps should be followed:

1. De-energize the motor.
2. Clean exterior of the motor.
3. Remove both the grease fill plug and grease relief plug.
4. If the grease has hardened, run a rod or wire a short distance into chamber to break grease. In severe conditions, run motor until bearing chamber becomes heated.
5. Regrease motor with low pressure hand-lever grease gun.
6. For optimum operation, the bearing chamber should be three-quarters full of grease.
7. When grease appears at outlet hole, discontinue greasing. Operate motor for minimum of one hour to expell excessive grease. Shut down motor.
8. Replace grease plugs.
9. Energize motor to return unit to service.

RECOMMENDED FREQUENCY OF LUBRICATION

H.P. at 1800 R.P.M. or Less	ENCLOSURE	STANDARD CONDITIONS	SEVERE CONDITIONS	EXTREME CONDITIONS
.5 - 7.5	ODP TEFC	24 Months	12 Months	6 Months
	EXP. PR.	18 Months	9 Months	6 Months
10 - 40	ODP TEFC	18 Months	9 Months	3 Months
	EXP. PR.	12 Months	6 Months	3 Months
50 - 150	ODP TEFC	12 Months	3 Months	3 Months
	EXP. PR.	9 Months	3 Months	3 Months

H.P. Above 1800 R.P.M.	ENCLOSURE	STANDARD CONDITIONS	SEVERE CONDITIONS	EXTREME CONDITIONS
.5 - 150	All	6 Months	3 Months	3 Months

STANDARD CONDITIONS

Normal or light loading, single eight (8) hour shift operation, clean environment, 104°F maximum ambient.

SEVERE CONDITIONS

One of the following: Twenty-Four (24) hours a day service; dusty location; light vibration; light shock; 104°F maximum ambient.

EXTREME CONDITIONS

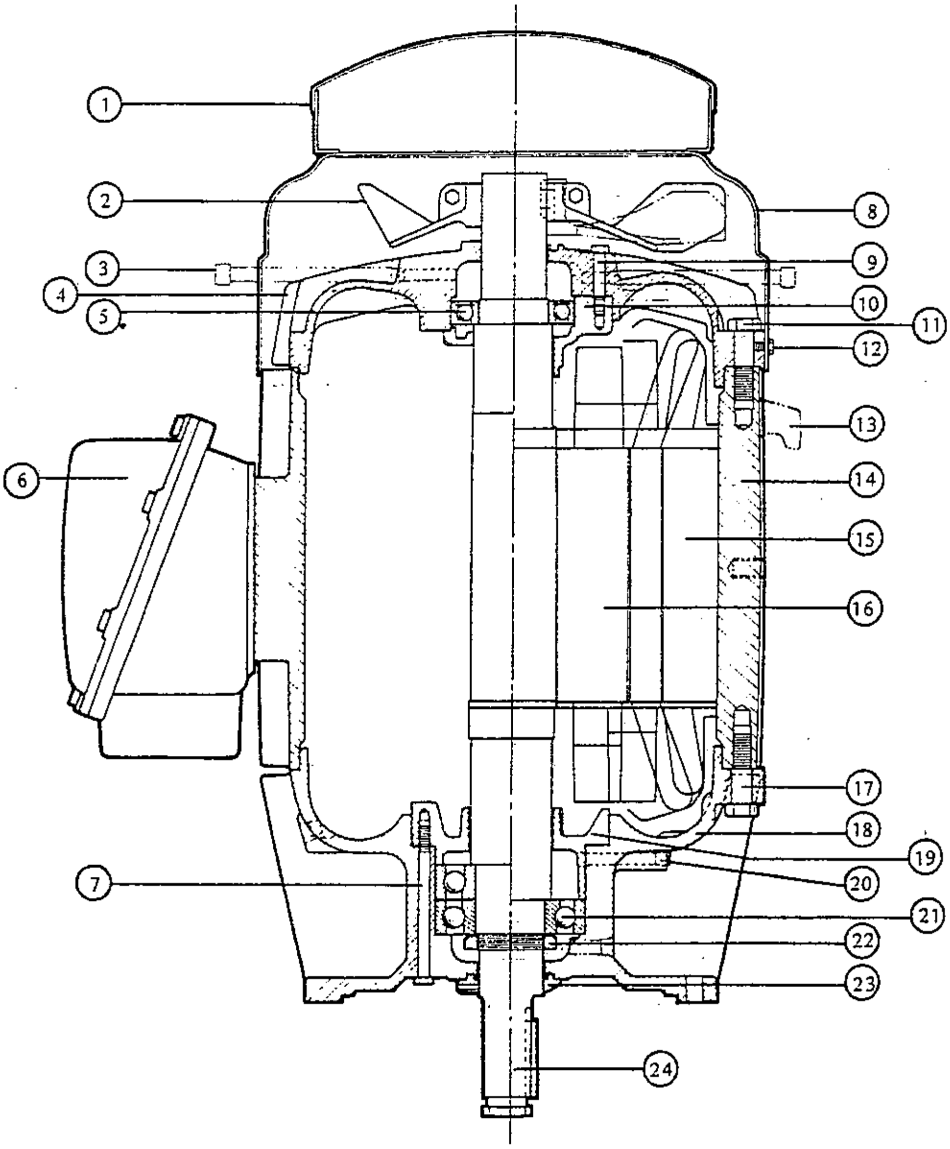
One of the following: heavy vibration; heavy shock; excessive dust; ambient between 104°F and 140°F.

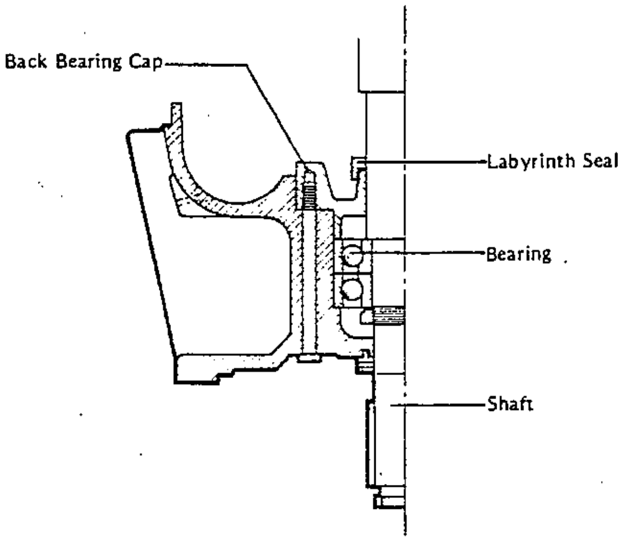
For other motor types or operating conditions not covered, consult factory.

The below listed greases, or their equal, are suitable for motors operating between 0°F and 104°F ambients.

Manufacturer	NORMAL Ambient Temperature −20°F to 105°F	HIGH Ambient Temperature 0 to 150°F
Chevron Oil Co.	SRI No. 2	SRI No. 2
Shell Oil Co.	Dolium R	Dolium R
Shell Oil Co.	Darina No. 2	Darina No. 2
Texaco	Premium RB	Premium RB
Texaco	AFB No. 2	AFB No. 2
Mobil	Mobilux No. 2	Mobil 28
Gulf Oil	Gulf Crown No. 2	Gulf Crown No. 2
Exxon	Unirex N2	Unirex

1. Drip Cover
2. Fan
3. Front Lub Fitting
4. Front Bracket
5. Front Bearing
6. Conduit Box
7. Back Cap Bolt
8. Inlet Guard
9. Front Cartridge Bolt
10. Front Cartridge
11. Front Bracket Bolt
12. Inlet Guard Mounting Bolt
13. Lifting Lugs
14. Housing
15. Stator Core and Winding
16. Rotor
17. Back Bearing Bracket Bolt
18. Back Bearing Bracket
19. Back Bearing Cap
20. Back Lub Fitting
21. Back Bearing
22. Back Bearing Locknut and Washer
23. Back Outside Slinger
24. Shaft



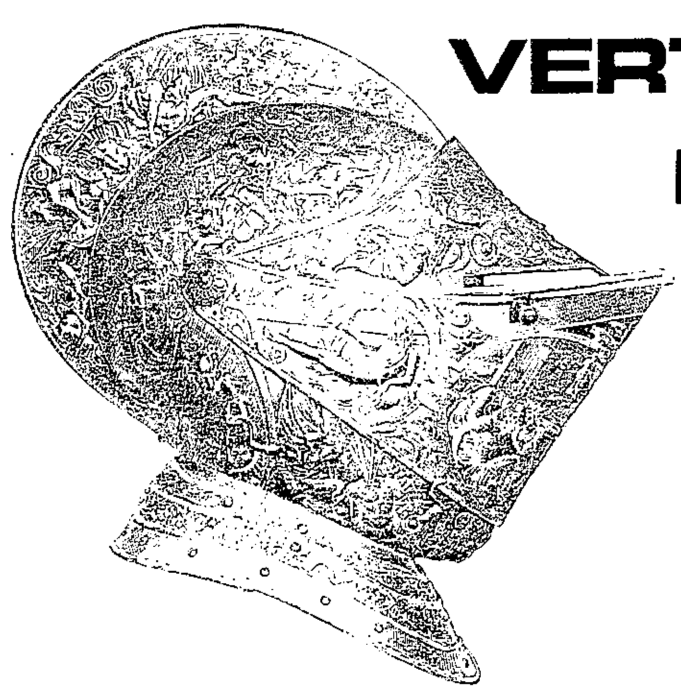


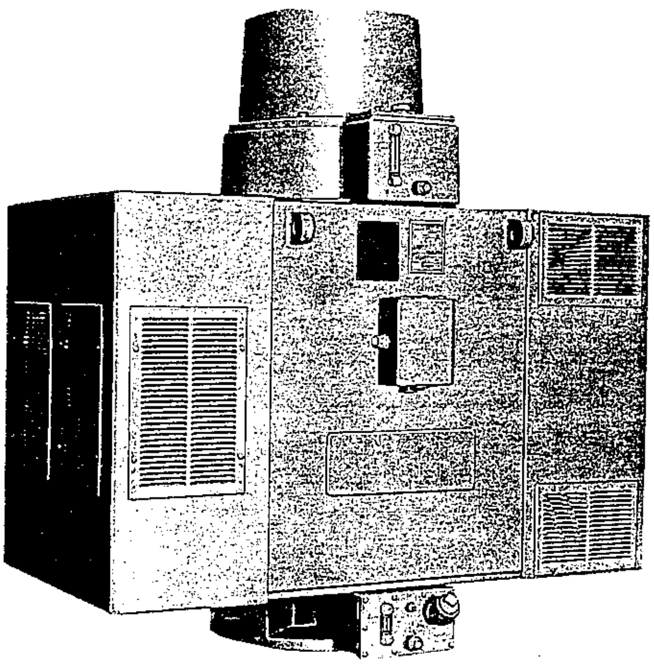
Explosion-Proof, Class I, Group C Inside Cap Labyrinth Seal

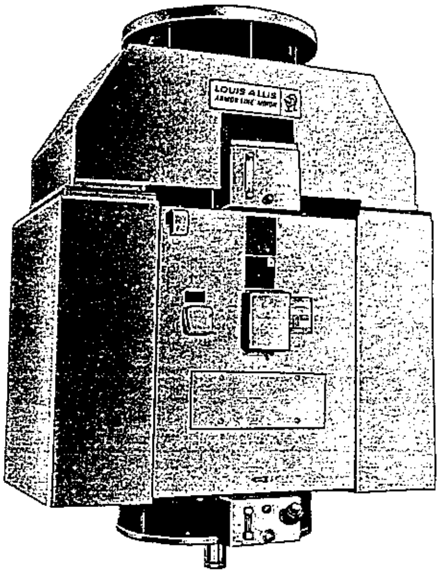
LOUIS ALLIS

ARMOR LINE® SERIES 7000

VERTICAL MOTOR INSTRUCTION MANUAL







FRAMES 7100 – 7500

PRICE $7.50

CONTACT YOUR LOUIS ALLIS DISTRICT OFFICE OR
PRODUCT SERVICE CENTER
MILWAUKEE, WIS. 53207

MANUAL 3356M - Revised 1/81

Litton

LOUIS ALLIS
Milwaukee, Wisconsin 53201

WARRANTY

Standard products manufactured by the Company are warranted to be free from defects in workmanship and material for a period of one year from the date of shipment, and any products which are defective in workmanship or material will be repaired or replaced, at the Company's option, at no charge to the Buyer. Final determination as to whether a product is actually defective rests with the Company. The obligation of the Company hereunder shall be limited solely to repair and replacement of products that fall within the foregoing limitations, and shall be conditioned upon receipt by the Company of written notice of any alleged defects or deficiency promptly after discovery and within the warranty period, and in the case of components or units purchased by the Company, the obligation of the Company shall not exceed the settlement that the Company is able to obtain from the supplier thereof. No products shall be returned to the Company without its prior consent. Products which the Company consents to have returned shall be shipped f.o.b. the Company's factory. The Company cannot assume responsibility or accept invoices for unauthorized repairs to its components, even though defective. The life of the products of the Company depends, to a large extent, upon type of usage thereof, and THE COMPANY MAKES NO WARRANTY AS TO FITNESS OF ITS PRODUCTS FOR SPECIFIC APPLICATIONS BY THE BUYER NOR AS TO PERIOD OF SERVICE UNLESS THE COMPANY SPECIFICALLY AGREES OTHERWISE IN WRITING AFTER THE PROPOSED USAGE HAS BEEN MADE KNOWN TO IT.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.

This warranty does not apply to experimental or developmental products.

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ARMOR LINE SERIES 7000

All Louis Allis vertical motors are designed for heavy duty industrial use. With proper operation and maintenance, they may be counted on to perform continuously for many years within the range and rating established by the design.

Like all good industrial machinery they will perform beyond the limits established by their ratings, but continuous operation beyond this rating will definitely shorten their life and in some cases will actually cause serious breakdown.

It is strongly recommended, therefore, that these instructions be carefully observed and that the motor be connected and operated as intended by its design. Observance of these procedures will result in long life, good performance and financial savings.

RECEIPT OF SHIPMENT

When your equipment arrives, it should be checked immediately to see that all components have been received, and that there is no evidence of damage in shipment.

In the event the complete assembly has not been received, or arrives in a damaged condition you should without delav notifv the carrier who handled the shipment and the nearest Louis Allis Sales Office.

When communicating with a Louis Allis Sales Office or the factory, make reference to our invoice numbers, the type and rating of the unit, Louis Allis Order No. and any other information such as district office from which ordered, your purchase order number, etc. that would be useful in identifying the equipment. If no other information is available, the equipment can be identified by serial numbers appearing on the nameplates.

Describe as completely as possible what damage has occurred, what shortages exist, what features have been omitted, or what problem you have encountered with the equipment.

Complete and precise information will enable us to understand and remedy your problem with minimum delay.

STORAGE

GREASE LUBRICATED EQUIPMENT

Louis Allis grease lubricated motors are shipped with the proper amount of grease in each bearing.

If the motor is placed in storage for a period in excess of three months, it is recommended that the shaft be turned over slowly by hand at least once in every three-month period. This will distribute the grease and prevent bearing corrosion due to condensation or contaminating gases in the vicinity of the motor.

If the motor is exposed directly to weather conditions during storage, it is important that a check be made to determine if the motor has actually become wet and if the grease contains droplets of water which have entered the bearing chamber due to normal breathing. If water has become mixed with the grease during the storage period, it is desirable to flush the bearing of all old grease and replace with new lubricant of the type recommended.

OIL LUBRICATED EQUIPMENT

All oil lubricated Louis Allis motors are tested with a rust preventative oil which protects the bearing structure from rust and corrosion. Before shipment, the oil is drained from the bearing chamber. OIL MUST BE ADDED TO THE MOTOR BEFORE OPERATING.

If the motor is to be in storage over three months, the bearing chambers should be filled with a rust preventative oil. The shaft should be rotated by hand or by use of a suitable wrench after the oil is added and at least once in every three month period. If the motor is exposed directly to weather conditions or adverse atmospheric conditions, it is recommended that the shaft be rotated at least once every month.

The following oils or their equivalents are recommended for use during the storage periods.

Shell Oil Company – ENSIS Oil 10 or 30
Texaco, Inc. – Preservative Lubricant Oil Code 788-30
Mobil – Mobilkote 500 Series

For recommended operating oils, see page 2114.

GENERAL INSTRUCTIONS

If the equipment is not put into immediate use it should be stored in a clean, dry location.

Take care to keep the equipment covered when moving from a cold location to a warm location. Otherwise, condensation may occur. If condensation does occur, and the equipment is moist, allow it to dry thoroughly before applying power.

LONG TERM ON-SITE STORAGE

In the event that in-place installation is longer than one month prior to the date of motor start-up the following on-site storage maintenance should be performed.

1. On in-place installation motor bearings should be filled with a rust preventative oil. The following oils or their equivalents are recommended for use during the storage periods.

   Shell Oil Company – ENSIS 10 or 30
   Texaco, Inc. – Preservative Lubricant Oil Code 788-30
   Mobil – Mobilkote 500 Series

   On Vertical motors bearings should be flooded with oil. Fill in accordance with motor nameplate number 118683. Shaft should be rotated on a monthly basis. See long term storage manual for further details. Louis Allis Service Manual Section 19, Page 2051.

2. Motors should be loosely covered with plastic film or similar covers.

3. During storage period motor space heaters should be energized to eliminate moisture condensation inside the housing. Where space heaters are not provided heat should be supplied inside the motor either using light bulbs or low voltage heating of one phase of the stator winding. Winding temperature should be maintained 5°C above ambient.

4. Megger readings should be taken on a monthly basis and a chart kept to determine if reading changes occur. Temperature of the winding must also be recorded when the megger reading is taken.

LIFTING

All lifting of the assembled motor should be done with the slings and clevises through the lifting lugs provided on the stator housing. A spreader bar should be used.

In handling the stator alone, never lift or support it by the core, laminations, or coils.

INSTALLATION

LOCATION

In selecting a location for the unit, first consideration should be given to ventilation. It should be far enough from walls or other objects to permit a free passage of air.

Less maintenance will be required if unnecessary dirt, dust, moisture, liquids and similar hazards are kept away from motors.

The motor should never be placed in a room with a hazardous process, or where flammable gases or combustible material may be present unless it is specially designed for this type of service.

ALIGNMENT AND ERECTION

The motor must be securely mounted to a pump head or similar support which is rigid enough to prevent any vibration of the unit or transfer of pump vibration to the motor. This must not impose bending or twisting strains on the motor structure. Make sure that the hold down bolt locations in the pump head are accurate.

The motor base has a machined lower face with a rabbet fit. It is not recommended that these parts be used for alignment purposes in place of a further check of the shaft alignment itself, because the motor base is not perfectly concentric and square with respect to the shaft.

After the motor shipping braces have been carefully removed, place the motor onto the pump head support using lifting means as described previously. Follow the instructions of the coupling manufacture for the correct method of shaft coupling installation. Rigid couplings should be checked for alignment and truth by loosening the bolts and measuring with thickness gauges between the coupling faces with the shaft set at four angular positions, equally spaced. The alignment should be sufficiently accurate to give no more than .001 inch variation between the faces for 12 inches of face diameter. After each corrective adjustment, the holding down bolts should be tightened and alignment checked. After alignment is completed, tighten the holding down bolts. If desired, the motor base may now be dowelled to the pump head support.

Care should be observed in checking coupling alignment to insure that the pilot fit in the coupling is not so tight as to affect the alignment measurements.

Flexible couplings should not be forced to accommodate excessive misalignments. This will produce undue wear and can cause vibration. Align these by checking between coupling hub faces with feeler gauges and with dial indicators from one hub cylinder surface to the other. This will eliminate both offset and angular misalignment. Mount the indicator on the shaft (Figure 1) and read radial as well as axial variations between the coupling halves as they are revolved slowly together. Where the two half couplings float axially with respect to each other, it is necessary to use two indicators mounted 180 degrees apart and obtain the difference in the two axial readings in order to check the angular alignment.

Scribe a reference mark on the machined diameter of the coupling hub at the indicator button. Rotate both shafts simultaneously, keeping the indicator button at the reference mark on the hub and note the reading on the indicator dial at each one-quarter revolution.

TOTAL RUN-OUT BETWEEN THE HUBS SHOULD NOT EXCEED .002 INCH.

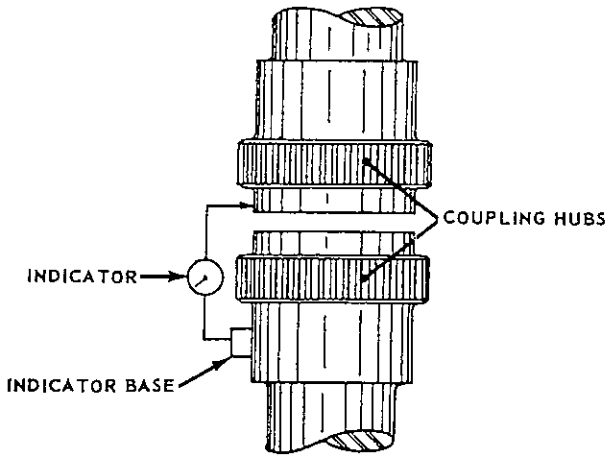


Figure 1

If it is not possible to rotate both shafts when checking alignment, the indicator should be clamped to the hub of the rotating shaft and the indicator button should sweep the ground diameter and face of the stationary hub. Distorted or cocked coupling hubs may cause errors in checking by this method, however, and the former method is preferred where possible.

When conditions make it impossible to check alignment with a dial indicator, a rough check of alignment can be made with a straight edge and feeler gauges. Check for angular misalignment by inserting feeler gauges between the faces of the coupling hubs at four equidistant points. Check for run-out by placing a straight-edge across the closely machined diameters of both coupling hubs. This method is not recommended unless a check with a dial indicator is impossible.

After the alignment has been checked, secure the mounting bolts on the motor and the driven equipment, and recheck the alignment before engaging the flexible coupling.

ALIGNMENT
(Vertical Hollow Shaft Motors)

On vertical hollow shaft motors, the coupling is designed as an integral part of the motor. Before assembling the coupling, check to make sure that the pump shaft is in the center of the motor shaft.

Check for runout using the procedure given in the left hand column on this page. Attach the indicator as shown in Figure 2.

TOTAL RUN-OUT SHOULD NOT EXCEED .002 INCH.

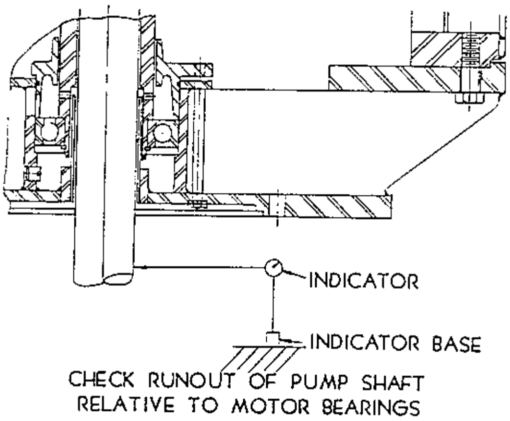
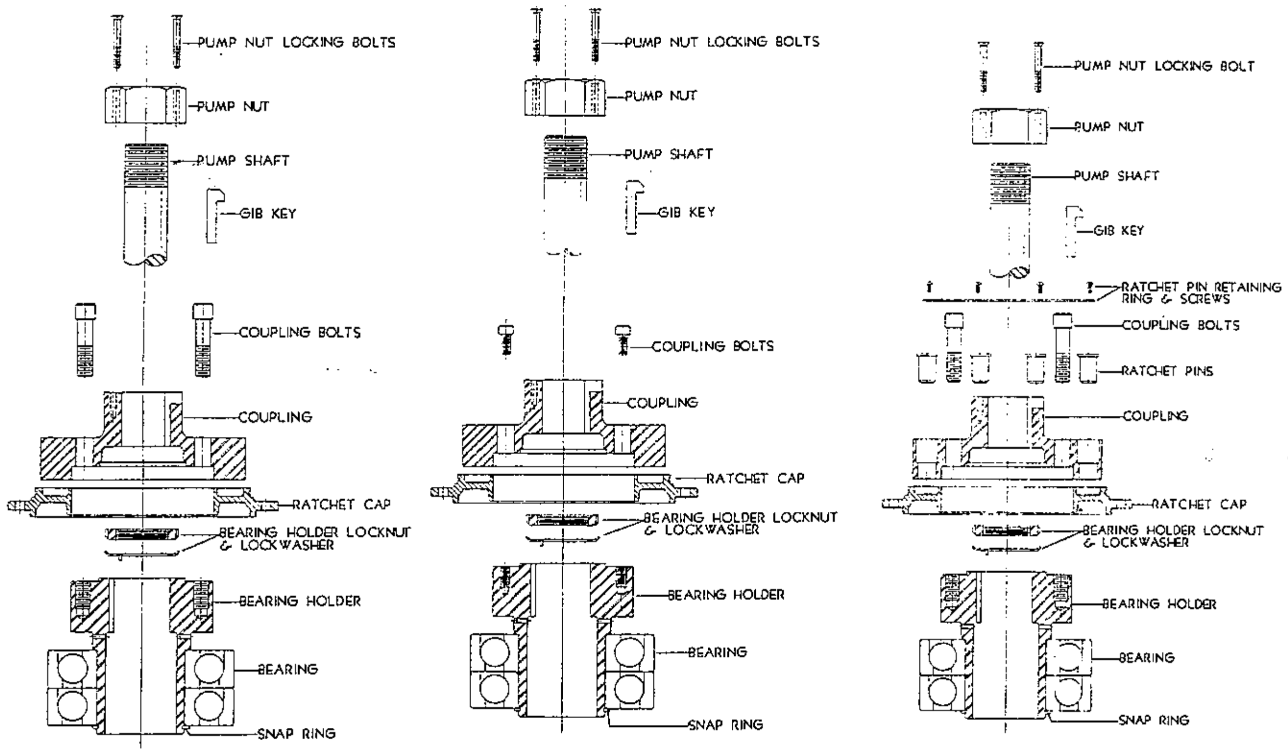


Figure 2

Once the pump shaft has been centered, assemble the rest of the coupling. The pump shaft can now be raised or lowered simply by turning the pump shaft adjusting nut. Lock the coupling and adjust the pump shaft adjusting shaft as required. See page 2105. When the pump shaft has been set at the proper height, the pump shaft adjusting nut can be locked into position by turning in the pump adjusting nut lock screws.

PUMP COUPLINGS

There are three variations of the pump coupling, namely the non-reverse ratchet, the solid coupling, and the self-release. The coupling is drilled with six holes. Three holes permit the self-release coupling cap screws to be inserted so that the caps of the bolts seat to the bearing holder and thus result in a self-release type coupling. The other set of three holes is drilled to engage the cap of the cap screw so as to form a solid or non-reverse coupling. The ratchet pins are inserted when a non-reverse type ratchet is desired. Construction details of the three types of couplings are shown in Figure 3.



EXPLODED VIEW OF BOLTED COUPLING

EXPLODED VIEW OF SELF RELEASE COUPLING

EXPLODED VIEW OF NON REVERSE RATCHET

Figure 3

VIBRATION

On new installations, vibration problems are sometimes encountered. When this happens, it is well to realize that there are many causes of excessive vibration. Some of these are: faulty alignment, vibration of driven equipment, improper or cracked foundations, sprung shafting, electrical unbalance, rotor unbalance and reed frequency. When vibration problems are encountered, always look for the simplest, most obvious cause of trouble. Keep in mind that the motor was tested by actual operation at the factory and when motors are tested at the factory, the vibration is much less than the vibration limits shown in Table 1. Always be sure that the motor is actually out of balance before considering balancing the rotor.

The measurement of vibration will require the use of specialized equipment. Portable vibration detectors are available which will measure the amplitude of the vibration. If excessive unbalance is detected, please contact your nearest Louis Allis district office.

Table 1 - Vibration Limits

Speed*	Amplitude (Inches)*
3000 & Above	0.001
1500 - 2999	0.002
1000 - 1499	0.0025
999 & Below	0.003

*Values per NEMA standard MG1-20.52.
Measured per NEMA standard MG1-20.53.

NEMA REED FREQUENCY REFERENCE

MG1-20.54 Reed Frequency of Vertical Motors

A. In a single degree of freedom system, the static deflection of the mass (Δs, inches) is related to the resonant frequency of the system (f_n, cycles per minute). as follows:

$$f_n = 187.6 \sqrt{\frac{1}{\Delta_s}}$$

B. Vertical or other flange-mounted motors are frequently mounted on some part of the driven machine such as pump adaptor. The resulting system may have a radial resonant frequency (reed frequency) the same order of magnitude as the rotational speed of the motor. When the resonant frequency of the system is too close to the rotational speed, a damaging vibration level may result.

C. The vertical motor manufacturer supplies the following information to the customer to aid in determining the system resonant frequency, fn. It is the responsibility of the pump adaptor designer to calculate system reed frequency.

1. Motor weight

2. Center of gravity location – This is the distance from the motor mounting flange to the center of gravity of the motor.

3. Motor static deflection – this is the distance the center of gravity would be displaced downward from its original position if the motor were horizontally mounted. This value assumes that the motor uses its normal mounting and fastening means but that the foundation to which it is fastened does not deflect. Authorized Engineering Information 7-13-1977.

Louis Allis furnishes the information under Item C on the motor outline drawing to the purchaser of the motor.

REED FREQUENCY TEST

The following procedure can be used to obtain excitation frequency and displacement data for each of two directions of vibration. For reference take readings with vibration instrument in the direction of the conduit box and then repeat it for vibration 90° from the conduit box.

1. Bolt the motor to the base. Record the size of the bolts. The motor flange bolts should be the correct length (no washer stacks) and properly tightened.

2. Select a vibrator having an appropriate force at the motor natural frequency. For motors (440 and larger) Formula 62 or equivalent vibration source.

3. Attach the vibrator to a main structural member near the top of the motor. Locate the vibrator on the side of the motor opposite the vibration instrument pick up.

4. Set the vibrator at a low frequency and read the vibration displacement indicated on the vibration instrument. Start taking displacement and frequency data at approximately 200 cycles per minute and repeat in approximately 200 cpm increments until the reed frequency has been determined. The reed frequency has been reached when the displacement maximum has been reached and further changes in frequency results in smaller displacement values. The peak must be clearly outlined by the data so continue taking new data points after the displacement peak has been reached. Take three more points or continue to the maximum vibrator frequency whichever comes first.

5. A typical curve is as shown below.

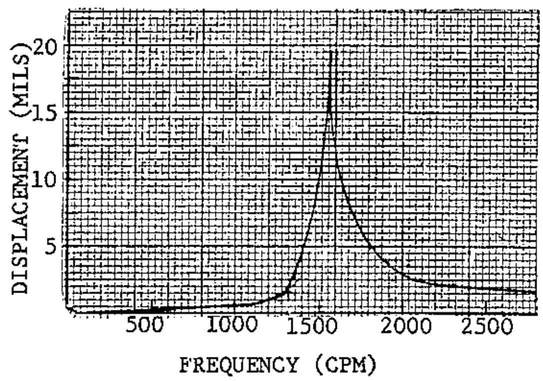


Figure 4

MOTOR STARTING

ACROSS-THE-LINE STARTING

Across-the-line starting is the most basic and widely used method of starting motors. The starting operation is as follows: (see Figure 5).

A pilot device (such as a start pushbutton) closes contactor M to connect the motor directly to the line.

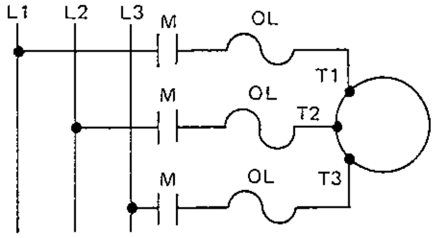


Figure 5

AUTOTRANSFORMER OPEN-CIRCUIT TRANSITION

After the start button is pushed, the sequence of operation is as described in figure 6 and 7. Note that during the transition from reduced voltage to full line voltage, the motor is temporarily disconnected from the line.

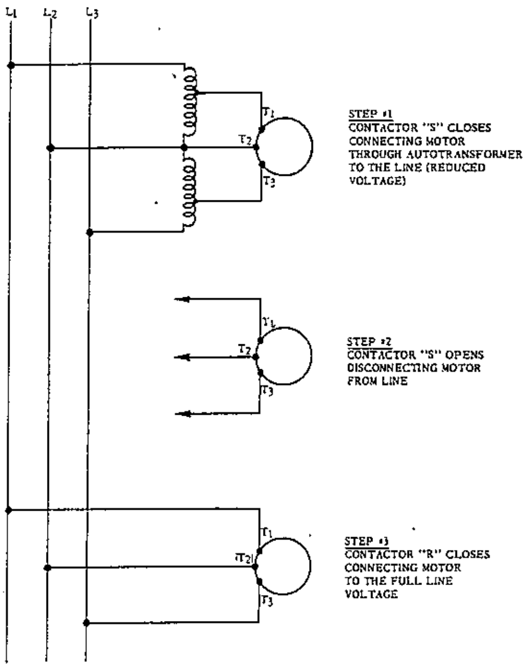


Figure 6
Sequence of Operation
Open Circuit Transition

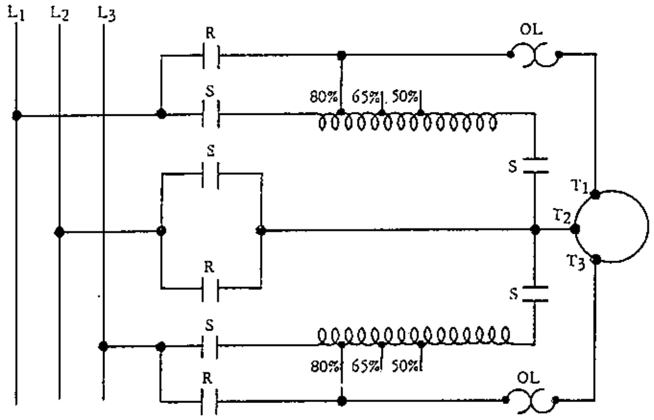


Figure 7
Schematic Diagram
Open Circuit Transition

AUTOTRANSFORMER CLOSED-CIRCUIT TRANSITION

As in the case of the open-circuit transition, the steps that take place after the start button is pushed are described by the sequence of operation and the schematic diagram (see figure 8 and 9). Note that during the transition from the first step reduced voltage connection to the full line voltage connection, part of the autotransformer windings are connected between the motor and the line. These series connected inductive reactances also act as a voltage reducing device.

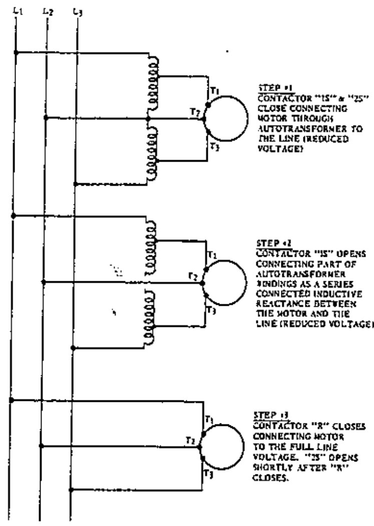


Figure 8
Sequence of Operation
Closed Circuit Transition

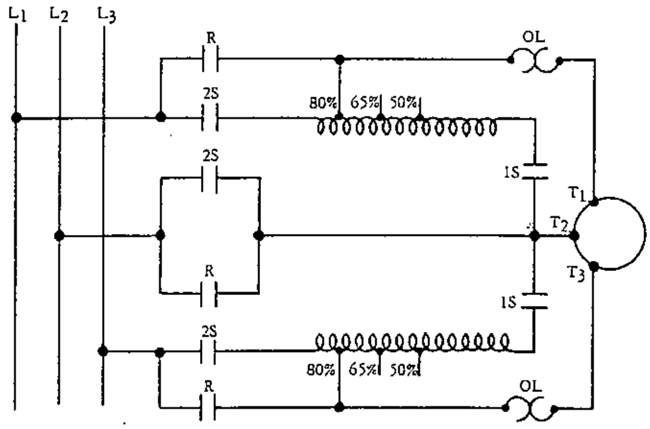


Figure 9
Schematic Diagram
Closed Circuit Transition

ELECTRICAL CONNECTIONS AND STARTUP

The outline drawing shows the location of the connections to main and accessory leads. Make the lead connections securely referring to the connection nameplate of outline drawing. Ground the motor as protection to the operator in case of a winding breakdown.

Before starting a machine after an extended period of idleness, give it a thorough inspection and cleaning. Measure the insulation resistance to determine whether or not drying out is required.

NOTE: When a machine is very wet or has been immersed in water, the insulation could be broken down by improper application of the test voltage itself. In such cases, dry out the winding thoroughly before testing.

Several methods of drying may be used. If the machine is too large to put in a drying oven, it can be covered with a canvas or similar covering under which stoves or heaters supply the necessary heat.

Squirrel cage motors can also be dried out by applying low voltage (usually no more than 10 per cent of rated) to one phase of the winding. Apply heat slowly to avoid insulation damage; winding temperatures should not exceed 75 - 80 degrees C.

The process should not be hurried, and must be continued until the insulation resistance reaches a satisfactory value.

Insulation resistance may be measured either by a Megger or by using a 500 volt direct current circuit and voltmeter.

The insulation resistance is calculated by the following formula:

$$R^1 = \frac{R\,(V - V^1)}{V^1\,(10^6)}$$

where V = line voltage
V^1 voltage reading with insulation in series with voltmeter
R = resistance of voltmeter in ohms
R^1 = resistance of insulation in megohms

A convenient connection diagram is shown in Figure 10.

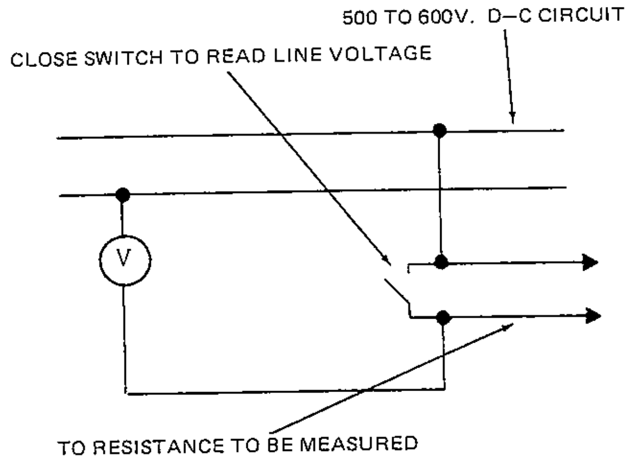


Figure 10

The insulation resistance of a machine at the operating temperature should not be less than:

$$R\,(\text{Megohms}) = \frac{\text{Rated terminal voltage}}{\left(\frac{\text{Rating in KVA}}{100}\right) + 1000}$$

If an unusually low value of IR is found with no obvious causes, and cannot be corrected by cleaning and drying windings, separate the phases and test each phase of the winding separately to localize the trouble.

NOTE: The IR of one phase, with the other two phases grounded, should be about twice that of the entire winding.

When the test voltage is applied for a period of ten minutes or more, the plotted graph of insulation resistance values obtained represents the dielectric absorption characteristic. This graph may be interpreted as follows: A steadily-rising curve is indicative of a clean, dry winding; a quick-flattening curve is the result of leakage current through or over the surface of the winding insulation, and is generally indicative of a moist or dirty winding.

To compare insulation resistance readings taken periodically over a long time, all should be converted to a standard 40 degree C temperature. Take a 500 volt d-c reading for 60 seconds, then convert as follows:

$$R \text{ at } 40^{\circ}C = \frac{R \text{ at known test temperature}}{K_t}$$

where K_t is the insulation resistance-temperature co-efficient.

See Figure 11 for approximate values of K_t at various winding temperatures.

START-UP PROCEDURE

Before starting the motor for the first time, follow these instructions carefully.

1. Be certain that the power supply corresponds to the line voltage on the motor nameplate.
2. Check that all connections are made correctly and securely.
3. Check that all bearing housings are filled with the proper lubricant and to the proper level. Do not overfill.
4. Check that all shipping braces or inserts have been removed.
5. Inspect all electrical clearances.
6. Check that all external cooling or oiling systems are operating correctly.
7. Carefully examine the motor interior, coil ends, air gap, and fans for loose foreign objects.

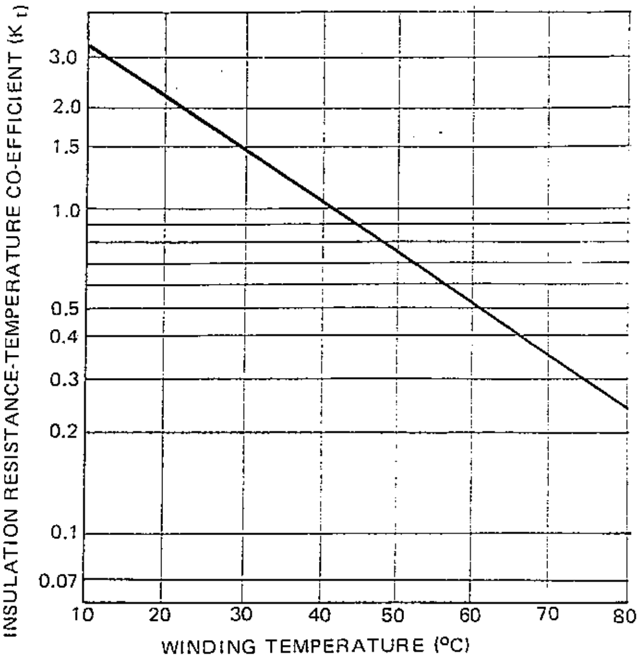


Figure 11

8. Be sure all rotating parts have sufficient clearance with respect to adjacent stationary parts.

9. If possible, bar the rotor over by hand to see that it rotates freely. "Bump" motor electrically to check rotation.

10. As soon as the motor starts, observe the oil level gauges to see that a favorable running oil level exists.

CAUTION - STARTING DUTY: Too frequent starting can cause serious damage to the squirrel cage windings of induction motors. Such motors are occasionally subjected to abusive starting duty while control equipment and relays are being adjusted during initial plant startup. Refer to the motor outline drawing for starting duty limitations.

MOTOR CONTROL

Location of the motor control or starter is dependent upon many factors. Some of these are: size of motor, voltage drop, moisture, dust, ambient temperature, vibration, etc.

Controls should be protected from moisture and weather conditions and must not be exposed to conductive dusts such as metal scale or carbon black. Care should also be taken to minimize wide differences in temperature between motor and control. Be sure to select the proper overload heater when installing the control. Heater selection rules are given below.

Before energizing the control, carefully check all connections to the control terminals. Check the mechanical operation of all relays, starters, etc., for any binding or damage in shipment, installation or storage. Be sure all protective devices are properly connected.

Should problems arise during start-up, look for the most obvious cause of trouble. Remember that the control was tested for proper operation before it was shipped.

THERMAL OVERLOAD HEATER SELECTION RULES

The overload heater motor current ratings used in control manufacturers' catalogs are applicable to 40°C rise continuous duty motors, where the motor and the thermal overload element are operating in the same ambient temperature. These values should be used as the basis for thermal overload heater selection, but should be modified according to the following rules.

1. Overload heater elements in a non-ventilated or enclosed cabinet should be increased by one size.

2. Overload heater elements for 50-55°C rise motors should be decreased by one size.

3. Overload heater elements should be decreased by one size when used in forced ventilated cabinets.

4. Overload heater elements should be increased by one size for each 15°C that the ambient temperature around the controller is higher than that around the motor.

5. Overload heater elements should be reduced one size for each 15°C that the ambient temperature around the controller is lower than the ambient temperature around the motor.

These rules are to be applied cumulatively. In other words, if the starter for a 80°C rise motor is located in a ventilated cabinet in which the ambient temperature is 15°C lower than the motor ambient, the overload heater size as selected from a manufacturer's catalog based on the motor current should be reduced by three sizes; once for the ambient temperature difference once because of the forced ventilation cabinet, and once for the 55°C rise motor. If a heater is selected for a 80°C rise motor for use on a starter located in an enclosed cabinet, the heater size will be the same as that given in the manufacturer's catalog. This is so because, while the heater should be reduced one size for the 80°C rise motor, it should be increased by one size because the starter is located in an enclosed cabinet.

SPACE HEATERS

When the electric motors are installed in damp locations, space heaters should be used to keep moisture from condensing on the windings when the motor is not in use. Resistance units are the most common type. A typical space heater which is used in Louis Allis motors is shown in Figure 12.

Heaters are usually located in the bottom of the motor so that convection currents carry the heat upward. They are usually placed so that they may be easily inspected.

The power requirements of the heater are listed on the motor outline drawing. A surface temperature of about 700°F is common. However, some hazardous locations require a surface temperature of approximately 400°F or less.

Controls for space heaters should be located in a prominent place and should be operated by a normally closed interlock on the motor starter. A pilot light is normally used to show when the heaters are on. In this way the heaters will be energized when the motor is stopped.

Heaters can also be controlled by a thermostat, arranged to turn on the heaters whenever the motor temperature drops to a preset value.

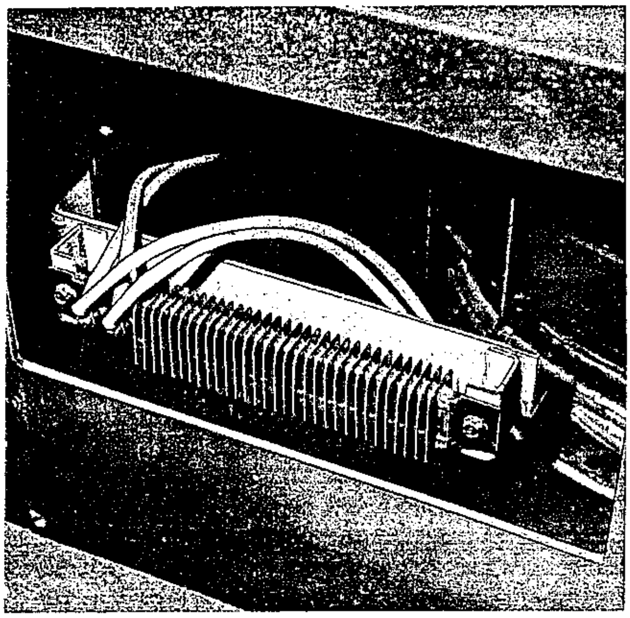


Figure 12

STATOR TEMPERATURE DETECTORS

Many large motors are now equipped with temperature detectors to detect stator winding temperature. The type of detector used is based solely on the customer requirements, with the leads brought out to a separate auxiliary terminal box or the main conduit box.

Four types of temperature detectors are available for sensing stator winding temperature. A separate auxiliary terminal box is furnished for high voltage motors. Leads are brought into the main conduit box on low voltage motors.

1. Thermostats

Thermostats are a small hermetically sealed button shaped device secured to the end turns of the stator. Temperature changes cause a pre-calibrated bi-metallic disc to change its characteristics at the pre-calibrated temperature to open or close a set of electrical contacts.

Three detectors are provided, located on the end turns of the winding. For a class "B" motor, unless otherwise specified, the thermostats will operate at 115°C ± 5°. The reset temperature is 100°C ± 5°. These devices operate when the temperature of the thermostat reaches the preset temperature for which they are to operate.

Supplier: Texas Instruments - KLIXON

Only AC circuits can be interrupted by these devices per the manufacturer.

When advising customer on use of the thermostats remember - - - -

a. Operating temperature is pre-calibrated. No provision for adjustment.

b. All are single-pole, single throw with N.O. or N.C. contacts.

c. Device is absolute. No indication of actual temperature or rate of rise is possible.

d. Device protects stators. Rotors are not protected.

2. Stator Savers

The stator saver is a winding protection system - positive temperature co-efficient thermistors and a completely encapsulated solid state switch in a contact module, which is the equivalent of a N.C. contact. The thermistors are located at the end turns of the winding and the contact module can be mounted on the motor or remotely mounted. This system is designed to produce a signal for either alarm or shutdown when thermistors reach a predetermined temperature.

Supplier: Power Control Corporation

a. Stator saver does not protect rotors.

b. It is an integrated system and must be furnished in its entirety.

System is designed for the following:

a. Generate signal which can be used for alarm, shut-down, etc.

b. Module power supply voltage (110 or 220).

c. Module motor mounted or remotely mounted

d. Input and output leads in same or separate conduit.

3. Resistance Temperature Detectors

Six RTD's are installed in the motor slots, two per phase. The detectors are designed to operate in a bridge circuit with temperature stable resistors, connected to a milliameter that is calibrated in degrees; a reading of temperature of the stator windings will be indicated.

Supplier: Minco

4. Thermocouples

The fourth method for the measurement of temperature rise is by embedded thermocouple. The thermocouple is connected to a bridge type instrument which usually gives a reading directly in degrees Centigrade. Care should be taken to insure that the bridge is calibrated for the type of thermocouple used.

BEARING TEMPERATURE DETECTORS AND RELAYS

Many machines are supplied with some type of bearing temperature detector and/or relay. These devices will provide warning or shutdown of the equipment if bearings are overheating as a result of misalignment or loss of lubrication. Ball bearing motors can also be protected with vibration detectors which will detect excessive vibration as a result of a rough bearing.

Bearing temperature detectors may be one of several varieties. Typical ones are resistance temperature detectors, thermocouples and thermistors. Each of these detectors required some type of control which may or may not be supplied with the detector. The control equipment is separately mounted either on the machine or with the control equipment. The relays for these various types of detectors may be directly or through auxiliary relays connected into the starter holding coil circuit to provide shutdown, or into a bell or light circuit to provide warning. Bearing temperature devices are normally recommended to operate at 185 to 200°F. Once the bearing operating temperature has been established, it should stay fairly constant as long as the ambient temperature doesn't change too much. It is recommended that the operator reset the relay temperature to about 10°F above the maximum expected operating temperature. In case of trouble, this setting should give enough time to make a quick investigation or shutdown the unit, and may be the difference between saving or losing the bearing.

MAINTENANCE

Electric motors are among the most efficient machines known today and will operate with a minimum of attention to keep the equipment operating at a high level of efficiency; however, a good maintenance program must be set up. Systematic inspections of the equipment should be scheduled, and records should be kept of the findings of these inspections. Examination of these records will indicate any sign of potential trouble. Periodically, at planned intervals, the equipment should be completely disassembled and overhauled.

Figures 13 and 14 show two typical 3" x 5" cards which are used to keep maintenance records on electrical equipment. When properly used, these cards will show how much repair has been done to a piece of equipment and also the condition of the equipment. The cards insure that each unit is inspected at least once a week and also show the inspector what to check.

Since each industry has its own special conditions, an overall plan for periodic maintenance is not outlined here. However the following pages give many tips on the maintenance of electrical equipment.

CLEANING

Dirt, dust and oil are the greatest enemies of electrical equipment. When dirt or dust settles on a machine, it may prevent heat dissipation and restrict ventilating passages. This in turn may lead to overheating and insulation breakdown. Some types of dust are electrically conducive and can also cause insulation breakdown.

Dust and dirt may be removed from electrical equipment with dry compressed air, with dry cloths or by brushing. The compressed air must be dry and at a low pressure (not over 50 P.S.I.) in order to prevent damage to the insulation. Grit, iron, dust, graphite, lamp black and copper dusts should be removed by suction. Hose tips for either pressure or suction should not be of metal.

Dust and dirt also have a harmful effect in that they tend to soak up oil or grease, forming a gum which is not easily cleaned off. Oil is particularily damaging since it tends to deteriorate insulating varnish. Once a motor or generator has become oil soaked, it is in serious danger of burning out.

RECORD OF REPAIR			
DATE	CAUSE OF DAMAGE	REMEDY	COMMENTS

BACK

INVENTORY CARD
MOTORS – GENERATORS – EXCITERS

LOCATION ______
APPLICATION ______
COMMENTS ______

HP–KVA ______	FRAME ______	VOLTS ______
TYPE ______	PHASE ______	AMPS ______
RPM ______	CYCLES ______	SERIAL NO. ______
BEARINGS	BRUSHES	CONTROL
TYPE ______	NUMBER ______	MFGR. ______
	SIZES ______	TYPE ______
FRONT NO. ______	GRADE ______	WIRING DIA. NO. ______
		SHAFT
BACK NO. ______	MFGR. ______	DIA. ______ LENGTH ______
	CAT. NO. ______	KWY ______ X ______ X ______

FRONT

Figure 13

CHECK SHEET 19 ______ No. ______

Date	*Jan	Feb	Mar	*Apr	May	Jun	*Jul	Aug	Sep	*Oct	Nov	Dec
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
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27												
28												
29												
30												
31												

Weekly Check–Vibration-Rubbing-Temperature-Sparking-Oil Level-Dirt.
*Quarterly Check–Connections-Brushes-Field Coil Tightness-Alignment-Belt Tension-Grease (Check Greasing Charts)-Clean if necessary-Starter Contacts-Noise-Temperature.

FRONT

INSPECTION RECORD No.

Date	Air Gap								Insulation Resistance		Volts			Load Check Amps/Phase		
	Front End				Shaft End						Phase					
	Top	Right	Bot-tom	Left	Top	Right	Bot-tom	Left	Temp	Res.	1	2	3	1	2	3

BACK

Figure 14

Oil or grease covered machines should be cleaned thoroughly and a fresh coating of insulating varnish applied. Usually most of the oil or grease can be removed with a cloth moistened with a solvent such as VM & P Naptha. A brush should be used for surfaces difficult to reach by hand. Use a spray gun to clean inaccessable slots and passages. After using the solvent, be sure to dry the windings with dry compressed air.

WARNING: Do not use a solvent which has toxic effects or which has a deteriorating effect on varnish.

No amount of cleaning will repair insulation which has been badly oil soaked. The motor will probably have to be rewound. Refer to the nearest Louis Allis district office for rewinding instructions.

LUBRICATION

The lubricating instructions shipped with each motor give the proper lubricating procedure for the specific motor. These instructions should be carefully followed, especially in the case of a motor using special bearings or lubricants. The following lubricating instructions apply only to standard motors and applications

Grease Lubrication

Under normal operating conditions it is only necessary to regrease Louis Allis ball bearing motors according to Table 2. The frequency of regreasing should be dependent upon the speed and operating conditions. Excessive greasing is a mistake which contributes to motor failure. It overheats the bearings and contaminates the windings which may reduce service life.

The following steps should be followed when greasing the motor.

a. Clean the exterior of the motor.

b. Remove both the lubrication fitting and the drain.

c. If grease has hardened, remove the hardened lubricant which has accumulated in the area around the relief plug with a wooden or plastic stick. In severe conditions, run the motor until the bearing chamber is warmed to the temperature which will allow the grease to flow more easily.

Table 2 - Recommended Ball Bearing Greases for Normal Conditions*

It is recommended that these greases or their equivalent be used in Louis Allis motors.

Company	NORMAL Ambient Temperature $-20^{\circ}F$ to $105^{\circ}F$	HIGH Ambient Temperature 0 to $150^{\circ}F$
Chevron Oil Co.	SRI No. 2	SRI No. 2
Shell Oil Co.	Dolium R	Dolium R
Shell Oil Co.	Darina No. 2	Darina No. 2
Texaco	Premium RB	Premium RB
Texaco	AFB No. 2	AFB No. 2
Mobil	Mobilux No. 2	Mobil 28
Gulf Oil	Gulf Crown No. 2	Gulf Crown No. 2
Exxon	Unirex N2	Unirex

*NORMAL conditions are considered to include most ambient atmospheres and operation requirements. SEVERE conditions include the following:

Extreme dust, dirt or other atmospheric contaminants.

Direct exposure to moisture beyond normal atmospheric humidity.

Shock, vibration or other loading beyond rated.

Extremes of operation cycle such as long shutdown, frequent starting or reversing.

For lubrication recommendations covering above SEVERE conditions refer to special lube instructions furnished, or consult nearest Louis Allis Sales Office.

For roller bearings refer to special lube instructions or Louis Allis Sales Office.

RECOMMENDED REGREASING SCHEDULE FOR BALL BEARINGS **

Motor Speed	Approximate Hours of Operation	
	Normal Conditions	Severe Conditions
1200 & Below	6000-8000	3000-4000
1800	3000-4000	1400-2000
3600	1500-2000	750-1000

**For roller bearings 1800 RPM & below and in the absence of other instructions, it is recommended that the above hours be reduced to 1/3 listed values.

Table 3 - Recommended Oil Specifications

Bearing Type	Oil Viscosity SSU at 100°F / SAE Equivalent For Ambients Of		
	−25°C to 0°C (1)	0°C to 40°C	40°C to 50°C
Angular Contact Ball Bearings	215SSU / 10W	315SSU / 20W	465SSU / 30
Spherical Roller Thrust Bearings	465SSU / 30	700SSU / 40	700SSU / 40
Tilting Shoe (Kingsbury)	465SSU / 30	700SSU / 40	700SSU / 40

(1) Oil heaters are required with oils that have pour points of −7°C (20°F). If heaters are not used oil with minimum pour points of −35°C (−30°F) should be used for ambients below 0°C.

Normal oil change is 8,000 hours of operation. For ambients above 40°C and other severe operating conditions reduce the interval by 1/2.

d. Regrease motor with a low pressure grease gun.

e. Run motor for approximately 10 minutes to assure that excess grease has been expelled. For optimum operation the bearing chamber should be three-quarters full of grease.

f. Replace lubrication fitting and drain.

NOTE: If the bearings are rough, the motor should be disassembled and the bearings replaced. Repack the bearings and the bearing chamber with enough grease to fill the chamber approximately three-quarters full at assembly.

Oil Lubrication

The oil used in both upper and lower bearings should be a premium grade lubrication oil, preferably of turbine quality. See tables 3 and 4. It should be solvent extracted. Oils of the desired corrosion and oxidation resistance characteristics can be obtained with or without inhibitors, but the former is recommended. Oxidation inhibitors retard oil deterioration and corrosion inhibitors prevent corrosion of parts in contact with oil in the presence of moisture. In addition, some rust inhibitors tend to decrease starting friction.

Fill the bearing chambers through the fill plug with the proper grade of oil to the level indicated at the center of the sight glass provided. Follow the instructions on the lubrication nameplate affixed to the motor.

NOTE: The quantities of oil shown on the nameplate are approximate, for guidance only. Fill to the proper level regardless of quantity; oil level should be checked daily during operation.

Examine the oil at regular intervals for contamination and acidity. Unless such harmful elements are found, oil should last for years without replacement. When oil is changed, carefully clean and flush the oil chambers to eliminate any chance of contamination in the fresh oil.

Table 4 - Typical Oils Satisfactory for use in Louis Allis Motors

Company	Brand Name
American Oil Co.	RPM Handy Oils Calol OC Turbine Oil American Industrial Oil
Atlantic Richfield Co.	Duro Oil
Continental Oil Co.	Dectol
Delta Oil Products Corp.	Electric Motor Oil
Exxon	Teresstic
Phillips Petroleum Co.	Mangus Oil
Shell Oil Co.	Tellus Oil
Mobil	Mobil DTE Oils
Texaco Inc.	Regal Oils R & O Grade Industrial

REPLACING BEARINGS

The repeated stressing of the balls and races as a bearing rotates may cause fatigue of the metal. The higher the load, the higher the stress and the shorter the time until the bearing fails. Bearings are rated by their probability of fatigue failure.

Bearing manufacturers have tested many groups of identical bearings under heavy loads to the point of fatigue failure. Bearings in a group have been found to have different lives even though they are under the same load. For this reason, bearings are rated for either minimum life or for average life. Minimum bearing life is a period of time, based on continuous operation at designed load, after which 90% of the bearings will still be operating. Average bearing life is five times minimum bearing life.

When removing or replacing a ball bearing there are several rules which should always be observed. Following these rules closely will prevent damage to the bearing or motor and will result in longer bearing life.

When removing a bearing, always use an approved bearing puller. See Figure 15.

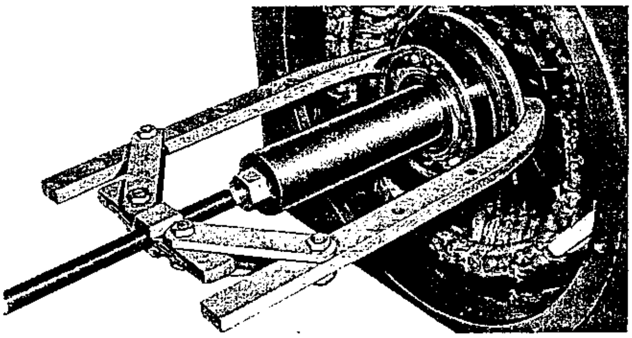


Figure 15

Never open the protective cover on new bearings where the bearing will be exposed to dust or dirt. Always open the package in a clean place and do not remove bearing from package until ready to install.

Never try to clean a new ball bearing. The slushing oil on new bearings should not be removed.

Do not force a bearing onto a shaft by means of the outer race. Do not attempt to force the bearing on a badly worn shaft or a shaft which is too large for the bearing.

Figure 16 shows a good method of installing a bearing. Note that the metal tube fits against the inner race of the bearing. Do not hit the tube very hard. Just TAP it.

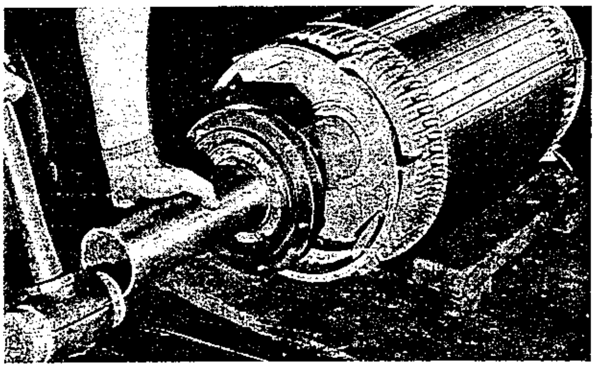


Figure 16

Another method of installing ball bearings would be to heat the bearing in an oven or oil bath so that it will slide onto the shaft. Before heating, be sure that bearing I.D. has been checked against shaft journal dimension to prevent too tight a fit after bearing cools. Use a temperature of approximately 200°F. Too high a temperature will damage the bearing and too low a temperature will cause the bearing to seize the shaft.

1. Remove the old bearing and inspect the bearing journal. The journal should be free from marks or scratches. Also make sure the shaft shoulder is square with the bearing seat.

2. Select the proper new bearing.

The pilot bearing should have a loose internal fit. Manufacturers' references are given below. If another make is used, check the manufacturer for nomenclature.

Marlin Rockwell Corp.	Q9 fit up
Fafnir Bearing	E5702 fit up
SKF Industries	C3 fit up

If duplex thrust bearings are used, be sure to note the proper assembly.

3. For best results, purchase bearings from Louis Allis. A complete stock of properly selected bearings is maintained at the factory. When purchasing bearings from local suppliers, be sure to specify Electric Motor Grade.

4. Measure bearing inside diameter and shaft bearing journal. The interference of the bearing bore to the shaft should be within good engineering practices.

5. Measure the bearing outside diameter and the bearing chamber. The bearing chamber should be .001 to .002 inches larger so that the bearing can move when subjected to thermal expansion of the shaft.

6. Figure 17 shows the general disassembly procedure for thrust bearings. In addition, Figures 18-23 show typical bearing construction for both solid shaft and hollow shaft motors.

THRUST BEARING INSPECTION OR REPLACEMENT

Disassemble the thrust bearing (see Figure 17) as follows:

1. Remove top cover bolts (2) and cover (1).
2. Remove retaining ring bolts (3) and ring (4).
3. Remove coupling bolts (5).
4. Remove coupling (8) with pins (6) and Gib Key (7).
5. Remove ratchet cap bolts (9).
6. Remove ratchet cap (10).
7. Remove bearing lock nut (11) and washer (12).
8. Insert puller bolts in hole provided in bearing holder (14).
9. Using puller bolts remove bearing holder (14) with key (13).
10. Remove bearing lock nut (17) and washer (16) or snap ring, see Figure 23.
11. Remove bearing (15)

1. Top Cover
2. Top Cover Bolt
3. Retaining Ring Bolt
4. Retaining Ring
5. Coupling Bolt
6. Ratchet Pin
7. Gib Key
8. Coupling
9. Ratchet Cap Bolt
10. Ratchet Cap
11. Bearing Holder Lock Nut
12. Bearing Holder Lock Washer
13. Bearing Holder Key
14. Bearing Holder
15. Bearings
16. Bearing Lock Washer
17. Bearing Lock Nut
18. Bearing Bracket
19. Motor Shaft
20. Puller Bolts

Key for Figure 17

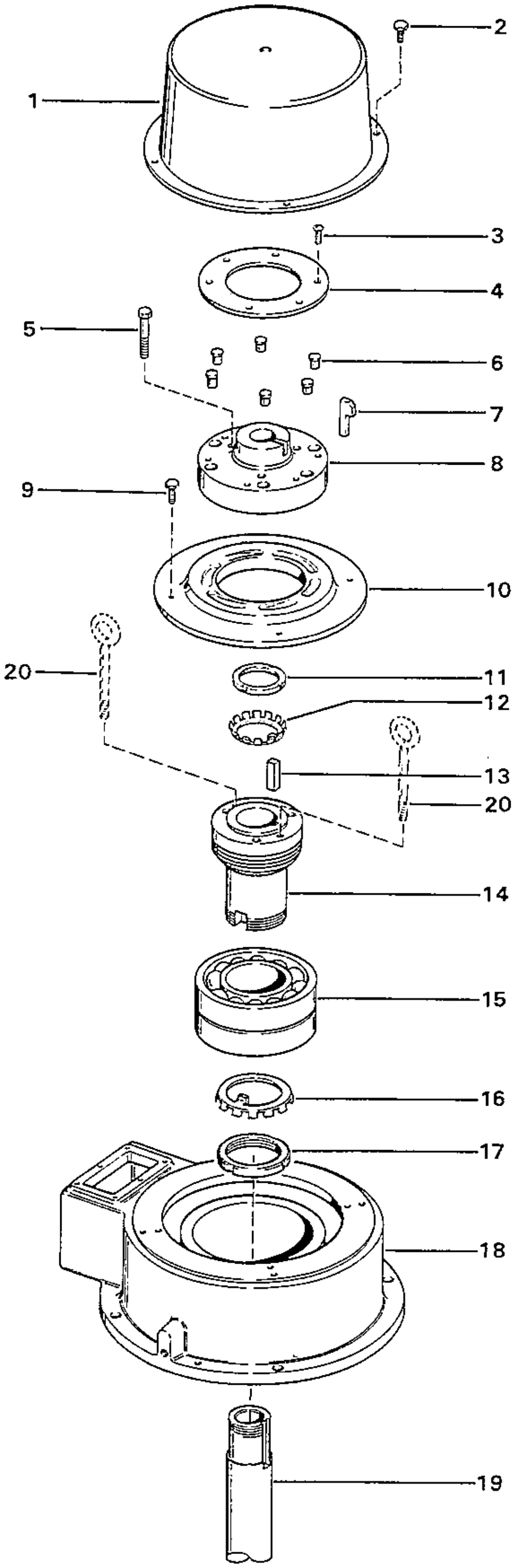


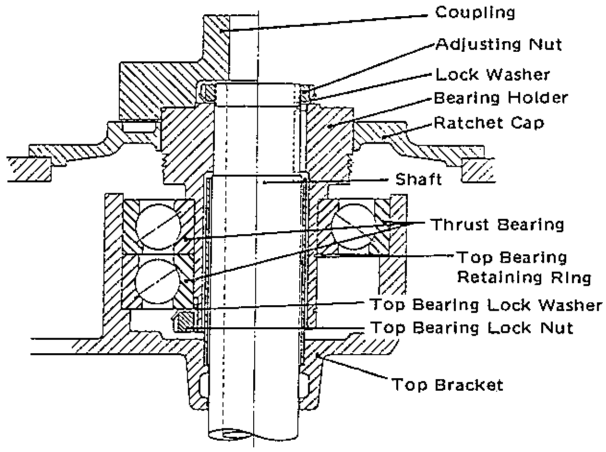
Figure 17

When replacement of shaft, rotor, bearings, caps, cartridges or bearing brackets of a vertical motor is required the assembly of the bearings must be in accordance with the following procedure.

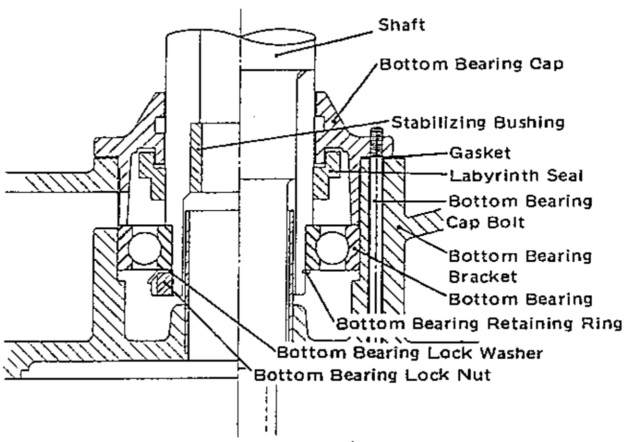
Case I - Thrust Load Down

The thrust bearing can be a single bearing or a duplex set. The bearing is assembled on the holder such that the side marked "thrust here" is down when holder is in vertical position. The bearing is held in position by a snap ring or a bearing lock washer and bearing nut. If a duplex bearing is used the bearings are assembled in tandem. The bearing holder with bearings is assembled to the shaft and secured in position with the bearing holder lock washer and lock nut. See Figure 18. The thrust bearing assembly is located at the top of the motor.

The bottom bearing for Case I assembly must be assembled such that the bearing is capable of carrying momentary up thrust. This is accomplished by machining the bottom end cap such that the cap skirt contacts the bottom bearing outer race. See Figure 19.



THRUST BEARING (TOP)
Figure 18



GUIDE BEARING (BOTTOM)
Figure 19

To check for proper assembly of single thrust or duplex DT bearing the following procedure must be followed:

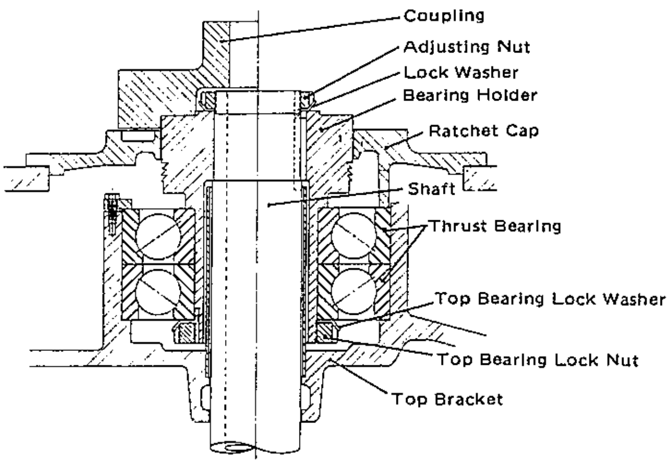
1. The motor should be completely assembled in a vertical position. The bearing holder nut should be loose.

2. Place a dial indicator at the end of the shaft so that it will show any vertical movement of the rotor. Tighten the bearing holder lock nut until the dial indicator shows zero end play when the rotor is raised.

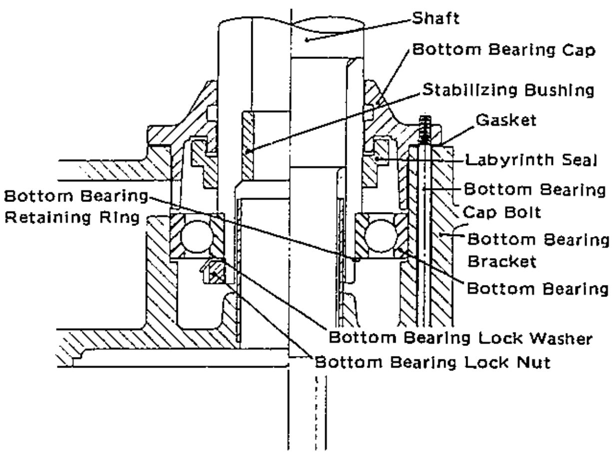
3. Back off the bearing holder lock nut approximately ¼ turn and re-check the end play. The end play should be 0.010 to 0.020 inch. When this is attained secure the lock nut with the lock washer.

Case II - Up and Down Thrust Bearing Assembled Back-to-Back DB

When up and down thrust is specified the motor is equipped with duplex bearings assembled back-to-back (DB).



THRUST BEARING (TOP)
Figure 20

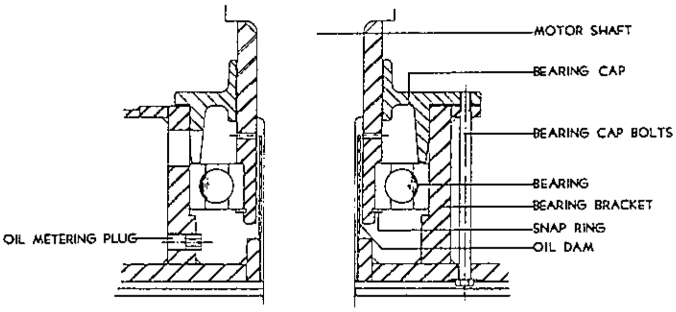


GUIDE BEARING (BOTTOM)
Figure 21

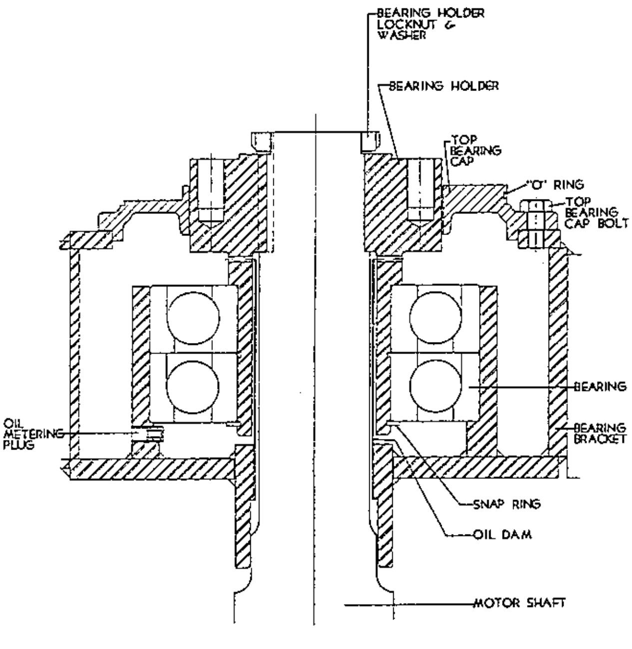
Assemble the top bearing as a duplex set on the bearing holder. The bearing is secured with a bearing lock washer and lock nut. The bearing holder with bearing is assembled to the shaft and secured by the bearing holder lock nut washer and lock nut. The bearing holder must seat firmly on the shaft shoulder. The outer race is held in position by the top cap skirt or a bearing retaining ring. The cap skirt and retaining ring must be machined to hold the bearing tight. See Figure 20.

The bottom bearing is assembled on the shaft and secured in position by a snap ring or bearing lock washer and lock nut.

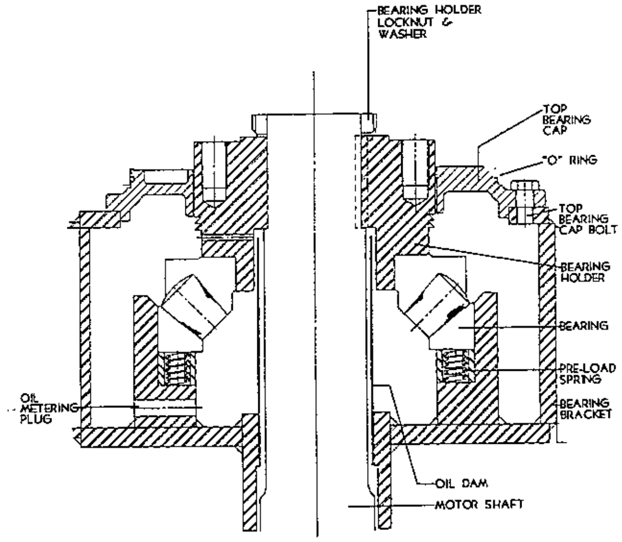
The bottom bearing is located so that ample clearance is allowed below the bearing to allow for thermal expansion of the rotor and shaft assembly.



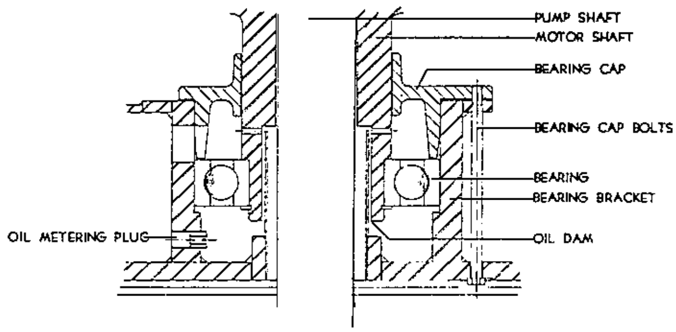
PILOT BEARING CONSTRUCTION SOLID SHAFT
Figure 22



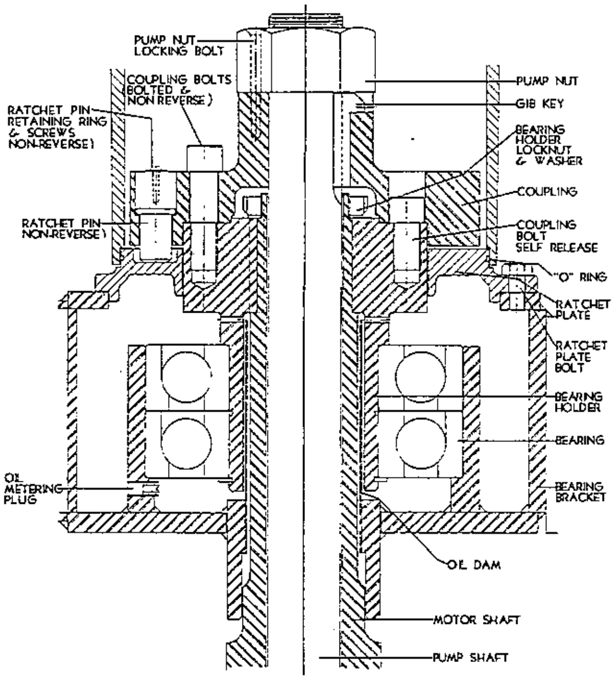
THRUST BEARING CONSTRUCTION SOLID SHAFT
Figure 23



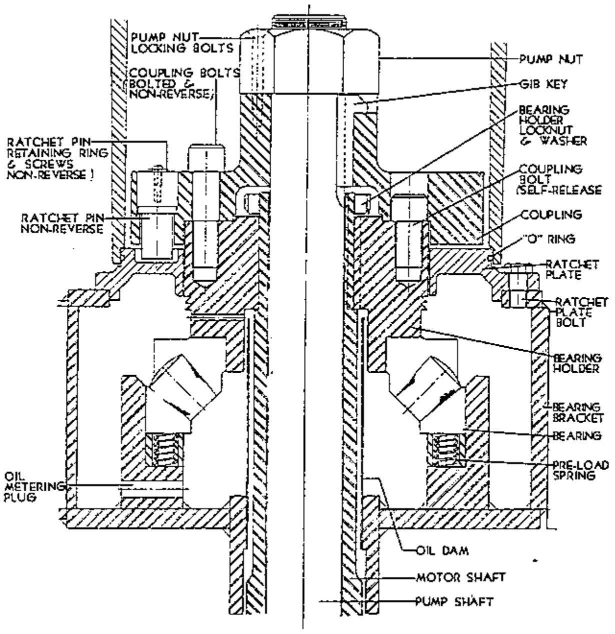
SPHERICAL ROLLER THRUST BEARING CONSTRUCTION SOLID SHAFT
Figure 24



PILOT BEARING CONSTRUCTION HOLLOW SHAFT
Figure 25



THRUST BEARING CONSTRUCTION HOLLOW SHAFT
Figure 26



SPHERICAL ROLLER THRUST BEARING
CONSTRUCTION HOLLOW SHAFT
Figure 27

DUPLEX BEARINGS

Duplex bearings can be mounted in different ways to suit various loading conditions. The positions are identified by symbols "DB", and "DT". The correct position for the particular motor is specified on the motor nameplate.

"DB" or Back-to-Back Mounting

With "DB" mounted bearings (Figure 28) the two halves of the bearing are placed so that the stamped faces (high shoulder) of the outer rings are together. In this type of mounting, zero preload is imposed when the inner rings are clamped. This arrangement is used for .001 to .005 end play.

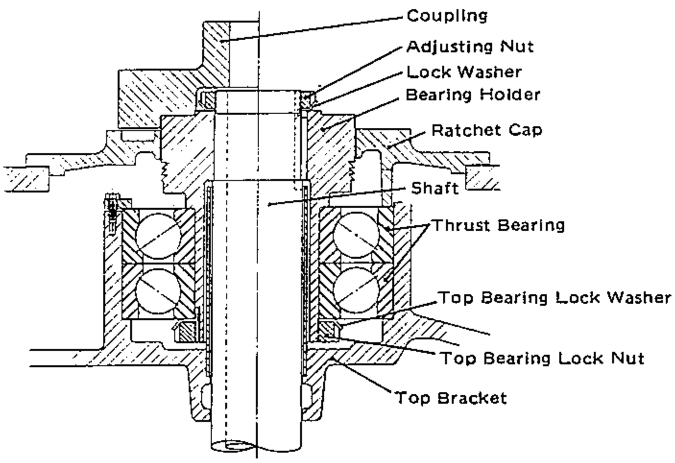


Figure 28

"DT" or Tandem Mounting

With "DT" bearings, the two bearing halves are placed so that the stamped face (high shoulder) of one outer ring is in contact with the unstamped face (lower shoulder) of the outer ring. See Figure 29.

This method of mounting is used for extremely large thrust loads in one direction and where extreme speeds or space limitations prevent the use of larger bearings. Duplex bearings will very nearly divide the thrust load. The thrust capacity in one direction of a Duplex 7000 D series bearing mounted in tandem is 1.63 times that of a single thrust bearing.

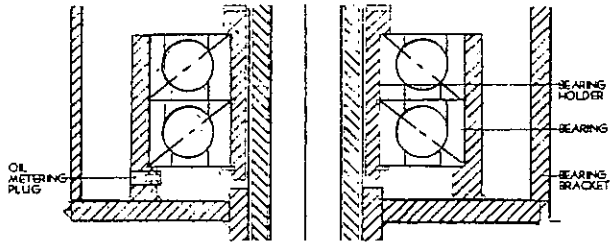


Figure 29

PLATE TYPE BEARINGS

The plate equalizing type upper thrust bearing consists of a runner or thrust collar keyed to the upper end of the motor shaft, and a set of segmental babbitted shoes which support the runner by means of oil film between the lower polished runner surface and the upper babbitted shoe surfaces. See figure 31. Each shoe is free to tilt slightly in any direction. This tilting allows the oil films between the bearing surfaces to take the natural wedge form.

Between the shoes and the supporting base ring beneath them is a set of segmented, overlapping "levelling plates" which form a circular chain of shoe supports. Through the ability of this chain of supporting elements to transfer load from a more heavily loaded to a less heavily loaded shoe, all the shoes are made to carry substantially equal loads.

The runner-shaft is stabilized against lateral off-center movement by the upper guide bearing assembly located just above the runner thrust surface.

The bottom guide bearing and the thrust bearing are flooded with lubricant and use their natural action to circulate this lubricant. The upper guide bearing receives oil through piping. The pumping effort necessary to cause this flow is supplied by the rotation of the thrust collar inside the oil volute.

Bearing Cooling Coils

Heat generated in the lubricating oil by the upper thrust and guide bearings is carried away by cooling water circulating in coils of copper tubing mounted inside the upper bearing chamber. Cooling water requirements are listed on the motor outline drawing. Inlet water temperature should

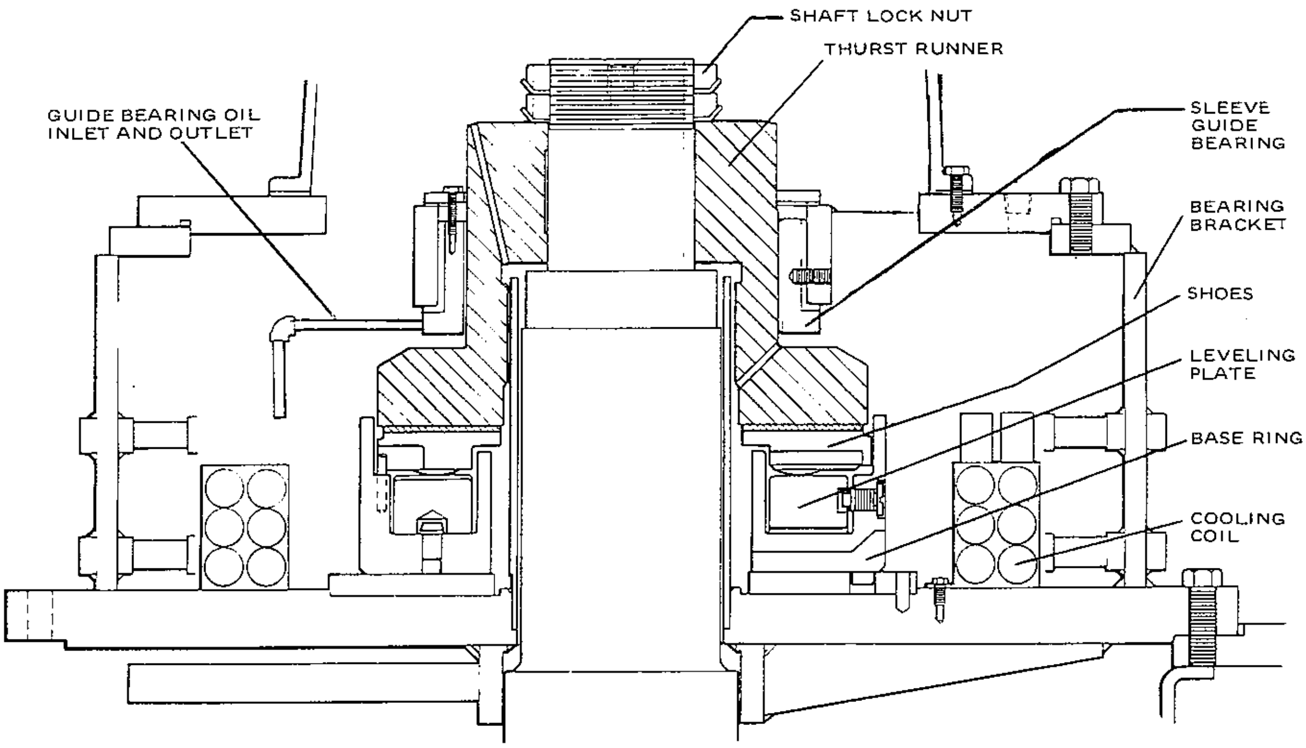


PLATE TYPE THRUST BEARING ASSEMBLY
Figure 30

not exceed 85 degrees F. Care should be taken that the water contains no corrosive or scaling elements or sediment which might damage or plug the copper tubing.

Precaution must be taken against starting with oil of insufficient viscosity to form an oil film. This condition exists if the motor is shut down "hot", due to loss of coolant, and allowed to remain idle for more than a few minutes, but not long enough to cool the oil to room temperature.

On a hot shutdown, the oil film is squeezed out from between the shoes and the runner in a few minutes. If the motor is restarted within, say, five minutes after shutdown, the oil film will be re-established. However, if restart is delayed to 15-30 minutes after shutdown, lack of residual film in combination with the low viscosity "hot" oil surrounding the bearing may prevent rapid renewal of the wedge-shaped film, and bearing failure can result. If the restart is delayed, it is advisable to wait until the oil has cooled to no more than 20°F above ambient temperature.

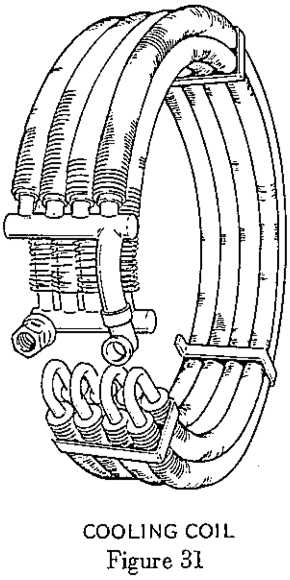
Bearing Insulation

Variations in reluctance in the magnetic circuit of large AC machines may cause periodic changes in the amount of magnetic flux linking the shaft. This in turn can generate sufficient voltage to circulate small currents through the circuit consisting of shaft, bearings, brackets, and housing.

If precautions are not taken to prevent this current flow, it may have a destructive affect on bearing parts. Small pits are usually formed on the surface of the shaft, bearing, or runner. In some instances, bearing babbitt is actually eaten away by the current.

It is impractical to eliminate entirely the cause of such circulating current. Therefore, on motors in frames 7400 and larger the upper bearing assembly is completely insulated from the bearing bracket to interrupt any possible circuit for flow of circulating current. The insulation consists of a thick pad of plastic material supporting the thrust bearing assembly, and an insulating collar around the upper guide bearing.

To avoid bypassing or short-circuiting this insulation, all metallic connections to the bearing assembly for thermocouples have also been insulated. Avoid short-circuiting or omitting any of this insulating material during maintenance or inspection work.



COOLING COIL
Figure 31

ELECTRICAL TESTING

RECOMMENDED FIELD INSULATION TEST FOR LARGE MOTORS

Field Insulation tests on large motors are performed to determine the following:

1. Impending failure of the insulation system.

2. The need to recondition insulation system to prolong life.

3. A long range program to detect progressive deterioration.

Each user must evaluate his specific conditions and applications to determine test method most suited for his needs.

Insulation resistance test is made with DC rather than AC to determine if system can be tested with high voltage. For induction machinery 0-13,800 volts, random and form wound, the tests in Table 5 are recommended.

AC High Potential Test

Pre-service

If an initial AC high-potential test is required or deemed necessary, the one minute test voltage should not exceed 85% of the factory test voltage (0.85) x (2E + 1000). The high-potential test voltage is to be applied successively between each electric circuit and the frame, with the winding not under test, auxiliary equipment, and accessories grounded to the frame.

In-service

Repetitive application of an AC high potential should be avoided. For machines that have seen service, the one minute test voltage should not exceed 60% of the factory test voltage (0.60) x (2E + 1000). The high-potential test voltage is to be applied successively between each electric circuit and the frame, with the winding not under test, auxiliary equipment, and accessories grounded to the frame.

DC Megger Test

A DC voltage (500 volts) is applied between winding and frame for a ten minute period. Readings of the insulation resistance are taken each minute. The polarization index (ten minute resistance reading/one minute resistance reading) is calculated. Values of the P.I. indicates the condition of the insulation and winding surfaces and are useful in determining whether maintenance is required.

DC High-Potential Test

DC High-potential tests will indicate such faults as cracks, discontinuities, thin spots or voids in the insulation and excessive moisture or dirt in the insulation system. Weaknesses in the insulation system can be found without causing a breakdown in the system. Equipment to be tested must be de-energized and grounded to eliminate any charge. Switches should be open and potential transformers disconnected. The motor winding temperature detectors and thermoguards should be grounded. Temperatures of equipment to be tested should be near ambient since resistance and dielectric absorption vary with temperature. A dielectric absorption characteristic should be established. The insulation resistance and polarization should be at or above a Pi of 2 and an insulation resistance of 100 megohms for a clean dry system. The DC proof test voltage is based on a calculated value which is determined as follows.

DC proof test voltage = Rated motor AC voltage x 125% x 1.7.

This test voltage may vary due to conditions to which motor insulation has been subjected.

NOTE: Consult factory if test procedure is required.

MEASUREMENT OF TEMPERATURE RISE

There are two fundamental methods for the determination of temperature rises on electrical equipment; namely, resistance, or by imbedded detector. Never attempt to measure temperature by hand.

Table 5 - Recommended Insulation Tests

Type of Winding	Voltage Range	Type of Test					
		AC HIPOT		DC MEGGER		DC HIPOT	
		Pre Service	In Service	Pre Service	In Service	Pre Service	In Service
Random	0-600	yes	yes	yes	yes	no	no
Form	0-600	yes	yes	yes	yes	no	no
	601-7000	yes	no	no	no	yes	yes

RESISTANCE

The method of determining temperature rise is by resistance. In this method it is necessary to have a Wheatstone or Kelvin bridge and measure the actual winding resistance at standstill when the motor is at room temperature and then measure the temperature again after the motor has operated at full load for four to six hours. The temperature rise in degrees centigrade may then be calculated from the following formula.

$$T = \left(\frac{R_H - R_C}{R_C}\right)(234.5 + t_1) - (t_2 - t_1)$$

where T = Temperature Rise in $^{\circ}C$
R_H = Winding Resistance in ohms (hot)
R_C = Winding Resistance in ohms (cold)
t_1 = Ambient Temperature in $^{\circ}C$ (motor cold)
t_2 = Ambient Temperature in $^{\circ}C$ (motor hot)

Since the resistance method measures the average temperature of the entire coil, the temperature rise when measured by resistance more closely approximates the hot spot temperature. As a result, it is customary in this method to use a differential of only about 5°C to determine the hot spot temperature for an open or splash-proof motor.

THERMOCOUPLE OR EMBEDDED DETECTOR

The method for the measurement of temperature rise is by embedded detector or thermocouple. The thermocouple is connected to a bridge type instrument which usually gives a reading directly in degrees Centigrade. Care should be taken to insure that the bridge is calibrated for the type of thermocouple used.

If there is any question as to whether or not the temperature measured is satisfactory for the motor, refer to the nearest Louis Allis district office. Be sure to give all nameplate information.

EFFECT OF ALTITUDE ON TEMPERATURE RISE

The altitude at which the motor is operated is normally assumed to be 3300 feet or less above sea level. Since most machines are cooled principally by convection and since the density and corresponding cooling ability of the air decreases with altitude, allowances must be made for altitudes above 3300 feet.

NEMA Standards specify that the temperature rise as tested at low altitudes shall be less than that tabulated in the "Temperature Rise Table" on page 2123 by 1% of the specified temperature rise for each 330 feet increase in altitude above 3300 feet.

As an illustration, an open motor tested at sea level must have a full load temperature rise of only 32°C to be suitable for operation at 9900 feet altitude with the standard temperature rise of 40°C. The calculations are shown below:

Standard Temperature Rise Open Motor – 40°C
Allowance for 9900 Feet Altitude

$$\frac{9900 - 3300}{330 \times 100} \times 40^{\circ}C = 8^{\circ}C$$

Maximum Permissible Temperature Rise at Low Altitude $= 40^{\circ} - 8^{\circ} = 32^{\circ}C$

NEMA TEMPERATURE RISE SPECIFICATIONS

The observable temperature rise under rated load conditions of each of the various parts of the induction motor, above the temperature of the cooling air, shall not exceed the values given in Table 6. The temperature of the cooling air* is the temperature of the external air as it enters the ventilating openings of the machine, and the temperature rises given in the table are based on a maximum temperature of 40°C for this external air. Temperatures shall be determined in accordance with the latest revision of the IEEE Test Procedure for Polyphase Induction Motors and Generators, Publication No. 112A.

*For totally-enclosed water-air-cooled machines, the temperature of the cooling air is the temperature of the air leaving the coolers. With a cooling water temperature not exceeding that for which the machine is designed:

1. On machines designed for cooling water temperatures up to 30°C – the temperature of the air leaving the coolers shall not exceed 40°C.

2. On machines designed for higher cooling water temperatures – the temperature of the air leaving the coolers may exceed 40°C provided the temperature rises of the machine parts are then limited to values less than those given in the table by the number of degrees that the temperatures of the air leaving the coolers exceeds 40°C.

Table 6 - NEMA Standard Temperature Rise Specifications

Item	Machine Part	Method of Temperature Determination	Temperature Rise, Degrees C — Class of Insulation System			
			A	B	F	H
1	Insulated windings					
	a. All horsepower ratings	Resistance	60	80	105	125
	b. 1500 horsepower and less	Embedded Detector†	70	90	115	140
	c. Over 1500 horsepower					
	(1) 7000 volts and less	Embedded Detector†	65	85	110	135
	(2) Over 7000 volts	Embedded Detector†	60	80	105	125
2	Cores, Squirrel-cage windings and mechanical parts, such as collector rings and brushes, may attain such temperatures as will not injure the machine in any respect.					

† Embedded detectors are located within the slot of the machine and can be either resistance elements or thermocouples. For motors equipped with embedded detectors, this method shall be used to demonstrate conformity with the standard.

NOTE I – Totally-enclosed water-air-cooled machines are normally designed for the maximum cooling water temperature encountered at the location where each machine is to be installed.

NOTE II – For motors which operate under prevailing barometric pressure and which are designed not to exceed the specified temperature rise at altitudes from 3300 feet (1000 meters) to 13000 feet (4000 meters), the temperature rises as checked by tests at low altitudes, shall be less than those listed in the foregoing table by 1 percent of the specified temperature rise for each 330 feet (100 meters) of altitude in excess of 3300 feet (1000 meters).

Suggested Standard for Future Design 5-24-1960, revised 11-15-1962, NEMA Standard 11-11-1965, revised 8-20 1966; 7-16-1969.

NOTE III – Temperature rises in the foregoing table are based upon a reference ambient temperature of 40°C. However, it is recognized that induction motors may be required to operate in an ambient temperature higher than 40°C. For successful operation of the motors in ambient temperatures higher than 40°C, it is recommended that the temperature rises of the motors given in the foregoing table be reduced, as indicated below, for the ranges of ambient temperature given.

Ambient Temperature, Degrees C	Values by which Temperature Rises in the Foregoing Table should be Reduced
Above 40 up to and including 50	10°C
Above 50 up to and including 60	20°C

■ Reproduced from NEMA Standards Dated June, 1978. Authorized Engineering Information 5-24-1960.

Table 7 - Temperature Conversion Table
Centigrade — Fahrenheit

FAHRENHEIT to CENTIGRADE				CENTIGRADE to FAHRENHEIT			
°F →	°C	°F →	°C	°C →	°F	°C →	°F
0	−17.8	105	40.8	0	32	105	221
5	−15	110	43	5	41	110	230
10	−12.2	115	45.8	10	50	115	239
15	− 9.44	120	49	15	59	120	248
20	− 6.67	125	51.8	20	68	125	257
25	− 3.89	130	54	25	77	130	266
30	− 1.11	135	56.8	30	86	135	275
32	0	140	60	35	95	140	284
35	1.67	145	62.8	40	104	145	293
40	4.44	150	66	45	113	150	302
45	7.22	155	68.8	50	122	155	311
50	10	160	71	55	131	160	320
55	12.8	165	73.8	60	140	165	329
60	15.6	170	77	65	149	170	338
65	18.3	175	79.8	70	158	175	347
70	21.1	180	82	75	167	180	356
75	23.9	185	84.8	80	176	185	365
80	26.7	190	88	85	185	190	374
85	29.4	195	90.8	90	194	195	383
90	32.2	200	93	95	203	200	392
95	35	205	95.8	100	212		
100	38	212	100				
FORMULA: Fahrenheit to Centigrade $(°F - 32)\frac{5}{9} = °C$				Centigrade to Fahrenheit $(°C \times \frac{9}{5}) + 32 = °F$			

NOISE

Since noise is undesirable and electric motors are a source of noise, we are concerned with limiting the noise which motors produce.

Electric motor noise source can be classified into three categories.

—Windage (air) noise.

—Mechanical noise.

—Magnetic noise.

WINDAGE (AIR) NOISE

This type of noise is created in the air stream used to cool the motor. Both dripproof and TEFC motors use fans to move air. Moving air removes the heat losses from the motor and thus maintains safe motor temperatures.

Windage or air noise is generated by the air flowing in and around the motor parts. Windage noise is developed by:

—Fan blades rotating in close proximity to mounting bolts.

—Restrictions in the air stream.

—Abrupt changes in direction of air flow.

In general, the external air flow system of the fan cooled motor generates somewhat higher noise levels than experienced in dripproof motors.

MECHANICAL NOISE

The vibration of mechanical parts causes mechanical noise. Electric motor mechanical noise or vibration results from:

—Rotor unbalance.

—Bearings.

—Loose internal parts.

MAGNETIC NOISE

The magnetic noise generated in an electric motor results from:

–The size and concentricity of the air gap.

–The number and shape of rotor and stator slots.

–Magnetic flux density.

The forces of attraction and repulsion between the stator and rotor magnetic poles in the air gap cause stresses or vibration of the rotor.

METHODS OF REDUCING NOISE

General

Noise is either radiated directly from the source as airborne noise or it is carried to other parts of the machine along structural paths. These other machine parts can then act as secondary sounding boards that increase the overall noise level. Noise may be reduced at the source or isolated.

Noise Reduction at Source

Electric motor noise can be reduced by:

Mechanical

–Improved rotor balance.

–Replacement of defective ball bearings.

–Improved ventilating technique.

Electrical

–Change connection arrangement of stator windings.

–Increase air gap size and improve concentricity.

–Change the number of rotor and/or stator slots.

–Design change of ventilation system.

–Lower magnetic flux densities.

The use of the foregoing noise reduction methods usually adversely affects motor performance. Generally, lower motor torques and higher winding temperatures result. It may therefore be necessary to build a motor in a larger frame or as non-vent to meet both performance and noise requirements.

Noise Reduction by Isolation

When it is impractical, uneconomical, or even impossible to lower motor noise at its source, various methods can be used to contain or isolate it.

–Use of special couplings for connecting motor and driven equipment shafts.

–Use of vibration absorption material beneath motor mounting surfaces.

–Use of noise barriers made of material that can absorb unwanted noise.

–Increase distance between noise source and people.

–Have people wear earplugs or other protective devices.

OTHER NOISE SOURCES

The equipment driven by the electric motor often contributes a very significant part to the total noise level.

Examples are:

1. Mechanical systems

   –Rotation of eccentric load.

   –An oscillation (either linear or in rotation).

   –An impact or collision between parts.

   –A speed changing movement.

2. Air moving systems

   –Fans and blowers.

3. Hydraulic systems

   –Pumps.

   –Cavitation and turbulance in pipes and controls.

NOISE MEASUREMENT

Instrumentation

Three instruments (see figure 30), used in conjunction with each other, are usually required for a noise analysis:

–Microphone.

–Sound Level Meter.

–Analyzer.

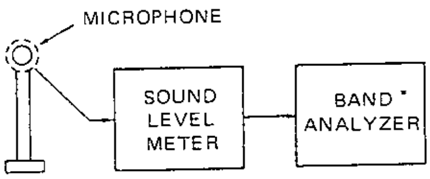


Figure 32

The normal accuracy from these measurement instruments varies with the octave band. (See Table 8).

Principles and Terms

The noise intensity reaching the listener's ears is dependent on:

1. The distance between listener and noise source. Noise intensity is inversely proportional to the distance.

Table 8
Decibel Tolerance at Various Bandwidths

Octave Band Bandwidth in Hertz	Total Tolerance* in db
90-180	± 5
180-355	± 3
355-710	± 3
710-1400	± 3
1400-2800	± 4
2800-5600	± 6
5600-11200	± 8
*Taken from IEEE No. 85	

2. The physical characteristics of the environment. This includes dimensions as well as the material of the objects in the surrounding area.

3. The strength of the sound generated by the source. The strength of the sound is better known as sound power which is measured in units called decibels (db) referred to watts.

Conclusion

When considering noise, it is important to remember that:

1. Both the scale and reference quantity must be specified. Two methods frequently used are sound power level and sound pressure level. See Table 9.

The sound power level of a noise source may be used to predict the noise that will result if the environmental characteristics are known.

Sound pressure level readings are a function of the environmental characteristics.

Table 9
Noise Scales and Reference

Scale	Reference	Units
Sound Power Level	10^{-12} Watts*	Decibel (db)
Sound Pressure Level	0.0002 microbars*	Decibel (db)
*Typical values		

2. Tolerances of noise measuring instruments must be considered.

AIR FILTERS

Air filters on motors are designed to trap air borne dirt before it gets into the working parts of a motor. Their usefulness is dependent upon how frequently they are cleaned and/or changed.

All series 7000 motors with bonnets can be adapted for air filters.

Metallic air filters are available. These are permanent cleanable viscous type filters made of all galvanized metal construction. Stainless steel and monel construction is also available. It is constructed of horizontal layers of galvanized wire screen mesh so arranged to provide a large filtering area and has no direct passages through the filter media.

All motors are designed to operate properly with or without air filters. However, air filters do tend to restrict and, therefore, reduce the volume of air cooling the motor. To insure that the motor does not reach critical temperature stator winding protection devices are suggested.

EFFECT OF VOLTAGE AND FREQUENCY VARIATIONS ON INDUCTION MOTOR PERFORMANCE

OVER AND UNDER VOLTAGE

Polyphase induction motors are ordinarily designed to give satisfactory performance on a line voltage up to 10% or below the rated value. Beyond this range there is an appreciable depreciation of certain performance characteristics. Table 10 demonstrates how the performance is affected by a condition of over or under voltage with rated frequency held constant.

It will be noted from Table 10 that the voltage affects the performance qualities in the following manner:

1. The starting or locked rotor torque varies approximately as the square of the applied voltage.
2. The maximum or breakdown torque varies approximately as the square of the applied voltage.
3. The starting or locked rotor current variation is directly related to this applied voltage.
4. The overload capacity or maximum developed horsepower varies as the square of the voltage. This does not mean that the motor can carry this overload continuously without overheating.
5. There is no change in the synchronous speed with a change in voltage.
6. There will be a change in the operating speed with a change in voltage. To explain further, for most standard motors the slip RPM will decrease as the square of the voltage on an over voltage power supply and conversely will increase as the square of the voltage on an under voltage supply.

An additional word of caution is in order. The difference between the temperature rise at rated voltage and the temperature rise at over or under voltage is difficult to generalize as it depends on the type of enclosure, the distribution of losses within the machine and on other factors. Generally, totally enclosed, totally enclosed fan cooled or explosion-proof motors will heat up faster than open motors.

HIGH OR LOW FREQUENCY

Motors built in accordance with NEMA standards are designed to operate successfully at rated load and at rated voltage with a variation in the frequency up to 5% above or below the rated frequency.

Table 11 shows that a change in frequency affects the performance in the following manner:

1. The starting torque and the maximum torque vary inversely as the square of the frequency. In other words, the torque will increase as the square of the decrease in frequency and vice versa.
2. The synchronous speed will vary directly with the frequency; that is, a 50 cycle motor will have 5/6 the synchronous speed of a 60 cycle motor.
3. The locked rotor current will vary inversely as the frequency.

Table 10 - Effects of Voltage Variation

Voltage	Starting and Maximum Torque	Syncronous Speed	% Slip	Full Load Speed	Full Load Efficiency	Full Load Power-Factor	Full Load Current	Locked Rotor Current	Temp. Rise Full Load	Maximum Overload Capacity	Magnetic Noise-No Load in Particular
120% Voltage	Increase 44%	No Change	Decrease 30%	Increase 1.5%	Small Increase	Decrease 5 to 15 Points	Decrease 11%	Increase 25%	Decrease 5 to 6°C	Increase 44%	Noticeable Increase
110% Voltage	Increase 21%	No Change	Decrease 17%	Increase 1%	Increase ½ to 1 Points	Decrease 3 Points	Decrease 7%	Increase 10 to 12%	Decrease 3 to 4°C	Increase 21%	Increase Slightly
Rated Voltage	RATED DESIGN VALUES										
90% Voltage	Decrease 19%	No Change	Increase 23%	Decrease 1.5%	Decrease 2 Points	Increase 1 Point	Increase 11%	Decrease 10 to 12%	Increase 6 to 7°C	Decrease 19%	Decrease Slightly

Table 11 - Effects of Frequency Variation

Frequency	Starting and Maximum Torque	Synchronous Speed	% Slip	Full Load Speed	Full Load Efficiency	Full Load Power-Factor	Full Load Current	Locked Rotor Current	Temp.-Rise Full Load	Maximum Overload Capacity	Magnetic Noise
105% Frequency	Decrease 10%	Increase 5%	Practically No Change	Increase 5%	Slight Increase	Slight Increase	Decrease Slightly	Decrease 5 to 6%	Decrease Slightly	Decrease Slightly	Decrease Slightly
Rated Frequency	RATED DESIGN VALUES										
95% Frequency	Increase 11%	Decrease 5%	Practically No Change	Decrease 5%	Slight Decrease	Slight Decrease	Increase Slightly	Increase 5 to 6%	Increase Slightly	Increase Slightly	Increase Slightly

VOLTAGE AND FREQUENCY VARIATION

We have seen how both voltage (with frequency held constant) and frequency (with voltage held constant) affect motor performance. It now remains to be seen how a combination of the two influences operate.

To keep the magnetic flux densities in a motor at the same value for which the motor has been designed, the voltage and frequency should vary directly with each other; that is, if the voltage is reduced, the frequency should also be reduced. Many 440 volt, 60 cycle motors have been operated at 400 volts, 50 cycles and some at 380 volts, 50 cycles. This is possible because 50 cycle standard motors are usually built in the same frame size as 60 cycle motors for NEMA ratings, although at some increase in temperature rise.

Any increase in temperature rise reduces insulation life. In general, each 10°C increase in temperature halves the insulation life expectancy. Thus, considerable caution must be exercised by the user in permitting motors to be used on other than nameplate conditions.

The variation in induction motor performance with a variation in voltage and frequency is shown in Table 12. The 440 volt, 60 cycle values are considered as 100%.

This data is, of course, approximate and does not include effect of saturation, "deep bar", etc. The heating figures are very approximate and are included merely to give the reader some idea of the magnitude of the temperature increase.

UNBALANCED VOLTAGES

From time to time the question arises as to the operation of polyphase squirrel cage induction motors on systems having unbalanced voltages.

The problem has been tackled rather extensively by the use of higher mathematics, but for a specific situation it is rather long and tedious. Certain general relations, however, can be concluded from the work that has been done.

The theoretically exact definition of voltage unbalance is rather involved. However, within the range of limits which are satisfactory for successful motor operation, the following definition gives results which are fairly accurate:

> The percent voltage unbalance may be defined as 100 times the sum of the deviation of the three voltages from the average without regard to sign, divided by twice the average voltage.

This can be illustrated by the following example of a 220 volt system. If the voltages between lines of an unbalanced system are 213, 219 and 222 volts, the percent voltage unbalance is calculated as follows:

$$\frac{(218\text{-}213) + (219\text{-}218) + (222\text{-}218)}{2 \times 218} \times 100 = 2.29\%$$

The effect of voltage unbalance on the following will now be taken up individually.

CURRENT

In general a small voltage unbalance on any type of induction motor results in a considerably greater current unbalance. For a given voltage variation the current variation is greatest at no load and decreases with loading with the least effect being exhibited under locked conditions. This phenomena is conveniently shown in Figure 33. The band indicates the spread that is likely to be encountered.

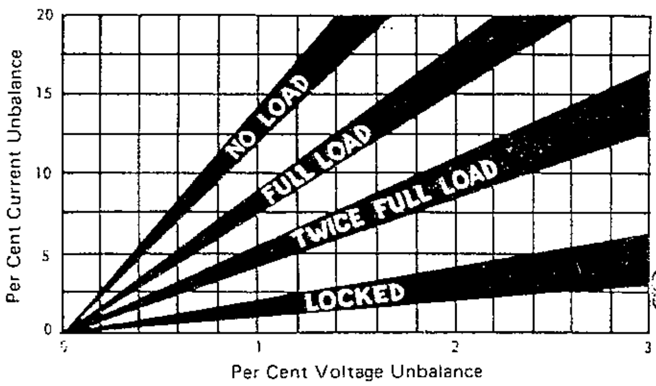


Figure 33

Table 12 - Effects of Voltage and Frequency Variation

Voltage-Frequency	Starting & Maximum Torque	Full Load Torque	Synchronous Speed	Full Load Efficiency	Full Load Power Factor	Full Load Current	Locked Rotor Current	Heating	Magnetic Noise
440-60	100%	100%	100%			100%	100%	100%	
380-50	100%	120%	83%	Dec. 2 Pts.	Dec. 1 Pt.	130%	100%	145%	Not Much Change
400-50	110%	120%	83%	Dec. 1 Pt.	Dec. 1 Pt.	120%	105%	135%	Slight Increase
420-50	121%	120%	83%	Dec. 2 Pts.	Dec. 2 Pts.	117%	110%	130%	Increase

TORQUE

Voltage unbalance within tolerable limits DOES NOT AFFECT INDUCTION MOTOR TORQUES APPRECIABLY EITHER AT LOCKED OR AT BREAKDOWN.

The locked torque, however, actually is reduced as the square of the voltage unbalance; that is:

$$\frac{\text{Locked Torque Unbal.}}{\text{Locked Torque Bal.}} = 1 - \left(\frac{\text{\% Voltage Unbal.}}{100}\right)^2$$

Hence, for a 30% voltage unbalance there is a 9% reduction in locked torque. The reduction in the breakdown torque is even more noticeable, and a voltage unbalance of 30% may amount to as much as a 15 to 20% reduction in the breakdown torque. Of course, a 30% voltage unbalance is entirely unacceptable.

SPEED

When the voltage unbalance is kept within tolerable limits, the speed is not affected appreciably. The tendency, however, is to slightly decrease the speed.

TEMPERATURE RISE

TEMPERATURE RISE IS INCREASED GREATLY BY A SMALL VOLTAGE UNBALANCE. No hard and fast rule can be given, but the percent increase in temperature rise is usually about twice the square of the percent voltage unbalance; that is:

$$\frac{\text{Temp. Rise on Unbal. System}}{\text{Temp. Rise on Bal. System}} = 1 + \frac{2\ (\text{\% Volt Unbal.})^2}{100}$$

An example may clarify the equation. Assuming 3.5% voltage unbalance, let us calculate the percent increase in temperature rise that will result.

$$\frac{\text{Temp. Rise Unbal.}}{\text{Temp. Rise Bal.}} = 1 + \frac{2\,(3.5)^2}{100} = 1.25$$

Hence, a 3.5% voltage unbalance results in a 25% increase in temperature rise.

On an unbalanced system the greatest permissible load (disregarding any liberality in the design itself) can be approximated by dividing rated load by the ratio found above. For the case of 3.5% voltage unbalance the permissible load amounts to 1/1.25 = 0.8 of the motor rating.

OVERLOAD PROTECTION

The large current unbalance corresponding to a small voltage unbalance introduces a serious problem in selecting the proper overload protection devices. In order to adequately protect the motor under unbalanced voltage conditions, complete information on individual line currents should be referred to the control manufacturer for their recommendation as to the type and size of overload relay heater coils to be supplied.

SINGLE PHASE OPERATION

A common cause for the failure of a polyphase induction motor is due to single phase operation. When inspecting a winding, it can readily be detected if a motor has been single-phased.

Figure 34 shows a schematic diagram of a star connected motor. The arrows show the normal flow of current with Phases A, B and C each carrying an equal and normal value.

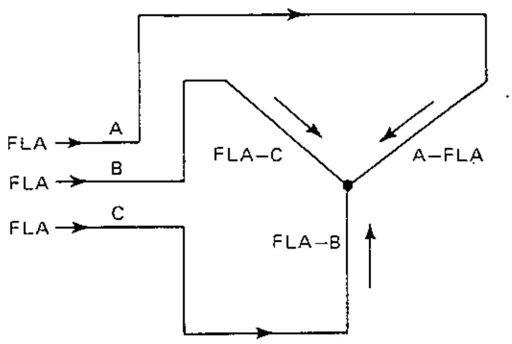


Figure 34

Figure 35 shows a break in Phase A, Phases B and C now equally share this normal full load current. This condition will cause the temperature on Phases B and C to increase as the square of the current. Within a short period of operation, this will cause the insulation of Phases B and C to completely roast out.

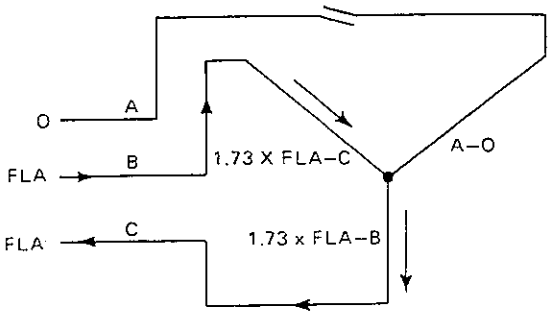


Figure 35

Figure 36, a schematic of a delta connected motor, illustrates the normal flow of current. If each phase is checked externally with a clamp-on ammeter, it would show the full loads amps as specified on the nameplate. However, from the schematic you will note that internally Phases A, B and C each carry a current which is full load amps divided by 1.73.

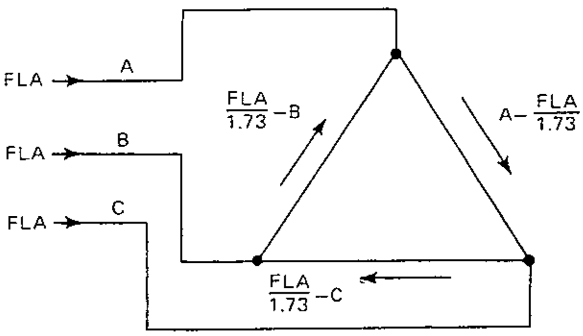


Figure 36

Figure 37 illustrates an externally disconnected Phase A. If checked with a clamp-on ammeter, no current reading will be obtained; however, Phases B and C should show a value 1.73 times normal full load amperes.

With an open in the line of Phase A, Phases B and A carry full load divided by 1.73. Phase C will carry twice the normal current.

There are many conditions that can cause a motor to run single phased. If there is a poor internal connection, the cause for single phase operation can readily be detected.

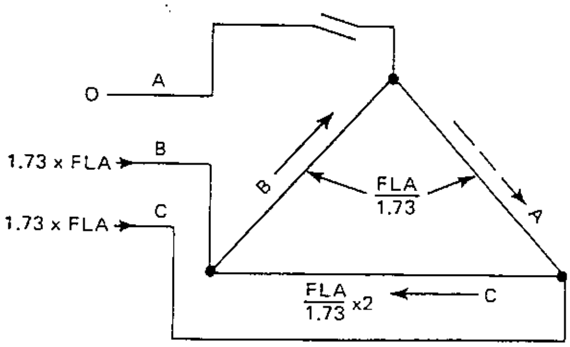


Figure 37

However, since there are many factors external to the motor that can cause a motor to operate single phased, it is suggested that when on inspection a winding appears as if a single phase failure has been experienced, make the following checks:

1. Check all motor connections to be sure that they are all properly secured.

2. Check for blown-out fuses.

3. Check the control and control contacts to be sure that they are in working order. With one or two contacts in a control welded together, the current will continue to flow through the motor after the control has been de-energized.

4. Check all thermall overload elements and observe whether they are properly sized.

SERVICE GUIDE

MOTOR WON'T START

1. Overload tripped – Reset.
2. Fuses blown – Replace fuses.
3. Motor not connected properly – Check all connections to motor and control.
4. Improper line voltage – Check motor nameplate to insure that motor is connected to proper voltage. Also check the voltage at the motor terminals to insure that wire size is adequate.
5. Jammed – Disconnect motor from load. If motor starts, check driven machine.
6. Control not operating – Check control circuit and components.
7. Overloaded – Reduce load or use larger motor.
8. Bearings stiff – Replace bearings.
9. Grease stiff – Replace grease. Be sure to use the right grease for the application. Consult the factory if in doubt.
10. Open circuit in stator or rotor – Check for open circuit.
11. Short circuit in stator – Check for short circuit.
12. Winding grounded – Check for ground.

MOTOR RUNS BACKWARDS

1. Reversed phase sequence – interchange two line connections at the motor.

MOTOR NOISY

1. Single phased – Stop motor and try to start. It will not start on single phase.
2. Loose coupling – Check alignment and tighten coupling.
3. Motor loose – Tighten mounting bolts – Check alignment.
4. Shaft bumping (sleeve bearing motor) – Check alignment.
5. Noisy bearing – Check lubrication and replace bearing.
6. Air gap not uniform – Center rotor. Replace bearings if necessary.
7. Vibration – Check alignment. Driven machine may be unbalanced. Remove motor from driven machine. If motor is still noisy, rebalance rotor.
8. Electrical unbalance – Check voltage and current.

OVERHEATING

1. Overload – Reduce load or use larger motor.
2. Poor ventilation – Check motor air passages. Make sure that ventilating air is not obstructed.
3. Bearing stiff – Replace bearings.
4. Belt too tight – Reduce belt tension.
5. Electrical unbalance – Check voltage and current.
6. Stator grounded – Check for grounded coil.
7. Stator shorted – Check for shorted coil.
8. Air gap not uniform – Center rotor.

BEARINGS HOT (General)

1. Misaligned – Check alignment.
2. Bent shaft – Straighten shaft
3. Bearings stiff – Free bearing or replace.

BEARINGS HOT (Ball Bearings) GREASE LUB.

1. Too much grease – Remove excess grease.
2. Insufficient grease – Add proper amount of grease.
3. Wrong grade of grease – Use recommended greases.
4. Grease contaminated – Relubricate. Be sure that grease supply is clean.
5. Bearings damaged – Replace bearings.

BEARINGS HOT, OIL LUBRICATED
(Sleeve Bearings and Ball Bearings)

1. Insufficient oil – Add proper amount of oil.

2. Motor tilted.

3. Wrong grade of oil – Use recommended lubricant.

4. Oil contaminated by foreign material – Drain oil. Relubricate using a recommended oil.

5. Defective bearings – Replace bearings.

SPARE PARTS

The recommended spare parts listed in Table 13 are those which are normally most subject to wear or damage. The table should be considered as a guide only. However, it will offer reasonable security for normal operations.

How large a stock of spare parts is maintained will depend primarily on the application. Critical applications where continuous operation is of primary importance will naturally require a larger supply of parts. Each user will have to evaluate his own requirements in this respect. For help in setting up a replacement parts program, contact the Service Department of Louis Allis.

If at all possible, spare parts should be purchased at the same time as the original equipment. This insures that the spare parts will duplicate the original material and dimensions and will also result in a reduction in the cost of the parts. In addition, it insures that spare parts will be on hand if required and will minimize expensive telephone orders and rush transportation.

ORDERING SPARE PARTS

All parts should be ordered from the nearest Louis Allis District Office, or the Service Department of Louis Allis Division of Litton Industrial Products, Inc., Milwaukee, Wisconsin 53201.

When ordering parts, determine the part number from the instruction book, drawings, and diagrams, wherever possible. These drawings contain parts lists of all parts ordinarily considered to be subject to replacement, but in case you are unable to find the part number, use one of the drawings indicating in pencil the part you wish to order. This drawing will then be returned to you or replaced. Always show the part number and the motor serial number. This will enable the factory to locate records in case you are unable to completely describe the part wanted.

Additional information on parts is always available at your request.

Table 13 - Recommended Spare Parts for A.C. Motors
(Adapted from NEMA Guide 3)

Item	Part Name	1 to 4 Units	5 to 9 Units	10 to 25 Units
1	Complete Motor or Generator	0	0	1
2	Stator Coils and Insulation	1 set	1 set	2 sets
3	Front Bearing	1	2	2
4	Back Bearing	1	2	2

Litton

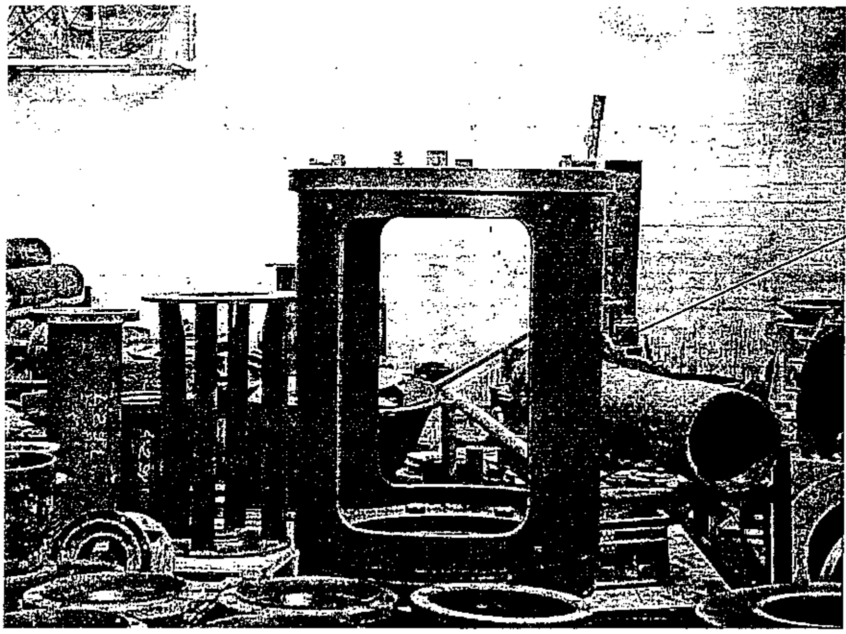
LOUIS ALLIS

Milwaukee, Wisconsin 53201

נספח למכתב איגוד ערים [illegible] חיפה

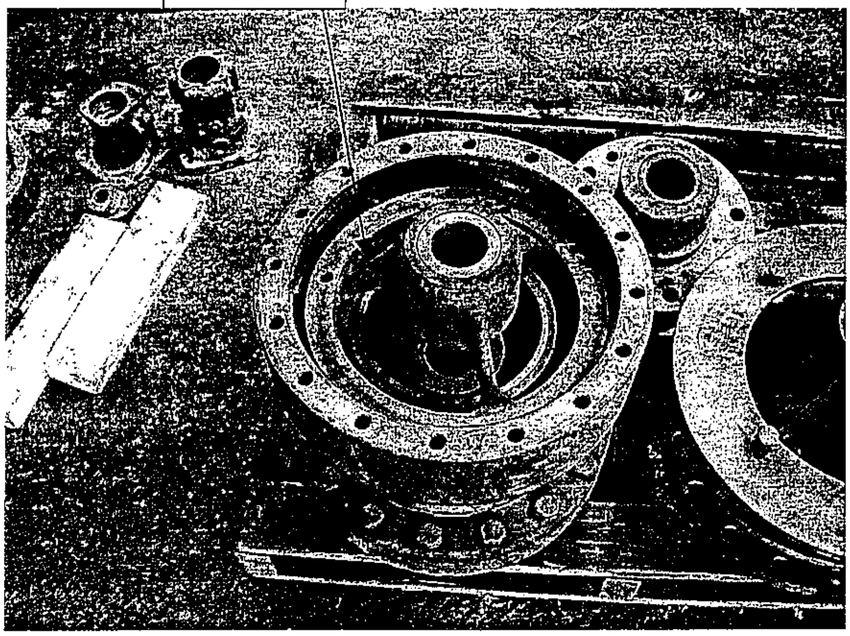
למכתב מס' 3

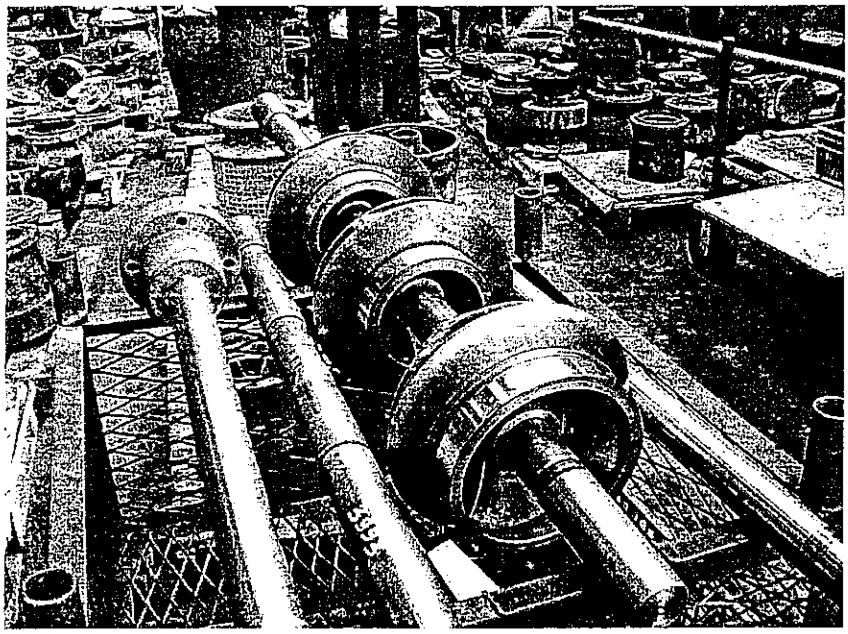
97/11/02



שיפוץ בסיס המשאבה

ייצור עכביש חדש +תושבות גרפית





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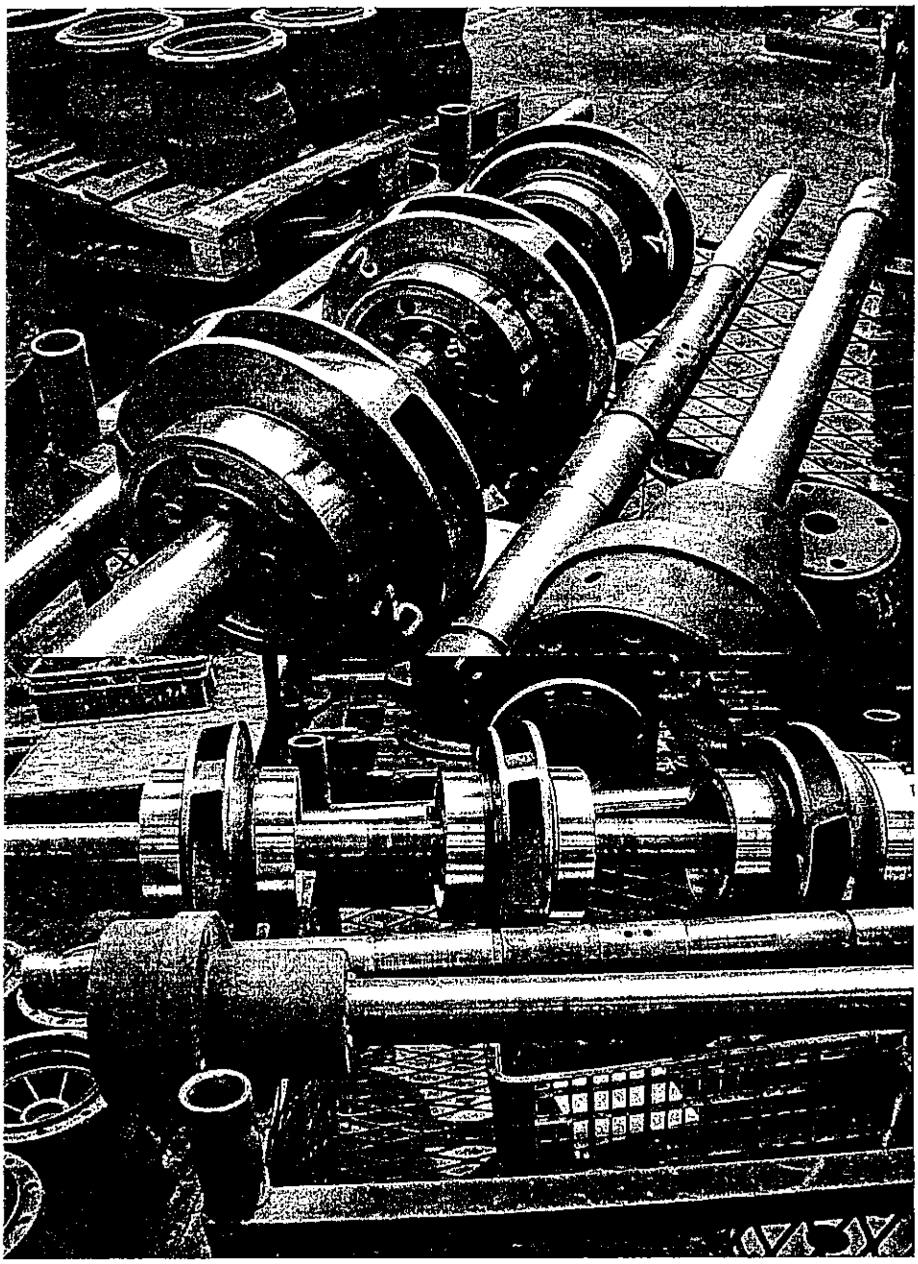
חדש עם מקשר בינו ובין
החלק הקיים



קמ״ד חיפה

VCR SIZE 8x12x16A 3-STG

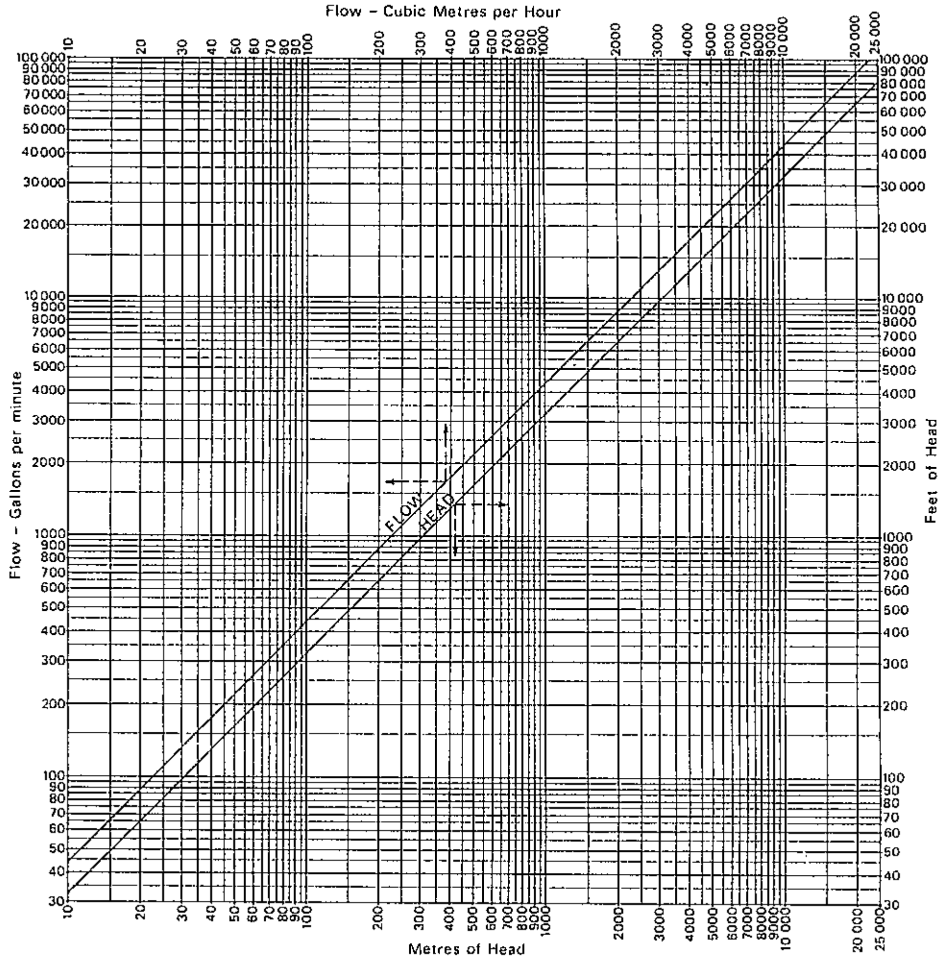
SER. No. 4B 290/1 WITH 100 HP

LOUIS-ALLIS 4P VSS MTR. SER# 3-144265

TO P/O # EG-9-2976 A&B

METRIC CONVERSIONS FOR FLUID HEAD & FLOW

FEET OF HEAD TO METRES OF HEAD		METRES OF HEAD TO FEET OF HEAD		GALLONS PER MINUTE TO CUBIC METRES PER HOUR		CUBIC METRES PER HOUR TO GALLONS PER MINUTE	
FEET	METRES	METRES	FEET	gpm	m³/h	m³/h	gpm
1	0.304800	1	3.280840	1	0.2271247	1	4.402868
2	0.6	2	6.6	2	.45	2	8.8
3	0.9	3	9.8	3	.68	3	13.2
4	1.2	4	13.1	4	.91	4	17.6
5	1.5	5	16.4	5	1.1	5	22.0
6	1.8	6	19.7	6	1.4	6	26.4
7	2.1	7	23.0	7	1.6	7	30.8
8	2.4	8	26.2	8	1.8	8	35.2
9	2.7	9	29.5	9	2.0	9	39.6
10	3.0	10	32.8	10	2.3	10	44
20	6.1	20	66	20	4.5	20	88
30	9.1	30	98	30	6.8	30	132
40	12	40	131	40	9.1	40	176
50	15	50	164	50	11	50	220
60	18	60	197	60	14	60	264
70	21	70	230	70	16	70	308
80	24	80	262	80	18	80	352
90	27	90	295	90	20	90	396
100	30	100	328	100	23	100	440
200	61	200	656	200	45	200	881
300	91	300	984	300	68	300	1321
400	122	400	1312	400	91	400	1761
500	152	500	1640	500	113	500	2201
600	183	600	1968	600	136	600	2642
700	213	700	2297	700	159	700	3082
800	244	800	2625	800	182	800	3522
900	274	900	2953	900	204	900	3963
1000	305	1000	3281	1000	227	1000	4403
2000	610	2000	6562	2000	454	2000	8806
3000	914	3000	9843	3000	681	3000	13 209
4000	1219	4000	13 123	4000	908	4000	17 611
5000	1524	5000	16 404	5000	1136	5000	22 014
6000	1829	6000	19 685	6000	1363	6000	26 417
7000	2134	7000	22 966	7000	1590	7000	30 820
8000	2438	8000	26 247	8000	1817	8000	35 223
9000	2743	9000	29 528	9000	2044	9000	39 626
10 000	3048	10 000	32 808	10 000	2271	10 000	44 029
				20 000	4542	20 000	88 057
				30 000	6814	30 000	132 086
				40 000	9085	40 000	176 115
				50 000	11 356	50 000	220 143
				60 000	13 627	60 000	264 172
				70 000	15 899	70 000	308 201
				80 000	18 170	80 000	352 229
				90 000	20 441	90 000	396 258
				100 000	22 712	100 000	440 287



INSTRUCTIONS

To obtain quick approximate conversions use the graph. The units for flow are on the top and left edges of the graph; the units for head are on the bottom and right edges of the graph.

For more exact conversions do one of the following:

1. Find the conversion for 1 unit, on the first line of the appropriate column, and multiply by the number of units involved. For example, 2146 feet of head times 0.3048 = 654 metres of head. Or,

2. Add together the conversions required to arrive at the exact number. For example (ref. columns 1 and 2 above) to find how many metres of head are equivalent to 2146 feet of head, find the conversion for 2000 ft. (= 610 metres), then 100 ft. (= 30 metres), then 40 ft. (= 12 metres), and then 6 ft. (= 1.8 metres). The total of these is 653.8 or 654 metres of head.

נמסר ל:
מ. קהל (2X)
מ. סגל
פרידמן - המשקובל
י. שוורצמן
ע. רוטנפלד

שרותי נפט בע"מ

אל:	תאריך: 12.9.83
מאת: ד. הסל	סימוכין:

הנדון: משאבות הזנה בתחנת חיפה

במצורף הנני מעביר אליך עותק
של ספר הוראות התקנה, שימוש ואחזקה
של משאבות ורטיקליות
VCR 8X12X16A 3-STG
ומנועי לואיס אליס המורכבים עליהן
אשר נרכשו במשאבות הזנה בתחנת
קמ"ז חיפה.
לידיעתך ולשימושך.

בברכה
[signature]

SERIAL No.	4B290/1
PUMP TYPE	VCR
SIZE	8x12x16A 3 STG.

Bingham-Willamette

IDENTIFICATION

USER	OIL PRODUCTS PIPELINE LTD.
LOCATION	TEL-AVIV, ISRAEL
PURCHASER	OIL PRODUCTS PIPELINE LTD.
P.O. NO.	EG-9-2796-A
ITEM NO.	--

SPECIFICATIONS

SERVICE PIPELINE

PUMPAGE	GASOLINE/JET FUEL/ DIESEL OIL	@	36-113 °F
		sp gr	0.86 MAX.
CAPACITY, gpm	1232 US	HEAD	196.8 ft
		SPEED	1460 rpm

EQUIPMENT

STUFFINGBOX ☐ PACKED ☒ MECHANICAL SEAL ☐ PACKINGLESS

VENDOR CRANE PACKING CO. LTD.
TYPE 8 B1 CODE: XF 1D1

BEARINGS CARBON

VENDOR BWL
TYPE SLV. BUSHING

* **DRIVER:** MOTOR

VENDOR LOUIS ALLISS
FRAME NO. 445 LP hp 100
VENDOR
FRAME NO. hp

COUPLING

VENDOR BWL
TYPE ADJUSTABLE FLANGED SPACER SIZE 77 ECA

(* INDICATES SUPPLIED BY CUSTOMER)

CONTENTS

SERIAL No. 4B290/1

BINGHAM-WILLAMETTE INFORMATION

MANUAL	VCR
CROSS SECTION	B-4B290-3 W/PARTS LIST
LOCKING OF IMPELLER RINGS:	A-52134
LOCKING OF BOWL RINGS :	A-52136
STUFFING BOX ASSEMBLY:	A-4B290-2
OUTLINE	B-4B290-1
VCR COLUMN DETAIL	B-4B290-2 W/PARTS LIST
SEAL CIRC PER API PLAN 13	B-4B290-4 W/PARTS LIST
CERTIFIED TEST PERF. CURVES	C-4258, C-4259 W/DATA
CALCULATED(SALES)CURVES	20131, VB-201-1

VENDOR INFORMATION

MECHANICAL SEAL J. CRANE CROSS-SECTION DWG: CF-SP 90067-1
J. CRANE INSTALLATION INSTRUCTIONS: FORM S-300

COUPLING WP-275, FIG. 6

BEARING --

DRIVER BY CUSTOMER

LUBE SYSTEM BY PUMPAGE

BINGHAM-WILLAMETTE LIMITED
QUALITY ASSURANCE DEPARTMENT
CERTIFICATE OF COMPLIANCE

SALES ORDER No. 4B290/1
CUSTOMER OIL PRODUCT PIPELINE LTD.
P.O. NO. EG-9-2796-A
SERIAL OR HEAT NO. ______

THIS IS TO CERTIFY THAT THE PROCESS/REQUIREMENT INDICATED BELOW WAS PERFORMED IN ACCORDANCE WITH CONTRACT SPECIFICATIONS:

PROCESS	PROCEDURE & REV.	PROCESS	PROCEDURE & REV.
☐ PASSIVATION		☒ HYDROSTATIC TEST	See Below
☐ DISMANTLING		☐ T.I.R.	
☐ ALL WELDERS USED WERE QUALIFIED UNDER ASME, SECTION IX		☐ LEAK TEST	
☐ BALANCE (Static)		☐ LIFT TEST	
☒ BALANCE (Dynamic)	See Below	☐ FUNCTIONAL TEST	
☐ WELD PROCEDURES USED WERE CUSTOMER APP'D.		☐ PACKAGING	
☐ CLEANING		☒ MATERIALS CONFORM TO SPECIFICATIONS	
☐ HEAT TREAT		☐	
☐ HARDNESS		☐	

BALANCING: TWO PLANE
- 1st STAGE IMP — Within 17.40 g.in
- SERIES IMP — Within 12.67 g.in

HARDNESS: ______ BRINNELL ______ ROCKWELL

T.I.R. ______

HYDROSTATIC TEST PRESSURE 735 P.S.I.G. FOR 1 Hr. on DISCHARGE HEAD
250 P.S.I.G. FOR 1 Hr. on RECEIVER CAN
300 " " 1/2 Hr. on BOWLS

HEAT TREAT:
OVEN HEAT NO. ______ DATE ______ TEMP. ______

WITNESS (WHEN REQUIRED) ______

DATE ______

Slecock - Chief Inspector (BWL 3)
BINGHAM-WILLAMETTE LTD.

Feb. 11, 1983
DATE

INSTALLATION
OPERATION
MAINTENANCE

VCR
VCR-DS
VTR
VTR-DS

Bingham-Willamette
MULTISTAGE
VERTICAL PUMPS

CAUTION
THE SETTINGS ON FACTORY PROVIDED AUXILIARY EQUIPMENT MUST BE CHECKED IN THE FIELD AND RESET AS NECESSARY

CONTENTS

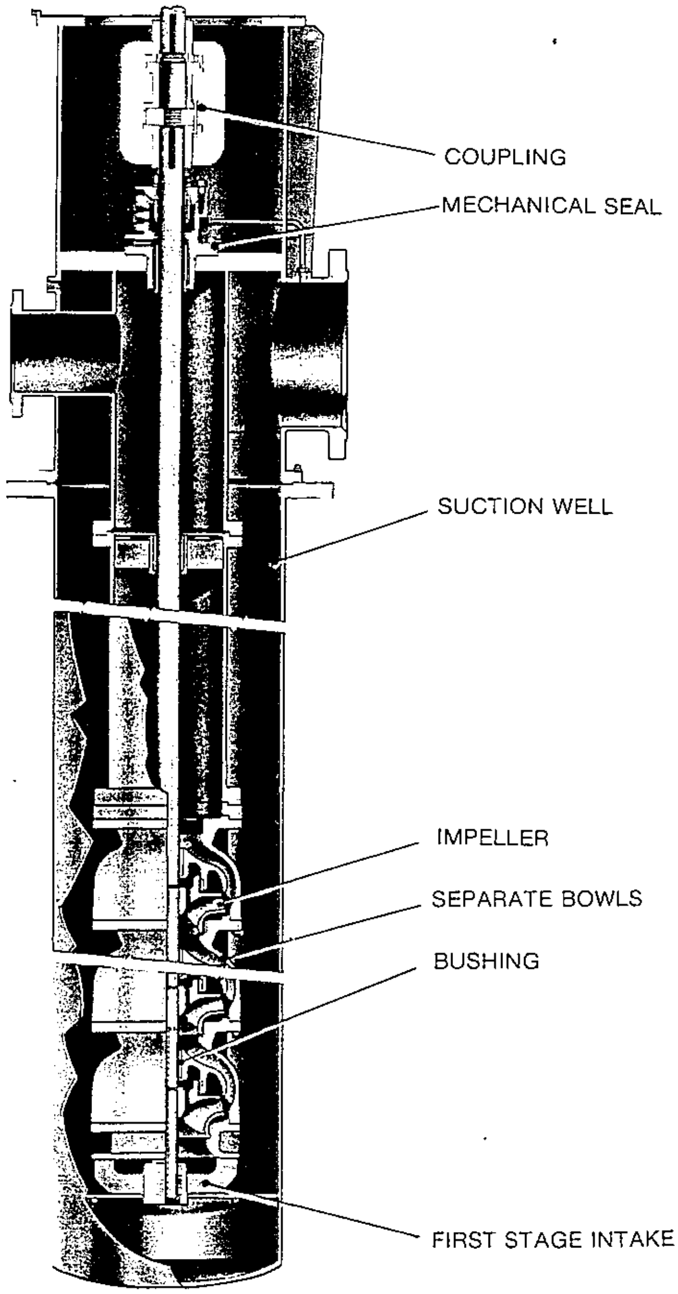


Fig. 1 VCR multistage vertical pump

INTRODUCTION

SCOPE

This manual provides installation, operation and maintenance instructions for Bingham-Willamette type VCR, VCR-DS, VTR and VTR-DS vertical bowl pumps. This manual is prepared for operation and maintenance personnel.

Read instructions carefully before operating pump.

Use this manual with a cross section drawing, parts list and outline drawing (see specific manual). Instructions on vendor equipment are included in the specific manual.

INSTALLATION Depending on size of pump and other factors, the pump may be shipped assembled or partially assembled. See INSTALLATION for appropriate instructions.

DESCRIPTION

VCR, VCR-DS, VTR, VTR-DS The Bingham-Willamette type VCR, VCR-DS, VTR and VTR-DS have a vertical bowl configuration and are mounted within a suction well. The VCR-DS and VTR-DS have a closed double suction first stage impeller. The VCR has closed series impellers and the VTR has semi-open series impellers.

COMPONENTS

PUMP BOWLS Pump bowls are of flanged construction with rabbet fits to assure alignment. The bowls are furnished with replaceable wear rings and bushings.

COLUMN AND COLUMN SPIDERS Columns are of flanged construction and are equipped with replaceable bushings.

SHAFTS Some extended setting pumps require two or more coupled shaft sections.

IMPELLERS The impellers are key driven and positioned axially with split lock collars bolted to the impeller hub or with retaining rings. Impellers may be equipped with replaceable wear rings.

SUCTION AND DISCHARGE HEAD The suction and discharge head provides the location for the shaft seal. The nozzle flanges match ANSI flange ratings.

SHAFT SEAL Shaft sealing is by mechanical seal or packed stuffingbox.

SUCTION WELL The bowl unit takes suction from the suction well. The suction well includes a pump mounting flange.

COUPLING The pump-driver coupling is either a split sleeve design or flanged type. Both offer variable axial adjustment of the rotating element. Selection is determined by speed, horsepower and thrust conditions. A spacer is provided for easy seal maintenance where applicable.

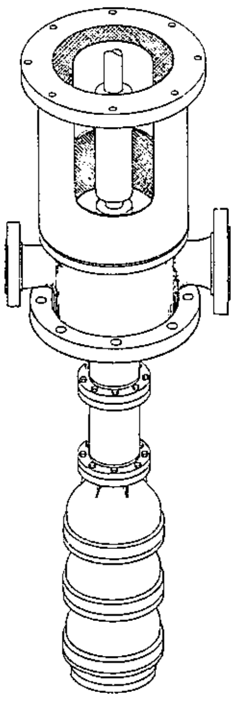


Fig. 2 VCR

PERFORMANCE FACTORS

Pump performance may be affected by changes in pumpage specific gravity, viscosity, pump operating speed and NPSH (Net Positive Suction Head). Centrifugal pumps are designed for specific service and may or may not be suited for any other service without loss of performance or damage to pump.

IMPORTANT NOTE: Do not change operating conditions from original design parameters without contacting a Bingham-Willamette representative.

INSTALLATION

INSPECTION

INSPECT UPON ARRIVAL Equipment is inspected prior to shipment. Check for shipping damage upon receipt. Report damage or shortage immediately to the carrier and to a representative of Bingham-Willamette.

STORAGE

NOTE: The following storage instructions apply only to the pump and may not be appropriate to driver units, switches, etc. Follow vendor instructions for all other components of the pump system.

REQUIREMENTS Prior to shipment the pump and its components are adequately prepared for outside storage, with the following additional requirements:

1. Store off ground on skids or cribbing so that no water will accumulate.
2. Protect pump and attachments with a vinyl coated nylon tarpaulin. Lash tarp down evenly to provide drainage that does not form pools. Maintain sufficient air circulation with a 3 in. (8 cm) minimum clearance between tarp and pump.
3. Locate in an area which is free from blowing sand and dirt.
4. Maintain desiccant effectiveness.
5. Do not stack on top of this equipment.
6. Prevent animal entry by keeping connections sealed.
7. Maintain rust preventive protection.

APPROVED STORAGE MATERIAL The following materials shall be used for maintenance:

1. Use packages of VPI crystals or a desiccant. Desiccant will be non-halogenated, non-deliquescent, chemically inert silica gel (or equivalent) to meet MIL-D-3464-D, type 11.
2. Vinyl-coated nylon tarpaulin.
3. OVER-COAT (Certified Laboratories, Fort Worth, Texas) or equivalent, rust preventive.

INSPECTION AND MAINTENANCE Inspect and perform maintenance every four weeks:

1. Remove protective tarpaulin.
2. Remove nozzle cover(s). Desiccant is attached to cover.
3. Change desiccant as necessary, or a minimum of every 6 months, and re-attach to cover.
4. Recoat surfaces requiring protection with approved rust preventive.
5. Wipe up spilled or excess rust preventive.
6. Replace and reseal protective cover(s).
7. Replace protective tarpaulin.

RECORDS Keep an inspection record with equipment:

1. Date of inspection.
2. Signature of person performing inspection and/or maintenance.
3. Results of inspection.
4. Date of maintenance.
5. Description of maintenance performed.
6. Amount and type of desiccant replaced.

NOTE: Requirements of a job specific Bingham-Willamette Storage Procedure will supersede the aforementioned instructions.

CLEANING

RUST PREVENTIVE Any internal parts of the pump that are vulnerable to rust are protected with a film of rust inhibitor.

NOTE: Rust inhibitors are not normally used on corrosion resistant materials. Flushing is unnecessary.

External nonpainted machined surfaces may be protected with a rust preventive. This external coating can be removed with kerosene or safety solvents.

FLUSH AND CLEAN Before installation, thoroughly flush to remove rust inhibitor and any foreign material that may have accumulated during shipping or storage. Use a mild alkali solution at 180°F (82°C), or a safety petroleum solvent. Flushing step may be eliminated if the pumpage is a petroleum product compatible with the rust preventive.

NOTE: Before cleaning, be sure to remove any desiccant.

SUCTION WELL SUPPORT

SUCTION WELL The suction well support must be sufficiently rigid to inhibit vibration. The suction well mounting flange must be level within .002 in./ft.

Pour any concrete in advance of installation to allow time for drying and curing. The pump must be supported securely to prevent movement resulting in straining/misalignment.

PUMP INSTALLATION

HOISTING The pump may be too long to be conveniently shipped or installed in one piece. The pump outline drawing has a headroom requirement reference.

Hoist and support requirements differ according to the site and size of each pump. Review in advance to determine what equipment and procedures are necessary.

Carefully support bowl and column unit throughout its length, especially when installing a fully assembled pump. Leave crating/skids attached when lifting from horizontal to vertical in order to prevent bowing of unit. Remove crating/skids after unit is in vertical position.

A chain fall reduces the possibility of damage due to bounce. The chain generally allows more precise control than cabling. This control is particularly needed during final column registration fitting or when maneuvering shaft sections into alignment.

NOTE: Do not lift by use of driver stand window openings.

CAUTION: When it is necessary to weld around pump system be certain ground connection is located very close to weld area. Keep electrical current from passing through pump or driver.

VCR AND VCR-DS SHAFT AXIAL MOVEMENT Determine pump shaft axial movement (end play) by moving shaft to determine total distance between end stops. Record measurement. This measurement is more easily accomplished with the pump in a horizontal position.

INSTALLATION OF ASSEMBLED PUMP Place O-ring into groove of mounting flange. Check that no foreign material was dropped into suction well.

Lower assembled pump into suction well. Tighten fasteners to ensure even loading, see TORQUE VALUES.

INSTALLATION OF PARTIALLY ASSEMBLED PUMP The following instructions are for on-site vertical assembly if pump was received partially disassembled. If there is sufficient headroom to install pump in one piece, the following instructions may be used to assemble pump in the horizontal as well as the vertical position.

The discharge head is the last item to be mounted while assembling the pump in the horizontal position. Driver stand and motor are added after securing pump to suction well.

Support full length of pump during horizontal assembly and when lifting to the vertical position. Take care to prevent excessive bowing and resultant damage.

VERTICAL ASSEMBLY, TWO COLUMN EXAMPLE If there is insufficient headroom to install pump in one piece use the following instructions for on-site vertical assembly:

1. Attach lifting eyebolts to top bowl of bowl unit. Rig to a hoist.

   CAUTION: Check that no foreign material is dropped into suction well or pump. It must be removed, even if pump must be completely disassembled!

2. Move bowl unit to suction well and ease assembly down until lower flange of top bowl is a few inches above suction well mounting flange.

   Place an I beam or similar support under lower flange of top bowl. To prevent I beam slippage, run bars of threaded stock through holes located at end web of each beam. Tighten nuts onto ends of each bar.

   Lower unit until flange is resting on support.

3. Install shaft sleeves, keys and retaining rings (if so equipped) to head/line shaft. (Extended setting pumps may utilize one or more line shafts between pump shaft and head shaft.)

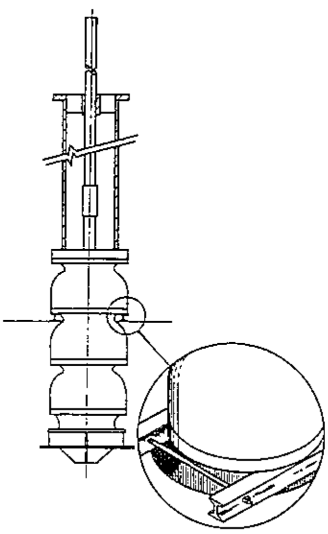


Fig. 3 Top bowl support

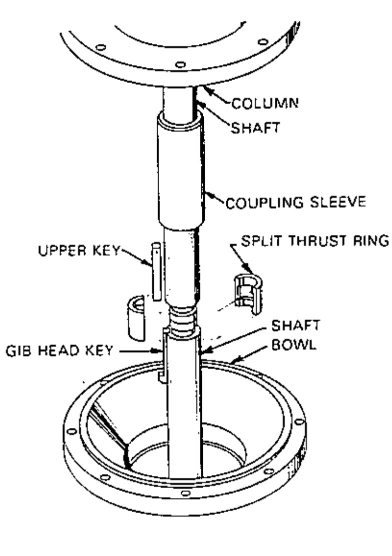


Fig. 4 Pump-head/line shaft coupling

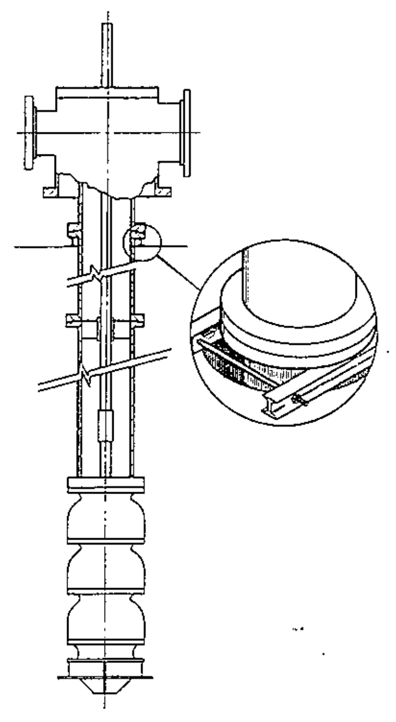


Fig. 5 Top column support

NOTE: The following steps presume sufficient headroom to couple the shafts, then in a separate step to lower the columns over an already installed head/line shaft. In an instance of restricted headroom the column(s) and shaft can be lifted together, coupling the shafts then fastening the column. Block shaft to lower end of column in order to maintain secure separation between column and shaft while lifting into position.

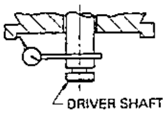
CAUTION: Take care to avoid damage to bushings when columns are lowered over shaft.

4. Lift shaft into alignment for coupling to pump shaft. Use caution to avoid bumping, hitting or springing the shaft.
5. Slip coupling body up over end of head/line shaft (upper).
6. Install gib head key into pump shaft.
7. Install split ring.
8. Insert upper key, then slide coupling body over upper key and split ring until resting on projection of lower gib key.
9. Lock coupling in place. Insert safety wire through upper key hole. Twist ends of wire to form a loop. Trim excess wire.
10. Lower column to top bowl. Secure fasteners. See TORQUE VALUES. Hoist remains attached to column.
11. Lift unit and remove I beam support. Lower unit and place support under column upper flange. Remove hoist and lifting eyebolts from lower column.
12. Ease upper column into position and secure available column to column fasteners. See TORQUE VALUES.
13. Raise unit and place I beam support under top flange of upper column. Remove hoist.
14. Install suction well to discharge head O-ring.
15. Place lifting eyebolts in driver stand mounting holes of discharge head. Lower over pump shaft to proper position on column flange and secure fasteners. See TORQUE VALUES.
16. Fasten discharge head to suction well. See TORQUE VALUES. Remove hoist and lifting bolts.
17. Install stuffingbox and O-ring (when so equipped) to discharge head. Orient stuffingbox connections per outline drawing.

18a. **Mechanical Seal** Slide mechanical seal over exposed shaft and fasten gland plate assembly to discharge head or stuffingbox.

CAUTION: Protect mechanical seal faces, imperfections of any kind will cause leakage. A light coat of propylene glycol, glycerine or distilled water will allow seal parts to move freely. Keep oil from contacting elastomeric components. See seal manufacturer's instructions.

Maximum face runout
.005 in. (.127 mm) TIR, 16½ in. and larger base diameter
.004 in. (.102 mm), below 16½ in. base diameter



Maximum shaft runout
.002 in. (.051 mm) TIR

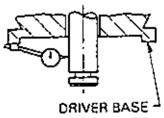


Fig. 6 Driver shaft runout

NOTE: Mechanical seal is set and fastened to shaft only after rotating element clearance is established and pump is coupled to driver.

18b. **Packing** See outline drawing for specific packing assembly sequence.

19. **Flanged Coupling?** (See Fig. 9) Install driver hub and pump hub if pump is equipped with flanged type coupling.

    The driver hub is an interference fit and requires heating. The pump flanged coupling hub is a loose fit and does not require heating.

    Preheat driver hub to 200-300° F. Place key into shaft, slip heated hub up so that bottom of hub is beyond circumferential grooves. Quickly install split ring then move hub down to contact split ring.

    Install pump hub and key.

20. Complete coupling installation. See COUPLING, ROTATING ELEMENT CLEARANCE.

21. Set mechanical seal. See seal manufacturer's drawing.

22. Connect piping. See PIPING.

DRIVER INSTALLATION

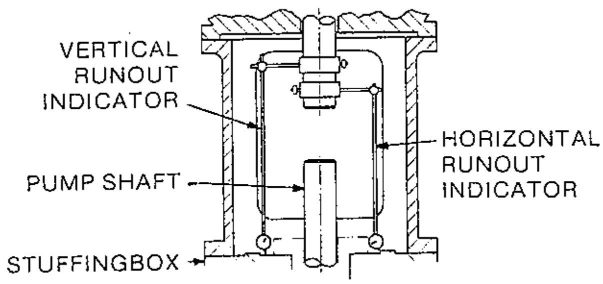


Fig. 7 Driver-pump alignment, size 12B-22

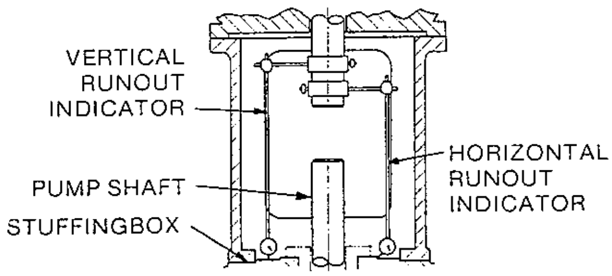


Fig. 8 Driver-pump alignment, sizes 6A thru 12A

DRIVER SHAFT RUNOUT It is important to check driver shaft runout, see Fig. 6. In case of an apparent out-of-tolerance driver, consult a Bingham-Willamette representative or the driver manufacturer.

Inspect all coupling components for dirt, burrs or any other interferences.

ALIGNMENT Install driver stand and lift driver onto driver stand. Install driver capscrews finger-tight.

Align driver to pump, see Fig. 7 or 8. Mount a dial indicator to check vertical runout, .002 in. (.051 mm) maximum TIR. Adjust by placing shims between driver base and driver stand.

Mount a dial indicator to check horizontal runout, .002 in. (.051 mm) maximum TIR.

Secure driver to driver stand. See TORQUE VALUES. Recheck vertical and horizontal runout.

DRIVER ROTATION Connect motor wiring according to motor manufacturer's instructions.

Before installing pump to driver coupling or completing a flanged coupling installation, momentarily start driver and verify correct rotation (CCW when looking down from driver).

Install coupling; see COUPLING, ROTATING ELEMENT CLEARANCE.

TAPER PINS Drill and ream flanges of driver and stand for acceptance of taper pins only after coupling is in place and alignment is rechecked. See COUPLING, ROTATING ELEMENT CLEARANCE.

COUPLING, ROTATING ELEMENT CLEARANCE

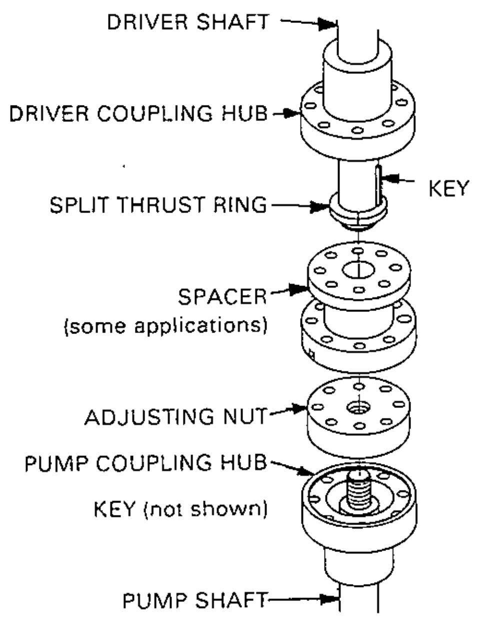


Fig. 9 Flanged coupling

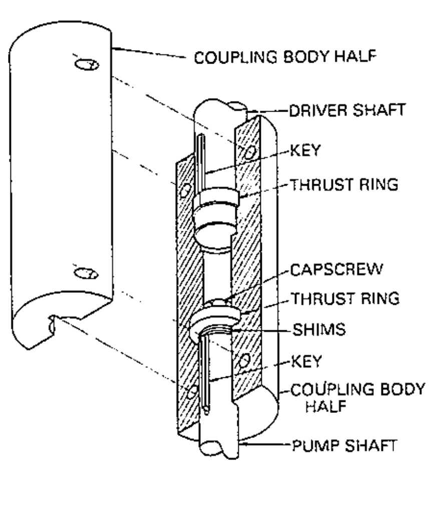


Fig. 10 Split sleeve coupling

FLANGED TYPE COUPLING Flanged coupling hubs are keyed to shafts with standard square keys. A split thrust ring locks driver coupling hub to driver shaft.

All mating surfaces must be clean and free of burrs or chips. Keys should be a push fit in all keyways.

Driver hub has been installed before mounting driver onto driver stand. See PUMP INSTALLATION.

1. Insert key in pump shaft, then slide pump coupling hub down on pump shaft.
2. Thread adjusting nut onto pump shaft.
3. Bolt spacer, if provided, to driver coupling hub.

4a. **VCR, VCR-DS (Closed Impeller)** Rotate adjusting nut so distance between top of adjusting nut and spacer mating surface is one half of total axial movement previously as determined in PUMP INSTALLATION.

4b. **VTR, VTR-DS (Semi-Open Impeller)** Rotate adjusting nut so distance between top of adjusting nut and spacer mating surface is .025 in. (.64 mm) for pump size 14B and smaller and .050 in. (1.27 mm) for pump size 16A and larger.

5. Now rotate adjusting nut to closest alignment of holes. Install capscrews and tighten evenly to raise the shaft, see TORQUE VALUES.

After assembly, check runout of the shaft immediately below the coupling. Shaft must be within .002 in. (.051 mm) TIR.

SPLIT SLEEVE TYPE COUPLING Rotating element end clearance is adjusted by placing appropriate thickness of shims between pump thrust ring and pump shaft.

Rotating element end clearance has been established at the factory. A tag stating this clearance (shim thickness) may have been attached to the pump. If the driver is supplied by Bingham-Willamette, the proper shim thickness has already been installed. Shims are provided for customer supplied drivers.

1a. **VCR, VCR-DS (Closed Impeller)** Insert thickness of shims required to lift rotating element to one half of total axial movement previously noted in PUMP INSTALLATION.

1b. **VTR (Semi-Open Impeller)** Split sleeve type coupling is not utilized on VTR's.

2. Assemble keyed half of coupling over pump and driver thrust rings, shims (under pump thrust ring) and shaft keys. Capscrew holding pump thrust ring and shims must be loosened in order to align pump thrust ring with groove in coupling.
3. Slowly raise rotating element by tightening capscrew into pump shaft.

4. Assemble other half of coupling. Install bolts in left or right side and draw up evenly to obtain metal to metal, contact. Install bolts in other side and draw up evenly. Due to manufacturing variations a gap may remain on this second side. If there is a gap, use a feeler guage to maintain equal top to bottom separation.

   After assembly, check runout of shaft immediately below coupling. Shaft must be within .002 in. (.051 mm) TIR.

MECHANICAL SEAL

MECHANICAL SEAL INSTALLATION The sealing surfaces of a mechanical seal must be protected from nicks or scratches. Imperfections of any kind on mechanical seal faces will cause leakage. Care must be used to keep these surfaces clean and free of substances that would mar seal faces.

Remove all burrs and sharp edges from the shaft or shaft sleeve, including edges of keyways and threads. Inspect stuffingbox bore and face for cleanliness and freedom from burrs.

A lubricant is recommended for installation, but match compatibility of lubricant to materials of the seal and pumpage. See manufacturer's instructions. A light coating of oil on the shaft or sleeve will allow the seal parts to move freely. A clean finger method of applying oil will avoid leaving lint.

Install mechanical seal. Bolt gland flange to stuffingbox or discharge head after coupling is installed. To determine correct seal setting, refer to seal manufacturer's drawing. Be sure to follow seal manufacturer's instructions for installation and maintenance.

Some units have special mechanical seals or auxiliary seal equipment, such as heat exchangers or cyclone separators. Refer to the manufacturer's instructions for general maintenance.

PACKING

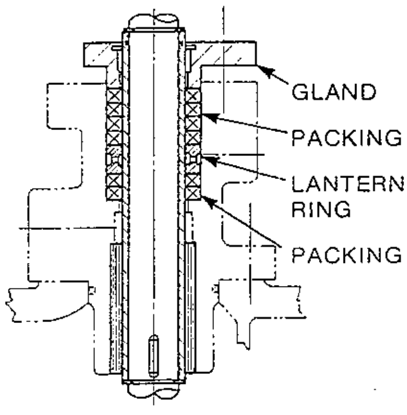


Fig. 11 Typical packing ring sequence

Packing is installed after pump is coupled to driver.

NOTE: Packing is not a complete seal. Some leakage must occur.

Success of packing depends upon even packing ring compression by the gland, along with a slight amount of leakage required to cool and lubricate the packing. Packing suppresses leakage by compressing against shaft and gland.

1. Remove gland ring halves. Use a hooked wire to slide lantern ring out of stuffingbox. Clean stuffingbox of any debris.

2. Note location of sealing liquid passages. Lantern ring openings line up with stuffingbox inlet and outlet.

   WARNING: It is imperative that lantern ring be aligned with liquid passageways.

3. Insert rings in sequence indicated on outline drawing (left to right is inside to outside). Begin with inner ring.

   To fit packing rings around shaft pull into a spiral. Attempting to expand radially results in breakage.

   Insert rings one at a time, seating each ring before installing next. Stagger joints of successive rings by 90 degrees.

4. When last ring is in place, install and assemble gland halves. Tighten gland adjusting nuts evenly until barely snug. Then back off nuts and retighten finger-tight. Do not tighten enough to compress packing rings against shaft sleeve. Gland nuts will be adjusted at start-up. See OPERATION.

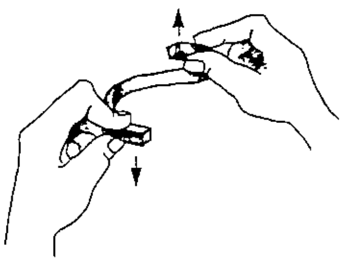


Fig. 12 Spiral twist is correct

PIPING

SUCTION AND DISCHARGE PIPING Use special care to prevent dirt, pipe scale, or welding residue from entering pump during installation. Thoroughly flush suction system before piping is connected.

It is suggested that a suction screen be in place at least the first 24 hours of operation. Install strainer into a spool piece and insert pressure gauges so that screen pressure drop can be monitored. See OPERATION.

Install piping so that no piping loads are imposed on pump. Allowable piping forces and moments are operational only and should not be used as justification for imposing excessive loads. Piping loads can adversely affect component life.

BYPASS PIPING If pump is to be operated at reduced discharge, it will be necessary to install a bypass pipe from discharge back to suction source. This protects against damage caused by heat generated within pumpage, created by throttling the discharge line.

CAUTION: Pump should not be operated below minimum flow.

Install a minimum-flow bypass line to regulate flow and thus control amount of recirculation.

AUXILIARY PIPING Auxiliary piping is sometimes required for stuffingbox coolant, seal coolant, and/or packing injection. Auxiliary piping is identified on the outline drawing.

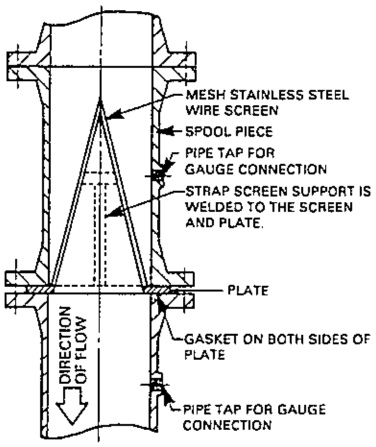


Fig. 13 Suction strainer example

OPERATION

PRE-START

Also see INSTALLATION.

1. Clean the unit. Be certain to remove drying agents.
2. Check tightness of bolted flange connections. Review external connections and function.
3. Inspect piping for correct installation.
4. Note that mechanical seal is set and locked to shaft, or packing is properly installed.
5. Verify shaft freely rotates.
6. Be certain driver is installed according to manufacturer's instructions.

STARTING PROCEDURE

COOLANT SERVICES Activate coolant systems. Follow manufacturer's instructions.

PRIME Before starting any centrifugal pump, case and suction piping must be *completely* filled with liquid. The liquid lubricates rotating parts within the pump. *Damage can be caused if operated dry.*

With discharge valve closed, slowly open pump suction valve to allow pumpage to enter.

1. When pump is located below suction level source, open vents to release trapped air or vapor, and pump will prime itself. Full prime is indicated when vented liquid no longer contains bubbles.
2. When pump is located above liquid level of pumpage, an ejector or other means must be provided to evacuate air or vapor from pump case.

   NOTE: Bleed air from any seal circulation piping. Damage to seals may be caused by absence of liquid.
3. Once suction valve is fully open, set discharge valve to approximately 10 percent open. A minimum flow bypass line may be used for start-up purposes.

NOTE: When pump is located above suction source, the discharge valve cannot be opened until driver has been started, since this would cause loss of prime.

HOT SERVICE When pumpage is hot, over 300°F (149°C), the pump should be heated before start-up. Circulate a small amount of hot liquid (induced pumpage is preferable) through pump until within 100°F (38°C) of product temperature.

START-UP Start pump and bring immediately to operating speed. As soon as pump begins to develop discharge pressure, start slowly opening discharge valve. Avoid making any abrupt change in discharge velocity in order to prevent surging within piping. *Surging can cause serious damage.*

NOTE: Pump should produce pressure at discharge as soon as rated operating speed is reached. If not, shut down immediately.

As soon as pump stops, open vent valves and reprime.

CAUTION: Do not operate against closed discharge valve, unless pump is equipped with bypass piping.

CAUTION: Never attempt to control pump output by throttling suction valve. Use of suction valve as a throttle causes cavitation damage.

BYPASS If pump is required to operate at less than design output it is necessary to utilize a bypass line. Consult with a Bingham-Willamette representative.

START-UP CHECKS

LEAKAGE Periodically check for leakage at stuffingbox. Excessive mechanical seal leakage indicates wear or damage.

Watch for any signs of leakage at suction and discharge lines and auxiliary piping.

PACKING RING LEAKAGE At start-up packing rings may leak substantially. A minimum leakage rate of 2 drops each second is required to cool and lubricate packing rings.

Correct excessive packing ring leakage by evenly tightening gland nuts one flat (one-sixth of a turn). Wait several minutes for leakage to stabilize, then check new leakage rate.

SUCTION STRAINER Observe pressure drop across suction strainer. Some drop is normal, even when screen is clean. Watch for any increase in pressure drop that indicates accumulation of debris.

Strainer must be cleaned if there is an increase of 5 psi (34.5 kPa) pressure drop. Leave strainer in line for at least first 24 hours of operation, or until system is cleansed.

SHUTDOWN The pump should be shut down rapidly to prevent internal parts from running dry and seizing.

EXTENDED SHUTDOWN

STANDBY SERVICE When pump is on standby for instant start-up service, it should be kept ready by circulating pumpage. Maintain any coolant services.

FREEZE DAMAGE Exposure to freezing temperatures requires care to prevent liquid from freezing within pump. Drain all cooling jackets to prevent freeze damage.

MAINTENANCE

MECHANICAL SEAL REMOVAL

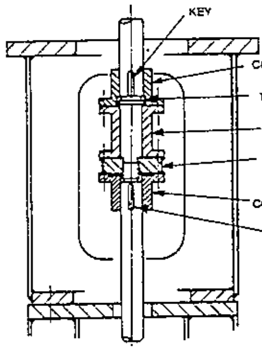


Fig. 14 Flanged coupling

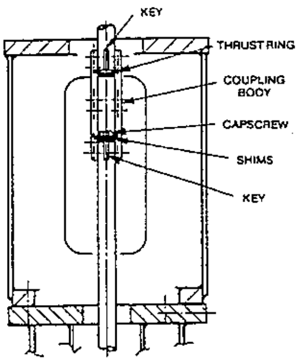


Fig. 15 Split sleeve coupling

The mechanical seal can be removed for inspection and replacement without disturbing pump and driver. Variations of seal design may result in different disassembly procedures. Refer to the manufacturer's information.

1. Lock power breakers to off position.
2. Disconnect any seal circulation lines at seal glands. Cap ends of lines to prevent dirt entry.
3. Loosen seal collar setscrews holding to the shaft. See seal manufacturer's drawing and instructions.

4a. **Flanged Coupling** Lower the shaft to rest position by removing coupling capscrews. Remove coupling spacer, adjusting nut, pump shaft hub, and key.

4b. **Split Sleeve Coupling** Remove non-keyed half of coupling. Slowly lower rotating element by unscrewing capscrew from pump shaft. Remove keyed half of coupling, thrust rings, shims, and shaft keys.

5. Unbolt and carefully remove seal and gland plate assembly.

   Be sure to follow seal manufacturer's instructions for installation and maintenance. See seal manufacturer's drawing for correct assembly and seal setting. New O-rings, springs and faces should be installed.

DISASSEMBLY

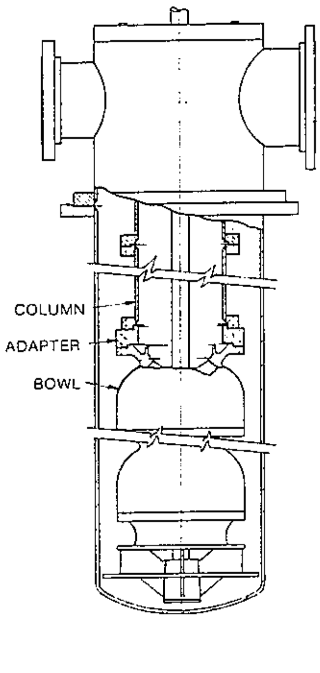


Fig. 16 Size 12A-22A with adapter

POWER Lock power breakers to off position.

TOOLS AND PROCEDURES A variety of equipment is required for disassembly. Review entire removal procedure in advance to determine what equipment and disassembly procedures are necessary.

Refer to specific outline drawing, cross section drawing and parts list.

All parts removed should be protected. Larger parts should be placed in a protected area and wrapped in cloth or plastic. Smaller parts should be placed in bags or boxes.

An overhead crane or boom, best rigged with a chain fall, is required. A chain fall reduces possibility of damage due to bounce. The chain generally allows more precise control than cabling.

NOTE: Do not lift by use of window openings on the driver stand.

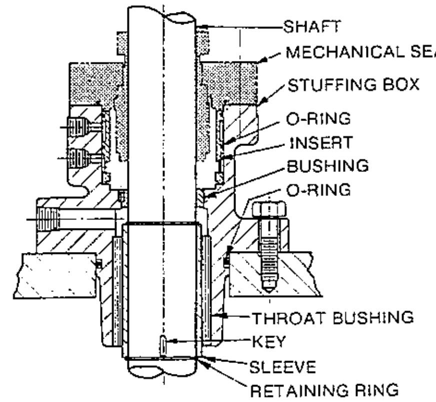


Fig. 17 Example stuffingbox with mechanical seal

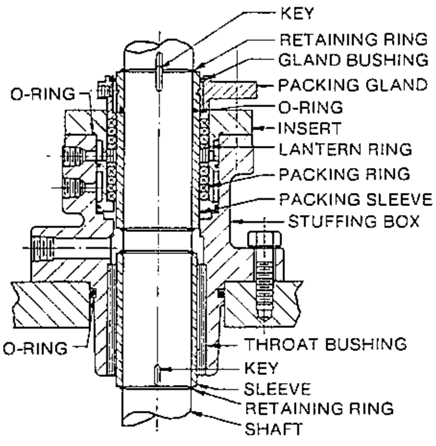


Fig. 18 Example stuffingbox with packing

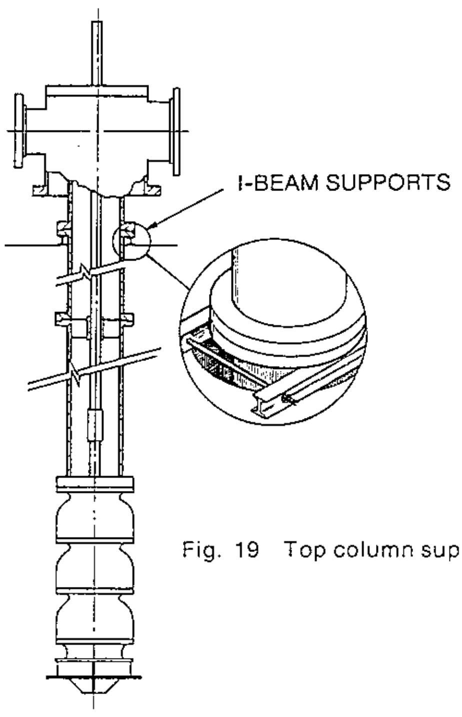


Fig. 19 Top column support

DISASSEMBLY AT SUCTION WELL The bowl and column unit components are removed at the suction well when headroom restrictions do not allow removal of an assembled pump. See outline drawing for required headroom to remove the assembled pump.

1. Disconnect power leads to motor.
2. Remove any restraint from motor.
3. Unfasten discharge piping.
4. Disconnect any seal system injection lines to seal gland.

NOTE: If size allows, the driver stand and motor may be removed together, without removing motor to driver stand fasteners.

5. Remove bolts and taper pins securing motor to driver stand. Lift motor to a storage or maintenance location. See manufacturer's information for correct motor handling, storage and maintenance.
6. Remove pump-driver coupling and mechanical seal. See MECHANICAL SEAL REMOVAL.
7. Place lifting eyebolts in the motor mounting holes of driver stand. Unbolt and set driver stand aside.
8. Use existing lifting lugs or place lifting eyebolts in driver stand mounting holes of discharge head. Remove discharge head to suction well flange bolts.

   NOTE: Entire pump may now be lifted from suction well if there is sufficient headroom above mounting surface. See outline drawing. Use care when lowering to a horizontal position. Support full length to prevent excessive bowing and resultant damage. If there is insufficient headroom, pump will be partially disassembled in vertical position at suction well.

   CAUTION: Take care not to drop foreign material into suction well. It must be removed or damage to pump could result!

BOWL, COLUMN, DISCHARGE HEAD DISASSEMBLY The following instructions are for on-site vertical disassembly of an example pump with two columns. If there is sufficient headroom to remove the assembled pump, the vertical instructions may be used to disassemble pump in the horizontal position.

9. Lift unit until upper flange of top column is a few inches above suction well mounting flange.

   Place two I beams or similar support under upper flange of top column. To prevent I beam slippage, run bars of threaded stock through holes located at end web of each beam. Tighten nuts onto ends of each bar.

   Lower unit until flange is resting on support.

10. Remove accessible fasteners holding discharge head to column. Lift pump, shift I beams and lower to rest again in order to remove remaining fasteners. Lift off discharge head.
11. Place lifting eyebolts in discharge head mounting holes of upper column.

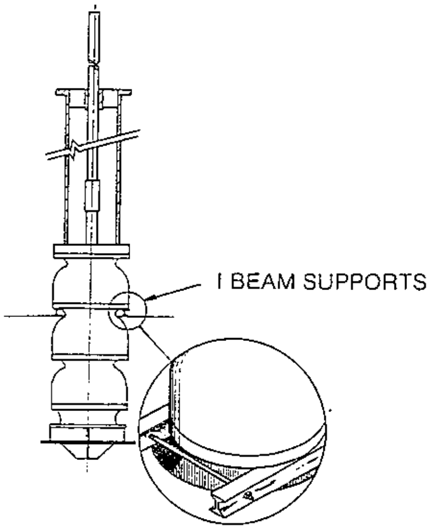


Fig. 20 Top bowl support

12. Lift pump, then lower unit until top flange of lower column is resting on I beam support.
13. Remove accessible fasteners holding column to column. Lift unit, shift I beams and lower again. Remove remaining fasteners and remove top column. Take care to avoid damage to column bushing.
14. Place lifting eyebolts in flange of remaining column. Lift unit, move I beams to support upper flange of top bowl. Remove accessible fasteners, lift pump, shift I beams and lower again. Remove remaining fasteners and raise lower column sufficient to expose shaft coupling.
15. Rig hoist to support shaft during shaft coupling removal.
16. Remove coupling upper key lockwire.
17. Move coupling body up to expose and remove lower gib key and split ring.
18. Raise shaft, coupling body and upper key.

    CAUTION: Use handling procedures adequate to avoid bumping, hitting or springing shaft. Support shaft evenly over complete length.
19. Set shaft aside.
20. Attach eyebolts to top bowl. Rig to hoist and lift until I beams can be removed. Carefully move bowl assembly to a maintenance shop.

BOWL UNIT DISASSEMBLY

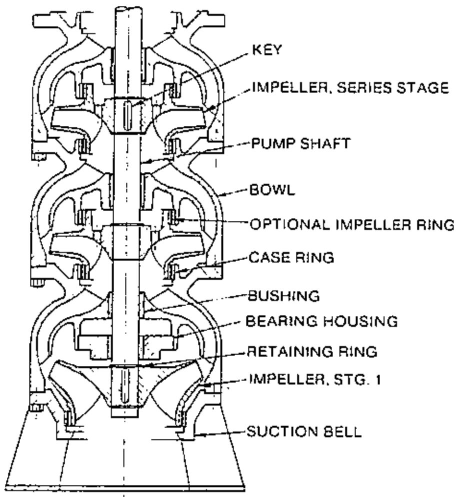


Fig. 21 Size 6½A-8½A with optional impeller ring

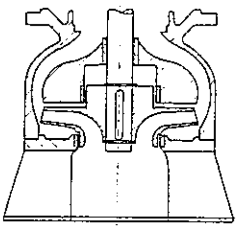


Fig. 22 First stage, size 6A

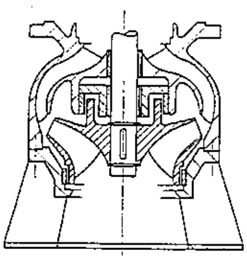


Fig. 23 First stage, sizes 9A, 10A, 10B

The bowl unit assembly should be removed to a maintenance shop where proper facilities are available for further disassembly.

NOTE: As the dismantling proceeds it is essential that the impellers, bowls and wear parts be marked as to their relative placement in the element.

The following procedure begins by first removing the top bowl. A pump with a six to fourteen inch bowl size (6A-14A) may be readily disassembled by starting with the bottom components. The suction bell would be the first item removed, exposing the first stage impeller for removal.

1. Unbolt and remove top bowl.
2. Remove sleeve and key (and shaft sleeves on some pumps).

3a. **Sizes 6A-14A** Remove impeller retaining ring(s) by use of retaining ring pliers.

3b. **Sizes 14B-22A** Remove lockwire and capscrews securing lock collar to impeller. Remove lockcollar.

4. Slide impeller from shaft. Clean and polish shaft ahead and behind impellers during disassembly.
5. Remove impeller key.
6. Repeat above steps for remaining bowls.

INSPECTION

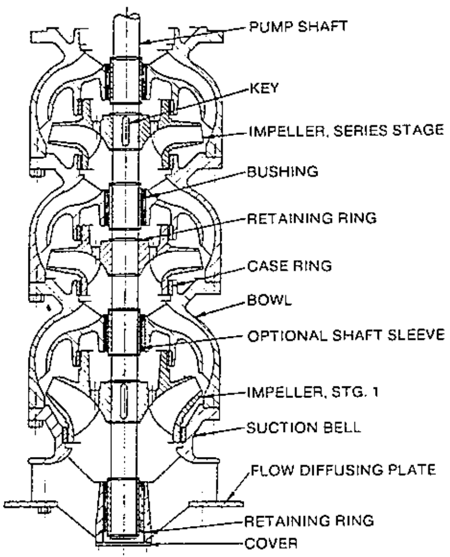


Fig. 24 Size 12-14A with optional shaft sleeve

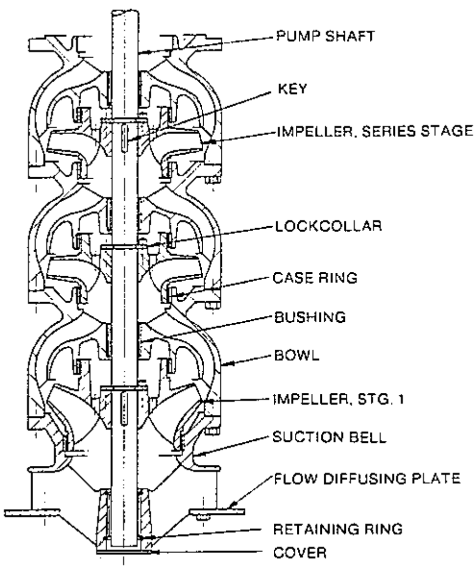
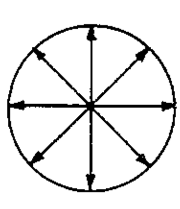


Fig. 25 Size 14B-22A



largest case ring ID — smallest impeller ring OD = diametrical clearance

CLEAN AND INSPECT After disassembly, clean all parts (not mechanical seal) in solvent and inspect for wear or damage. Inspect shaft sleeves, bushings, seal components and wear rings.

All running clearances (wear rings, etc.) must be accurately measured for excessive wear. No damaged or worn parts should be re-used.

MECHANICAL SEAL The sealing surfaces of mechanical seals are highly polished and optically flat. Care must be used to keep these surfaces perfectly clean and free from substances that would mar seal faces.

Before completing seal installation, wipe sealing faces perfectly clean.

Be sure to follow seal manufacturer's instructions for installation and maintenance. See the seal manufacturer's drawing for correct assembly and seal setting. New O-rings, springs, and faces should be installed.

SHAFTS Inspect shafts for burrs or scratches. File off burrs and smooth resulting file marks with crocus cloth. Polish shaft with crocus cloth at location of impellers, seal, coupling, sleeves and bushings.

The shaft must be handled with care and supported evenly throughout its length to insure straightness. Avoid bumping, hitting or springing the shaft.

Check runout. Carefully rest the shaft on precision rollers to perform concentricity inspection. Straighten or replace if runout exceeds specification maximum.

A shaft up to 2½ in. diameter must be straight within .0005 in./ft (.0127 mm/.305 m) with maximum runout of .005 in. (.127 mm) TIR. A shaft of 2½ in. and larger diameter must be straight within .001 in./ft (.0254 mm/.305 m) with maximum runout of .010 in. (.254 mm) TIR.

IMPELLERS Inspect impellers for wear or damage. Particularly look for cavitation marks (pits) in the suction opening, erosion of vanes and cracks in the shroud. Minor irregularities may be smoothed with a fine file and crocus cloth. Rings may be machined if proper equipment is available, but only within allowable clearance.

BOWLS Check bowls for burrs, chips, cracks or other damage. Minor irregularities may be smoothed with a fine file and crocus cloth.

WEAR RINGS, BUSHING AND SLEEVE INSPECTION Inspect wear rings, bushings and sleeves for nicks and scratches.

WEAR RING CLEARANCES Replace wear rings when pump performance drops below system standards.

Measure clearance between corresponding sets of rings. Compare impeller ring OD and case ring ID. Use several measurement locations, then subtract smallest OD from largest ID to determine diametral clearance.

Shaft diameter	Minimum running clearance (diametral)
0.50 - 1.49 in.	.005 in. (.127 mm)
1.50 - 2.49	.006 (.152)
2.50 - 3.49	.007 (.178)
3.50 - 4.49	.008 (.203)
4.50 - 4.99	.009 (.229)
5.00 - 5.49	.010 (.254)

Fig. 26 Bushing clearance at pumpage temperature

WEAR RING MINIMUM RUNNING CLEARANCES Minimum running clearances for API Standard 610 and Bingham Standard Clearance are listed. Unless specified, wear ring clearances on the VCR, VCR-DS, and VTR are in accordance with Bingham Standard Clearances.

DIAMETER OF ROTATING MEMBER AT CLEARANCE	MINIMUM DIAMETRAL CLEARANCE	
	BINGHAM STANDARD	BINGHAM "HOT" OR API STANDARD
2.000 - 2.499 in.	0.008 in. (0.203 mm)	0.011 in. (0.279 mm)
2.500 - 2.999	0.009 (0.229)	0.012 (0.305)
3.000 - 3.499	0.010 (0.254)	0.014 (0.356)
3.500 - 3.999	0.011 (0.279)	0.016 (0.406)
4.000 - 4.499	0.011 (0.279)	0.016 (0.406)
4.500 - 4.999	0.012 (0.305)	0.016 (0.406)
5.000 - 5.999	0.013 (0.330)	0.017 (0.432)

For cast iron, bronze, hardened 11-13 percent chromium, and materials of similar low galling tendencies, the minimum clearances shall be used. For diameters greater than 5.999 in. (152.37 mm), add 0.001 in. (0.025 mm) for each additional inch (25 mm) of diameter or fraction thereof.

For material with greater galling tendencies and/or operating temperature above 500° F (260° C), 0.005 in. (0.127 mm) shall be added to API Standard diametral clearances.

CARBON BUSHING REPLACEMENT

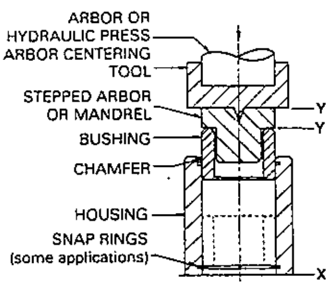


Fig. 27 Graphite bushing press

Remove graphite bushings by pressing or breaking them out of their seat. Use care to avoid housing damage.

Use an arbor centering tool, a stepped arbor or mandrel and a hydraulic press to install the bushings. The self-centering tool and arbor are machined in the field. The arbor or mandrel insures that the bushing is correctly positioned.

The small diameter of the arbor should be 1/32 in. (.8 mm) smaller than inside diameter of the bushing. The large outside diameter of the arbor should be 1/32 in. (8 mm) smaller than the outside diameter of the bushing.

Surfaces X and Y (Fig. 27) must be parallel before and during pressing to insure final correct fit.

The bushings can be pressed dry, but a dip coat of water will provide additional lubrication. During the press, pressure must be applied continuously. Maximum press speed is 8 inches per minute.

NOTE: Graphite bushings can be broken if incorrectly installed. While installing the bushing do not stop and start the press, use a continuous motion.

Renew retaining rings at time of bushing renewal.

The ID of a graphite bushing becomes smaller after installation due to the reaction of press fitting. Wait 24 hours before measurement of ID.

WEAR RING REPLACEMENT

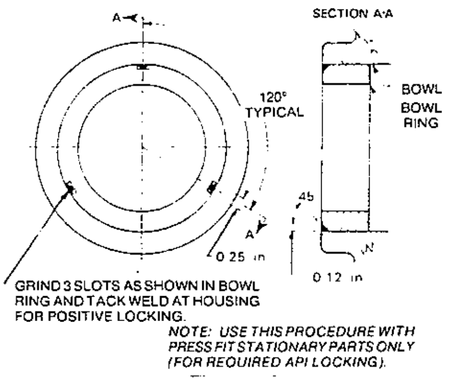


Fig. 28 Size 6A-10B bowl ring locking

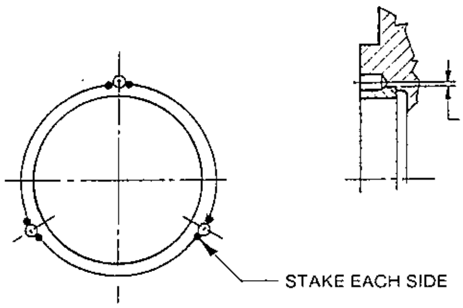


Fig. 29 Size 12A-22A bowl ring locking

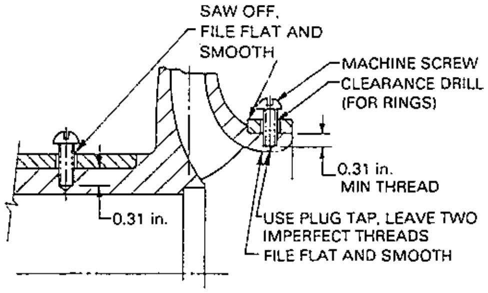


Fig. 30 Impeller ring locking

RING DIA. OD. in.	ROUND HD MACHINE SCREWS AISI 316 MAT'L qty. & size in.	DRILL SIZE (FOR RINGS) alpha drill=in.
to 6.50	3 of ¼ - 28 x .75 long	"F" drill = .257
6.51 - 10.00	3 of ¼ - 28 x .75 long	"F" drill = .257
10.51 - 15.00	6 of 5/16 - 18 x 1.00 long	"P" drill = .323
15.01 - up	6 of ⅜ - 24 x 1.00 long	"W" drill = .386

Fig. 31 Impeller locking screw size

NOTE: If new impeller rings are installed, case rings should also be replaced.

WEAR RING REMOVAL Remove wear rings by first removing setscrews and/or grinding off welds. Drill out setscrews; an extractor may be used. A hole may be drilled into the ring to further relax the metal.

Insert a pulling tool or pry bar between ring and seat. Apply pressure evenly to remove ring.

BOWL RINGS Before installing new case rings, be sure rings and seats are clean and free of burrs.

1. Carefully tap rings into place, chamfer to inside.

   Lock case ring in place as originally fastened, by tack welding or setscrews.

Setscrews:

2. Drill and tap for installation of three 1/4-20 UNC x 3/4 in. long stainless steel hexagon socket, cup point, setscrews. Offset drilled hole .03 in. (.76 mm) toward case in order to minimize drill wander.
3. Install socket head setscrews. Use care during installation in order to avoid ring distortion.
4. Use a center punch and hammer to stake setscrews in place.

IMPELLER RINGS Before installing new impeller rings, be sure rings and impeller seats are clean and free of burrs.

1. New locking screw holes will be drilled in the impeller. The old screw holes may be filled by installing stainless steel machine screws. Saw screws off close to impeller. Then file screws flush with surface.
2. Heat rings before installation.

   NOTE: Preferred method of heating wear rings is by electric oven or hot oil bath. Heating by torch is not recommended due to uneven heating stresses. If heated with a torch, use a "soft" flame and heat slowly and evenly.
3. Install rings so locking screw holes do not align with old holes or with any impeller vanes. Note that chamfer is in correct position. Let rings cool.
4. Drill new locking screw hole into impeller, using ring holes as a guide. Holes must be at least as deep into impeller as they are wide. Be very careful not to drill through impeller shroud.
5. Tap threads but leave imperfect threads at bottom so screws will bind to lock.
6. Install stainless steel machine screws so that they bind tightly within imperfect threads. Being very careful of ring surface, saw off tops of screws, file flush and finish with crocus cloth. Remove any slivers left after filing.

CAUTION: Check dress of screws. High spots or loose pieces can quickly score the close-fit wear ring surfaces.

ASSEMBLY, GENERAL

CLEANLINESS During assembly, it is essential that all parts be absolutely clean and free of oil or dust. Technical grade acetone is recommended for cleaning machined surfaces immediately before assembly. Air dry (use filtered, dry air) cleaned parts in a dust-free area.

WARNING: Acetone is extremely volatile and flammable. Work only in a well-ventilated area, away from heat or flame. A "no smoking" rule must be strictly enforced, and care must be taken to prevent sparks.

USE NEW PARTS All gaskets, O-rings, lockwire and retaining rings must be replaced each time pump is disassembled.

ROTATING ELEMENT Ensure that shaft has been polished at locations of impeller, seal and coupling.

BINDING Check for freedom of rotation during bowl unit assembly. A half turn of the shaft is sufficient to indicate binding.

TORQUE VALUES

COLUMN NUMBER SELECTION Look for a grade identification marking on the fastener, then refer to appropriate column in the torque table. The material into which the fastener is threaded must also be considered. A ¾ in. fastener of A193 Gr B7, threaded into AISI 316 SS material, is torqued to 70 lbf•ft. The same fastener in a steel raised face flange with gasket is torqued to 165 lbf•ft. (column 1). Where material is unknown, select proper column according to following guidelines:

FASTENER APPLICATION	COLUMN NUMBER
bowl - bowl bowl - suction bell column - column discharge head - suction well	*1, with steel fastener or 3, with SS fastener*
impeller retainer seal gland	*2*
driver stand - discharge head driver-driver stand pump mounting coupling	*3*

TYPE VCR/VTR TYPICAL TORQUE SELECTIONS Torque selections given here are based on typical fastener size, applications and material. Best results are obtained by use of the correct torque value based on fastener grade identification marking.

Suggested torque values are recommended to attain proper gasket compression and achieve tight, evenly stressed joints with a minimum probability of nuts, bolts or studs breaking or loosening.

THREAD LUBE Lubricate all threads with graphite and oil, molybenum disulphide, or another lubricant of comparable quality, except in instances where lubricants are incompatible with fastener application.

EVEN LOADING Tighten opposing fastenings in an alternating sequence to ensure even loading. Avoid possible distortion by use of correct tightening sequence.

Run up all nuts finger tight. Develop the required fastener stress in three steps, with a maximum 50 percent torque on the first pass.

VENDOR EQUIPMENT Refer to vendor instructions for proper torque values on vendor-supplied equipment.

COLUMN NUMBER		1	2	3
MATERIAL AND GRADE		Med. Carbon & Alloy Steel SAE Gr 5 ASTM A193 Gr B7, B7M A325, A449	AISI 304, 316 SS ASTM A193 Gr B8, B8M Monel Al Bronze	Carbon Steel SAE Gr 1 or 2 ASTM A307 Gr A or B
CLAMPING LOAD PRODUCED	(lubricated)	60,000 psi	20,000 psi	37,500 psi
	(non-lube)	45,000 psi	15,000 psi	28,000 psi
⅜ in. - 16		24 lbf•ft (33 N•m)	8 lbf•ft (11 N•m)	15 lbf•ft (20 N•m)
7/16 - 14		40 (54)	13 (18)	25 (34)
½ - 13		60 (81)	20 (27)	38 (52)
⅝ - 11		120 (163)	40 (54)	75 (102)
¾ - 10		220 (298)	70 (95)	135 (183)
⅞ - 9		340 (461)	110 (149)	210 (285)
1 - 8		520 (705)	170 (230)	325 (441)
1⅛ - 8		750 (1,017)	250 (339)	470 (637)
1¼ - 8		1,050 (1,424)	350 (475)	655 (888)

ASSEMBLY

BOWL UNIT ASSEMBLY The following procedure begins by adding components to the first stage, working upward. A pump with a six to fourteen inch bowl size (6A-14A) may be readily assembled by starting with the top components. A specific pump may have component variations, see cross section drawing and parts list:

1. Install first stage impeller key into shaft.
2. Slide first stage impeller onto shaft, over the key.

3a. **Sizes 6A-14A** Secure impeller with retaining rings.

3b. **Sizes 14B-22A** Secure impeller with lockcollar. Tighten capscrews, see TORQUE VALUES. Use lockwire to secure capscrews.

3c. **Shaft sleeves**, if provided, are now mounted.

4. Install suction bell sleeve, key and retaining rings.
5. Install first stage sleeve, key and retaining rings.
6. Slide suction bell and first stage bowl into place, taking care not to damage bowl bushing. Fasten bowl to suction bell. See TORQUE VALUES.

7a. **VCR AND VCR-DS (Closed Impeller)** Continue to assemble remaining impellers and bowls, checking after each stage is assembled for freedom of rotation.

7b. **VTR AND VTR-DS (Semi-Open Impeller)** Push shaft to suction end until second stage impeller is resting on wear surface then lock shaft and impeller by utilizing tapped hole at shaft bottom. When assembling stage 3 and higher, use shims as necessary between impeller hub and thrust ring so that each suceeding impeller is positioned against the bowl wear surface (within .002 in. or .051 mm).

BOWL, COLUMN, DISCHARGE HEAD ASSEMBLY See INSTALLATION, INSTALLATION of PARTIALLY ASSEMBLED PUMP.

TROUBLESHOOTING

MALFUNCTION	PROBABLE CAUSE	REMEDY
Pump fails to start pumping.	A. Pump not properly primed.	Reprime pump, be sure that suction line shutoff valve is fully open.
	B. Suction line clogged.	Check suction line pressure. If low, locate and remove obstructions.
	C. Impeller clogged with foreign material.	Back-flush pump to clean impeller.
	D. Wrong direction of rotation.	Be sure pump and driver rotate in indicated direction. See "direction of rotation" arrows on pump and driver cases.
	E. Suction lift too high.	Check with vacuum gauge. Suction pipe too long; shorten.
Pump output not up to capacity or pressure.	A. Air leak in suction line or through stuffingbox.	Check for leakage and correct.
	B. Impeller partly clogged.	Back-flush pump to clean impeller.
	C. Worn case rings or impeller rings.	Replace defective parts as required.
	D. Insufficient positive head in suction line.	Ensure that suction line shutoff valve is fully open and line is unobstructed.
	E. Defective or broken impeller.	Inspect and replace if necessary.
Pump starts, then stops pumping.	A. Improperly primed pump.	Reprime pump.
	B. Air or vapor pockets in suction line.	Rearrange piping as necessary, to eliminate air pockets.
Undue vibration of pump.	A. Partly clogged impeller caus-causing imbalance.	Back-flush pump to clean impeller.
	B. Broken or bent impeller or shaft.	Replace defective parts as required.
	C. Worn bearings.	Replace.
	D. Suction or discharge piping not anchored or properly supported.	Anchor them per Hydraulic Institute Manual recommendations.
	E. If pump is noisy, it is vaporbound.	Vent and bleed case. Reprime pump.
Excessive leakage from	A. Defective mechanical seal parts.	Replace defective parts.
	B. Overheating mechanical seal.	Check lubrication and cooling lines.
Motor runs hot.	A. Suction head lower than rating; pumping too much liquid.	Contact nearest Bingham-Willamette sales office for rating review.
	B. Motor rated at lower viscosity/ specific gravity than that of pumpage.	Contact nearest Bingham-Willamette sales office for rating review.

REPLACEMENT PARTS

SPARE PARTS

Spare parts should be kept on hand to reduce downtime. Service of a particular pump determines number of spare parts. It is recommended that the following parts be stocked:

1 Set of Gaskets and O-Rings
1 Set of Wear Rings with Setscrews
1 Set of Shaft Sleeves
1 Mechanical Seal
1 Set of Impellers
1 Set of Bushings
1 Set of Retaining Rings

ORDERING INFORMATION

Order parts through a local Bingham-Willamette field office. Provide:

(1) Pump serial number
(2) Cross section drawing number
(3) Description of part
(4) The number of part as shown on cross section drawing and parts list.

BINGHAM-WILLAMETTE COMPANY
A Division of GUY F. ATKINSON Company
PORTLAND, OREGON • SHREVEPORT, LOUISIANA

BINGHAM-WILLAMETTE LTD.
A GUY F. ATKINSON Company
VANCOUVER, B.C. • CAMBRIDGE, ONTARIO
CANADA

Parts List

PUMP: GASOLINE/JET FUEL/DIESEL/PIPELINE FOR, OIL PRODUCTS PIPELINE LTD. TEL-AVIV, ISRAEL		PUMP SERIAL NO. 4B290/291
TYPE: 8x12x16A VCR 3 STG.	SHEET NO. 1 of 1	DRAWING NO. B-4B290-3

FORM NO. 429

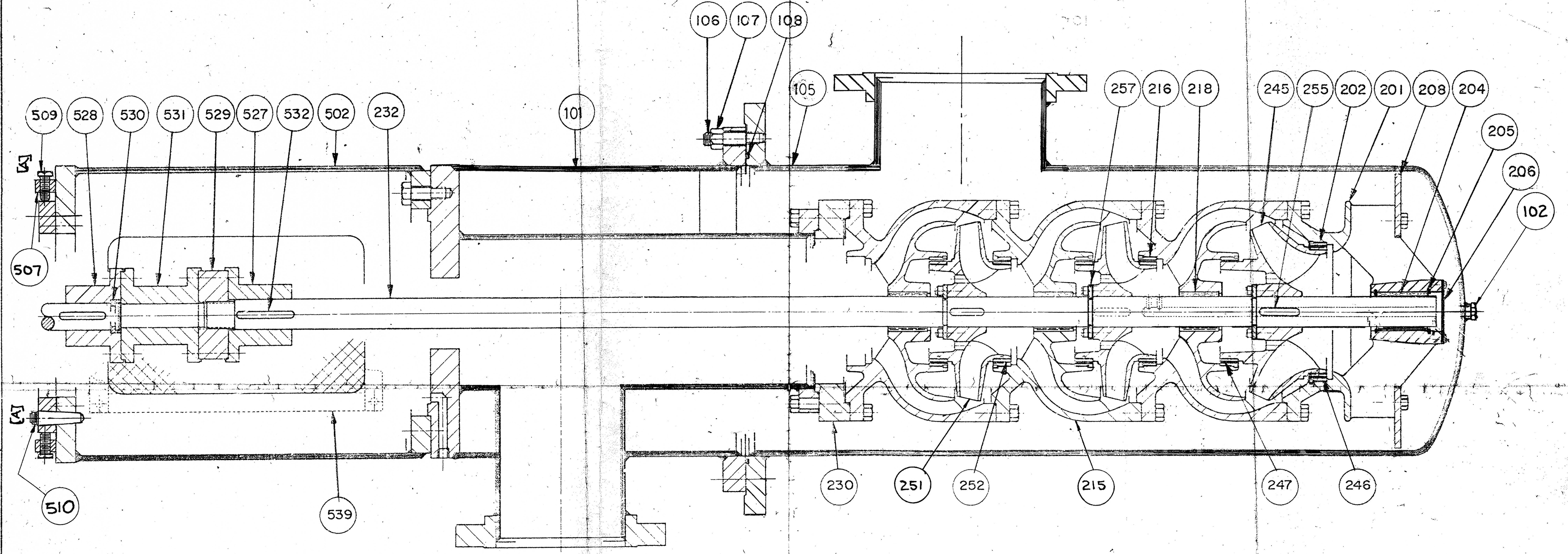
PART NO.	DESCRIPTION	PART NO.	DESCRIPTION
101	DISCHARGE HEAD	527	COUPLING HUB-PUMP
105	RECEIVER CAN	528	COUPLING HUB-DRIVER
106	STUD	529	ADJUSTING NUT
107	NUT	530	THRUST RING
108	"O"-RING	531	SPACER
201	BELL, SUCTION	539	COUPLING GUARD
202	RING, CASE	102	PLUG - 3/4"
204	BUSHING		
205	RING, RETAINING		
206	COVER		
208	PLATE, FLOW DIFFUSING		
215	BOWL		
216	RING, CASE		
218	BUSHING		
230	ADAPTOR, ELEMENT		
232	PUMP SHAFT		
245	IMPELLER, 1ST STAGE		
246	RING, WEAR (IMPELLER EYE)		
247	RING, WEAR (IMPELLER HUB)		
251	IMPELLER, SERIES STAGE		
252	RING, WEAR (IMP. EYE AND HUB)		
255	KEY		
257	COLLAR, LOCK		
502	DRIVER STAND		
507	JACKSCREW PAD		
509	JACKSCREWS		
510	TAPER PINS		

FOR BINGHAM OFFICE USE ONLY.

FOR BINGHAM OFFICE USE ONLY.

Unnumbered parts in the illustrations are the same as corresponding parts with numbers.

Bingham Factories: PORTLAND, OREGON • SHREVEPORT, LOUISIANA • VANCOUVER, B. C. CANADA



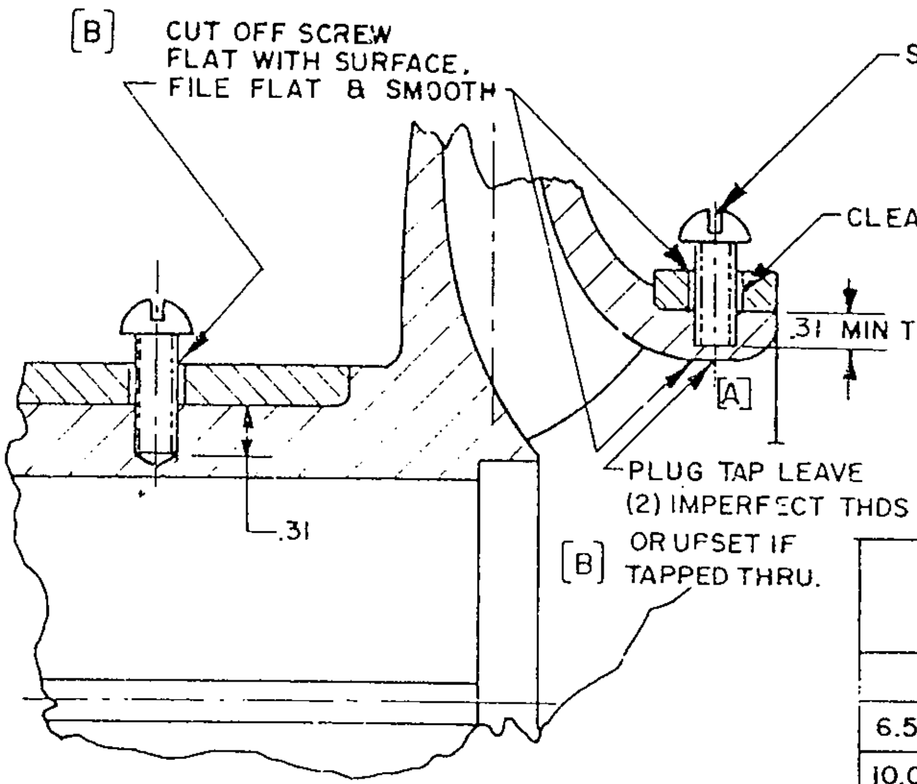
REV	REVISION DESCRIPTION	INIT.	APPD.	DATE
[A]	ITEM 533 DELETED; ITEMS 507, 509 & 510 ADDED	AHD	Ry	3-3-'83

Bingham-Willamette Company	PORTLAND, OR. SHREVEPORT, LA.	VERTICAL TURBINE PUMP BINGHAM TYPE "VCR"	B-4B290-3	REV [A]
Bingham-Willamette Ltd.	VANCOUVER, B.C. CAMBRIDGE, ONT.			

REV.	REVISION DESCRIPTION	INIT.	APPD.	DATE
[A]	ELIMINATED DRILL THRU AND ADDED NOTE TO SEE TYPE "H"	RVC		3/13/80
[B]	ADDED NOTES	WF	JH	12-15-82

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
GENERAL TOLERANCES:
MACHINING: ANG ± 0°30' LIN ± .02
FABRICATION: ANG ± 1°0' LIN ± .12

A52134



NOTE: RING DETAILS TO INCLUDE QTY AND SIZE OF CLEARANCE HOLES FOR SCREWS.

RING DIA (O.D.)	*QTY & SIZE/SCREWS* RD. HD. MACH. SCREW MATERIAL ✱ AISI 316	*DRILL SIZE* FOR RINGS
TO 6.50	3 - 1/4-28 x .75 LG.	'F' DRILL = .257
6.51 TO 10.00	6 - 1/4-28 x .75 LG.	'F' DRILL = .257
10.01 TO 15.00	6 - 5/16-18 x 1.00 LG.	'P' DRILL = .323
OVER 15.01	6 - 3/8-24 x 1.00 LG.	'W' DRILL = .386

FOR LARGE DIAS AT HIGH SPEEDS AND HIGH TEMPS CONSIDERATION SHOULD BE GIVEN AS TO SIZE & QUANTITY. (SEE TYPE "H" DWG. A-54927) [A]

SEE INSTRUCTIONS (E21.2) UNDER TYPE "D"

Bingham-Willamette Company	PORTLAND, OR. SHREVEPORT, LA.	LOCKING OF IMPELLER RINGS TYPE "D" E21.2	
Bingham-Willamette Ltd.	VANCOUVER, B. C.	DR. / APPD. / DATE / SCALE: — REF. E21.2 USED FIRST TYPE "D"	A52134 REV. B

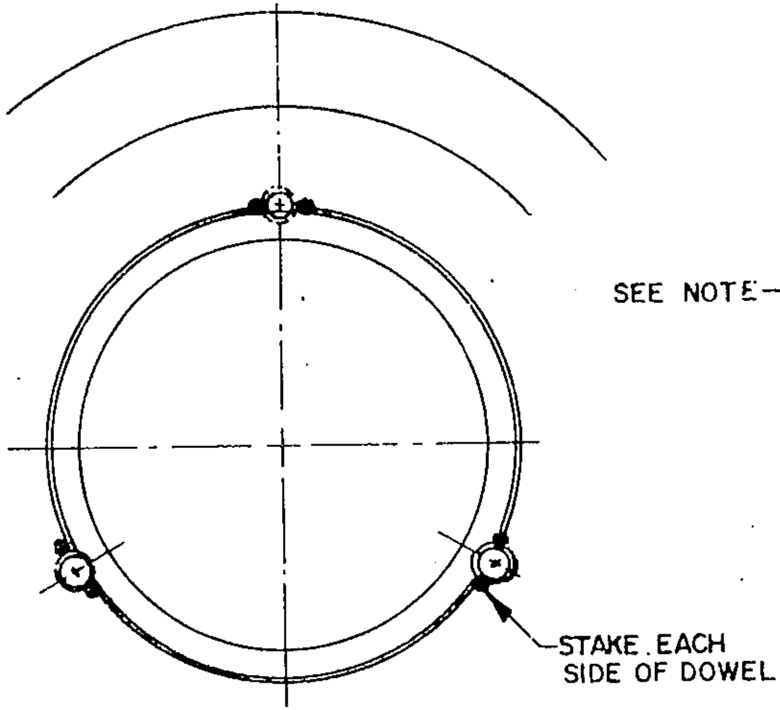
FORM No. 566-1

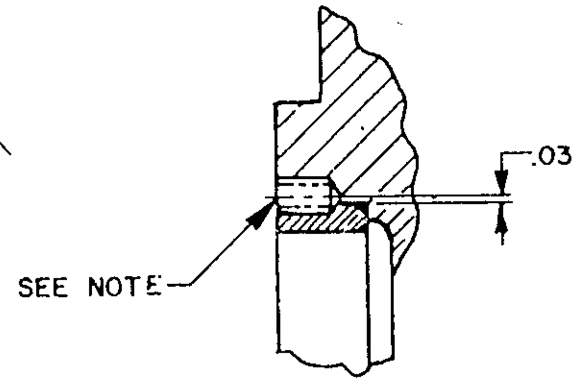
A52136

REV.	REVISION DESCRIPTION	INIT.	APPD.	DATE
[A]				
[B]				

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
GENERAL TOLERANCES:

MACHINING:	FABRICATION:
ANG ±0°30'	ANG. ±1°0'
LIN ±.02	LIN ±.12





NOTE:

DRILL & TAP FOR 3-1/4-20, EQ. SPACED. ℄ OF HOLE IS TO BE OFFSET .030 INTO CASE TO MINIMIZE DRILL WANDER.

INSTALL SCREWS CAREFULLY TO PREVENT RING DISTORTION.

SCREWS = 3-1/4-20 x .38LG. ALLEN SOCKET SET SCREWS 18-8 SS <u>TO BE CALLED OUT ON LIST</u>

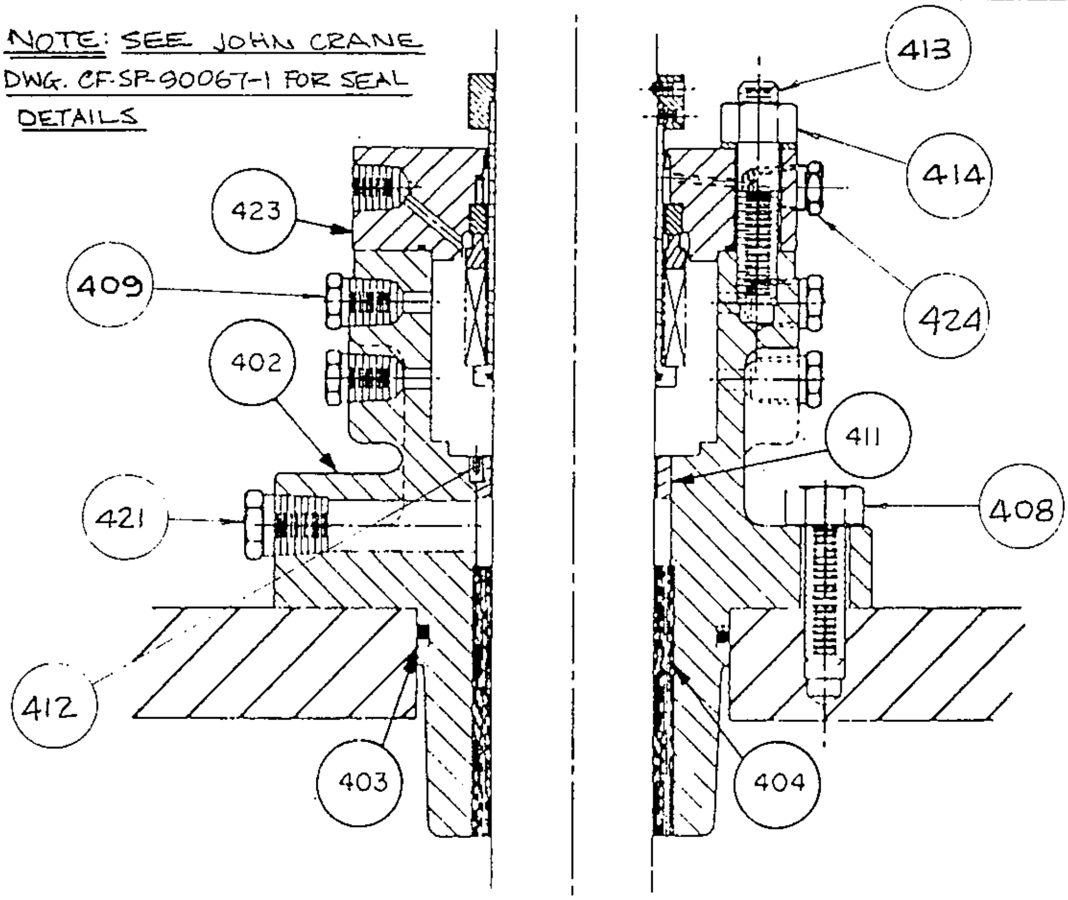
SEE INSTRUCTIONS (E21.2) UNDER TYPE "F"

Bingham-Willamette Company	PORTLAND, OR. SHREVEPORT, LA.	LOCKING OF BOWL RINGS (ABOVE 10B VERT. PUMPS) TYPE "F"
Bingham-Willamette Ltd.	VANCOUVER, B. C.	DR. [signature] APPD. [signature] DATE: 10/20/77 SCALE: [signature] — REF. E 21.2 — USED FIRST TYPE "F" — A52136 — REV.

FORM No. 566-1

PART NO.	DESCRIPTION	B.W. USE ONLY
402	STUFFING BOX	
403	"O" RING	
404	BUSHING, STUFF. BOX	
408	CAPSCREW 3/4 x 2½ LG.	
409	PIPE PLUG ½	
411	THROAT BUSHING	

PART NO.	DESCRIPTION	B.W. USE ONLY
412	SCREW ¼ x 3/8 LG	
413	STUD 3/4 x 4½ LG	
414	NUT 3/4	
421	PLUG 3/4	
423	MECHANICAL SEAL	
424	PLUG ½	



STUFFING BOX ASSEMBLY

STUFFING BOX ASSEMBLY FIGURE 2

Bingham

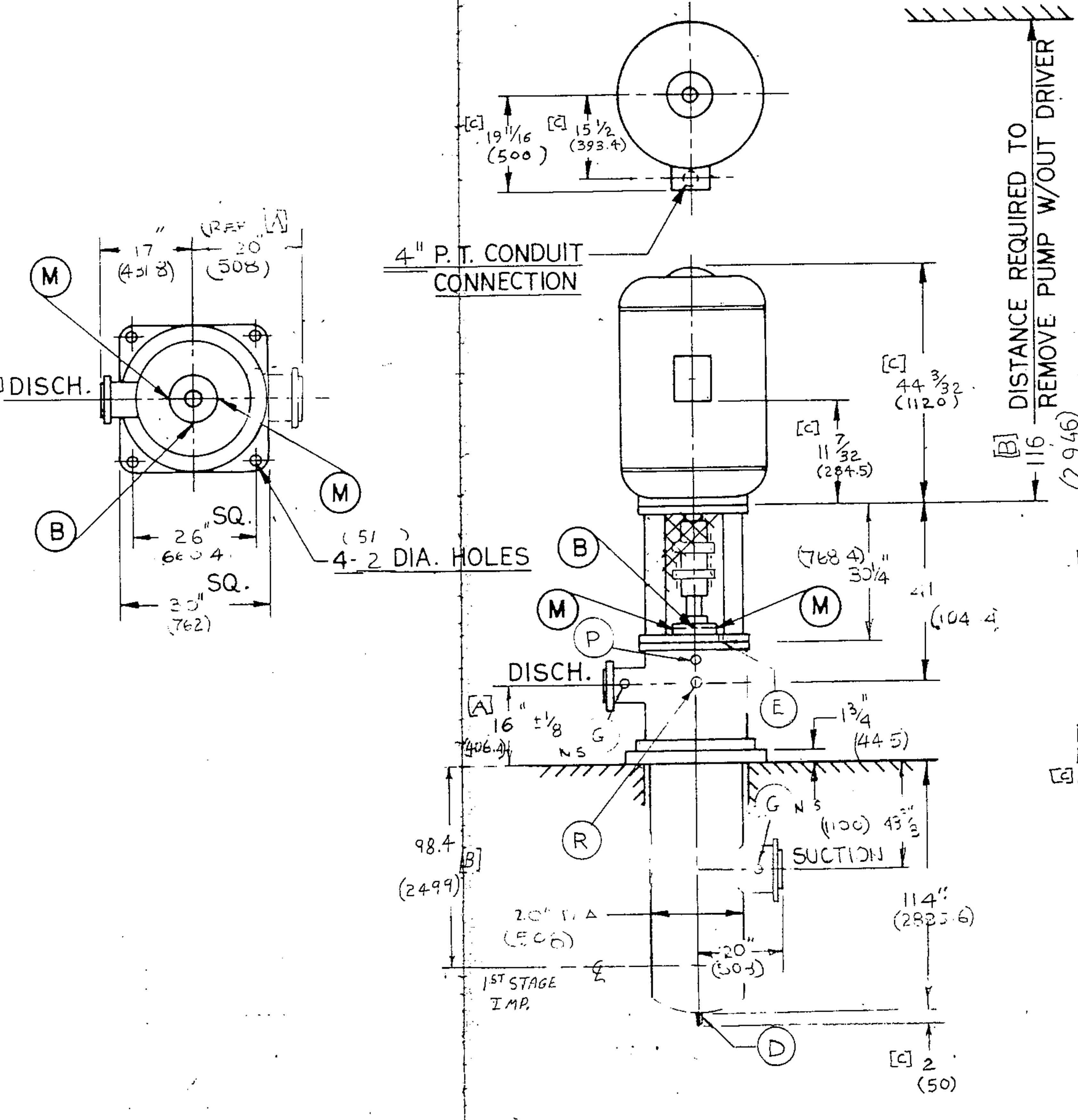
PUMP DEPARTMENT of BINGHAM-WILLAMETTE CO.
PORTLAND, ORE. - SHREVEPORT, LA.
PUMP COMPANY LTD.
VANCOUVER B. C., CANADA

A-4B290-2

MASTER B21733

ITEM	LEGEND ▲ PIPE PLUG ■ PROTECTIVE CAP ● PIPED BY BINGHAM		PIPE TAP	
A				
B	BY-PASS CONNECTION	●	1/2	
C				
D	DRAIN CONNECTION	▲	3/4	
E	DRIVER STAND DRAIN		1/2	[D]
F				
G	GAGE CONNECTION	▲	3/4	
H				
K				
M	QUENCH-IN and OUT	▲	1/2	[C]
N				
P	VENT CONNECTION	▲	3/4	
R	RETURN TO SUCTION CONN.	o	3/4	[C][D]
S				

NOTE
1. DIMENSIONS IN BRACKETS ARE IN MILLIMETERS [D]
2. REFER TO DWG B-4B290-4 FOR SEAL CIRCULATION PIPING SCHEMATIC [C]



ADD ITEM E (WAS R); ITEM R RELOCATED; SEAL CIRCULATION DWG NOW B-4B290-4
[D] BY: mgm DATE: 1-2-83

CAUTION! Carefully Check Alignment Before Starting Unit. All Holes in Flanges Straddle Centerlines. Unit Should be Relieved of Excess Piping Strains.

UNIT DATA

PUMP SPECIFICATIONS
- SIZE and TYPE: 8x12x16A VCR
- NO. STAGES: 3 RPM: 1460 [B]
- ROTATION: CCW (AS VIEWED FROM DRIVER)
- DISCHARGE FLG. 8"-300 #ANSI R.F.
- SUCTION FLANGE: 12"-300 #ANSI R.F.
- MECH. SEAL: CRANE 8B1
- TYPE: CARTRIDGE CODE: XF1D1
- ~~PACKING:~~
- ~~NO. RINGS: SIZE:~~
- ~~ASSEMBLY:~~

COUPLING
ADJUSTABLE FLANGE SPACER TYPE
MFG. BY BINGHAM-WILLAMETTE
CPLG GD. - ALUMINUM

DRIVER SPECIFICATIONS
- DRIVER: LOUIS ALLIS
- FURNISHED BY: OTHERS
- FRAME: 445LP
- HP: 100 SPEED: 1460 RPM
- 380 VOLT, 3 PHASE, 50 CYCLE
- [C] DIMEN. PRINT: E-130034-0002

WEIGHTS
[B]	PUMP ASSEMBLY:	2981 KG
[B]	RECEIVER CAN:	724 KG
[C][B]	DRIVER:	930 KG
	TOTAL:	4698 KG

CUSTOMER DATA
- USER: OIL PRODUCTS PIPELINE LTD TEL AVIV
- FOR INSTALLATION AT: TEL AVIV, ISRAEL
- PURCHASER: OIL PRODUCTS PIPELINE LTD. TEL AVIV
- PURCHASE ORDER NO.: EG-9-2796-A
- ITEM NO.:
- SERVICE: GASOLINE, JET FUEL, DIESEL OIL
- PUMP SIZE and TYPE: 8x12x16A VCR

REVISIONS			
930 KG WAS 993 KG; NOTE ADDED; ITEM "D" WAS CAPPED, NOW PIPE PLUG; ADD 2" TO REC'R CAN; ADD MOTOR DIMENSIONS [C] BY: mgm DATE 6-12-82	ADDED 993 Kg ADDED 116"; 2981 KG was 6572 LBS; 724 KG was 1596 LBS; RPM was 3560 ADDED 1ST STAGE IMP. [B] BY: BRC DATE 11-5-82	-DIM WAS 14 3/4 ... 16; -2 ...; ADDED ...; -DIM WAS 41 1/4 ... 41" [A] BY AHD DATE 11/2/82	

	BY	APPROVED	DATE
☒ CERTIFIED FOR INSTALLATION	mgm		8-12-82
☒ PRELIMINARY-CERTIFIED FOR NOZZLE & MOUNTING LOCATIONS ONLY	AHD	WB	10/7/82
☐ PRELIMINARY-FOR REVIEW ONLY			

Bingham-Willamette Company — PORTLAND, OR. SHREVEPORT, LA.
Bingham-Willamette Ltd. — VANCOUVER, B.C.

PUMP SERIAL NUMBERS 4B290/1

OUTLINE DIMEN. DRAWING B-4B290-1 REV D

Parts List

PUMP: COLUMN DETAIL OF PIPELINE PUMP FOR OIL PRODUCTS PIPELINE LTD. TEL-AVIV, ISRAEL		PUMP SERIAL NO. 4B290
TYPE: 8x12x16A VCR 3 STG.	SHEET NO. 1 of 1	DRAWING NO. B-4B290-2

FORM NO. 429

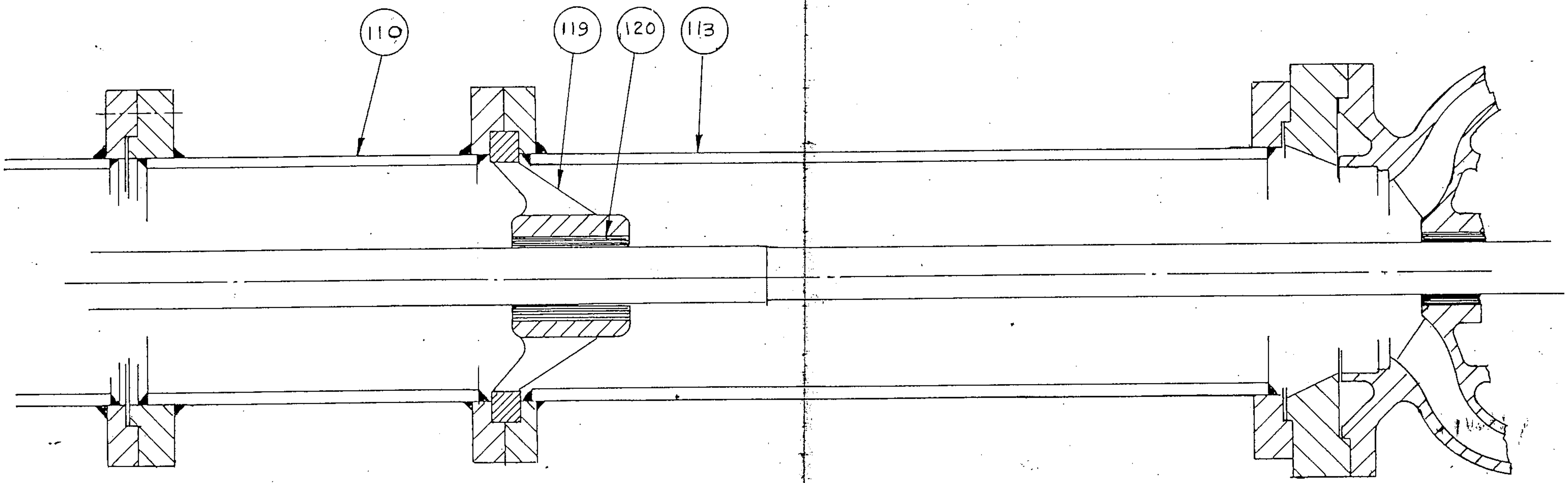
PART NO.	DESCRIPTION	FOR BINGHAM OFFICE USE ONLY.	PART NO.	DESCRIPTION	FOR BINGHAM OFFICE USE ONLY.
110	COLUMN, 19-1/2" LG.				
113	COLUMN, 34" LG.				
119	HOUSING, BEARING				
120	BUSHING				

Unnumbered parts in the illustrations are the same as corresponding parts with numbers.

MASTER DRG. B-39877

B-4B290-2

REV.	REVISION DESCRIPTION	INIT.	APPD.	DATE
[A]				
[B]				



UNLESS OTHERWISE SPECIFIED DIMENSIONS NOT BRACKETED ARE IN ______ DIMENSIONS IN BRACKETS [ ] ARE IN ______

GENERAL TOLERANCES

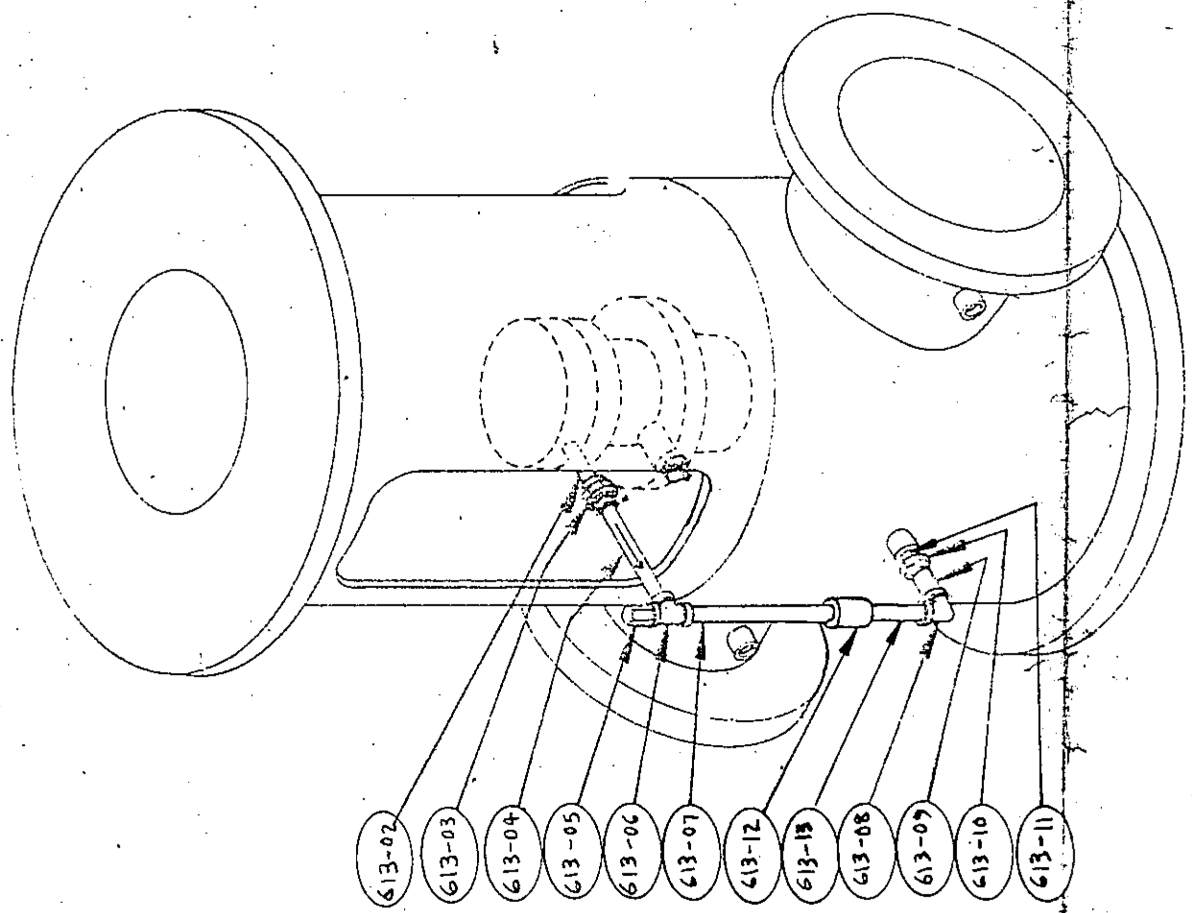
TYPE OF DIMEN.	INCH SYSTEM MACHINING	INCH SYSTEM FABRICATION	METRIC SYSTEM MACHINING	METRIC SYSTEM FABRICATION
ANGULAR	± 0.5°	± 1.0°	± 0.5°	± 1.0°
LINEAR	± 0.02 in	± 0.12 in	± 0.5 mm	± 3 mm

Bingham-Willamette Company	PORTLAND, OR SHREVEPORT, LA.	PATT. NO.	VCR COLUMN DETAIL	B-4B290-2
Bingham-Willamette Ltd.	VANCOUVER, B.C. CAMBRIDGE, ONT	REF.	FIRST USED B-38021 · DR. AHD · APPD. Ag · DATE JAN 9, 1983 · SCALE: NONE	REV.

FORM NO. 567-2

B-4B290-4

REV.	REVISION DESCRIPTION	INIT.	APPD.	DATE
[A]	COMPLETE ITEM N[os] (WERE SUB N[os] ONLY)	mjm	Ry	FEB 10 '83
[B]	LEGEND ADDED	AHD	Ry	MAR 8 '83



ITEM NO	PARTS DESCRIPTION
613-13	NIPPLE 3/4 x 2" LG
613-12	COUPLING 3/4" x 1/2"
613-11	NIPPLE 3/4" x 2" LG
613-10	UNION 3/4"
613-09	NIPPLE 3/4" x 2" LG
613-08	ELBOW 3/4"
613-07	PIPE 1/2" SCH 80
613-06	TEE 1/2"
613-05	PLUG 1/2"
613-04	PIPE 1/2" SCH 80
613-03	UNION 1/2"
613-02	NIPPLE 1/2" x 2" LG

613 ASSEMBLY

613 ASSEMBLY

UNLESS OTHERWISE SPECIFIED DIMENSIONS NOT BRACKETED ARE IN ________ DIMENSIONS IN BRACKETS [ ] ARE IN ________

GENERAL TOLERANCES

TYPE OF DIMEN.	INCH SYSTEM MACHINING	INCH SYSTEM FABRICATION	METRIC SYSTEM MACHINING	METRIC SYSTEM FABRICATION
ANGULAR	± 0.5°	± 1.0°	± 0.5°	± 1.0°
LINEAR	± 0.02 in	± 0.12 in	± 0.5 mm	± 3 mm

Bingham-Willamette Company	PORTLAND, OR. SHREVEPORT, LA.	PATT. NO.	SEAL CIRC. PIPING API PLAN 13-PIPE
Bingham-Willamette Ltd.	VANCOUVER, B.C. CAMBRIDGE, ONT.	REF. B-39714 FIRST USED 4B290	DR. mjm APPD. Ry DATE 1-2-83 SCALE: ——

B-4B290-4

REV.

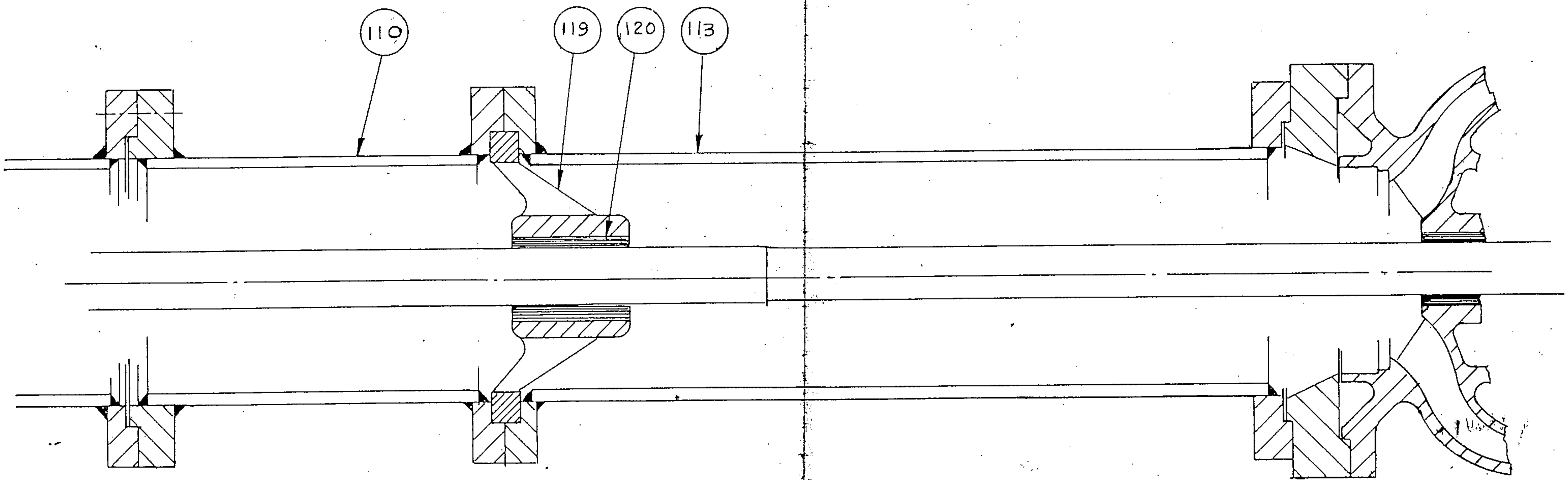
FORM NO. 567-2

11-23-82

MASTER DRG. B-39877

B-4B290-2

REV.	REVISION DESCRIPTION	INIT.	APPD.	DATE
[A]				
[B]				



UNLESS OTHERWISE SPECIFIED DIMENSIONS NOT BRACKETED ARE IN ______ DIMENSIONS IN BRACKETS [ ] ARE IN ______

GENERAL TOLERANCES

TYPE OF DIMEN.	INCH SYSTEM MACHINING	INCH SYSTEM FABRICATION	METRIC SYSTEM MACHINING	METRIC SYSTEM FABRICATION
ANGULAR	± 0.5°	± 1.0°	± 0.5°	± 1.0°
LINEAR	± 0.02 in	± 0.12 in	± 0.5 mm	± 3 mm

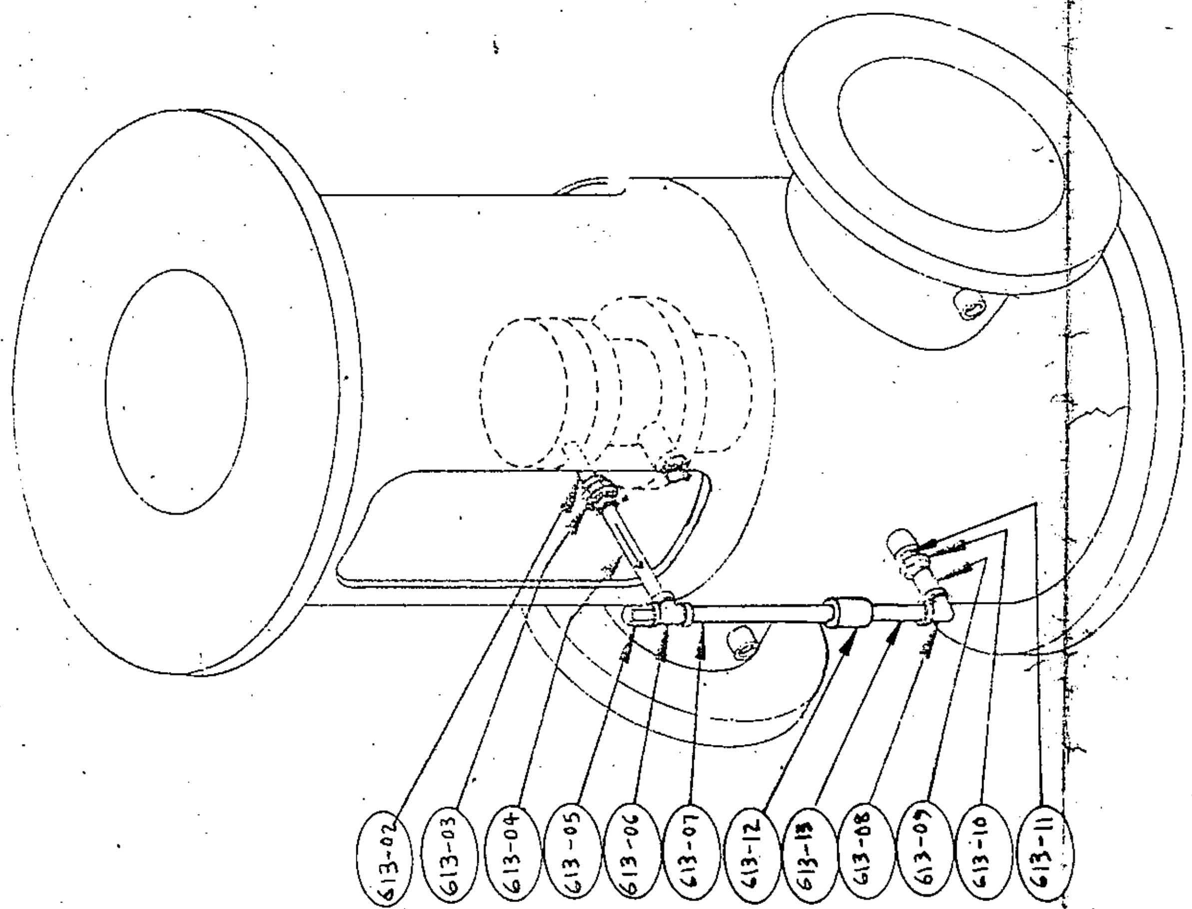
Bingham-Willamette Company	PORTLAND, OR SHREVEPORT, LA.	PATT. NO.	VCR COLUMN DETAIL	B-4B290-2
Bingham-Willamette Ltd.	VANCOUVER, B.C. CAMBRIDGE, ONT	REF.	FIRST USED B-38021	DR. AHD · APPD. [illegible] · DATE JAN 9, 1983 · SCALE: NONE

REV.

FORM NO. 567-2

B-4B290-4

REV.	REVISION DESCRIPTION	INIT.	APPD.	DATE
[A]	COMPLETE ITEM N^os (WERE SUB N^os ONLY)	mgm	Ry	FEB 10 '83
[B]	LEGEND ADDED	AHD	Ry	MAR 8 83



ITEM NO	PARTS DESCRIPTION
613-13	NIPPLE 3/4 x 2"LG
613-12	COUPLING 3/4" x 1/2"
613-11	NIPPLE 3/4" x 2" LG
613-10	UNION 3/4"
613-09	NIPPLE 3/4" x 2" LG
613-08	ELBOW 3/4"
613-07	PIPE 1/2" SCH 80
613-06	TEE 1/2"
613-05	PLUG 1/2"
613-04	PIPE 1/2" SCH 80
613-03	UNION 1/2"
613-02	NIPPLE 1/2" x 2" LG

613 ASSEMBLY

613 ASSEMBLY

UNLESS OTHERWISE SPECIFIED DIMENSIONS NOT BRACKETED ARE IN ______. DIMENSIONS IN BRACKETS [ ] ARE IN ______

GENERAL TOLERANCES

TYPE OF DIMEN.	INCH SYSTEM		METRIC SYSTEM	
	MACHINING	FABRICATION	MACHINING	FABRICATION
ANGULAR	[illegible]	[illegible]	± 0.5°	± 1.0°
LINEAR	[illegible]	± 0.12 in	± 0.8 mm	± 3 mm

Bingham-Willamette Company	PORTLAND, OR. SHREVEPORT, LA.	PATT. NO.	SEAL CIRC. PIPING API PLAN 13-PIPE
Bingham-Willamette Ltd.	VANCOUVER, B.C. CAMBRIDGE, ONT.	REF. B-39714 — FIRST USED 4B290	DR. mgm — APPD. Ry — DATE 1-2-83 — SCALE: ——

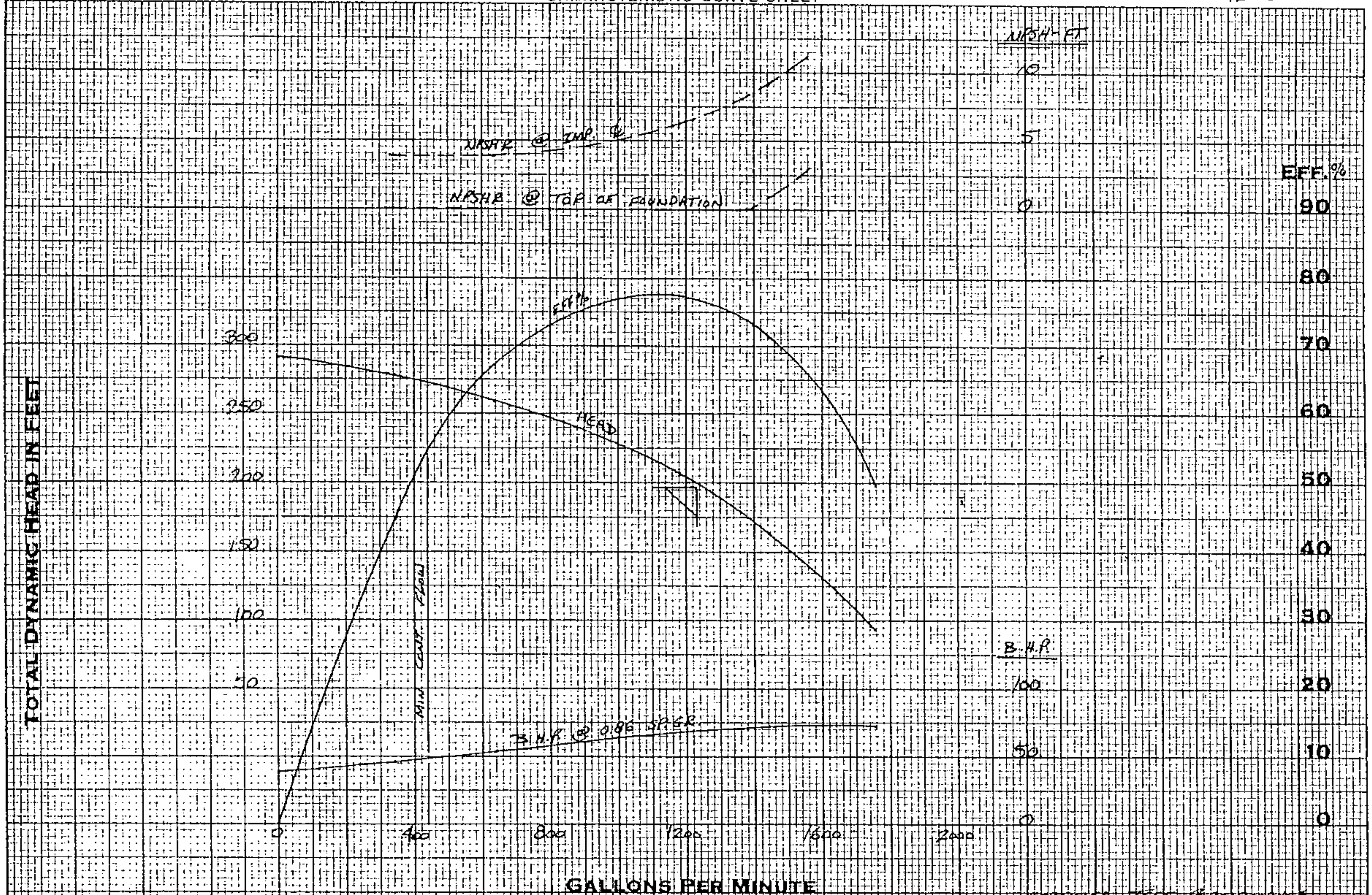
B-4B290-4

REV.

FORM NO. 567-2

11-23-82

CHARACTERISTIC CURVE SHEET   C-4258



CERTIFIED TEST PERFORMANCE
BINGHAM-WILLAMETTE LTD
VANCOUVER, B.C.

** NOTE: TRIMMED AFTER TEST
* NOTE: ACTUAL TEST WAS RUN @ 1780 RPM

OIL PRODUCTS PIPELINE LTD. PRESENT: PIPELINE PUMP FUTURE: FEEDING HIGH PRESS. BOOSTERS PUMP.	PUMP ENGINEERING DEPT BINGHAM-WILLAMETTE COMPANY PORTLAND OREGON & SHREVEPORT LA BINGHAM-WILLAMETTE LTD. VANCOUVER B.C. & CAMBRIDGE ONTARIO	IMPELLER MAX. ① 11⅝" BD @ 25" DIA ③ 12 3/16" BD @ 12½"	8×12×16 A VCR 3 STG. PUMP		
		MIN DIA	** DIA. IMPELLER ① 10 15/16" B.D. @ 25" ③ 11 3/8" B.D @ 12½"	IMPELLER PATT. ① 1613 VCL ③ 1613 VC-1	1460* R.P.M.
PUMP Nº 4B290	D.G.N. 4 FEB '83	EYE AREA 43.6 SQ. IN.	N.P.S.H. REQUIRED	REFERENCE	CURVE No C-4258

I: 29 . H' 3.9' V.: [illegible] 24+ 1.8

TEMP: ① 71.2°F ② 73.1°F ③ 74.3°F ④ 76.1°F

HVP: ① 0.9' ② 0.9' ③ 1.0' ④ 1.0'

$Hv^2/2g$: $0.125\left(\frac{GPM}{1000}\right)^2$ = ① 0.0' ② 0.1' ③ 0.3' ④ 0.4'

BINGHAM-WILLAMETTE CO. PORTLAND, OREGON - SHREVEPORT, LOUISIANA
BINGHAM-WILLAMETTE LTD. BURNABY B.C. CANADA
HYDRAULIC TEST DATA SHEET

PUMP SIZE & TYPE	STGS	CUSTOMER	CURVE Nº	PUMP TEST
8x12x16 A VCR	3	OIL PRODUCTS PIPELINE LTD.	C-4258	4B290

CONDITION	RPM	T D HEAD	G P M	EFF	SP GR
FIELD	1460	196.8	1233	74.3	0.86
TEST					

ASSEMBLY	EYE DIA	EYE AREA	TEST MOTOR	JOB
	8	43.6 SQ IN	VM-9 150 H.P.	4B290/1

DISCHARGE PIPE I D — SUCTION PIPE I D

R P M 1800 — EFF @ ¼: @ ½: @ ¾: @ 1: @ 1¼: @ 1½:

TESTED BY: D.G.N. — DATE: 4 FEB '83 — START: 0810 HR. — STOP: 1030 HR

STG	IMP PATT	VANE	IMP MAX DIA	IMP. TEST DIA	TRIM AFTER TEST
1	1613 VCL	3	11⅝" B.D. @ 25°	11⅜" B.D. @ 25°	10 15/16" B.D. @ 25°
S	1613 VC-1	6	12 3/16" B.D. @ 12½°	11 13/16" B.D. @ 12½°	11⅜" B.D. @ 12½°

REMARKS. NPSH = Ha + Hs + $Hv^2/2g$ − Hvp ± H ELEV.
① 6.0' = 33.9 + Hs + 0.0 − 0.9 + 1.8 ∴ Hs = −28.8
② 6.0' = 33.9 + Hs + 0.1 − 0.9 + 1.8 ∴ Hs = −28.9
③ 9.5' = 33.9 + Hs + 0.3 − 1.0 + 1.8 ∴ Hs = −25.5
④ 13.6' = 33.9 + Hs + 0.4 − 1.0 + 1.8 ∴ Hs = −21.5

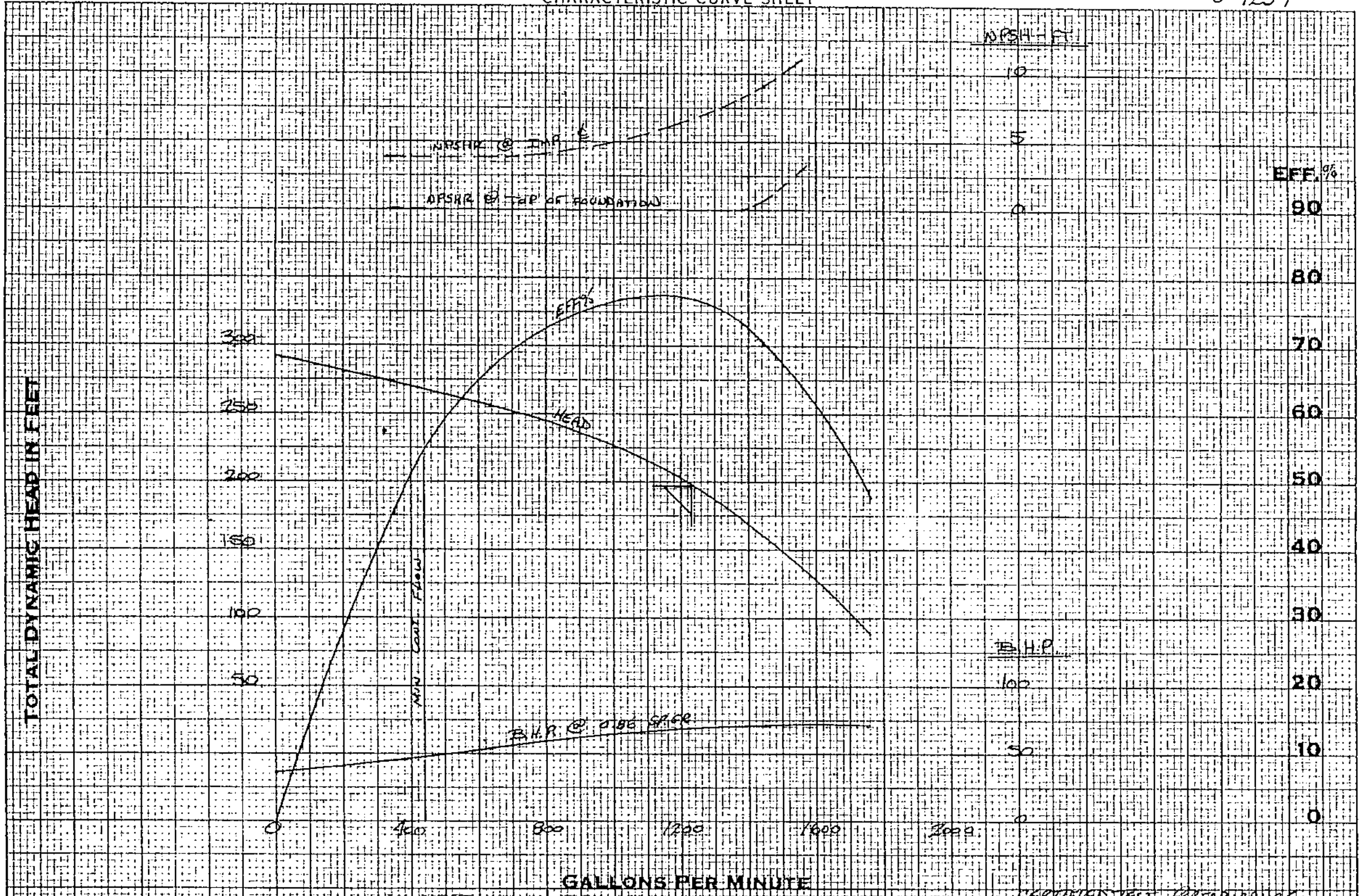
Suction: HG COL — Discharge: DWT 'C' — Hv: 0.50 FT PER /1000 GPM — Capacity: METER 4"x6" VENTURI K=366.1 — Power: F=200 — Corrected to constant speed of 1460 RPM & IMPELLER TRIM

RUN NO.	SPEED RPM	SUCTION IN HG / PSI	SUCTION FEET OF WATER	DISCHARGE PSI	DISCHARGE FEET OF WATER	GAGE TO GAGE ELEV	Hv GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY IN. HG	IN. H2O	CAPACITY G P M	WATTS READ		B H P OUTPUT	WATER H P	PUMP EFF %	T D H	G P M	B H P	BHP @ 0.86 SP.GR.
1	1788		9.4	202	466.6		0.1	457.3	1.45		440.8	460		113.5	50.9	44.9	278.7	344.1	54.0	46.4
① 2			−28.8	183¾	424.5		✓	453.4	✓		✓	✓								
3	1786		9.1	187¼	432.5		0.3	423.7	5.0		818.6	529		130.5	87.6	67.1	258.8	639.7	62.3	53.6
② 4			−28.9	169½	391.5		✓	420.7	✓		✓	528								
5	1780		8.3	149¼	344.8		1.1	337.6	16.9		1505.0	670		166.2	128.3	77.2	207.6	1180.1	80.1	68.9
③ 6			−25.5	133¼	307.8		✓	334.4	✓		✓	669								
7	1779		7.8	118½	273.7		1.7	267.6	25.25		1839.6	700		174	124.3	71.5	164.7	1443.3	84.0	72.3
④ 8			−21.5	104¼	240.8		✓	264.0	✓		✓	700								
9	1778		7.1	68	157.1		2.5	152.5	37.35		2237.4	700		174	86.2	49.5	94.0	1756.4	84.2	72.4
10	1789		9.4	211¼	488.0		—	478.6	0		0	385		94.5	—	—	291.3	0	44.9	38.6
11																				
12																				
13																				
14																				

CERTIFIED TEST PERFORMANCE
BINGHAM-WILLAMETTE LTD.
VANCOUVER, B.C.
BY: [signature] DATE: 4 FEB '83

CHARACTERISTIC CURVE SHEET

C-4254



** NOTE: TRIMMED AFTER TEST

* NOTE: ACTUAL TEST WAS RUN @ 1780 RPM

CERTIFIED TEST PERFORMANCE
BINGHAM-WILLAMETTE LTD
VANCOUVER, B.C.

OIL PRODUCTS PIPELINE LTD. PRESENT: PIPELINE PUMP FUTURE: FEEDING HIGH PRESS. BOOSTERS PUMP	PUMP ENGINEERING DEPT. BINGHAM-WILLAMETTE COMPANY PORTLAND OREGON & SHREVEPORT LA BINGHAM-WILLAMETTE LTD. VANCOUVER B.C. & CAMBRIDGE ONTARIO	IMPELLER MAX ① 11 3/8" B.D @ 25 DIA ⑤ 12 1/2" B.D @ 12 1/2	8 × 12 × 16 A VCR 3 STG. PUMP		
		MIN. DIA	* DIA. IMPELLER ① 10 5/16" B.D. @ 25" ⑤ 11 3/8" B.D @ 12 1/2"	IMPELLER PATT ① 1613 VCL ⑤ 1613 VC-1	1460* R.P.M.
PUMP Nº 4B291	D.G.N. 3 FEB '83	EYE 43.6 SQ AREA IN	N P S H REQUIRED ,	REFERENCE	CURVE NO C-4259

TEMP: ① 69.3°F ② 71.4°F ③ 74.5°F ④ 76.1°F

Hvp: ① 0.8' ② 0.9' ③ 1.0' ④ 1.0'

BINGHAM-WILLAMETTE CO. PORTLAND, OREGON - SHREVEPORT, LOUISIANA

BINGHAM-WILLAMETTE LTD. BURNABY B.C. CANADA

$Hv^2/2g : 0.125 \left(\frac{GPM}{1000}\right)^2 =$ ① 0.0' ② 0.1' ③ 0.3' ④ 0.4'

HYDRAULIC TEST DATA SHEET

PUMP SIZE & TYPE	STGS	CUSTOMER	CURVE No	PUMP TEST
8×12×16 A VCR	3	OIL PRODUCTS PIPELINE LTD.	C-4259	4B291

CONDITION	RPM	T D HEAD	G P M	EFF	SP GR
FIELD	1460	196.8	1233	74.3	0.86
TEST					

ASSEMBLY: — EYE DIA: 8 — EYE AREA: 43.6 SQ IN — DISCHARGE PIPE: I D — SUCTION PIPE: I D

TEST MOTOR: YM-9 150 H.P. — RPM: 1800 — EFF @ ¼: @ ½: @ ¾: @ 1: @ 1¼: @ 1½:

JOB: 4B290/1 — TESTED BY: D.G.N. — DATE: 3 FEB '83 — START: 9000 HR — STOP: 1150 HR.

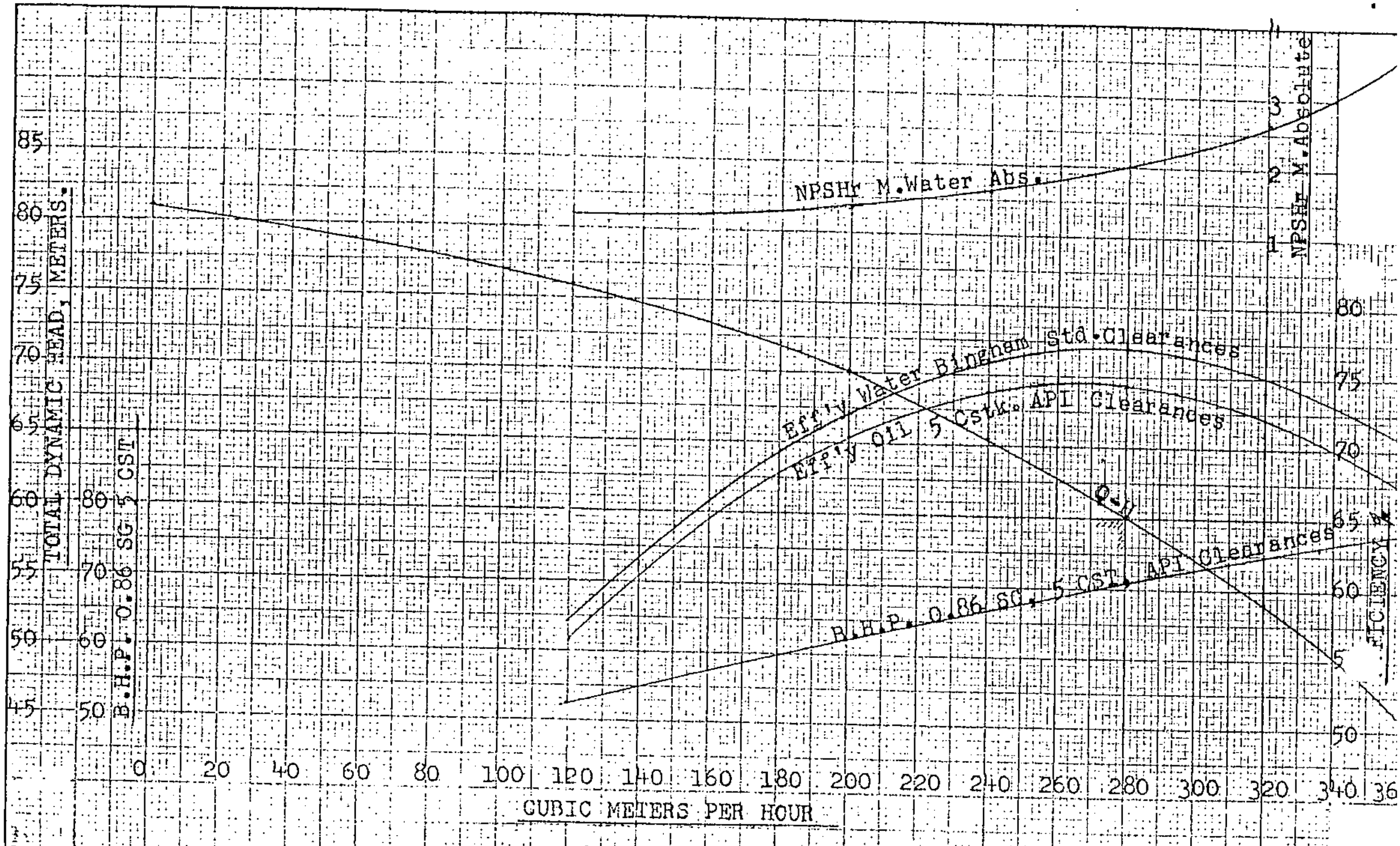
STG.	IMP PATT	VANE	IMP MAX DIA	IMP TEST DIA	TRIM AFTER TEST
1	1613 VCL	3	11 5/8" B.D. @ 25°	11 3/8" B.D. @ 25°	10 15/16" B.D. @ 25°
S	1613 VC-1	6	12 3/16" B.D. @ 12½°	11 13/16" B.D. @ 12½°	11 3/8" B.D. @ 12½°

REMARKS: NPSH = Ha + Hs + $Hv^2/2g$ − Hvp ± Helev.
① 6.0' = 34.0 + Hs + 0.0 − 0.8 + 1.8 ∴ Hs = −29.0
② 6.0 = 34.0 + Hs + 0.1 − 0.9 + 1.8 ∴ Hs = −29.0
③ 9.5 = 34.0 + Hs + 0.3 − 1.0 + 1.8 ∴ Hs = −25.6
④ 13.6 = 34.0 + Hs + 0.4 − 1.0 + 1.8 ∴ Hs = −21.6

Suction: HG COL — Discharge: DWT 'C' — Meter: 4"×6" VENTURI K = 366.1 — Power: F = 200 — Corrected to constant speed of 1460 RPM, 6" IMPELLER TRIM

	RUN NO.	SPEED RPM	SUCTION IN HG	SUCTION FEET OF WATER	DISCHARGE PSI	DISCHARGE FEET OF WATER	GAGE TO GAGE ELEV	H_v 0.50 FT PER 1000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY IN HG	CAPACITY IN H2O	CAPACITY G P M	WATTS READ			B H P OUTPUT	WATER H P	PUMP EFF %	CORRECTED T D H	CORRECTED G P M	CORRECTED B.H.P	B.H.P. @ 0.86 SP.GR.
	1	1788		9.3	199¼	460.3		0.1	451.1	1.45		440.8	450			111	50.2	45.2	274.9	344.1	52.8	45.4
①	2			-29.0	181	418.1		✓	447.2	✓		✓	✓									
	3	1786		9.2	186½	430.8		0.3	421.9	4.9		810.4	523			129	86.3	66.9	257.7	633.3	61.6	53.0
②	4			-29.0	168¼	388.7		✓	418.0	✓		✓	✓									
	5	1780		8.4	148	341.9		1.1	334.6	16.9		1505.0	662			164.5	127.2	77.3	205.7	1180.1	79.3	68.2
③	6			-25.6	131½	303.8		✓	330.5	✓		✓	✓									
	7	1779		7.8	115½	266.8		1.7	260.7	25.2		1837.8	692			172	121.0	70.3	160.5	1441.9	83.1	71.4
④	8			-21.6	101	233.3		✓	256.6	✓		✓	✓									
	9	1778		7.0	64½	149.0		2.5	144.5	37.55		2243.4	689			171.5	81.9	47.7	89.0	1761.1	83.0	71.4
	10	1789		9.3	211¾	489.1		—	479.8	0		0	316			92.2	—	—	292.1	0	43.8	37.7
	11																					
	12																					
	13																					
	14																					

CERTIFIED TEST PERFORMANCE
BINGHAM-WILLAMETTE LTD.
VANCOUVER, B.C.
BY: [signature] DATE: 3 FEB '83



OIL PRODUCTS
PIPELINE
SPECS. # EG-9-E

by JJ Roszzold, 1.31.82

CHARACTERISTIC CURVE SHEET

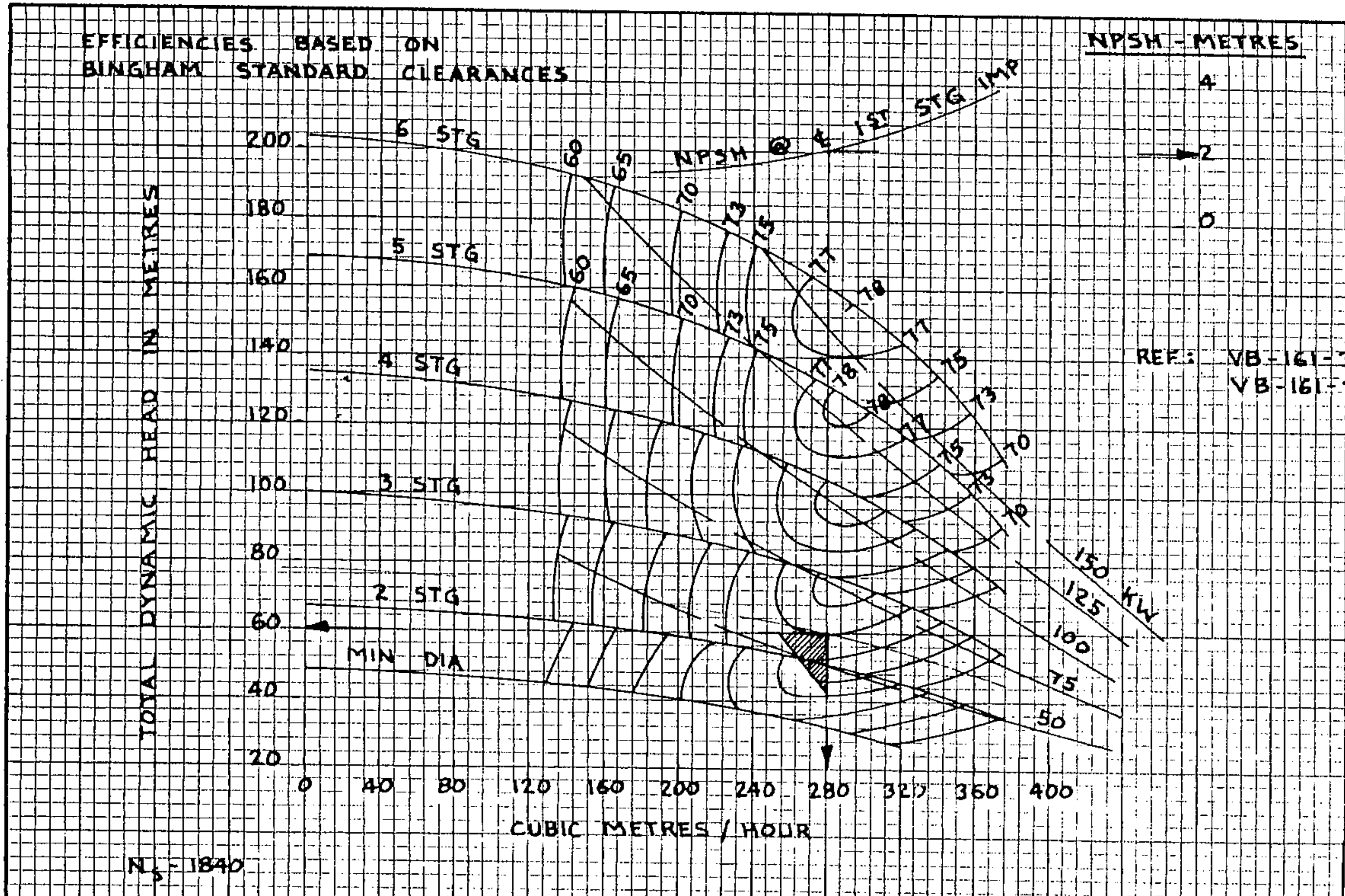
Bingham

Portland, Ore.

Shreveport, La. — Vancouver B.C., Canada

VERTICAL CAN TYPE 3-STAGE SIZE 16-A PUMP

DIA. IMPELLER	IMPELLER	REFERENCE	
11-15/16" (1st)	E. 8789 (1st) VB-161-3	VB.201-1 p. P.119S.11.90	1 4 6 0 R.P.M.
EYE AREA 43.6 SQ. IN.	Max.11 15/16 Min.10 3/16	SUPERSEDES Bowls E8762	CURVE No. 2 0 1 3 1



CHARACTERISTIC CURVE SHEET

Bingham

Portland, Ore.
Shreveport, La. — Vancouver B.C., Canada

16A VC PUMP

DIA. IMPELLER	IMPELLER	REFERENCE	1460 R.P.M.
EYE SQ. AREA IN.	VOLUTE OR BOWL	SUPERSEDES	CURVE NO. VB-201-1

INSTALLATION INSTRUCTIONS FOR JOHN CRANE TYPE 8B-1 SEAL

GENERAL INSTRUCTIONS

1. BE SURE TO READ ALL INSTRUCTIONS CAREFULLY BEFORE INSTALLING SEAL.

2. A seal installation drawing containing specific dimensional data and notes is packaged with each seal. It is important that this information be read and followed closely for best operating results.

3. The "JOHN CRANE" Type 8B-1 seal is a precision product. To assure satisfactory operation handle it with care. Take particular caution to see that the lapped sealing faces are not scratched or marred.

4. Packaged shaft seals are shipped as a completely assembled unit for easy installation (See Figure 2).

PREPARING THE EQUIPMENT

1. Check concentricity between the bore of the stuffing box and the shaft. This should not exceed .010" TIR.

2. Check to see that the face of the stuffing box is square with shaft to within .005" TIR. This face must also be smooth enough to form a good sealing surface for a gasket or "O" ring. (On field conversions a portable facing tool can be furnished by Crane Packing Company.)

3. After dismantling pump, check to see that shaft or sleeve is completely free of pits, burrs, or sharp edges to prevent cutting or improper sealing of "O" ring. Surface finish of shaft or sleeve must be highly polished to dimensions and tolerances indicated on seal installation drawing.

4. Check to see that end of shaft or sleeve has a proper 1/16" R.

5. Check shaft or sleeve diameter and stuffing box bore dimensions to see that they agree with those shown on layout drawing.

6. Check pump at coupling for proper alignment of the driver. (Spool type coupling are recommended and when used on split case pump permits replacement of inboard seal without removing top half of casing. This type coupling is especially recommended for vertical type pumps where final adjustment of shaft is required.)

BEFORE STARTING UNIT

1. Check to make certain that the by-pass line is open and free of any obstruction which might interfere with circulation or cooling liquid for seal.

2. Before start up bleed all vapor from seal cavity. It is necessary to insure a liquid environment for effective seal operation. A gaseous entrapment within the seal cavity will cause dry running and diminished seal life.

John Crane®
MECHANICAL SEAL DIVISION
CRANE PACKING COMPANY
6400 OAKTON STREET • MORTON GROVE, ILLINOIS

INSTALLING THE SEAL ASSEMBLY IN UNIT

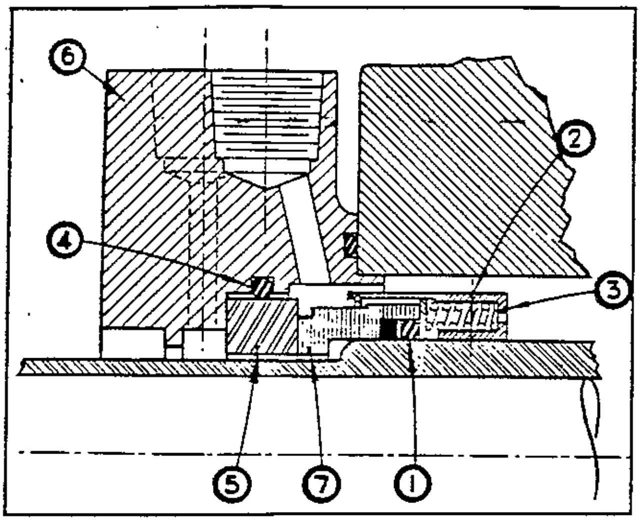


FIGURE 1

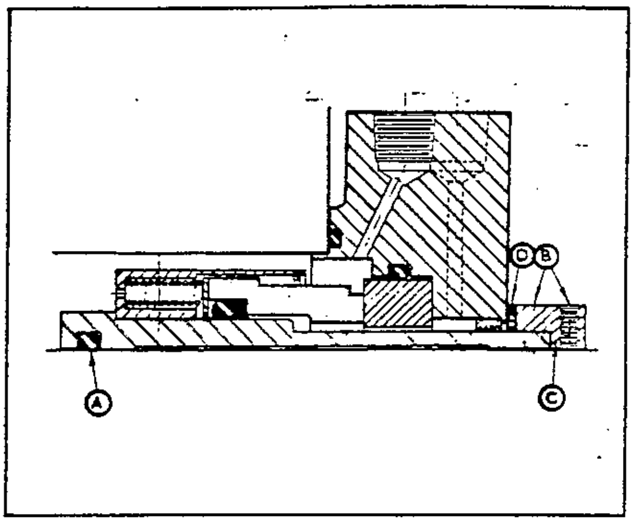


FIGURE 2

1. Before installing seal, lubricate ID of seal "O" ring (1). Also coat shaft or sleeve, over which seal will pass, with a film of lubricant. Required lubricant for all "O" ring materials except Cranelast* is to be SAE #10 or #20 lube oils. When Cranelast material is used for "O" rings, no oil may be used. Oil is harmful to Cranelast Elastomer. It is recommended that a 3% detergent solution be used or other types of mild soap solutions for installation purposes.

2. Lock Pump Bearings in place.

3. Install seal on shaft or sleeve to dimensions noted on seal installation drawing, tighten set screws (2) in retainer (3). We suggest locking set screws with a punch to prevent loosening. (Bear in mind that at some future date the set screws will have to be removed.)

4. Before installing seat, lubricate seat "O" ring (4). (For proper lubricant to be used see note #1.) Insert seat (5) into end plate (6) using finger pressure only.

5. Thoroughly clean both lapped faces of seat (5) and washer (7) with a clean, but lint-free, cloth or lens wiper. Lubricate both seat and washer faces with a light film of clean SAE #10 oil. If Cranelast materials are being used lubricate the seal faces with same lubricants indicated in paragraph 1.

6. Bring up end plate (6) against face of stuffing box and draw bolts up evenly. Use special care in assembling to avoid damaging rotating washer and stationary seat.

7. Important Note: Tighten end plate until metal to metal contact between plate and housing is realized. Do not over-stress due to hazards of distorting seal seat

1. This seal is shipped as a completely assembled "PACKAGED" unit. It is not necessary to do any dismanteling as the seal is assembled at our factory for easy installation.

2. Lubricate sleeve "O" ring (A) and shaft thoroughly with lubricant and slip complete assembly on shaft. Required lubricant for all "O" ring materials except Cranelast is to be SAE #10 or #20 lube oils. When Cranelast material is used for "O" rings, no oil may be used. Oil is harmful to Cranelast Elastomer. It is recommended that a 3% detergent solution be used or other types of mild soap solutions for installation purposes.

3. Bolt end plate to face of the pump.

4. Tighten end plate until metal to metal contact between plate and housing is realized. Do not overstress due to hazards of distorting seal seat.

5. Lock pump bearings in place.

6. Securely tighten all set screws (B) in the set screw collar (C). (On vertical pump this operation is done after coupling is made up.)

7. Remove the split spacer gasket (D) from between the end plate and set screw collar.

*Cranelast is a Crane Packing Company trade name for a special elastomeric compound.

DWG. NO. CF-SP- 90067-1

	ITEM	PART NUMBER	MAT'L CODE	PART NAME	QUANTITY	MATERIAL
*	1	D-2750-288		SEAT	1	TUNGSTEN CARBIDE
*	2	-236		SEAT RING	1	VITON
*	3	A8-3000-049		WASHER	1	CARBON
* *	4	-234		[redacted] 'O'RING [redacted]	1	VITON
	5	A9-3000-022		RETAINER	1	SS
	6	# 1461		SPRING	12	316 SS
	7	A9-3000-012		DISC [redacted]	1	SS
	8	A9-2875-043		[redacted] SNAP RING	1	SS
	9			SPRINGHOLDER		
	10	D-8766		SLEEVE	1	316 SS
*	11	-230		'O'RING (SLV.)	1	VITON
	12	A-778		DRIVE COLLAR	1	SS
	13	1/4-20×3/8 LG		SET SCREW	3	SS
	14	D-8767		GLAND PLATE [redacted]	1	ASTM A-276-316
*	15	-251		[redacted] 'O'RING	1	VITON
	16			GLAND		
	17			CAP SCREW		
	18	2 3/4×3 3/4×1/8		SPACER	1	# 555 (SPLIT)
	19			DRIVE KEY PACKING		
	20	5/16-24×1/2 LG		SET SCREW	12	HARDENED STL
	21	D-1751		BUSHING	1	CARBON
*	22	A-6515-41		BACK-UP RING	1	G.F. TEFLON
	23					

RECOMMENDED SPARE PARTS*

SEAL ASS'Y NO. A8-3000-068
SEAT ASS'Y NO.
SPEC. NO.

+ SPECIAL PART
CODE: XF IDI

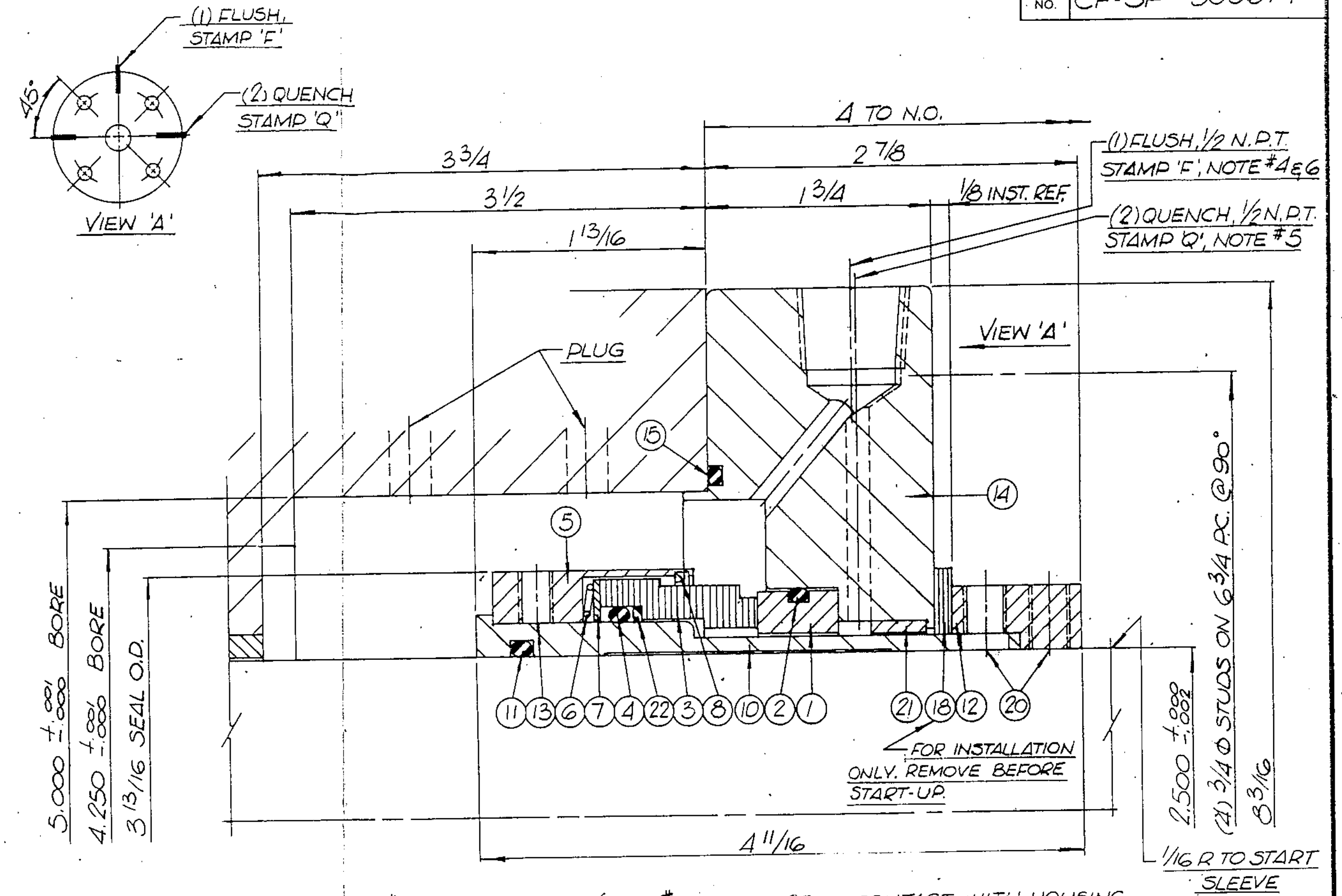
OPERATING CONDITIONS: S.G. .86 MAX.
LIQUID GASOLINE, JET FUEL, DIESEL OIL
SPEED 1460 R.P.M. TEMP. 36-113 F PRESS 73.3 P.S.I. SUCT. / P.S.I. DISCH.

UNIT REF. BINGHAM PUMP 8×12×16A VCR
SER. # 4B 290/1
CUST. P.O. # EG-9-2796-A

B.P. REF BINGHAM DWG D-19717, REV. 'C'

P.O. # 84900 S.O. # 4493-S

REVISIONS A



NOTE #7: GLAND PLATE (ITEM #14) MUST BE IN CONTACT WITH HOUSING. DO NOT OVERSTRESS.

INSTALLED AT: OIL PRODUCTS PIPELINE LTD; TEL-AVIV, ISRAEL

IMPORTANT NOTES

1. OIL ITEMS # 2, 4, 11 & 22 IN SEAL ASS'Y BEFORE INSTALLING IN UNIT
2. SHAFT MUST BE CORROSION RESISTANT MATERIAL [redacted] TO DIM AND TOL INDICATED
3. BEFORE COMPLETING THE SEAL INSTALLATION WIPE THE LAPPED SEALING FACES OF THE SEAT AND WASHER PERFECTLY CLEAN. THEN OIL BOTH FACES WITH CLEAN LIGHT OIL. SURFACE OVER [redacted] WHICH SEAL IS INSTALLED MUST BE SMOOTH AND POLISHED
4. GLAND PLATE PIPE TAPS ARE MARKED AS FOLLOWS "F" INDICATES FLUSH OVER SEAL FACES OR INJECTION HOLE
5. "Q" INDICATES QUENCH LIQUID OR TO VENT AND DRAIN
6. BY-PASS TO SUCTION (API PLAN 13) IS ABSOLUTELY NECESSARY TO PROVIDE PROPER COOLANT AND LUBRICATION FOR SEAL FACES; OTHERWISE SEAL MAY RUN DRY AND FAILURE OCCUR

PRESS IN SEAL CHAMBER MUST BE MAINTAINED AT 25 PSI MIN. ABOVE VAPOR PRESS AT PUMPING TEMPERATURE OR SEAL MAY RUN DRY AND FAILURE OCCUR.

"John Crane"
REG. CANADIAN PAT. OFF.
CRANE PACKING COMPANY, LTD.
HAMILTON, ONTARIO

'JOHN CRANE' TYPE 8B1
3" SHAFT SEAL
FOR
BINGHAM-WILLAMETTE LTD

DR M.K.	CH K.S	AP	DATE 10.18.82	SCALE N.T.S.

DWG. NO. CF-SP-90067-1

SW

SHEET SIZE C

CHANGE NOTICE

R.B.P. 1951

BINGHAM VERTICAL DRIVER COUPLINGS

SPLIT SLEEVE COUPLINGS and FLANGED COUPLINGS

SLEEVE COUPLINGS

Fig.1 SPLIT SLEEVE SPACER COUPLING

This coupling is used on closed type impeller pumps at speeds of 1170 rpm and higher.

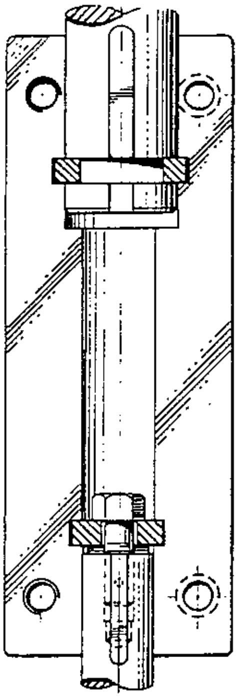


Fig.2 SPLIT SLEEVE SPACER COUPLING

This coupling is similar to Fig.1 and is used on semi-open impeller pumps to permit vertical adjustment of shaft for proper impeller clearances.

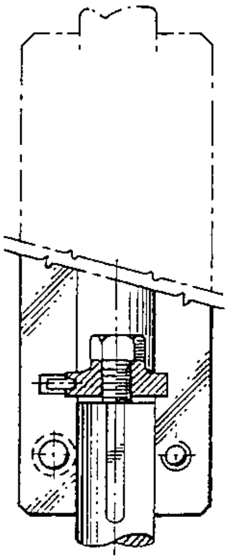
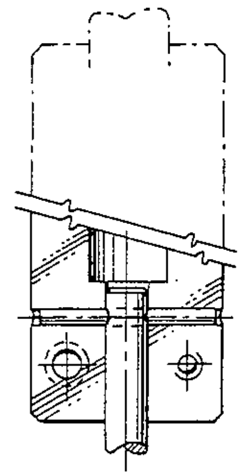


Fig.3 SPLIT SLEEVE SPACER COUPLING

This coupling is similar to Fig.1 and is used on process type pumps having high suction pressures and generally low horsepowers.

The small diameter pump shaft reduces the pump end thrust, thus enabling a normal thrust driver to be used. A pinned type coupling design is shown.

A threaded design is available to allow for shaft adjustment on semi-open type impeller pumps.



FLANGED COUPLINGS

Fig. 5

FLANGED TYPE COUPLING without SPACER

This coupling is used on pumps with shaft diameters above 2" and not exceeding 1800 rpm.

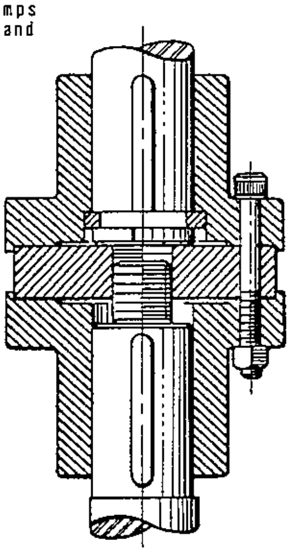
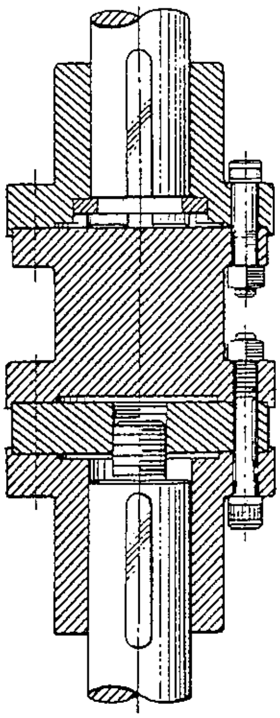


Fig. 6

FLANGED TYPE COUPLING with SPACER

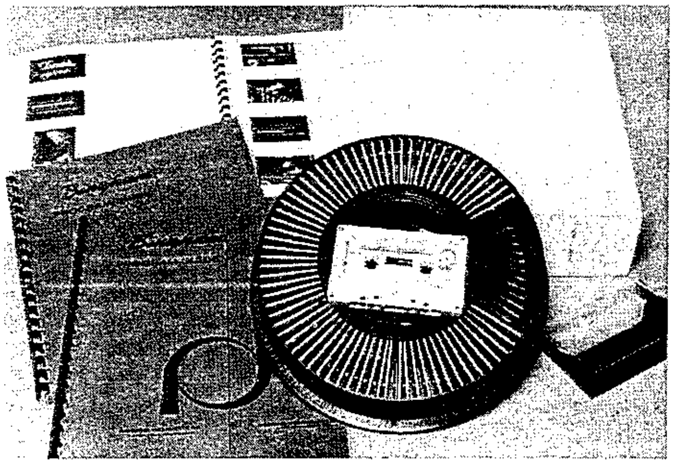
This coupling is similar to Fig.5 but has a spacer to allow for mechanical seal maintenance without disturbing the driver.



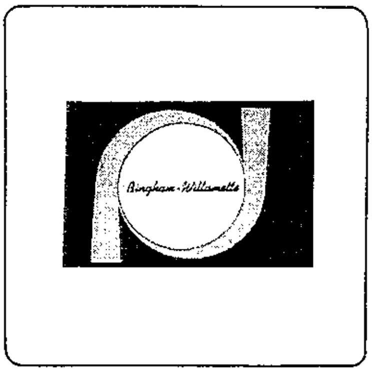
DRAWING NO. WP-275

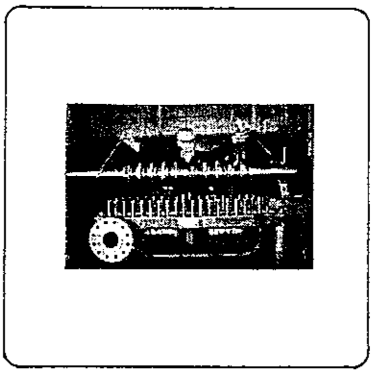
AUDIO-VISUAL TRAINING PROGRAMS

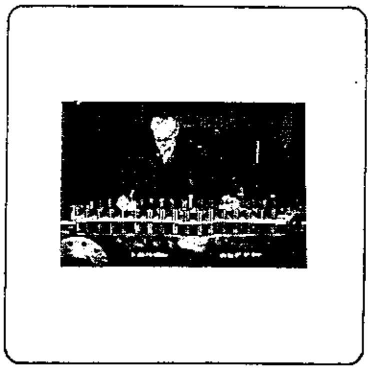
Audio-visual training programs are available for many types of Bingham-Willamette pumps. Most programs deal with pump and bearing disassembly, inspection and reassembly.



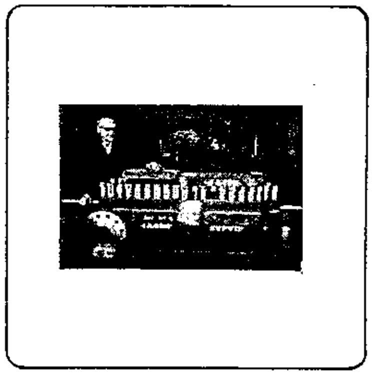
The programs are in 2X2 slide format with an automatically synchronized cassette tape. Program guides are also furnished. The guides are a written version of the program, including photographs and script.







New programs are constantly being developed for typical pumps. In addition, Bingham can provide programs for individual orders on a contractual basis. Contact your Bingham-Willamette sales office for more information on program availability.



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USEFUL **METRIC** CONVERSIONS FOR PUMP CHARACTERISTICS & RELATED UNITS

adopted by: •API (American Petroleum Institute) •ANMC (American National Metric Council) •ASME (American Society of Mechanical Engineers) •HI (Hydraulic Institute)

MEASUREMENT	U.S. UNIT	U.S. ABBREV. OR SYMBOL	METRIC (SI) UNITS (All metric units decimalized)	METRIC ABBREV. OR SYMBOL	CONVERSION U.S. TO METRIC MULTIPLIER	CONVERSION METRIC TO U.S. MULTIPLIER
LINEAL DIMENSIONS (Engineering Dwgs)	inch (decimalized)	" or in.	millimetre	mm	25.4000	0.03937
PLANE ANGLE	degree, minute, second	°, ′, ″	degree (only)	°	1	1
MASS (WEIGHT)	pound (decimalized)	lb. or #	kilogram	kg	0.4536	2.2046
FORCE	pound-force (decimalized)	lbf	newton	N	4.4482	0.2248
TORQUE (rotational)	pound-force•foot	lbf•ft	newton•metre	N•m	1.3558	0.7376
WORK ENERGY	foot•pound-force	ft•lbf	Joule (N•m)	J	1.3558	0.7376
HEAT ENERGY	British Thermal Unit	BTU	kilojoule	kJ	1.0551	0.9478
TEMPERATURE	degree Fahrenheit	°F	degree Celsius	°C	$(t_F - 32) \times \frac{5}{9}$	$(t_C \times 1.8) + 32$
POWER	horsepower (550 ft•lbf/s)	hp	kilowatt (kJ/s)	kW	0.7457	1.3410
DENSITY (mass density)	pounds per cubic foot	lb/ft^3	kilogram per cubic metre	kg/m^3	16.0185	0.0624
FLUID "HEAD"	foot	ft, ′	metre	m	0.3048	3.2808
PRESSURE	pounds per square inch	psi	kilopascal (kN/m^2)	kPa	6.8948	0.1450
SOUND PRESSURE LEVEL	decibel or microbar (0.002 μbar)	db μbar	micropascal (20 μPa)	μPa	100 000	0.000 01
FLOW (pumpage)	gallons per minute	gpm	cubic metre per hour	m^3/h	0.2271	4.4029
VELOCITY	foot per second	fps	metre per second	m/s	0.3048	3.2808
ACCELERATION	foot per second squared	ft/s^2	metre per second squared	m/s^2	0.3048	3.2808
FREQUENCY	cycle per second	cps	hertz	Hz	1	1
SPEED OF ROTATION	revolutions per minute	rpm	revolutions per minute	r/min	1	1
WR^2 (moment of inertia)	pound•foot-squared	$lb•ft^2$	kilogram•metre squared	$kg•m^2$	0.04214	23.7304
ROTATIONAL UNBALANCE	gram•inch	g•in	gram•millimetre	g•mm	25.4000	0.03937
	ounce•inch	oz•in			720.1	0.001 389
VISCOSITY	centipoise	cP	millipascal second	mPa•s	1	1
SPECIFIC SPEED (per stage)	$\frac{rpm\sqrt{gpm}}{(\text{feet of head})^{.75}}$	N_S	$\frac{rpm\sqrt{m^3/h}}{(\text{metres of head})^{.75}}$	N_S (Unofficial)	1.1620	0.8608

NOTE: ELECTRICAL UNITS SUCH AS AMPERE, VOLT & WATT ARE SAME IN BOTH SYSTEMS

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