Levee District No. 1 of Sutter County
Lower Feather River Setback Levee at Star Bend

Tudor Mutual Water Company
Star Bend Pumping Plant and Discharge Piping System
Operations and Maintenance Manual

March 2011

WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS

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ABRREVIATIONS LIST

abs	Absolute
ARV	Air Release Valve
BEP	Best Efficiency Point
CCP	Concrete Cylinder Pipe
cfs	Cubic Feet per Second
D-box	Distribution Box
gpm	Gallons per Minute
hp	Horsepower
LED	Light Emitting Diode
MCC	Motor Control Center
O&M	Operations and Maintenance
mgd	Million Gallons per Day
RCP	Reinforced Concrete Pipe
SB/ARV	Siphon breaker/Air Release Valve
TDH	Total Dynamic Head
TMWC	Tudor Mutual Water Company
USACE	U.S. Army Corps of Engineers
VFD	Variable Frequency Drive
VVF	Volcano Vista Farms
WSP	Welded Steel Pipe

PROJECT AND PRIMARY FEATURES DESCRIPTION

General

The Star Bend Setback Levee Project (Project) is located along the west levee of the Feather River between Star Bend Road and Tudor Road. The Star Bend Project was authorized by the Central Valley Flood Protection Board (CVFPB) under Permit No. 18191. The Project significantly affected irrigation facilities on the landside of the existing levee, which required relocating and modifying the existing facilities. The facilities are owned and operated by the Tudor Mutual Water Company (TMWC, CVFPB Permit No. 18437) and Volcano Vista Farms (VVF, CVFPB Permit No. 18438).

The TMWC facilities directly impacted by the Project consist of a system of pump discharge pipelines, a flow distribution structure, and irrigation distribution pipelines. The VVF facilities directly impacted by the Project consist of a pump discharge pipeline and an irrigation distribution pipeline. Photographs of the discharge pipelines at the river bank and the manifold are shown on Figure 1. The TMWC facilities that are indirectly impacted by the Project include the pumping equipment at the TMWC Star Bend pumping plant and the PG&E electrical service to the pumps.

This Operations and Maintenance Manual (O&M Manual) pertains primarily to the relocations and modifications made to the TMWC Star Bend pumping and irrigation system. The VVF system is also discussed, since the relocations and modifications made to this smaller system are similar and in close proximity to the TMWC system.

The purpose of this O&M Manual is to describe the modified TMWC water supply system (pumps, pipes, and appurtenances), the basic system operation, and to recommend maintenance and operational procedures for the system.

Description of Water Supply System

The water supply system for both the TMWC and VVF start at the TMWC Star Bend Pumping Plant on the right bank of the Feather River at Star Bend near River Mile 18. The pumping plant consists of an elevated steel platform and five vertical turbine pumps that pump water from the river into irrigation pipelines on the landside of the existing levee, which convey the water to farms westerly of the Feather River (Figure 1). Four of the pumps are owned and operated by the TMWC

and the fifth pump is owned and operated by VVF. The TMWC pumps range from 60 hp to 100 hp and with three pumps operating, have a combined capacity in the 25,000 to 30,000 gpm range depending upon water levels in the river and distribution box. (Please note that the TMWC pumping plant has been in existence since the 1950's and was not part of the noted modifications and improvements authorized under CVFPB Permit Nos. 18191, 18437, and 18438).

The TMWC irrigation supply system north of Tudor Road and east of Star Bend Road was extensively modified as part of the Project. The modifications included:

- Relocating the pump discharge pipelines.
- Relocating the flow distribution structure.
- Relocating most of the TMWC irrigation pipeline between Star Bend Road and Tudor Road.
- Relocating the TMWC irrigation pipeline east of Star Bend Road.
- Installing positive closure devices in the two 30-inch TMWC discharge pipelines and the 18-inch VVF pipeline at the top of levee.
- Installing a variable frequency drive (VFD) on Pump 1.
- Replacing the Pump 1 motor.
- Installing a vacuum priming system.

Primary Features Description

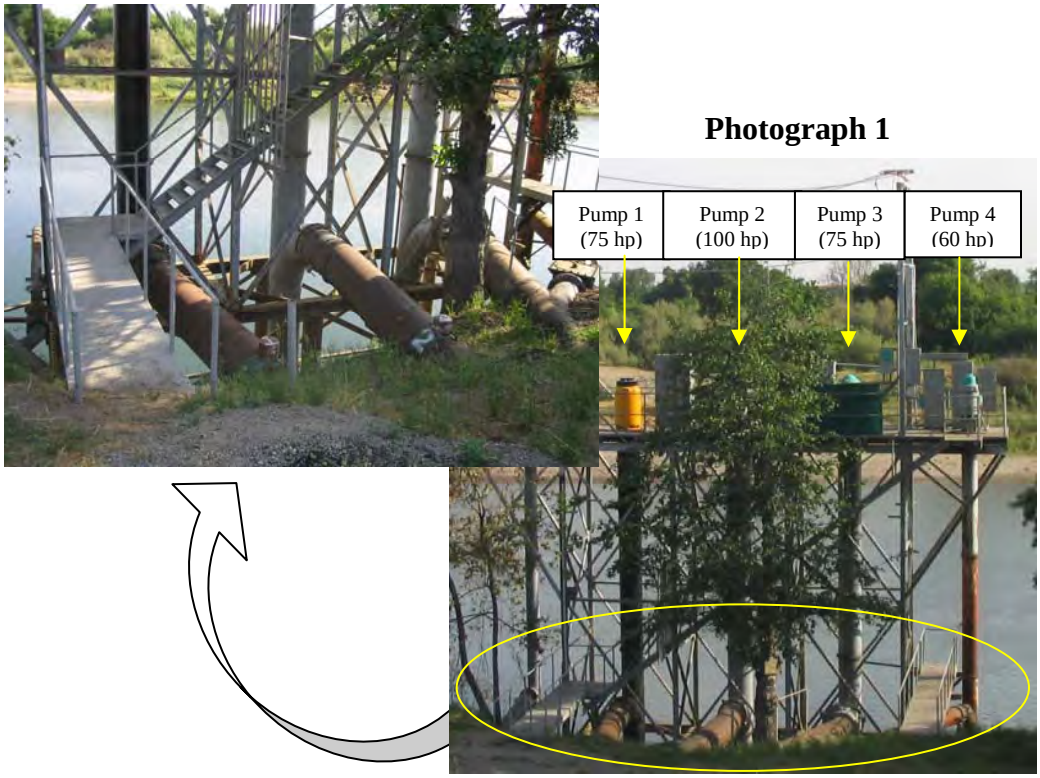
The TMWC water supply system consists of four pumps in a parallel arrangement that pump water from the Feather River into a discharge pipeline, which bifurcates into two 30-inch lines over the levee and conveys the water to the flow distribution box on the landside of the new levee. The components of the water system are described and discussed in the following sections of this O&M Manual. The discussion of the system components is presented in accordance with the direction of flow from the Feather River to the distribution box.

1. Supply Pumps

TMWC's irrigation supply pumps consist of four 1-stage vertical turbine pumps. The pump bowls are submerged approximately four to 7 feet below the summer river levels. The submergence level during the irrigation season varies with the river level, usually being the

lowest in the spring at the start of the irrigation season and highest during the summer. The four pumps are configured in parallel, and discharge into a manifold connected to a discharge pipeline leading to the distribution box located at the east end of Star Bend. The pumps are numbered 1 through 4 from left to right looking northeast at the river Road (Figure 2 and Photograph 1). Pump 1 and Pump 3 are driven by 75 hp motors, Pump 2 is driven by a 100 hp motor, and Pump 4 is driven by a 60 hp motor (refer to Appendix A-1 and Appendix A-2 for the pump curves and nameplate information obtained for the pumps). The Pump 1 motor was replaced as part of the Star Bend Setback Levee Project. It is an Emerson Motor Company inverter-duty rated 3-phase, 60 Hz, 460V electric motor, with a nominal speed of 900 rpm. The manufacturer's O&M Manual for the new Pump 1 motor is located in Appendix B.

The output (flow) of Pump 1 can be adjusted by means of a VFD controller. The VFD controller settings can be manually adjusted by the system operator or they can be set to AUTO mode. In the AUTO mode, the VFD will control the pump motor speed based upon the target depth setting for the water in the distribution box. The VFD controller is located in the remote pump control panel within the fenced enclosure around the distribution box, which is located on the landward bench of the levee system at the east end of Star Bend Road. The Pump 1 motor is equipped with a 100 hp, 480V, 3-phase VFD manufactured by Dan Foss, Inc and supplied by Tesco Controls, Inc. The manufacturer's O&M Manual for the VFD is located in Appendix B.



Photograph 1

2. Transmission Pipeline

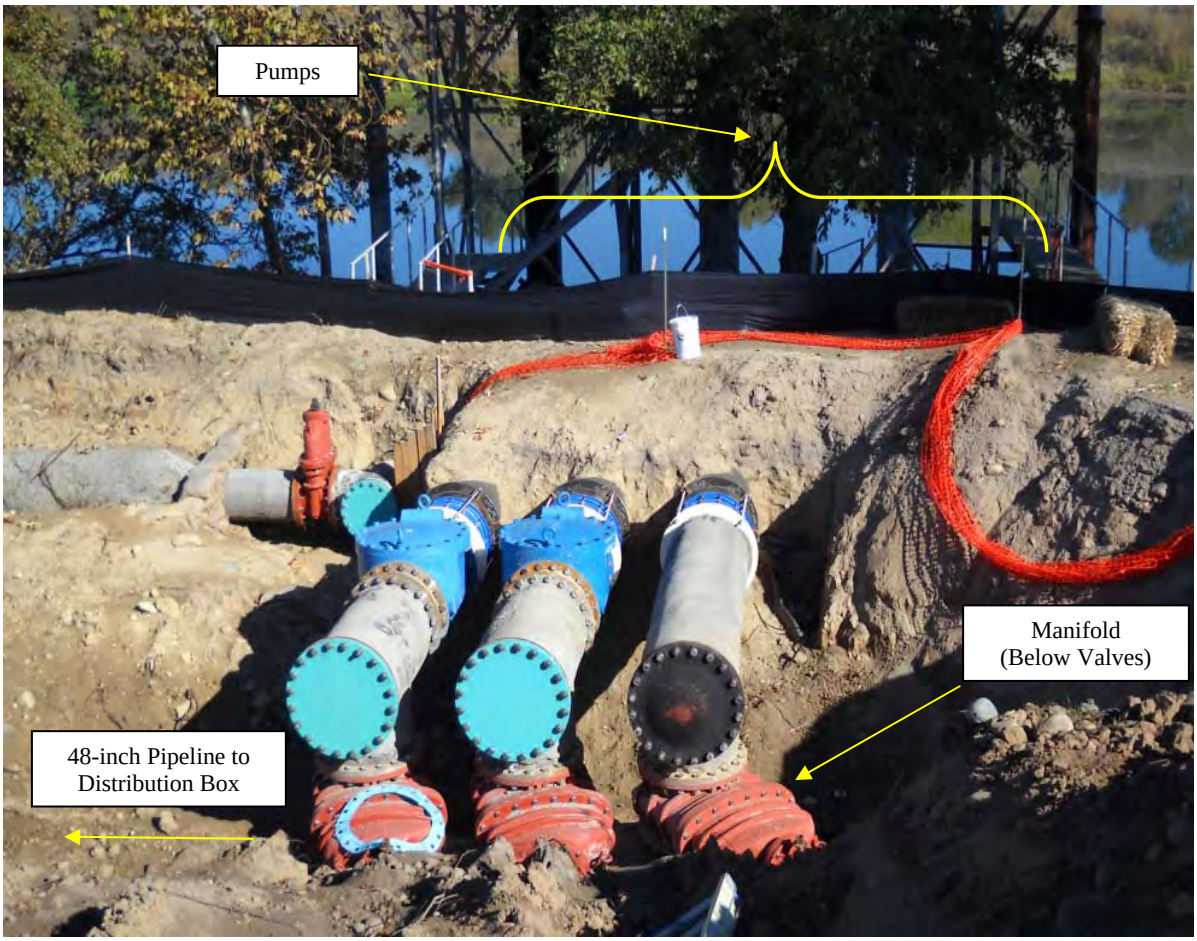
The discharge pipes of Pump 1 and Pump 2 convey flow through 24- and 26-inch-diameter lines, respectively, to a common 48-inch-diameter pipe manifold located on the west river bank. The discharge pipes from Pump 3 and Pump 4 converge at a wye, which combine into a 26-inch pipeline that connects to the pipe manifold. The discharge column on Pump 4 is fitted with a 16-inch tee and a manually-operated gate valve that can be opened to "trim" the flow from this pump by allowing some of the pumped water to be discharged back into the river (as noted on Figure 2 and shown in Photograph 2).

Photograph 2

Propeller flowmeters are installed in each of the three discharge pipes between the pumps and the river bank, one in each line from Pump 1 and Pump 2, and one in the common line from Pump 3 and Pump 4 (after the wye). The flowmeters allow measurement of individual flows from Pump 1 and Pump 2, and the combined or individual flow from Pump 3 and Pump 4.

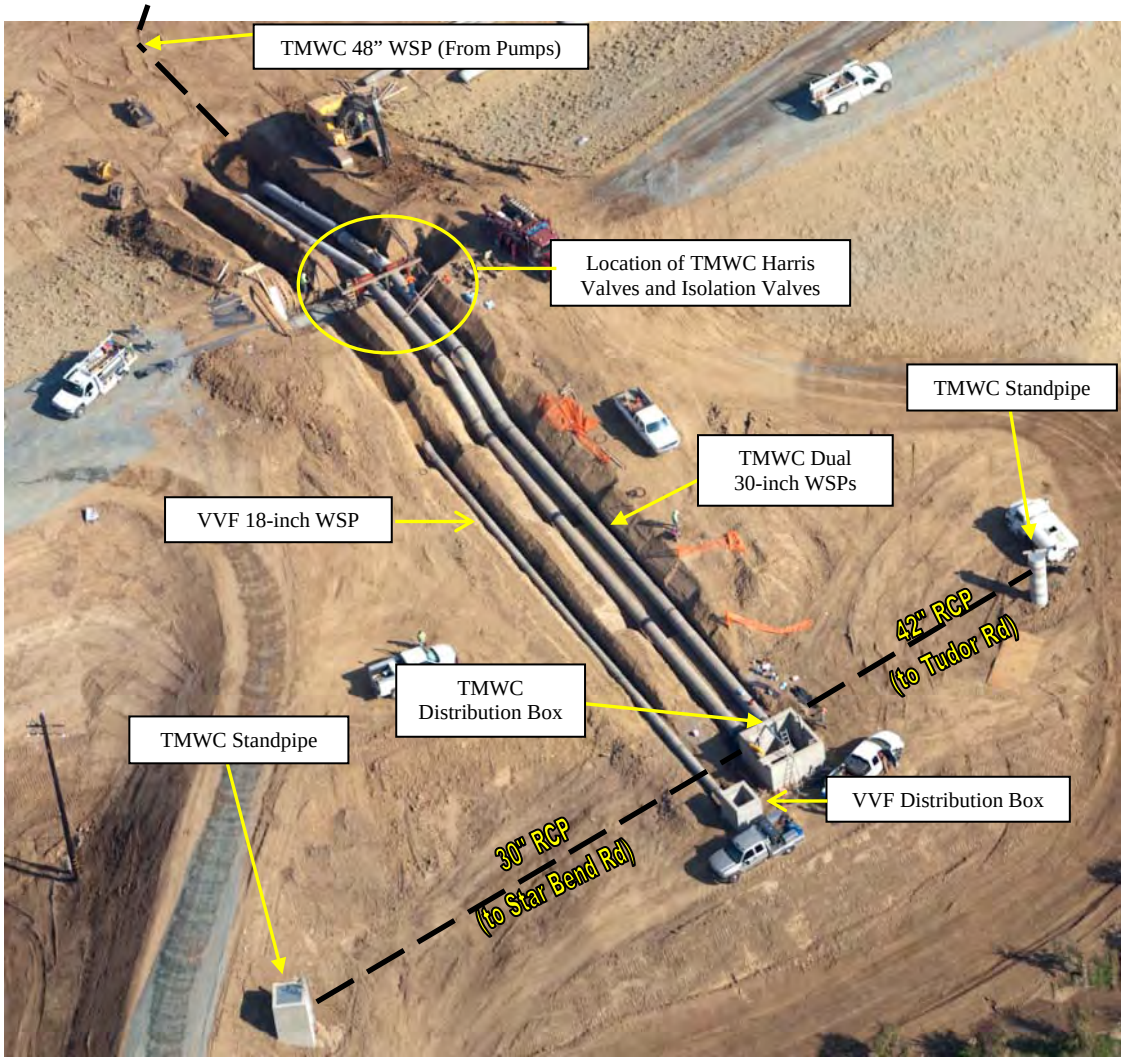
During the pump and pipeline testing performed in 2010, pump flows were measured with both sonic equipment and computed using volumetric-time measurements and found to be in substantial disagreement with the flow readings taken with the existing propeller flowmeters. It is recommended that the existing flowmeters be removed, shop-calibrated, and repaired or replaced, as necessary.

Check valves have been installed in the discharge pipes from Pump 1 and Pump 2, as noted on Figure 2 and shown in Photograph 3. The discharge pipes from Pump 3 and Pump 4 already had check valves installed and did not require new valves (as noted on Figure 2 and shown in Photograph 2). Isolation valves were installed in the three discharge pipelines at the pipe manifold. Air Release Valves (ARV) were installed on each pump discharge pipe (at the manifold) and at the wye in the 48-inch pipeline at the waterside levee toe (as depicted in the pump discharge pipeline profile on Figure 3). The discharge piping system at the pumping plant is depicted schematically on Figure 2.



Photograph 3

The pipe manifold discussed above connects to a 48-inch-diameter transmission pipeline. The TMWC pipeline consists of approximately 1,440 lineal feet of bell and spigot concrete cylinder pipe (CCP) extending to the riverside toe of levee. This is followed by approximately 280 lineal feet of double 30-inch butt-welded steel pipe (WSP), which extends over the levee to the distribution box on the landside of the levee. The TMWC 48-inch-diameter pipe on the waterside of the levee branches to dual 30-inch-diameter pipes near the waterside toe of the levee. The dual lines convey the flow over the levee to the distribution box. The TMWC transmission pipeline on the waterside of the levee is buried approximately 4 feet, and generally follows the access road between the levee and the Star Bend pumping plant.



Photograph 4

On the top of the levee, a gate valve and a combination siphon breaker (SB) and ARV were installed on each of the 30-inch pipes at the high point in the pipeline profile. The gate valve and SB/ARV are housed in a cast-in-place concrete vault adjacent to the roadway on the levee crown. The gate valves are installed as positive closure devices for the purpose of preventing floodwaters from flowing through the irrigation supply pipelines to the landside of the levee. These gates would be closed when flood stages in the Feather River are predicted to exceed that of the USACE 1957 flood (El. 64 at Star Bend Road).

Also housed in the gate vault is a vacuum priming system for evacuating air trapped in the pipelines so the pipes will flow full and the full benefit of operating the pumping system as a siphon can be realized. The priming components of the vacuum priming system include a vacuum pump, a receiving tank, priming valves, a control panel, and various valves and gages.

On the landside levee slope there are two 3-inch steel pipes that tee off of the 30-inch pipes. The 3-inch pipes are controlled by 2-inch gate valves that can be used to admit air into the pipes for the purpose of throttling flows in the 30-inch pipes. The 2-inch gate valves are located in valve boxes on the landside levee slope. Throttling can be accomplished by partially opening the 2-inch valves to allow air to enter the pipes, which reduces the available cross-sectional flow area within the lines. The profile of the pump discharge piping system is shown on Figure 3.

3. Distribution Box

The distribution box is a cast-in-place concrete box structure located on the south side of Star Bend Road, approximately 150-feet westerly of the levee centerline. The pump discharge pipelines from the Star Bend pumping plant discharge into the box, which distributes water into the irrigation distribution system. At the distribution box, both of the 30-inch pipelines elbow to a vertical drop and terminate 2 feet above the floor of the distribution box. The distribution box contains two slide gates, which can be used to control the flow into the irrigation distribution system. The slide gates are equipped with manual hand-crank operators. Two pipelines, a 30- and a 42-inch-diameter reinforced concrete pipe (RCP), connect the distribution box to the TMWC irrigation system and farms west of the levee. The distribution box also includes an emergency overflow provision, should the high level off switch fail to turn off the pump(s).

The TMWC distribution box, including the inflow and outflow pipes and control gates, are shown on Figure 4. Also shown on Figure 4 is a photograph of the pump control panel before the VFD controller was installed.

OPERATION

The following section describes the individual operation of each of the elements of the system, and provides a recommended procedure for operating the portion of the TMWC system between the Star Bend pumping plant and the distribution box at Star Bend Road.

Operation of System Components

1. Star Bend Pumping Plant

The four TMWC pumps can either be operated individually and locally from control panels on the pump platform, or remotely from a pump control panel located within the fenced area surrounding the distribution boxes. The local controller at the pump platform has a switch for each pump with the following settings: "LOCAL," "OFF," and "REMOTE." When the control switch is set to "LOCAL" mode, the motor will energize and the pump will begin pumping water through the irrigation supply system. When the control switch is set to "REMOTE" mode, the pump motor control is set for control at the remote pump controller at the distribution box. When the control switch is set to "OFF," the pump motor does not operate.

The remote pump control panel at the distribution box contains operation switches and status display indicator lights for each of the four pumps. The operator modes for the control switches are "RUN" and "OFF," to turn each of the pumps on and off, respectively. Each pump has two display lights that indicate whether the pump is "ON" (green illuminated), "OFF" (no light), or "FAULTED" (red illuminated).

In addition to the above controls, Pump 1 is equipped with a process controller that controls a VFD on Pump 1. This controller is also located in the pump control panel by the distribution box. The VFD controller has a "RUN-OFF" button to run the pump with VFD control ("RUN") or simply at full speed ("OFF"). When the controller is in the "RUN" mode, other selector buttons on the process controller are enabled to operate Pump 1 in either the "MANUAL" or "AUTO" modes. In "MANUAL," the VFD controls pump motor speed based upon the manual adjustment of a digital "slider" on the controller. A dual 40-segment LED bar graph indicates motor speed (each segment representing a 2.5% incremental adjustment). Motor speed can be varied from 0% to 100%, representing the range of pumping rates between zero flow and full-throttle flow and is adjustable with "UP" and "DOWN" arrow keys on the

controller panel. See the paragraph below regarding the operational lower limit for the VFD. In "AUTO" mode, the pump motor speed is based upon the target water level in the distribution box measured by a capacitive level probe. At a pre-determined low-level "START" set point, Pump 1 will turn on. The VFD controller will then vary the motor speed of Pump 1 to maintain a pre-selected operating level. The VFD will slow down the pump motor as the water level in the box increases above the pre-set operating level, and will speed up the pump motor as the water level in the box falls below the pre-set operating level. Finally, if the water level in the distribution box reaches a pre-determined high level shut-off point, the controller will automatically shut the pump motor off. The start level, operating level, and the shut-off level set points are all operator adjustable at the process (VFD) controller.

As noted above, the VFD is capable of varying the pump output from full flow to zero or very low flow. However, Pump No. 1 should not be operated at zero or very low flow. At low discharge rates and especially at zero flow, recirculation of the water causes an unbalanced radial thrust against the impellor that causes flexing of the pump shaft which can lead to bearing failure or fatigue of the shaft. It is usually safe to operate a pump at discharge rates of 30% or more of the discharge at the best efficiency point at rated speed. For Pump No. 1, the rated discharge at its best efficiency point (new pump assumed) is estimated to be about 8,400 gpm at 890 rpms and 30% of this discharge is about 2,500 gpm. Since there is not currently accurate flow measurement capability at the site, it is best to report this lower operating limit in terms of motor speed, which can be viewed on the VFD control panel. Figure 7 provides the relationship between motor speed and pump flow for Pump 1 for a total dynamic head (TDH) of 25 feet. It is noted that a reduction in pump speed (as a percentage of rated speed) results in a greater reduction in flow (as a percentage of maximum flow capacity). **To ensure the pump is not operating at zero or very low flow, the motor speed should not be reduced to 75% or less of maximum speed.**

A password authentication is required to change set point water levels. Further information on controller adjustment is provided in the process controller operator manual, see Appendix B-1.

The Star Bend pumping plant consists of four Bryon Jackson vertical turbine pumps on a platform in the Feather River. Figure 5 shows the approximate capacity of the four existing pumps that are installed on the platform for a Total Dynamic Head (TDH) or a "head" of 25 feet. The part of the Pump 1 capacity that can be controlled by the VFD is labeled "VFD," and the part of the Pump 4 capacity that can be controlled by the gate valve is labeled "GV." Figure 5 can be used as a general guide for selecting which pump(s) to operate to meet a certain

water demand. Flow rates indicated in Figure 5 apply only to a head of 25 feet. Greater flow rates can likely be obtained for heads lower than 25 feet, and lower flow rates are associated with pumping heads greater than 25 feet.

Figure 6 indicates the performance of the pumps operating at the nameplate speed over a range of different head conditions. Pump flows are based upon Bryon Jackson performance curves for new pumps of the size, type of pump, and operating at the speed indicated on the nameplate (Appendix A-2). The performance curves shown on Figure 6 are based upon the minimum diameter impellor for the pump size, type, and operating at the speed indicated on the nameplate (Appendix A-2). Since the Star Bend pumps are not standard speed pumps, the curves (Figure 6) were calculated based upon the Pump Affinity Laws for centrifugal pumps.

The performance curves for Pump 1, Pump 2, and Pump 3 have a characteristic "hump" or dip, which is an unstable zone that should be avoided. This zone is where very small changes in head and/or speed can cause substantial flow changes**.** The unstable zone for Pump 1 and Pump 3 occurs for flows in the 4,500 to 6,500 gpm range at 890 rpm (Figure 6). The unstable zone for Pump 2 is in the 4,000 to 8,500 gpm range. Pump 4 does not have an unstable zone and should be used instead of Pump 1, when it is necessary to operate in the 4,500 to 6,500 gpm range. The performance curve for Pump 1 operating at a head of 25 feet over a range of speeds from approximately 650 rpm to 870 rpm (75% to 100%) as indicated on Figure 7. As previously noted, Pump 1 should not be operated at flows below approximately 2,500 gpm, or 75% of the maximum speed in rpm, whichever is greater.

Performance curves for the existing pumps were also developed by Kit Burton (see Appendix A-3) during the Independent Technical Review of the modifications made to the TMWC facilities. These curves are intended to represent 2010 conditions and were developed from both the manufacturer's information and pump flow data collected by Wood Rodgers, Pump Efficiency Testing Services, and others. The manufacturer's standard pump curves have been reformatted and are also included in Appendix A-1. These standard curves are for the same pumps but operating at the indicated speed which are higher than the corresponding TMWC pump.

2. Pump 4 Flow Trimming Valve

A manually-operated gate valve located on a tee fitting in the Pump 4 discharge column can be used to return a portion of the pumped flow to the river. The valve operator is accessible from the lower level of the pump platform (Photograph 2).

3. Flowmeters

Three existing (pre-project) propeller meters located in discharge pipes 1, 2, and 3 near the river bank, provide information on the flow and amount of water pumped. The meters "read" instantaneous flow in cfs (rotating dial display) and volume of water pumped in hundreds of an acre-foot (digital readout). The flowmeters are not electronic and do not record data, so all data must be collected manually. It is recommended that TMWC either recalibrate or replace all three flowmeters to obtain more accurate flow values.

4. Check Valves

Check valves have been installed in the discharge pipelines of Pump 1 and Pump 2, to prevent backflow through the discharge pipe of a pump that is not currently being operated. Check valves were already installed in the discharge pipelines of Pump 3 and Pump 4, upstream of the wye in Pipe 3 (Photograph 2).

5. Gate Valves

Gate valves were installed in each of the 24- or 26-inch discharge pipes at the river upstream of the 48-inch manifold. The valves are installed on the inlet pipes to the 48-inch manifold and can be used to isolate one or more pumps during maintenance or repair operations (see bottom of Photograph 3). These valves are normally open and would be operated only during or prior to high river stage events.

6. Air Release and Siphon Breaker Valves

Air release valves are located along the pump discharge pipeline, as indicated on Figure 3. The ARVs allow air to be evacuated from the pipeline during filling operations (after the pumps start) and also any dissolved air that comes out of solution. The ARVs are the "floating-ball" type, which operate passively and do not require operator adjustment.

The Harris valves at the top of levee are a combination of SB/ARVs located at the high point in the pipeline profile. These valves permit air to be evacuated from the pipelines during filling, and have an added feature that opens the valves and admits air when the pumps shut off, preventing a potentially destructive vacuum from developing. The operation of the SB/ARVs is based upon a paddle arm that extends into the flow in the pipe, which operates only when there is flow in the pipe. When water is pumped through the pipelines, the flow acts upon the paddle arm and operates an internal mechanism that closes a port in the valve; when the pump shuts off and the flow stops, the water action against the paddle arm stops and the air ports in the valves open. Once opened, air enters the pipelines and breaks the siphon/vacuum in the pipelines, permitting the water in the pipelines downstream of the high point in the pipe profile to drain into the distribution box. The valves also prevent a potentially destructive vacuum from developing within the pipelines on the waterside of the levee when they are drained.

7. Positive Closure Valves

Gate valves in each of the TMWC 30-inch discharge pipelines have been provided to prevent water from flowing through the pipes during high water events in the river and flooding areas on the landside of the levee. The gate valves are located in a vault at the east end of the Star Bend Road access ramp. The valves are normally open and should be closed when river levels are predicted to exceed El. 64 at Star Bend Road. There is singular or positive closure device for the 18-inch VVF discharge pipeline that crosses the levee within 15 feet north of the TMWC 30-inch lines. Additionally, these valves can be used for throttling flow by partially closing one or both of the 30-inch pipelines. However, the valves require hundreds of turns to fully open or close, and operating these valves for throttling is not recommended.

8. Vacuum Priming System

The vacuum priming system consists of an oil-less rotary vane vacuum pump installed within the valve vault located at the levee waterside top of slope. The pump operates on 240 VAC power and is connected to a control panel that is located within the gated area of the distribution box. The vacuum pump is mounted on a 60-gallon vertical air receiver tank, which separates and stores water condensed from the evacuated air. One-inch-diameter pipes connect the vacuum pump to each of the 30-inch pipelines crossing the levee at the high point in the pipeline profile. Manually operated solenoid valves are actuated at the vacuum pump control panel and determine which pipeline(s) the vacuum will be applied to. A pressure transducer located in the vacuum piping between the south 30-inch pipeline and the receiving tank measures

pressure/vacuum in the 30-inch pipelines. When pressure in the pipeline is higher than a specified value, the vacuum pump will be actuated and will begin to remove air from the pipeline(s). The pressure set point for the call to operate the vacuum system can be adjusted at the vacuum control panel by the operator. The pressure set point for the vacuum pump to reduce pipeline pressure can be programmed to be equal to the target water elevation in the distribution box plus hydraulic losses between the distribution box and the high point in the pipeline profile. Alternatively, the set point can be set to a pressure pre-determined by the operator to provide satisfactory results. Typically these operational set points should be in the range of 12 to 16-inches of Hg. The water elevation in the distribution box is determined electronically by a capacitive probe level transmitter installed at the distribution box. During the peak of the 2010 irrigation season, the water level in the distribution box was typically set by the operator to be between El. 45 and El. 48 (NGVD 29). A band of target pressures is allowed within the vacuum pump control panel such that frequent starts and stops of the vacuum priming system are avoided. It is critical that the Harris valves are properly adjusted and not leaking air into the pipelines. Ensuring that the valves are not leaking air will minimize the amount of time the vacuum priming system is required to operate.

The vacuum priming system will operate to remove air trapped in the section of the TMWC 30-inch pipelines across the top of the levee. The vacuum system starts when the pump or pumps are started and operates until the maximum vacuum setting is reached and then shuts off. The system is designed to operate automatically and will restart when/if the vacuum level falls to the low vacuum setting.

9. Distribution Box Slide Gates

Two manually-operated slide gates in the TMWC distribution box can be operated to control the flow into two irrigation pipelines that drain the distribution box. The two pipelines convey water to the TMWC irrigation system west of the levee. The gates can also be used to shut off flow into one or both of the pipelines. If both gates are closed, the distribution box will fill within a few minutes.

Operational Considerations

1. Siphon Condition

The pump discharge system is best operated in siphon mode because when in siphon mode, the capacity of the pump or pumps is maximized and energy consumption is minimized. Below is a brief discussion of how a siphon forms and its effect upon water deliveries to the TMWC distribution box at Star Bend Road.

At the start of pumping operations, the portion of the pipeline between the high point in the pipeline profile and the distribution box is empty. As these pipelines fill, the Harris valves installed at the high point in the pipeline are open and allow the air in the pipelines to escape. When the outlet end of the 30-inch discharge pipelines becomes submerged and the section of pipe across the top of the levee becomes mostly full, the Harris valves close and a partial siphon condition develops. At this point, the head on the pump(s) starts to decrease from about 40 to 45 feet required at start-up to less than 30 feet when a siphon is established. When all of the air is evacuated from the pipelines and a full siphon is established via the vacuum priming system, the head on the pump(s) is minimized and the flow is maximized.

In order to create a siphon condition, the water in the distribution box must submerge and seal the outlet end of the discharge pipes and most of the air trapped in the pipe must be removed. Field tests of the discharge system indicate that a siphon can be established with only one pump operating; however, a siphon can be established faster if two or more pumps are operated until a siphon has been established. Once a siphon is established, it can be maintained with a single pump operating at full capacity. It is currently unknown how much the flow from Pump 1 and Pump 4 can be reduced without losing the siphon in the 30-inch pipes. At some point, the velocity of the water in the pipelines becomes insufficient and the siphon will be broken. When this occurs, the head on the pumps will significantly increase and the flow will dramatically decrease.

2. Flow Control

The TMWC irrigation supply system delivers water on an as-ordered basis to meet customer irrigation demands. As water orders are received and subsequently filled, adjustments are made to the supply system (e.g., flows pumped from the river) to match the changing water needs of TMWC customers. Typically, TMWC operates 1 or 2 pumps (usually Pump 1 and Pump 4) to

meet most of the water demands during the irrigation season. However, a third pump may be needed during periods of high demands. The fourth pump is a spare or back-up pump. All four pumps at the Star Bend pumping plant can be operated concurrently, but are not likely required to meet current water demands. The pumps each have a different flow capacity that is determined by the head on each pump, which, in turn, is determined by the water levels in the river and the distribution box, pipe friction, and various other hydraulic losses in the conveyance system between the pump and the distribution box.

Additionally, beyond adjusting the number of pumps operating, adjustments can be made with various components of the delivery system to control flow. Typically, these flow adjustments are made to trim flow rates that cannot be achieved by simply adjusting the number and/or the combination of pumps operating.

For example, if a Pump 1 and Pump 4 combination is delivering too much flow to the distribution box:

1. The flow rate from Pump 1 can be changed using the VFD controller to maintain a target water depth in the distribution box or to change motor speed (if the pump flow is delivering too little or too much water to the distribution box). The minimum flow for Pump 1 based on the manufacturer's recommendation is 2,500 gpm. A speed of 78% (of the rated speed) will reduce the flow to approximately 2,500 gpm at a head of 25-feet.

2. The flow can also be reduced by opening the gate valve on the Pump 4 discharge column. This method of trimming flow is less efficient and less desirable than using the VFD controller to reduce flows from Pump 1.

3. Increasing the water level in the distribution box can also be used as a means to control flows. The water level in the distribution box can be increased by partially closing the slide gate(s) in the box. This increases the water level in the box, which:

    - Increases the back pressure that the irrigation pumps must operate against.

    - Increases the discharge flow rate into the irrigation distribution system downstream of the distribution box.

4. Flows can be controlled by either partially closing the gate valves in the 30-inch pipelines (at the top of levee) or by partially closing one or more of the gate valves at the pipe manifold. However, this flow control method is both difficult and slow because it requires several hours to manually open or close each valve. Additionally, closing off a line or throttling flows increases the back pressure on the pumps and decreases pump efficiency.

5. Flows can also be reduced by opening the air intake lines on the 30-inch pipelines at the landward top of the levee to admit air into the pipelines. These lines are controlled by 2-inch gate valves on the landward slope of the levee, which, when opened, allow air to enter the pipelines. The air forms an air pocket or "bubble" within the pipe(s), which reduces the flow rate in the pipe by reducing the effective cross-sectional flow area, inducing additional hydraulic losses into the pipeline and increasing the head on the pump(s). If too much air is admitted the siphon can be broken.

Flow control method 3 was incorporated into the modifications made to the TMWC system at the request of TMWC; however, during system testing it was found to be ineffective in controlling flows in the modified system and is currently not being used.

The Star Bend Pump Station is a manually operated system requiring frequent adjustments as the demand for irrigation water changes throughout the day and season. The system operator should minimize the number of pump starts and stops as frequent re-starts can reduce the life of the motor. Generally, a pump should not be operated for less time than is required for the motor to reach normal operating temperatures and should not be restarted until it has cooled down.

3. Recommended Flow Control Strategies

Two or more control strategies will usually be needed to maintain an adequate flow into the distribution box and to run the supply system efficiently. These strategies are indicated below in order of effectiveness. Strategy 1 should be employed first. If that does not provide sufficient adjustment, then Strategies 1 and 2 in combination should be employed, and then Strategies 1, 2, and 3 and so on.

Strategy 1 – This strategy consists of selecting the pump or pumps and wells that are required to most closely match the current water demand from the TMWC's

customers, and to maintain adequate pressure in the distribution system. Because the TMWC pumps each have a different capacity (due to pump size, motor horsepower, motor speed, and other factors), the operator should select the pump(s) that meet or exceed the current water demand. If the resulting inflow exceeds the water demand, the operator will need to adjust the flow from the pump(s) until the pumped flow equals the water demand. The adjustments needed are discussed in the following strategies.

Strategy 2 – The flow rate from Pump 1 can be reduced by using the VFD to decrease the speed of the motor (and pump). Figure 7 indicates the performance of Pump 1 at TDH of 25 feet at speeds from 100% to 70% of the nameplate speed of the pump (890 rpm). The maximum reduction in motor speed (at 25 feet of head) is 22%. At this speed the flow rate will be reduced approximately 2,500 gpm.

Strategy 3 – This strategy involves using the gate valve on the discharge column of Pump 4 to trim the flow to the desired rate. This is accomplished by opening the gate valve, which returns a portion of the flow back to the river. This strategy is energy inefficient and "wastes" energy by pumping water that is not needed to meet demands of the irrigation system. Operating the trim valve is estimated to have the potential of reducing the flow from Pump 4 to approximately 50%.

Strategy 4 – This strategy involves raising the water level in the distribution box to decrease the pumped flow rate. This is accomplished by increasing the head on the pumps by increasing the static lift (the difference between water elevations in the distribution box and the river). This operating strategy reduces the flow from the operating pump or pumps into the distribution box approximately 300 gpm/ pump/foot of additional TDH. Because this strategy increases water pressures in the irrigation distribution system it may be necessary to compensate for this side effect by partially closing the slide gates that control the pipes/flow entering the irrigation system. This strategy also increases energy consumption per unit of water pumped although not as much as Strategy 3.

Less Effective Control Strategies

Other flow control strategies have been suggested by others or have been used by TMWC on the pre-project system; however, these strategies are less effective or less efficient than the recommended strategies.

Strategy 5 – This strategy involves throttling with the gate valves at the top of levee or at the pipe manifold. Partially closing one or both of the 30-inch gate valves in the vault at the top of levee mechanically reduces the effective cross-sectional area of the pipe, which in turn increases the head on the pump or pumps and reduces the flow. A significant disadvantage with this strategy is that the manual operation of the valves requires hundreds of turns, and an hour or more to achieve significant flow reductions. The use of motor-driven hydraulic actuators is required if this strategy is to be effectively employed. This strategy is similar to Strategy 4, because if the gates reduce the flow too much, the siphon can be broken.

Strategy 6 – This strategy involves changing the settings on the vacuum system so that a full siphon is not achieved. By decreasing the vacuum pressure target setting of this system, the quantity of air removed is decreased and the total flow delivered to the distribution box is decreased proportionally.

Strategy 7 – This strategy involves using the two 2-inch gate valves on the air intake pipes located on the landside levee slope. Opening one or both of these valves admits air into the pipe(s) at the high point in the pipeline profile. The air becomes trapped in the pipe and forms a "bubble" that reduces the effective cross-sectional area of the pipe, which reduces the flow by increasing the head on the pump or pumps.

This strategy should not be used in conjunction with the vacuum system, since it conflicts with the vacuum system that is acting to remove air so that the flow is increased. Opening the air intake valves can introduce too much air into a pipeline operating in siphon mode and will break the siphon. Breaking the siphon will cause a significant increase in the head and a dramatic reduction in the flow.

4. Vibration Control

There is potential for vibrations to occur during pumping operations for pumps installed on raised platforms, which was the case during pre-project conditions at Star Bend. Vibrations can be caused by many factors, but the most common involve unbalanced components (such as warped shafts, worn bearings, etc.), cavitation, and equipment running at the natural resonance frequency of the structure (common for pumps with VFD controllers). From an operations standpoint, when vibrations occur, the operator should make adjustments to the system before checking for unbalanced components. The factors affecting vibration that can be addressed by making adjustments are cavitation and harmonic resonance between the pumps and the platform. These factors are discussed below.

Cavitational Vibrations – Cavitation occurs when the absolute pressure of the pumped water is reduced to a value equal to or below the vapor pressure of the water. Small vacuum pockets or bubbles form, then collapse in high pressure areas at the pump impeller. The collapse of these vapor pockets is so rapid that it makes a rumbling and crackling noise that sounds as if gravel is passing through the pump. The collapsing vapor pockets can create forces high enough to cause minute pockets of fatigue on the metal surface of the impeller and pump bowl. Over time, cavitation can cause serious pitting and damage to the pump impeller.

Cavitation can also cause:

- Excess vibration, which can cause rotating parts, such as the impeller, to contact non-rotating parts, such as the wear plates or wear rings, causing damage. Excessive vibration may also cause premature failure to mechanical seals and bearings.
- Small bits of metal released from the impeller and pump bowl due to the collapsing vapor pockets noted above can break off and collide with other moving parts. The damage typically occurs to the impeller and can severely reduce the operating life of the pump.
- Reduce the pumping capacity of the pump.

There are a number of conditions that cause cavitation; however, at the Star Bend pumping plant the most probable causes from an operations standpoint are inadequate pump bowl submergence (low river levels) and/or a clogged intake. Sometimes vortexing occurs during cavitation. Vortexing can be evidenced at times by a small whirlpool that forms at the water surface near

the pump intakes. If vortexing is observed, it is evidence of seriously inadequate pump inlet submergence resulting from very low river water levels. Vortexing is not always visible, and it is not always present during cavitation, but vortexing is evidence of cavitation. The pumps should be monitored regularly for cavitation noise and any pump suspected of cavitating should be taken off-line and the problem should be investigated further.

Because Pump 1 has been equipped with a VFD, if this pump is cavitating or making excessive noise or causing excessive vibration, the operator may need to restore the speed of this pump, which may reduce the conditions causing cavitation. However, it is unlikely to resolve or eliminate major submergence issues.

Cavitation can also occur if the pump is operated at too low a head. This causes the pump to run too far to the right of the Best Efficiency Point (BEP) on the pump curve. This condition is also known as pump "run-out" and essentially means that the duty point does not fall on the typical performance curve due to insufficient discharge pressure on the pump. Correction of this problem involves increasing the back pressure on the discharge side of the pump. This can be accomplished by increasing the water level in the distribution box, reducing the high vacuum setting, or by throttling with a valve in the discharge line.

Pump and Structure Harmonic Resonance – The use of a VFD controller on pumps installed on elevated platforms can result in vibrations when the pump is operated at a speed that resonates with the supporting structure. In new pumping plants, this condition can be prevented or minimized by using a finite element analysis to design the structure. However, the Star Bend station is a 55+-year old existing structure on which the VFD controller was installed in 2010. Operational observations can determine if resonance is occurring and the operating range in which it occurs. The system should then avoid the operational range in which vibrations occur. Correcting vibration problems due to resonance can also be accomplished by making structural modifications to the pump platform (by changing the spring rate or mass of the system). A pump vibration analysis can be conducted if the vibration problem is determined to be significant.

MAINTENANCE

General

In general, all mechanical and electrical equipment should be maintained in accordance with the manufacturer's recommendations. This O&M Manual is intended to provide general "good practice" advice as to the minimum frequency of various maintenance activities. This O&M Manual does not provide information on how the various maintenance tasks should be performed. The information presented herein is meant to supplement the manufacturer's equipment manuals. The operator should refer to the appropriate equipment manuals for detailed maintenance information. Conflicts between this document and the manufacturer's recommendations should be resolved in favor of the most stringent guidelines. The manufacturer's manuals are included in Appendix B-1 through B-4.

Pumping Plant

The maintenance schedule presented below is intended for general service and environments. Some of the maintenance items are preventive and involve simple checks, which can be conducted by the pump operator while others require a qualified pump or electrical technician.

1. Pumps

Pump shaft packing should be lubricated bi-monthly. The packing should be checked regularly for leaks. The packing should be completely replaced (not just the upper gland) when leakage cannot be controlled by tightening the packing gland.

Pump capacity head tests should be conducted annually to compare pump operation to design values. When a pump starts operating off its design curve, the pump should be evaluated by a qualified pump repair technician, since this may indicate impeller, bowl, or bearing wear and/or damage.

2. Motors

The pump motor oil levels should be checked on a weekly basis and refilled, as needed. The oil in the reservoirs should be checked for condensation, and flushed and refilled if condensation is present. Motor bearings should be lubricated quarterly. Insulation resistance testing of the

motor winding insulation of each pump should be tested annually by a qualified technician to prevent electrical shocks, ensure personnel safety, and prevent motor downtime.

Pump motor electrical efficiency tests should be conducted annually. A drop in efficiency can indicate motor wear and should be investigated by a qualified service technician. A copy of the manufacturer's Installation, Operation, and Maintenance Manual for the new electric motor is included in Appendix B-4.

3. Motor Control Center (MCC) and Variable Frequency Drive

Electrical components of the MCC and VFD should be inspected annually by a qualified electrical technician.

The water level measuring devices and switches in the distribution box should be checked before the start of the irrigation season, to determine if they are functioning properly.

During each operation it should be noted if excessive heat is present. Some equipment is designed to run hotter that it is possible to touch. Non-conducting parts should never exceed a temperature of 176 F and conducting parts should never exceed a temperature of 191 F. It is recommended that TMWC install a means to measure the operating temperature of the motor.

4. Pump Starter and Metering Panels

The pump starter and metering panels on the Star Bend pump platform should be opened and checked for rodent activity before the start of the irrigation season. When installing electrical modifications in 2010, the Star Bend levee contractor found significant rodent damage in some of these panels.

Valves

1. Check Valves

Flapper-type check valves are designed and manufactured to need little attention under normal circumstances. Normally they do not require any routine maintenance or lubrication.

2. Air Valves

It is recommended that the following maintenance be performed before the start of the irrigation season and at least one time during the season:

- Observe the SB/ARVs operation during pump start up. Check that air vent ports are clear of debris and the valve is evacuating air and seating properly.

- Observe the SB/ARVs during pump shut down. Check that the valve opens to break the vacuum when the pumps shut off.

- Inspect all valves and surrounding area for leakage at all connection fittings.

3. Gate Valves

It is recommended that the following maintenance be performed before the start of the flood season:

- Cycle the three gate vales at the pump station manifold and the two 30-inch positive closure gate valves located in the vault at the top of the levee from fully-open to fully-closed then back to fully-open to assure operability.

- Inspect the valves and surrounding area for leakage at the flange face and stem area.

It is recommended that the following maintenance be performed on (at least) an annual basis, particularly for the two 30-inch valves located in the vault at the top of the levee:

- Lubricate the valve stem and packing. The threads of the stem should be kept lubricated, clean, and dust free.

- Check for stem leaks to prevent damage to the stem packing and to the valve. Stem leaks can normally be remedied by adjusting the stem packing.

- The valves should be exercised annually to ensure the valves will remain operational.

Other Equipment

1. Slide Gates Inside Distribution Box

It is recommended that the following maintenance be performed before the start of the irrigation season and periodically during the season:

The threads on the gate stem should be cleaned and lubricated, as indicated by visual inspection. Dirty grease or a lack of grease will increase the operating force necessary to open or close the gate and will accelerate wear in the stem nut. Stem covers should be removed at least twice a year to inspect, clean, and lubricate the stems.

2. Flowmeters

It is recommended that the following maintenance be performed before the start of the irrigation season and monthly during the season:

Regular inspections should be conducted to listen and look for signs of mechanical wear and breakage, such as any grinding or growling noises that can be detected. Properly operating flowmeters operate very quietly and noises indicate a problem. Visual cues also indicate problems:

- The rate of flow should remain steady once a siphon has been established in the discharge pipeline.
- Erratic readings or non-zero readings when the pump is not operating indicates that the meter needs factory servicing or replacing.
- Fogging usually indicates a leak, either from the bearing assembly, or from an external seal.

Flowmeters can be checked in the following manner:

- After the flow through the meter has stabilized and is indicating steady flow.
- Check the volume totalizer for agreement with the flow rate indicator.

In addition to monthly inspections, the meters should be field-calibrated annually and factory-calibrated every two years.

3. Vacuum Priming System

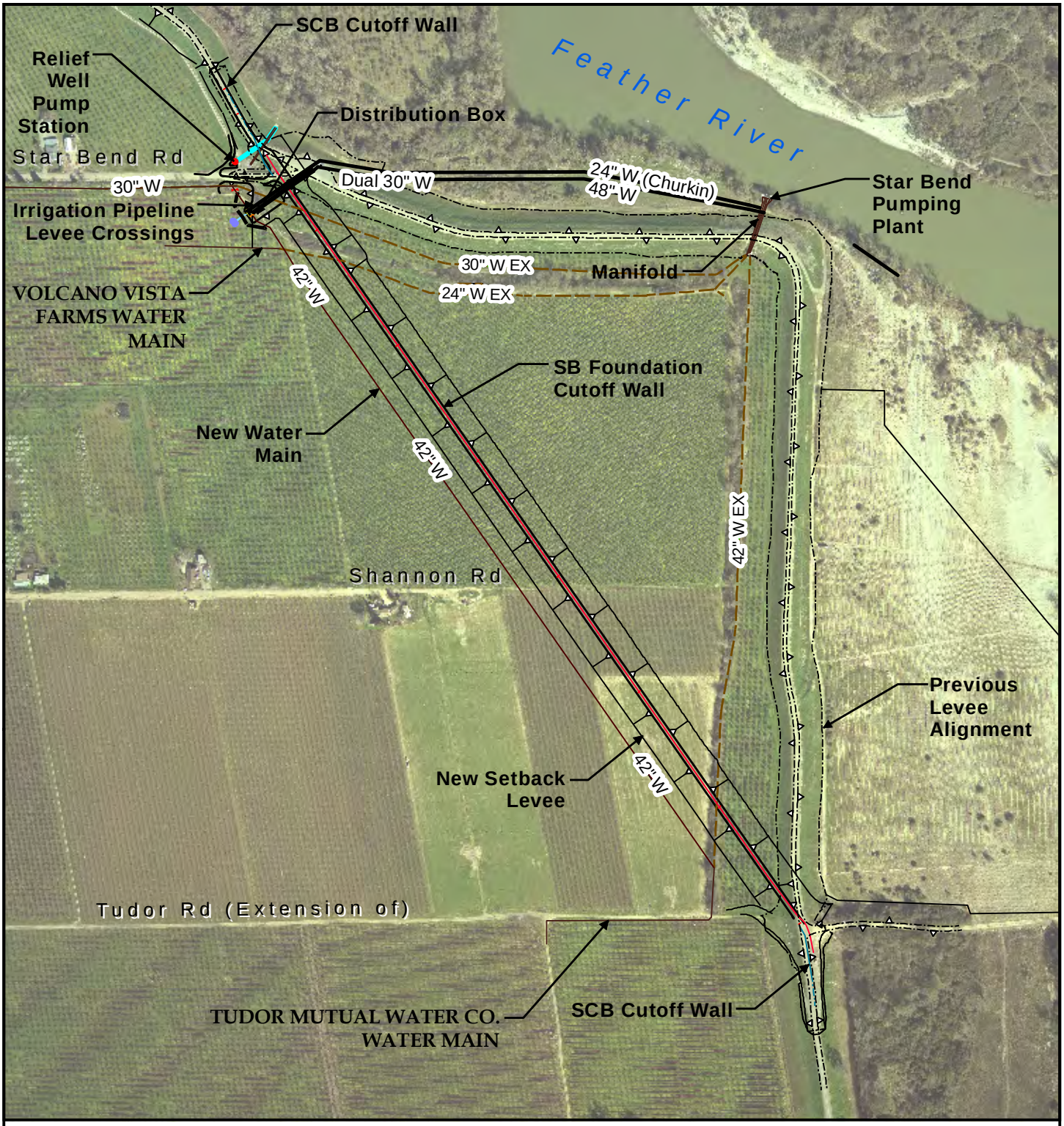
The vacuum pump should be inspected and tested annually before the start of the irrigation system to ensure the unit is functioning normally. It should also be monitored and checked for leaks at least monthly during the irrigation season. If the pump vacuum performance is not in accordance with the manufacturer's specifications, the pump should be serviced and repaired, as necessary.

The receiver tank should be checked and drained on a regular basis, as indicated in the manufacturer's O&M Manual.

4. Valve Vault and Associated Sump Pump

The gate vault at the top of the levee has a small sump pump to drain water that may accumulate from leaking pipes, valves, and precipitation that can enter the vault through the slotted manhole cover. The vault should be inspected periodically for standing water and at least monthly during the flood season between November 1 and April, and during irrigation season operations. If water is found in the vault, the source of the water should be identified and corrected and the sump pump checked and repaired. The sump pump should be operated at least annually to ensure the pump is functioning normally.

FIGURES



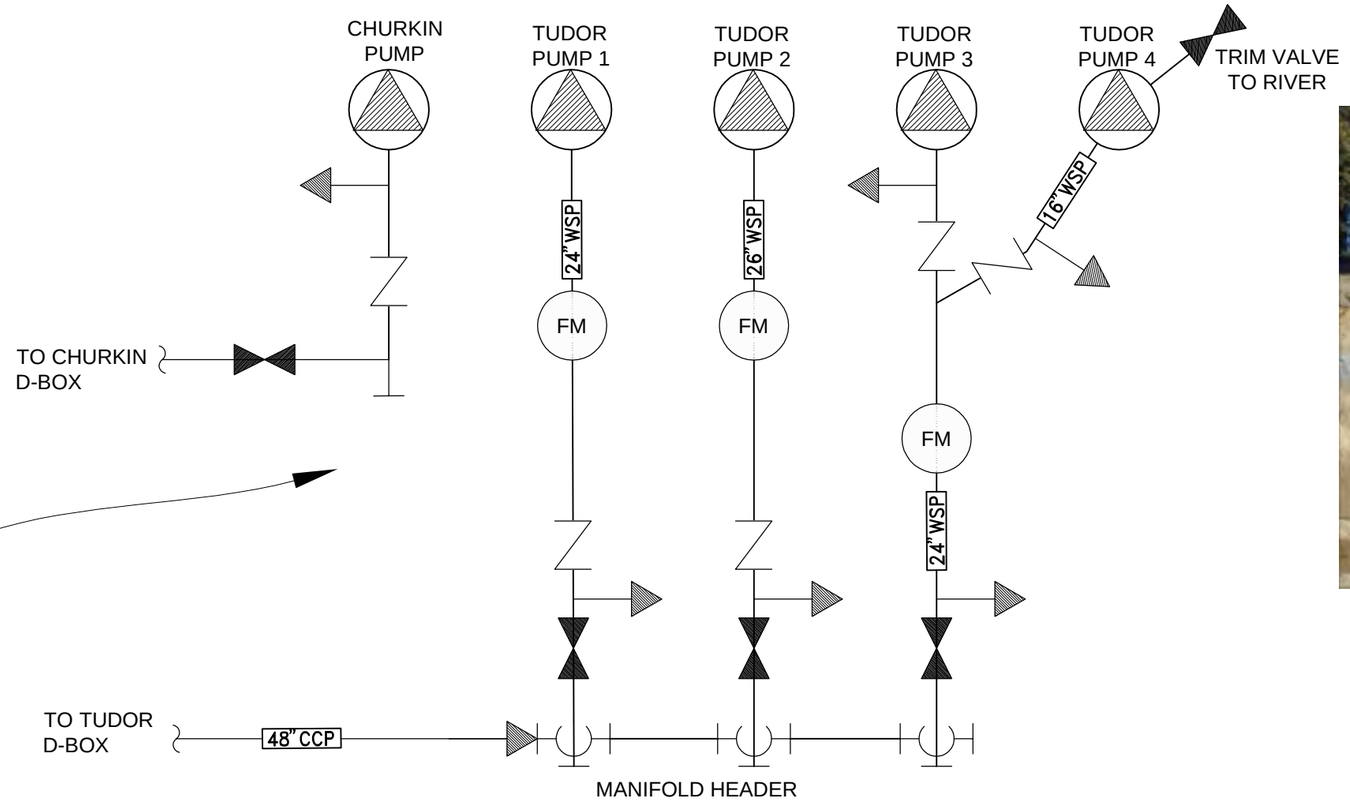
W EX = Existing Pipe Line Abandoned or Removed
W = New Water Line

FIGURE 1
STAR BEND SETBACK LEVEE AND
TUDOR MUTUAL WATER COMPANY
IRRIGATION FACILITIES

NORTH

0 250 500
FEET

WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS
3301 C Street, Bldg. 100-B Tel: 916.341.7760
Sacramento, CA 95816 Fax: 916.341.7767



VIEW

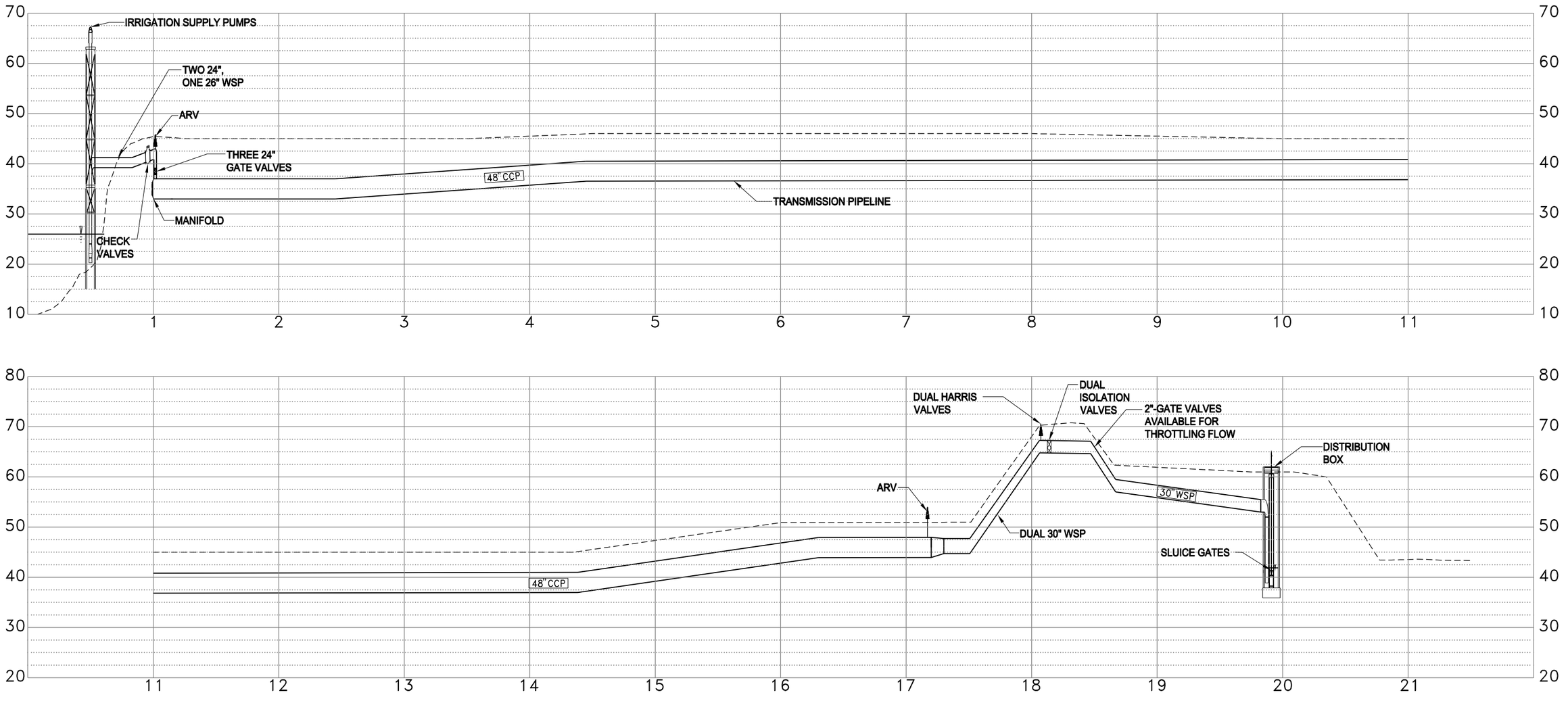
VIEW

SCHEMATIC ONLY
(NOT TO SCALE)

FIGURE 2
PUMP AND DISCHARGE PIPE SCHEMATIC

WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS

FIGURE 3
PUMP DISCHARGE PIPELINE PROFILE



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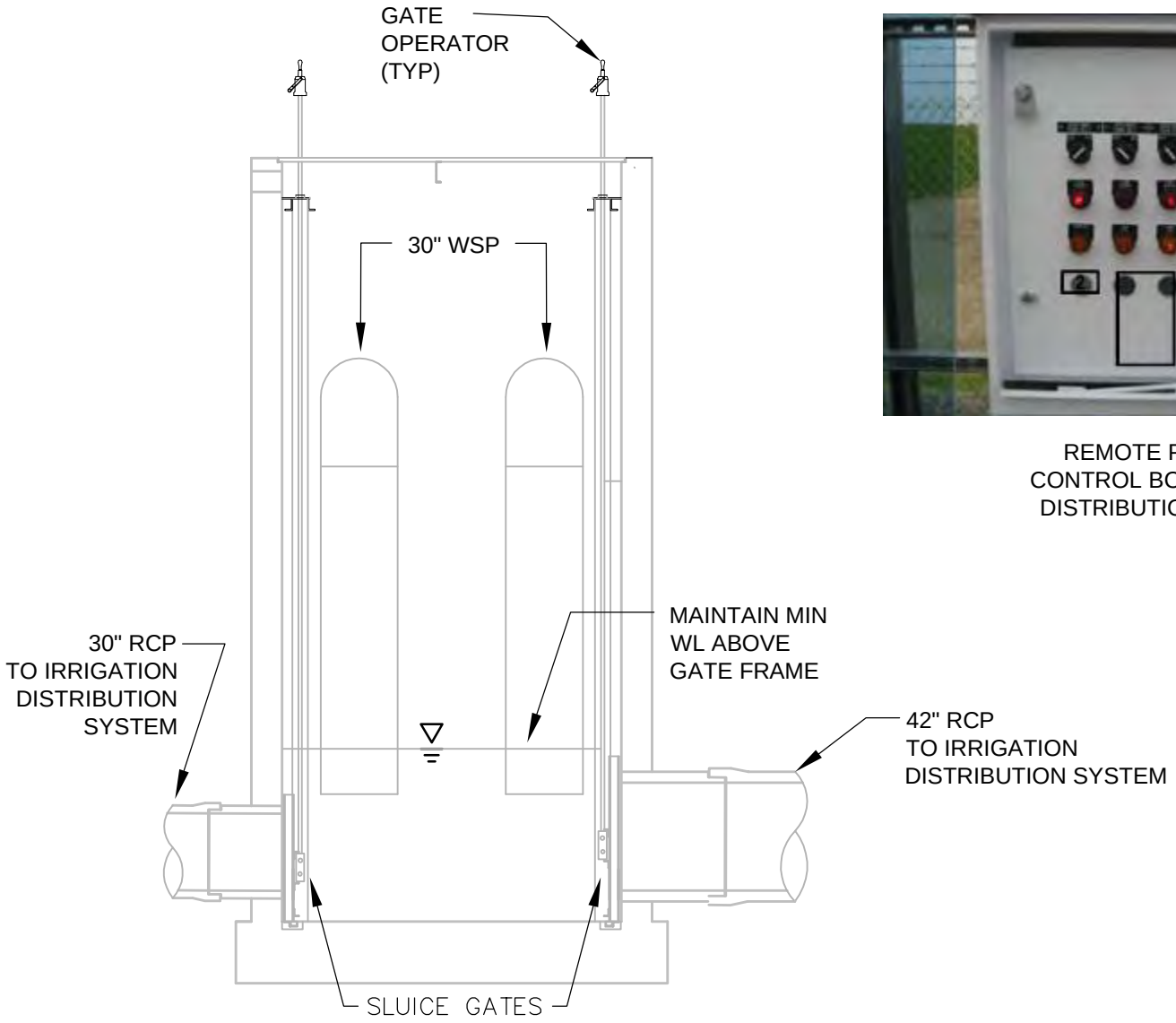

REMOTE PUMP
CONTROL BOX NEAR
DISTRIBUTION BOX

NOT TO SCALE

FIGURE 4
DISTRIBUTION BOX

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Sacramento, CA 95816 Fax 916.341.7767

FIGURE 5
APPROXIMATE PUMPING CAPACITIES STAR BEND PUMPING PLANT

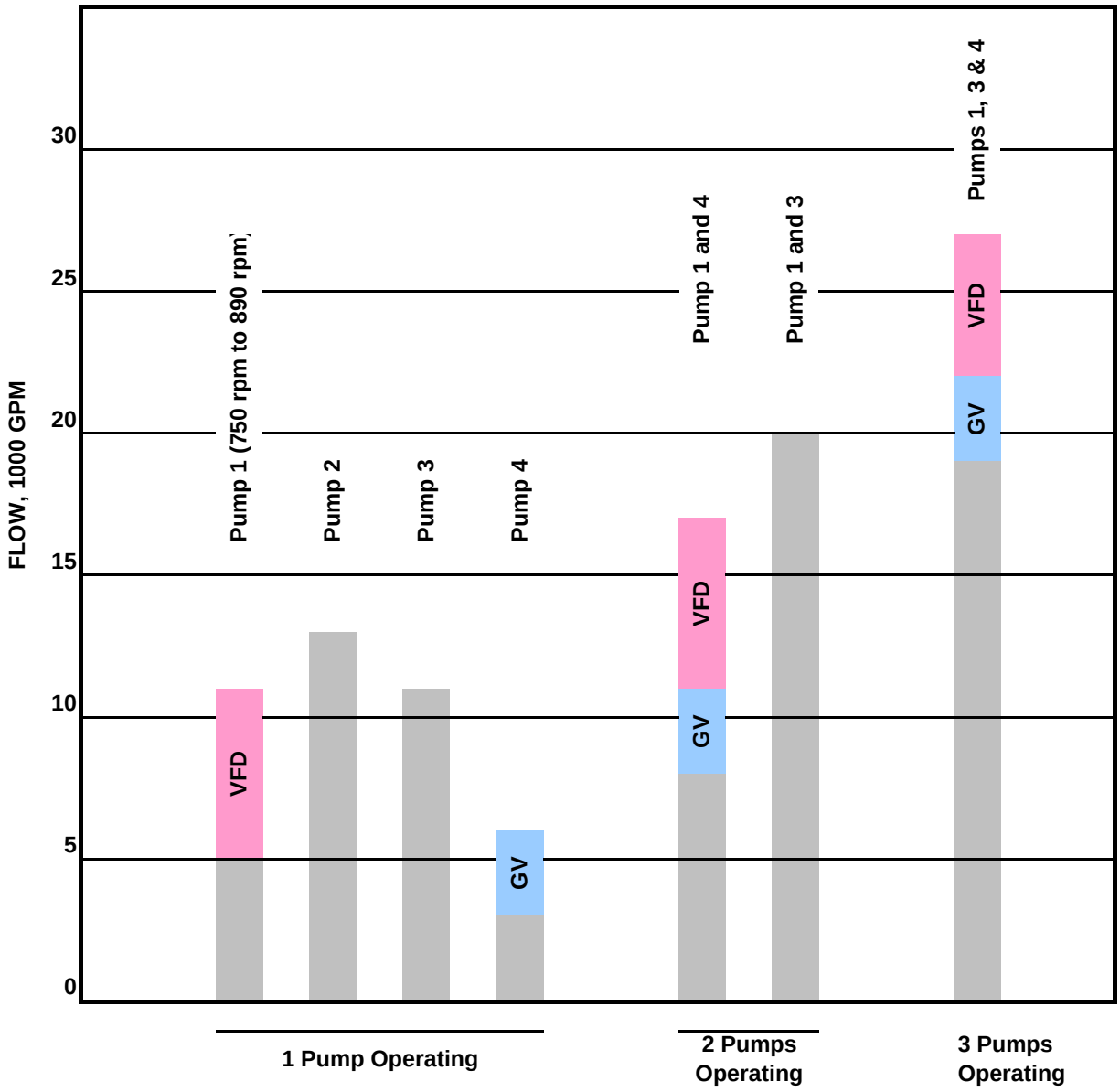


FIGURE 6
PUMP PERFORMANCE CURVES

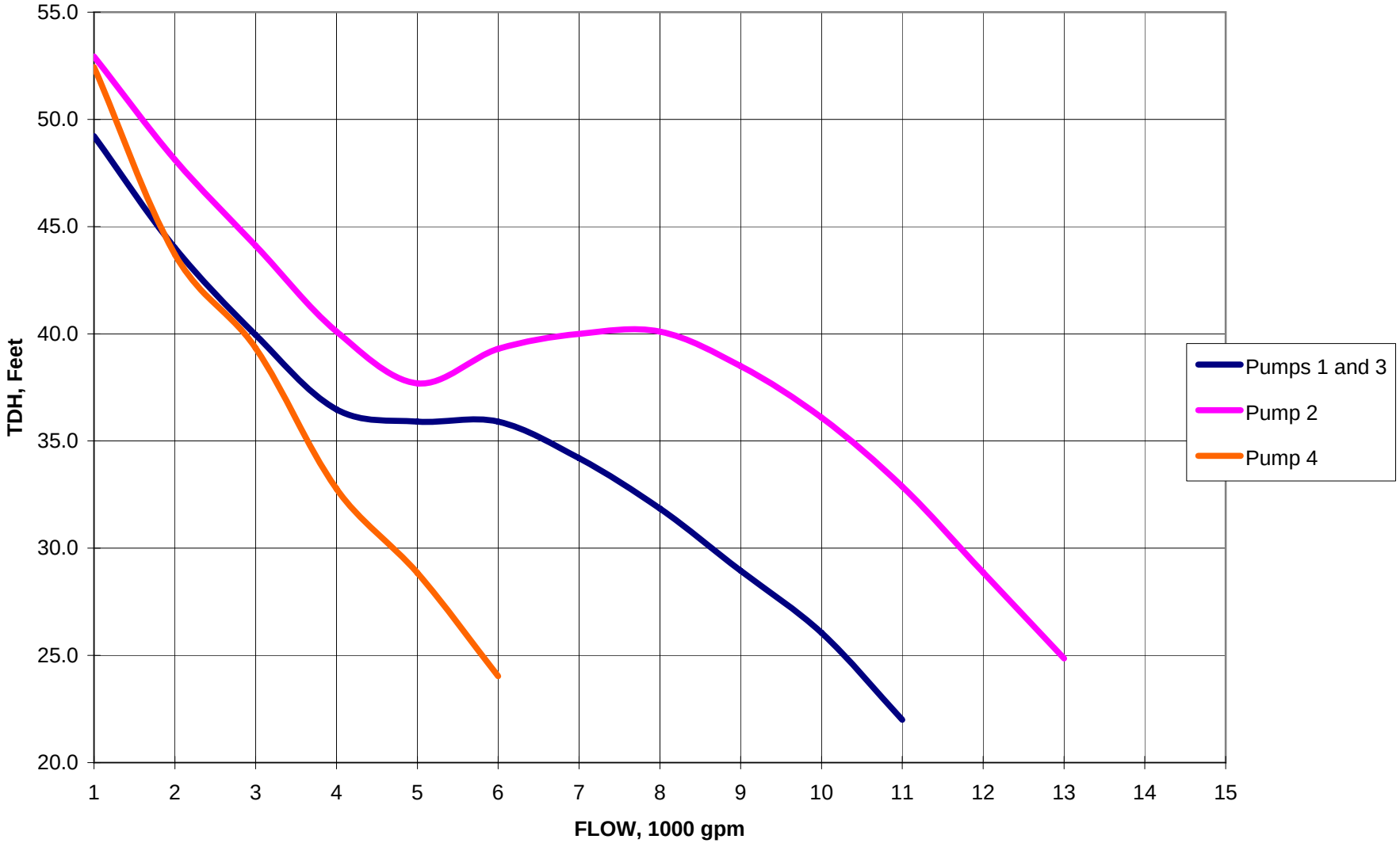
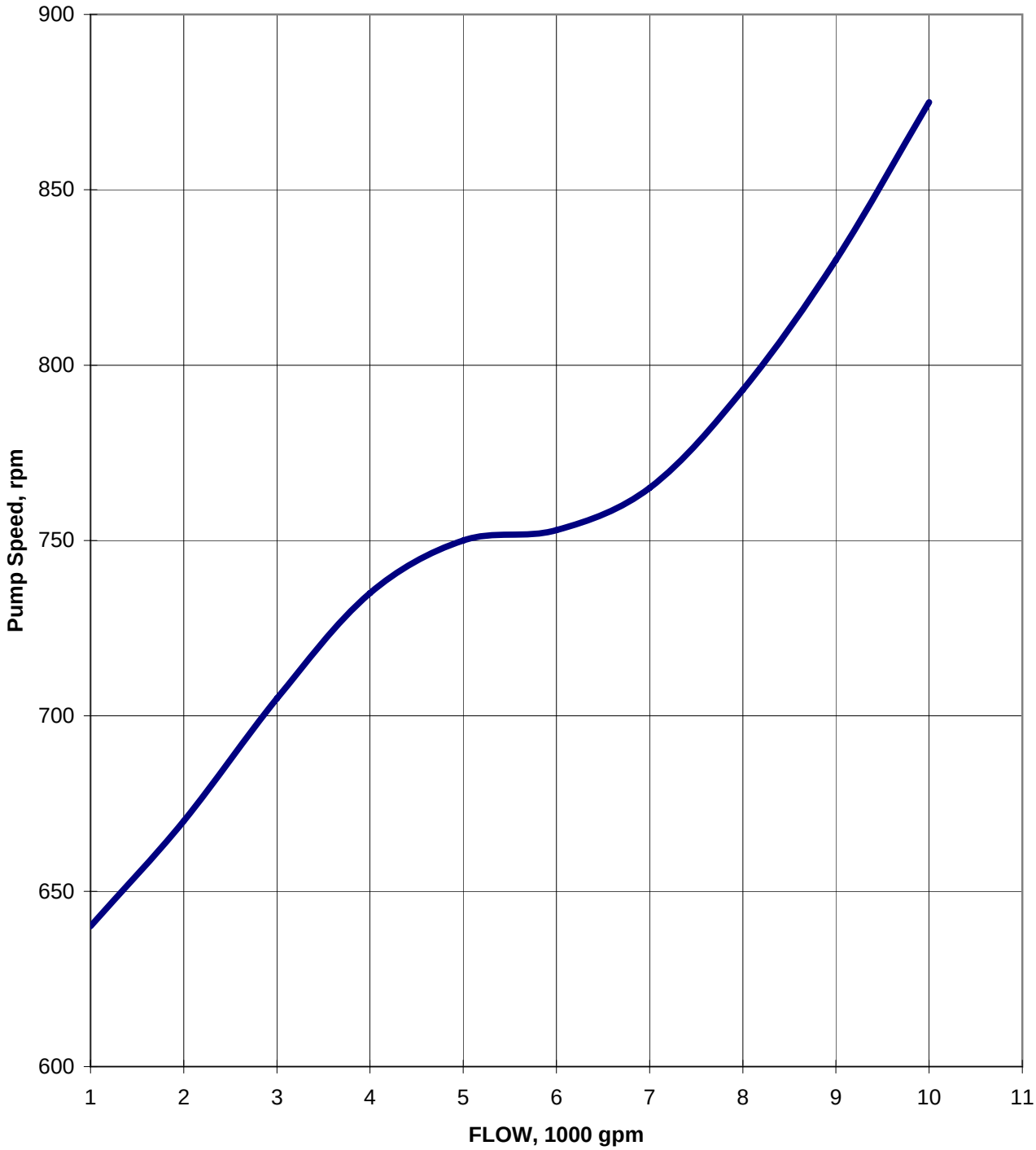


FIGURE 7
PUMP 1 PERFORMANCE WITH VFD
(AT TDH = 25 FEET)



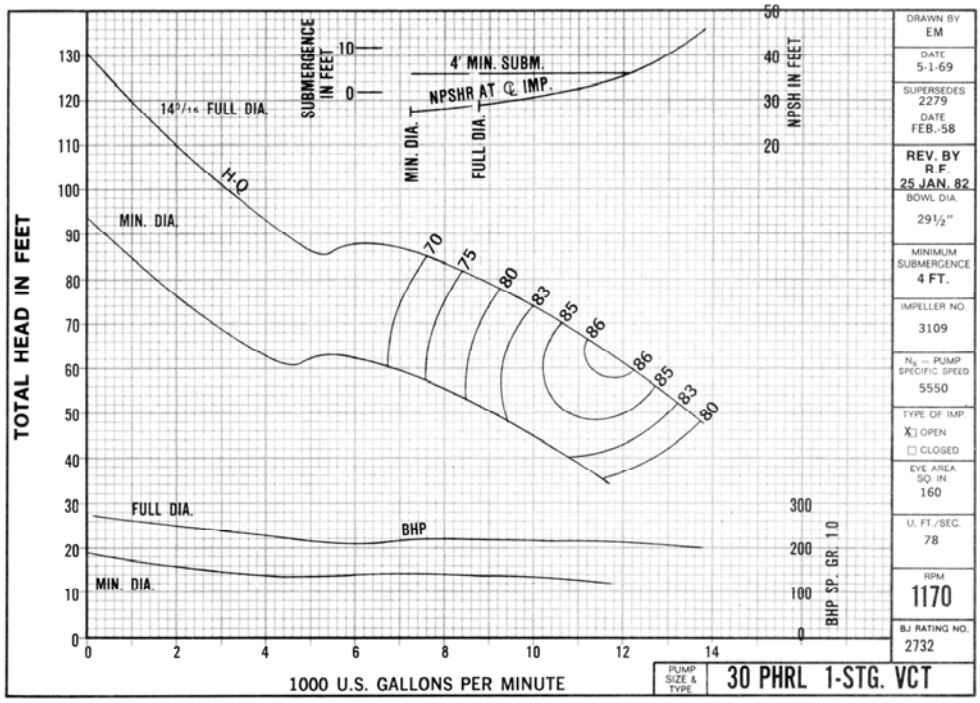
APPENDICES

APPENDIX A

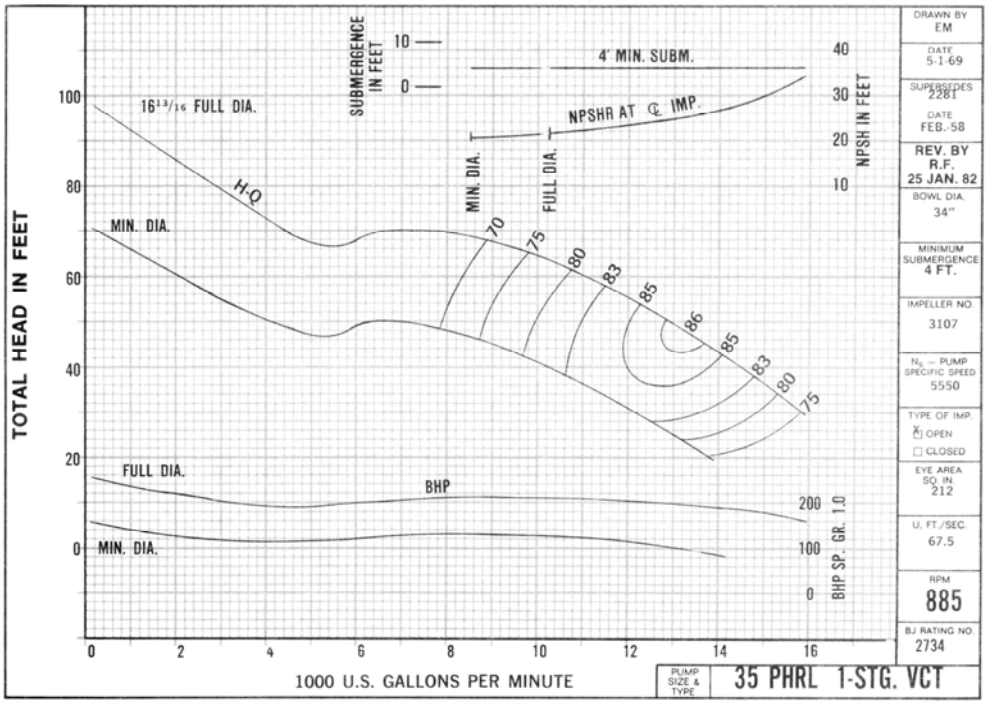
APPENDIX A-1
BYRON JACKSON PUMP CURVES

APPENDIX A-1
TUDOR MUTUAL WATER COMPANY
STAR BEND PUMPING PLANT AND DISCHARGE PIPING SYSTEM
OPERATIONS AND MAINTENANCE MANUAL

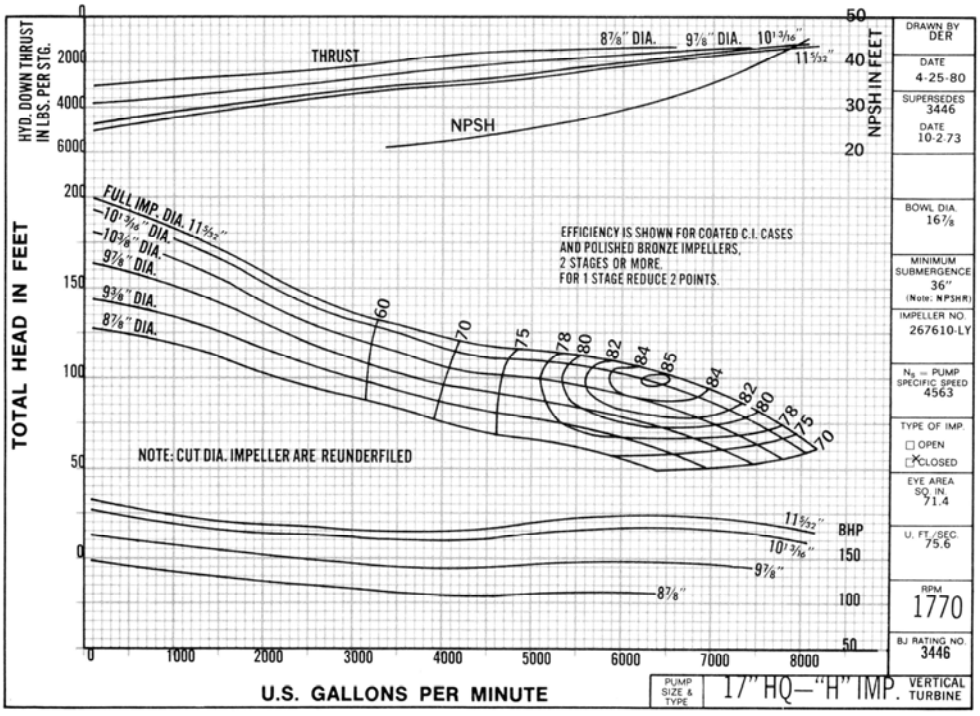
Performance Curves Pump 1 and Pump 3 – 1170 RPM



Performance Curves Pump 2 – 885 RPM



Performance Curves Pump 4 – 1170 RPM



APPENDIX A-2
BYRON JACKSON NAMEPLATE DATA

APPENDIX A-2
TUDOR MUTUAL WATER COMPANY
STAR BEND PUMPING PLANT AND DISCHARGE SYSTEM
OPERATIONS AND MAINTENANCE MANUAL

BYRON JACKSON NAMEPLATE DATA

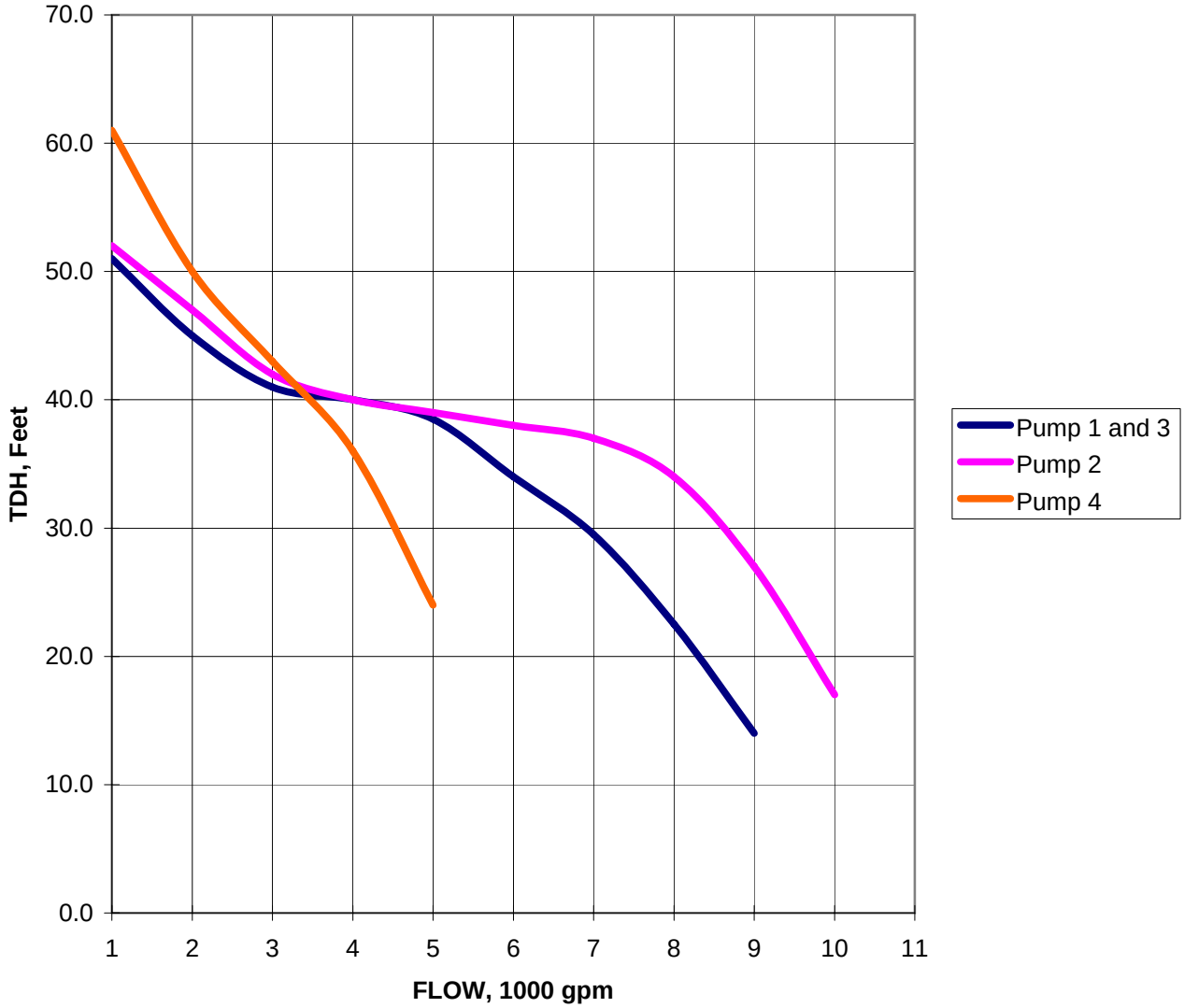
		PUMP			
		1*	2	3	4
Motor					
	Manufacturer	Emerson Motor Co.	US Motor	US Motor	GE Motor
	Horsepower	75	100	75	60
	Serial No.	S0120087036-0001R0001	1062211	1055462	5K6276XC2A
	CFV Frame	H444VP	587	587	A444UP
	Voltage	460	440	440	220/440
	Hertz, Phase	6-60, 3	60, 3	60, 3	60, 3
	Speed, rpm	90-900	710	900	1175
Pump					
	Manufacturer	Bryon Jackson	Bryon Jackson	Bryon Jackson	Bryon Jackson
	Model	30PHRL	35PHRL	30PHRL	17HQH
	Serial No.	318281	318280	318282	721S550
	Impellor Diameter	Unk	Unk	Unk	Unk
	Speed, rpm	890	720	890	NOT CLEAR
	Head, feet	30	30	30	Unk
	Rated Flow, gpm	8,500	11,250	8,500	Unk

*VFD rated motor. See Appendix B-1 for additional data.
Pump 1 is equipped with a 100 hp, 480V, 3-phase VFD manufactured by Dan Foss, Inc., supplied by Tesco Controls, Inc.

APPENDIX A-3
PUMP CURVES DEVELOPED BY KIT BURTON

APPENDIX A-3
TUDOR MUTUAL WATER COMPANY
STAR BEND PUMPING PLANT AND DISCHARGE SYSTEM
OPERATIONS AND MAINTENANCE MANUAL

PUMP PERFORMANCE CURVES 1/



1/ Curves from Independent Technical Review by Kit Burton (June 2010)

Pump	Size, Type, rpm, hp
1	BJ 30PHRL at 890 rpm, 75 hp
2	BJ 35PHRL at 710 rpm, 100 hp
3	BJ 30PHRL at 890 rpm, 75 hp
4	BJ 17HQH at 1175 rpm, 60 hp

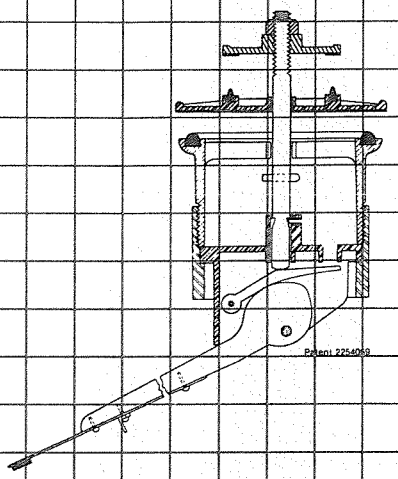
APPENDIX B

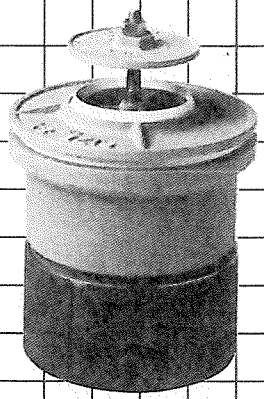
APPENDIX B-1
VARIABLE FREQUENCEY DRIVE (VFD) SYSTEM
(TESCO CONTROLS, INC. – CD)

APPENDIX B-2
HARRIS SIPHON BREAKER AND AIR RELEASE VALVES (SB/ARV) AND WATERMAN AIR VENT VALVES

HARRIS

Siphon Breaker and Air Relief Valve





For Reliability
For Efficiency
For Economy
For Safety

The Harris Siphon Breaker & Air Relief Valve is designed to control the natural siphon action of drainage pump station pipelines. It is the only valve of its type with over 40 years of proven market experience. During that time, Harris Siphon Breaker & Air Relief Valves have provided years of trouble-free service to government entities and private individuals both nationwide and overseas.

It offers:

- Increased pump efficiency
- Controlled siphon action
- Positive siphon break
- Pump back wash
- Reasonable prices

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Cont. Lic. Nos. CA 315722 Nev. 12368A

Harris Siphon Breaker & Air Relief Valve Valve Sizing

The Harris Siphon Breaker & Air Relief Valve is available in five sizes. To determine the size needed for your application you need to find:

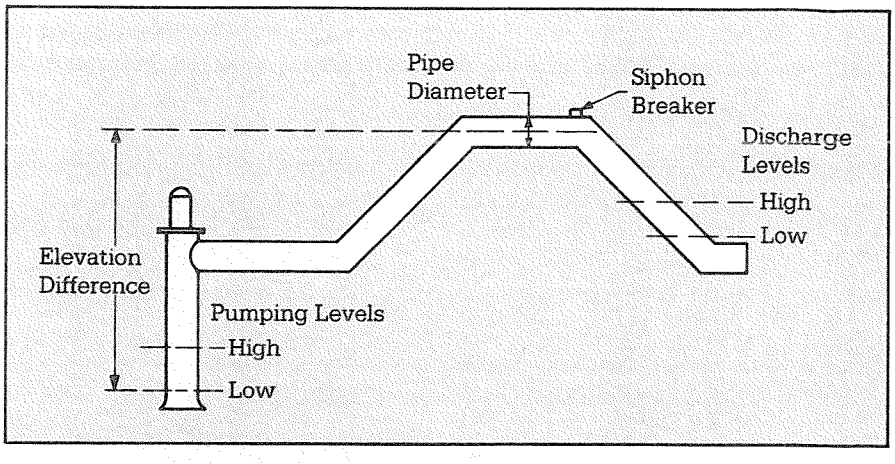
a. the inside diameter of the pipe
b. the volume (GPM) or velocity (CFS) of flow
c. the elevation difference between lowest water and highest pipe centerline

(see figure 1).

Harris valves can be fitted with arms to operate within a range of pipe sizes (figure 3). Since there is some overlap in size, the flow rate chart (figure 2) is used to identify the best valve for the application. To use figure 2 you need to know the cubic feet per second (CFS) flow. If you know the gallons per minute (GPM) you can convert to CFS by dividing by 450.

Locate the CFS of your installation on the bottom line of figure 2. Lay a straight edge perpendicular at that spot and see which valve performance line is crossed. Select the smallest valve possible for that flow which also falls at or below the optimum air velocity of 300 F.P.S.

Figure 1



1. Inside diameter of pipeline in inches
2. Volume (GPM) or Velocity (CFS)
3. Difference between low water and highest pipe centerline

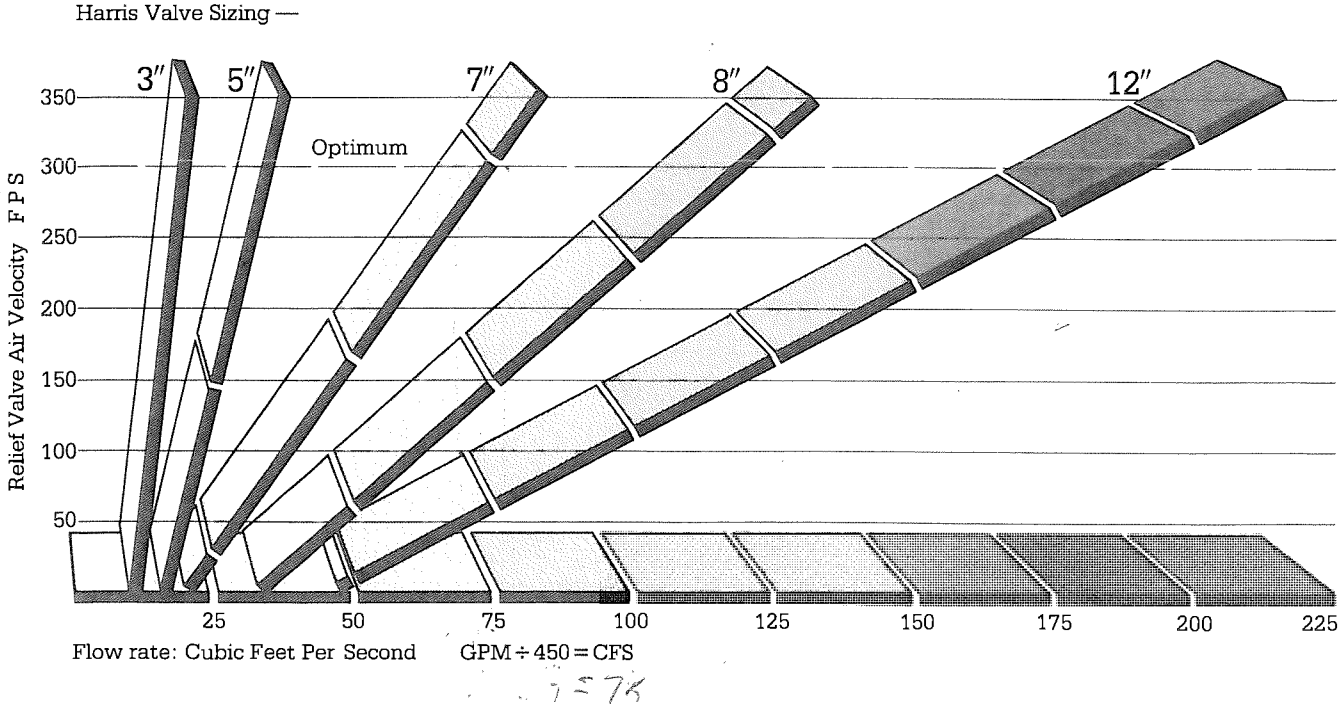
Example 1:

Assume a 30″ line with 50 CFS velocity flow. A 7″, 8″, or 12″ valve could work but since the 7″ valve is the smallest valve under 300 FPS (figure 2) it would be most economical.

Example 2:

Assume a 48″ line with 225 CFS. In this case the optimum capacity of the 12″ valve is exceeded and additional vent type valves would be required. 225-185 (optimum) = 40. 40 CFS would require a 7″ vent valve ahead of the 12″ valve in the line.

Figure 2



Use the elevation difference and figure 4 to determine the siphon vent area of the cover for the size valve you have selected. The model number of the valve is in the left hand column. Add a dash and the pipe size in inches and you have a complete description for ordering.

Valve numbering system:

Harris Siphon Breaker — pipe line size (inside diameter)

HSB 05 A 18

size — siphon vent area

A = 1.4 sq. in.
B = 4.2 sq. in.
C = 10.5 sq. in.
V = vent only

Figure 4

Model #	Base Size	Allowable Elev. Diff.	Air Vent Area	Siphon Vent
HSB 03 A	3″	all	4.2 sq. in.	1.4 sq. in.
B*	3″	10′	4.2	4.2
HSB 05 A	5″	all	10.5	1.4
B	5″	16′	10.5	4.2
C	5″	10′	10.5	10.5
HSB 07 B	7″	all	26.5	4.2
C	7″	15′	26.5	10.5
HSB 08 B	8″	all	40.0	4.2
C	8″	15′	40.0	10.5
HSB 12 C	12″	all	92.0	10.5

*one piece cover.

Figure 3

3″ for pipelines 8″ to 14″ in diameter
5″ for pipelines 12″ to 22″ in diameter
7″ for pipelines 16″ to 36″ in diameter
8″ for pipelines 24″ to 48″ in diameter
12″ for pipelines 30″ to 72″ in diameter

Valve Dimensions NOTE: See Figure 5

Number on Drawing	Valve Sizes 3″	5″	7″	8″	12″
1	4″	6¼″	9⅛″	10⅛″	14¾″ OD of largest part
2	7¾″	10½″	14″	14¼″	15½″ full open
3	2″	3″	4″	4″	4″ height of steel base ring
4	3½″	5⅝″	7¾″	8⅝″	12¾″ OD of steel base ring

The above sizes are minimum for proper installation and operation of Harris Siphon Breaker & Air Relief Valves

Harris Siphon Breaker & Air Relief Valves Standard Construction

Valve Body
– Gray iron casting, painted

Weight
– Gray iron casting, cold galvanized

Spider, cam, & finger
– Bronze castings

Arm
– Manganese bronze

Taper pin
– 18/8 stainless steel

Valve Stem & Hinge Pins
– Type 303 stainless steel

Base Ring
– Extra heavy pipe or tubing

Vane
– 16ga. half hard sheet brass

Screws & Lock Nut
– Brass or stainless steel

Valve Seat (Gasket)
– Neoprene, special formula

Valve Cover(s)
– Brass, painted, on 3″ thru 8″ and gray iron casting, cold galvanized for 12″ valves.

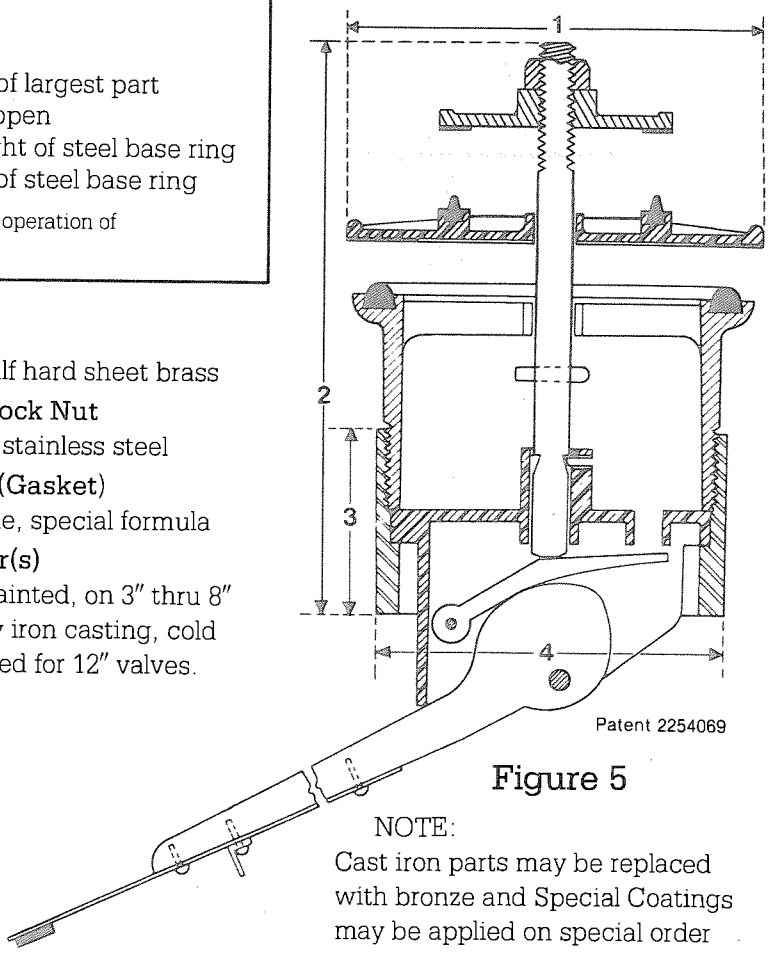


Figure 5

NOTE:
Cast iron parts may be replaced with bronze and Special Coatings may be applied on special order and at additional cost. Please request quotation.

Harris Siphon Breaker & Air Relief Valve Typical Installation

1. Locate installation point approximately one to two pipe diameters before the highest break point on the discharge line.
2. Cut hole in pipe to accept the base ring.
3. Weld the steel base ring in place. Top of base ring must be level.
4. Insert bronze spider unit with arm into base ring. Arrow on spider unit must point in direction of flow when pumping.
5. Remove cover from valve body, coat threads on valve body with pipe dope, thread body into base ring and tighten. Be sure spider unit does not turn (it is usually necessary to turn spider unit so that arrow points slightly to left of center before starting to tighten valve body.)
6. Replace valve cover and adjust opening to allow approximately 3/8" to 5/8" gap between cover and gasket with arm hanging free. Install and tighten locknut.

NOTE:
Full instructions for installation of the valve and adjustment of the cover are sent with each valve. Proper adjustment is essential for proper operation of the valve.

Harris Valve Parts List

ITEM NO.		3"	5"	7"	8"	12"
1	Base Ring	010-03	010-05	010-07	010-08	010-12
2a	Spider & Arm Assem	370-03	380-05	390-07	391-08	395-12
2	Spider	070-03	080-05	090-07	091-08	095-12
3a	Arm Assem	123-XX	145-XX	137-XX	138-XX	172-XX
3	Arm – Regular	020-XX	040-XX	030-XX	030-XX	107-XX
	Extra Long		041-XX	042-XX	042-XX	106-XX
4	Body	300-00	500-00	700-00	800-00	120-00
5	Body Gasket	300-01	500-01	700-01	800-01	120-01
6	Valve-Cover – Model A	032-03	052-05			
	Model B	033-03	053-05	072-07	082-08	
	Model C		051-05	073-07	083-08	120-12
7	Gasket – Model A	300-34	300-34			
	Model B	300-01	300-01	300-01	300-01	
	Model C		500-01	500-01	500-01	500-01
8	Top Cover – Model A	031-03	031-05			
	Model B	033-03	033-05	033-07	033-08	
	Model C		051-05	051-07	051-08	051-12
9	Vent Cover	033-03	051-05	071-07	081-08	121-12
10	Valve Stem	100-03	100-05	100-07	100-08	100-12
11	Vent Stem	110-03	110-05	110-07	110-08	110-12
12	Finger Cam	002-03	010-05	060-07	060-08	060-12
*	Poppet	130-03	130-05	130-07	130-08	130-12
*	Keeper Cam	004-03	003-05	050-07	050-08	050-12
*	Keeper Pin	150-03	150-05	150-07	150-08	150-12
*	Cam Cover	160-03	160-05	160-07	160-08	160-12
*	Cover Screw	6/32 × 1/4	6/32 × 1/4	6/32 × 1/4	6/32 × 1/4	6/32 × 1/4
*	Hingepin – Cam	1/8 × 1-3/8	3/16 × 1-3/8	1/4 × 1-3/8	1/4 × 1-3/8	1/4 × 1-3/8
13	Hingepin – Arm	1/4 × 1-3/8	3/8 × 1-3/8	3/8 × 1-3/8	3/8 × 1-3/8	3/8 × 1-3/8
14	Hingepin – Finger	1/8 × 3/8	3/16 × 1-3/8	1/4 × 1-5/8	1/4 × 1-5/8	1/4 × 1-5/8
15	Vane	210-XX	210-XX	210-XX	210-XX	210-XX
16	Weight	220-03	220-05	420-07	420-08	420-12
17	Rivets	3/16 × 2	3/16 × 2	1/4 × 2	1/4 × 2	1/4 × 2
18	Taper Pin	240-03	240-05	240-07	240-07	240-12
19	Stem Lock Nut	3/8-NC	1/2-NC	5/8-NC	5/8-NC	3/4-NC

See exploded drawing, left flap.

XX-Pipeline O.D.
*These parts for valves built PRIOR to March 1987 only.

MANUFACTURED AND DISTRIBUTED BY —

WM. P. WILSON & SONS, INC.

TURBINE PUMPS — IRRIGATION SYSTEMS

Kentucky and North Cleveland, Woodland, CA
Mailing Address: P.O. Box 2203, Woodland, CA 95776
530 / 662-8654
Cont. Lic. Nos. CA 315722 Nev. 12368A

Harris Siphon Breaker and Air Relief Valve General Description of Operation

With the pump stopped, the arm of the valve will hang straight down from the position shown in figure 5 of the brochure. The small, or siphon breaker, cover is held open by the arm, and air is free to leave or enter the pipeline.

When the pump starts, air pressure in the pipeline forces the larger cover open, to create an opening of nearly a full valve diameter for air relief. This large capacity air flow reduces the starting load on the pump, and assures a rapid elimination of air. Water flow acts on the arm and vane to move it to a position opposite that shown in figure 5. The cam on the arm allows the stem and covers to drop by gravity and the partial vacuum created by the siphon seats the covers tightly against the gaskets. The natural siphon then assists the pump and increases its efficiency.

Upon pump shut-down, the arm will return to vertical, or in the event of a reverse siphon, to the position shown in figure 5. The cam action forces the siphon breaker cover open and air enters the pipeline to allow the water to flow away from the high point. Water between the valve and pump flows back through the pump, dislodging debris from the screen. The valve is now open and ready for the next cycle.

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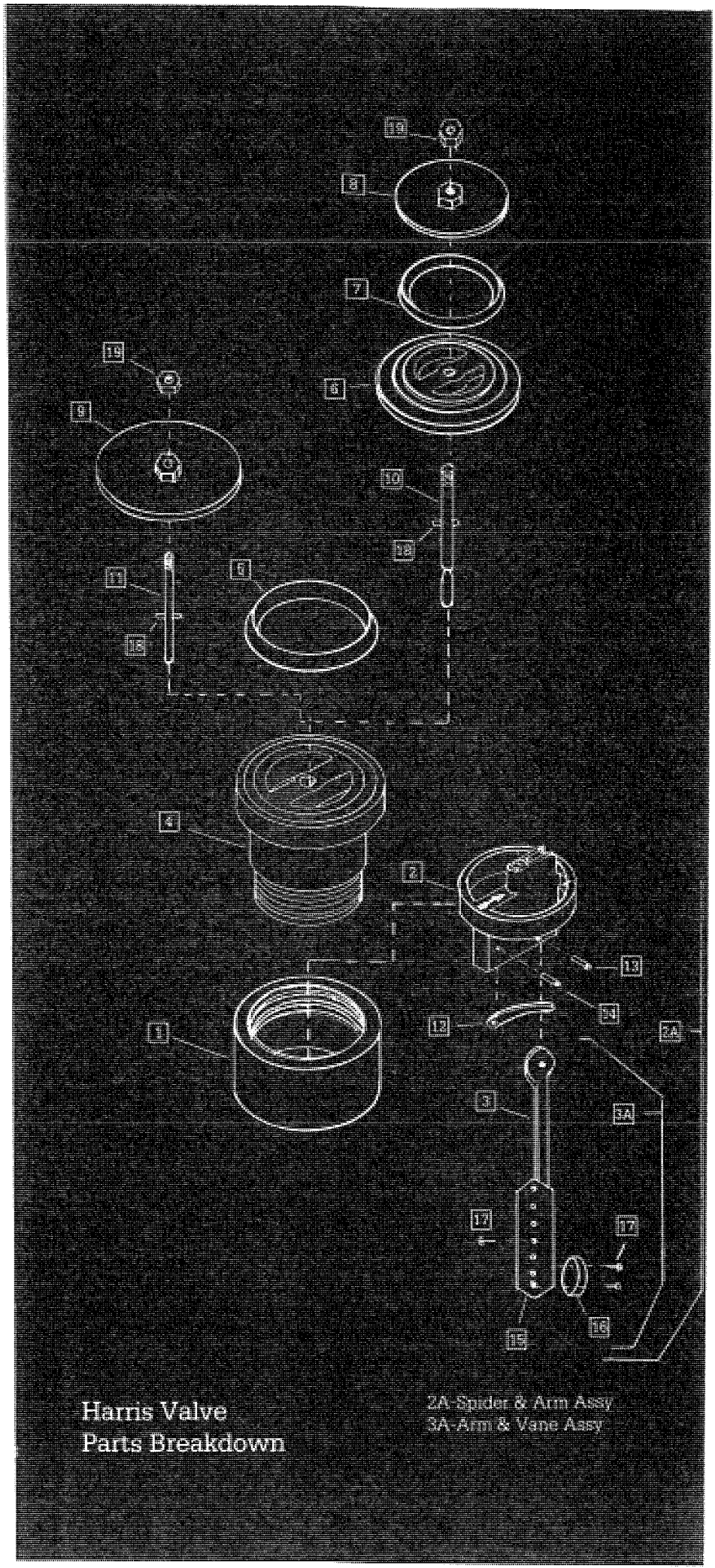


Harris Valve
Parts Breakdown

2A-Spider & Arm Assy
3A-Arm & Vane Assy

AV-150 AIR VENT

AND VACUUM RELIEF VALVE

USES:

Waterman Model AV-150 Air Vents are designed for evacuation of air when filling a pipe line and provide positive vacuum relief when pipe is draining.
Use on gravity or higher pressure systems.

FEATURES:

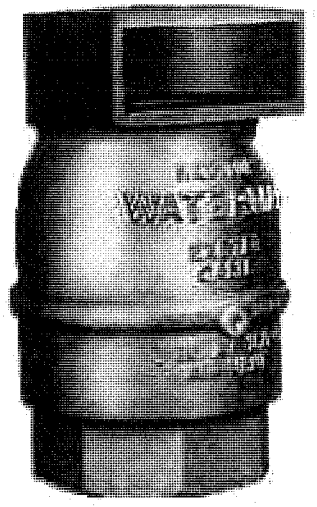
The Model AV-150 uses a semi-hard, precision ground, inert solid plastic float ball. The float seats against a precision "o-ring" providing a tight seal at very low pressures where other vents often leak. They have excellent seating characteristics and operate trouble-free at pressures up to 150 psi on the 1½" and 2" units and 100 psi on the 3" and 4" units.

The aerodynamic "air-flow" design of a high strength alloy aluminum body and full baffle assures maximum vent capacity without premature closing. Material selection prevents "sticking" in the closed position.

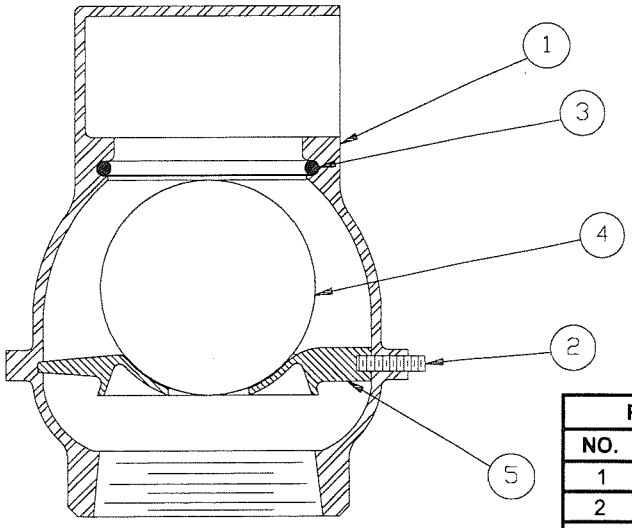
Units are furnished with standard female pipe threads which should be protected with "Never-Seize" or equivalent when installed.

VENT CAPACITY = INLET SIZE
VACUUM RELIEF CAPACITY = CLEAR OPENING SIZE

1½" INLET	= 1⅛" dia. clear opening
2" INLET	= 1¾" dia. clear opening
3" INLET	= 2⅜" dia. clear opening
4" INLET	= 3½" dia. clear opening

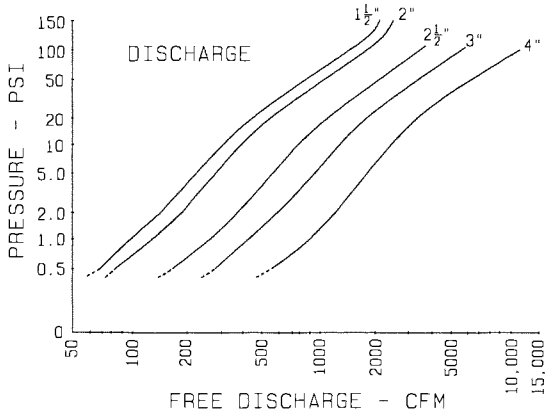


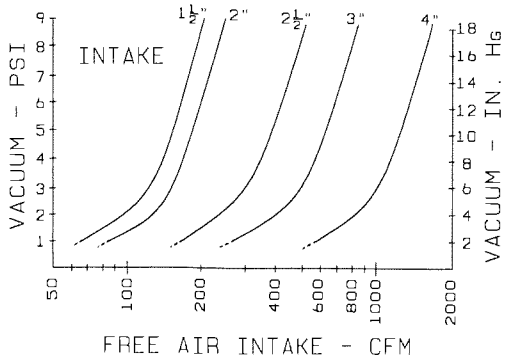
MODEL AV-150



PARTS LIST	
NO.	NAME
1	Body
2	Set Screw
3	O-Ring
4	Float Ball
5	Baffle

DISCHARGE CURVES





APPENDIX B-3
GATE AND CHECK VALVES

CLOW

Clow Valve Co.
902 South 2nd Street
Oskaloosa, IA 52577
Telephone: 641 673-8611
Fax: 641 673-8269

14" - 48" RESILIENT SEAT GATE VALVE
WITH ROTORK/EXEECO GEARING

O & M Manual

TABLE OF CONTENTS

CLOW

Clow Valve Co.

902 South 2nd Street
Oskaloosa, IA 52577

Telephone: 641 673-8611
Fax: 641 673-8269

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

RESILIENT SEAT GATE VALVE

GENERAL; *Inspect all valves at time of delivery for shipping damage and to confirm compliance with specifications. Valves are completely tested per the appropriate standards and specifications by the manufacturer. The valves should be stored in such a manner to protect them from weather and blowing dirt and debris. In cold climates, if water is allowed to freeze in the valve, severe damage to the valve components could result. Any packaging should be replaced if removed for inspection. Proper slinging and handling methods should be used when moving valves. Do not place slings or other devices around operating stem or through the valve port opening.*

I. Installation

1. *Check that valve end joints are clean. Again check for damage to the valve. Open and close valve to insure proper operation. Close wedge before placing valve in trench or line.*

2. *Handle valve carefully. Do not drop into position. Do not sling through the port opening.*

3. *Prepare pipe ends according to manufacturer's instructions. Install valve per proper methods according to end joint type. All piping should be properly supported to avoid line stress on the valve. Do not use the valve as a jack to force a pipeline into position.*

4. *A valve box or vault should be provided for each valve used in buried service application. These should be installed such that no load is transferred to the valve.*

5. *Before pressurization of the pipeline and valve, all pressure containing bolting (cover, follower plate, end connection) should be inspected for adequate tightness (usually 90 ft. lb.).*

6. *Buried valves should be pressurized before backfilling.*

7. *With valve in open position, the entire system should be thoroughly flushed to clean the system. Debris in the valve could prevent valve from closing or possibly damage the resilient material on the wedge.*

8. *Upon completion of the installation, gate valve location, size, type, date of installation, number of turns to open, direction of opening, and any other special information should be entered on permanent records.*

II. Operation

1. *Do not operate valves in systems that exceed the rated working pressure of the valve, (14"-48" 250 psi).*

   System should be completely flushed before valve is operated in normal cycle.

2. *The R/W valve opens and closes by turning the main valve stem with an operating nut or handwheel. The valve closes by compressing the resilient material bonded to the wedge against the valve body. As the material is being compressed (at end of closing cycle) torque requirements will approach maximum. Opening the valve requires significantly less torque.*

3. *If the valve should fail to seal after necessary number of turns, open the valve four or five times and reseat.*

   Emergency Operation;

   Turn the handwheel of operating nut faster in the desired direction.

III. Inspection and Maintenance

1. *Frequency of inspection should be based on frequency of operation. Semi annual inspections are minimum recommended. Valves should not be disassembled unless a breakdown has occurred.*

2. *During inspection, the valve should be opened and closed with pressure in the pipeline. The valve should function freely with no binding or vibration. Count the number of turns to full closed, this will reveal an obstruction if correct number of turns are not achieved. See table;*

TURNS TO OPEN

14" - 52	*with spur gear - 104*	*with bevel gear - 104*
16" - 52	*with spur gear - 104*	*with bevel gear - 104*
18" - 64	*with spur gear - 192*	*with bevel gear - 192*
20" - 64	*with spur gear - 192*	*with bevel gear - 192*
24" - 76	*with spur gear - 228*	*with bevel gear - 228*
30" - 98	*with spur gear - 588*	*with bevel gear - 588*
36" - 114	*with spur gear - 684*	*with bevel gear - 684*
42" - 100	*with spur gear- 800*	*with bevel gear - 800*
48" - 100	*with spur gear - 800*	*with bevel gear - 800*

3. *All gaskets and joints should be checked for leakage and tightness.*

4. *With the valve closed and pressure against the disc, a check for leakage Is possible by "listening" to the valve for flow. A stethescope will help in this procedure.*

5. *Attached actuators should be inspected per manufacturer's recommendations provided with those units.*

6. *OS&Y valves should have the exposed stem lubricated at each inspection. Check stuffing box bolts for tightness.*

7. *A permanent inspection record should be kept for each valve.*

RECORDS

1. Trouble can be anticipated with a good Inspection Program. Such a program can not exist without good records. Poor records are worse than none.

2. A printed 5 x 8 record card for each valve and hydrant in the system is most convenient.

   a. Identification of each valve and hydrant is essential. Setting up a numbering system is one of the first steps to take. A reasonably simple method is to assign a number to each street intersection, then identify each valve of hydrant numerically or alphabetically between intersection numbers.
   For instance; I9-I10, would be the number of second valve from street intersection number 9 in going toward street number 10.

   Another convenient device is to assign only odd numbers to existing hydrants. When hydrants are added later they can be giving numbers which will fit in the numerical sequence.

   b. Location should be recorded first. Measurements must be made from property lines or street center lines – not power poles fence lines - or the like.

VALVE RECORD

No._____

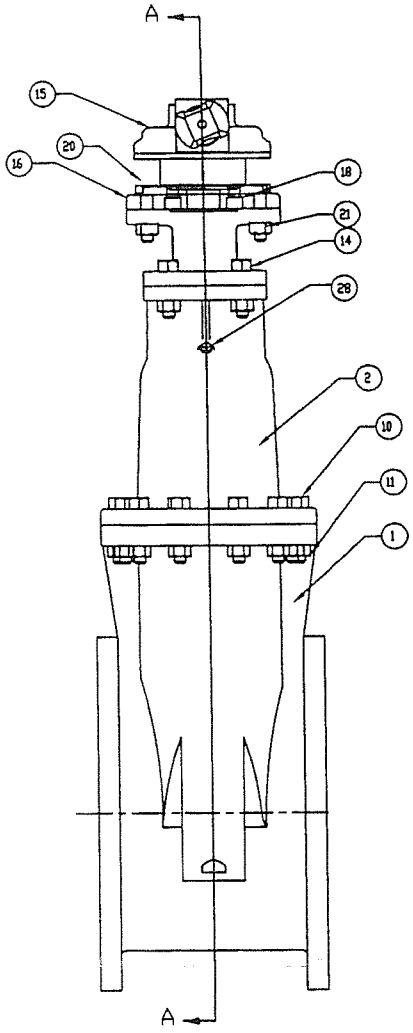
Location _____FT._____of_____Prop. Line of_____
And_____ FT._____of_____Prop. Line of_____
Size_____Make_____Type_____ Gearing_____Bypass_____
Opens_____Turns to Operate_____Depth of Nut_____
Remarks_____
_____
_____

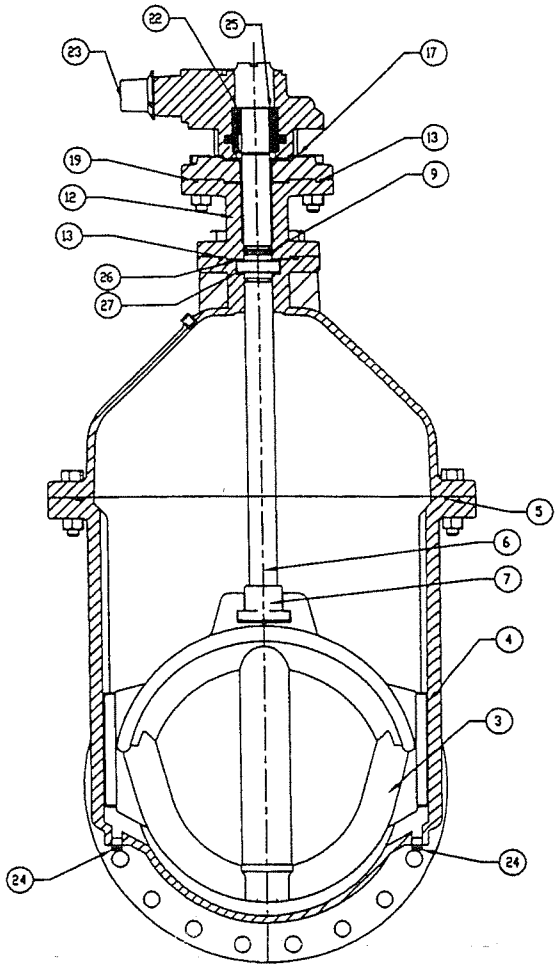
Maintenance & Inspection Record

Date	Work Done	O.K.	By	Date	Work Done	O.K.	By

Complies with
AWWA C515

14"-20" R/W VALVE
BEVEL GEAR MATERIAL LIST
CLOW VALVE COMPANY
MODEL 2638





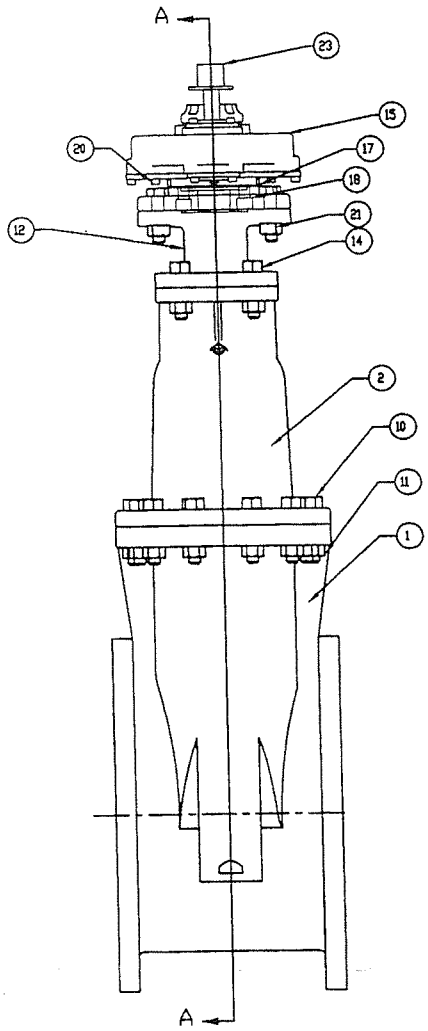
	ITEM NO.	DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION
	1	Body	Ductile Iron	ASTM A536 65-45-12
	2	Cover	Ductile Iron	ASTM A536 65-45-12
	3	Wedge	Ductile Iron/Rubber	ASTM A536 65-45-12/EPDM
	4	Wedge Cap (18"-20" only)	Delrin	Delrin
**	5	Oring	Rubber	EPDM
	6	Stem	Brass	ASTM B584 C86700
**	7	Stem Nut	Brass	ASTM B584 C86700
**	9	Oring	Rubber	EPDM
	10	Hex Head Bolt	Stainless Steel	ASTM F593 304 SST
	11	Hex Nut	Stainless Steel	ASTM F594 304 SST
	12	Extension	Ductile Iron	ASTM A536 65-45-12
**	13	Oring	Rubber	EPDM
	14	Hex Head Bolt	Stainless Steel	ASTM F593 304 SST
	15	Actuator - 3:1 (18-20") 2:1 (14-16")		
	16	Adaptor Plate	Ductile Iron	ASTM A536 65-45-12
	17	Actuator Gasket	Rubber	NBR
	18	Socket Head Bolt	Alloy Steel	Alloy Steel
**	19	Oring	Rubber	EPDM
	20	Hex Bolt	Stainless Steel	ASTM F593 304 SST
	21	Hex Nut	Stainless Steel	ASTM F594 304 SST
	22	Key	Steel	----------
	23	Op Nut	Ductile Iron	ASTM A536 65-45-12
	24	Pipe Plug - 3/4 NPT with square hd	Stainless Steel	AISI 304
	25	Drive Sleeve	Steel	AISI 1023
	26	Thrust Bearing	Delrin	----------
	27	Thrust Bearing (18"-20" only)	Delrin	----------
	28	Pipe Plug - 1/2 NPT with square hd	Stainless Steel	AISI 304

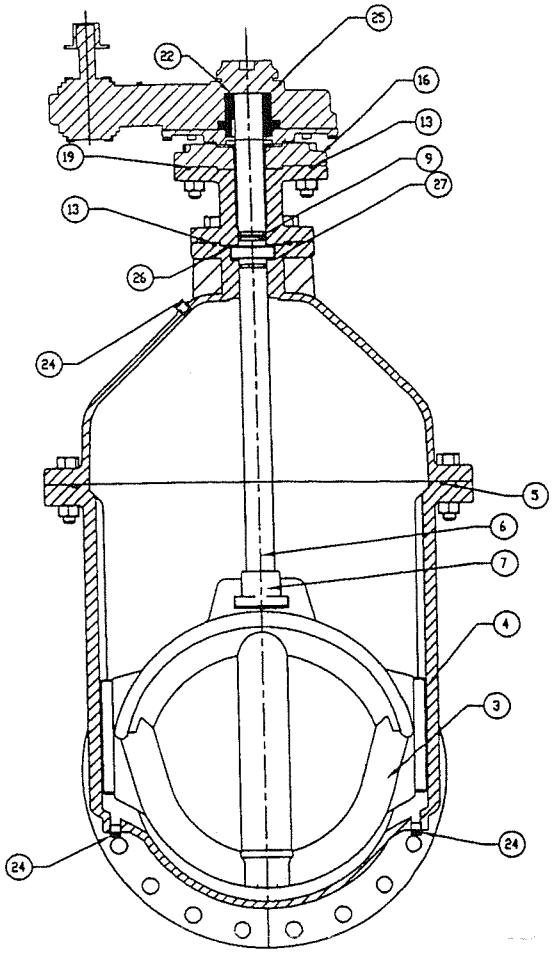
2638-20
F 10/17/06

** RECOMMENDED SPARE PARTS

Complies with
AWWA C515

14"-20" R/W VALVE
SPUR GEAR MATERIAL LIST
CLOW VALVE COMPANY
MODEL 2638





	ITEM NO.	DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION
	1	Body	Ductile Iron	ASTM A536 65-45-12
	2	Cover	Ductile Iron	ASTM A536 65-45-12
	3	Wedge	Ductile Iron/Rubber	ASTM A536 65-45-12/EPDM
	4	Wedge Cap (18"-24" only)	Delrin	Delrin
**	5	Oring	Rubber	EPDM
	6	Stem	Bronze	ASTM B584 C86700
	7	Stem Nut	Bronze	ASTM B584 C86700
**	9	Oring	Rubber	EPDM
	10	Hex Head Bolt	Stainless Steel	ASTM F593 304 SST
	11	Hex Nut	Stainless Steel	ASTM F594 304 SST
	12	Extension	Ductile Iron	ASTM A536 65-45-12
**	13	Oring	Rubber	EPDM
	14	Hex Head Bolt	Stainless Steel	ASTM F593 304 SST
	15	Actuator - 3:1 (18-24") 2:1 (14-16")		
	16	Adaptor Plate	Ductile Iron	ASTM A536 65-45-12
	17	Actuator Gasket	Rubber	NBR
	18	Socket Head Bolt	Alloy Steel	Alloy Steel
**	19	Oring	Rubber	EPDM
	20	Hex Bolt	Stainless Steel	ASTM F593 304 SST
	21	Hex Nut	Stainless Steel	ASTM F594 304 SST
	22	Key	Steel	----------
	23	Op Nut	Ductile Iron	ASTM A536 65-45-12
	24	Pipe Plug - 3/4 NPT with square hd	Stainless Steel	AISI 304
	25	Drive Sleeve	Steel	AISI 1023
	26	Thrust Bearing	Delrin	----------
	27	Thrust Bearing (18"-20" only)	Delrin	----------

2638-27
C 07-19-05

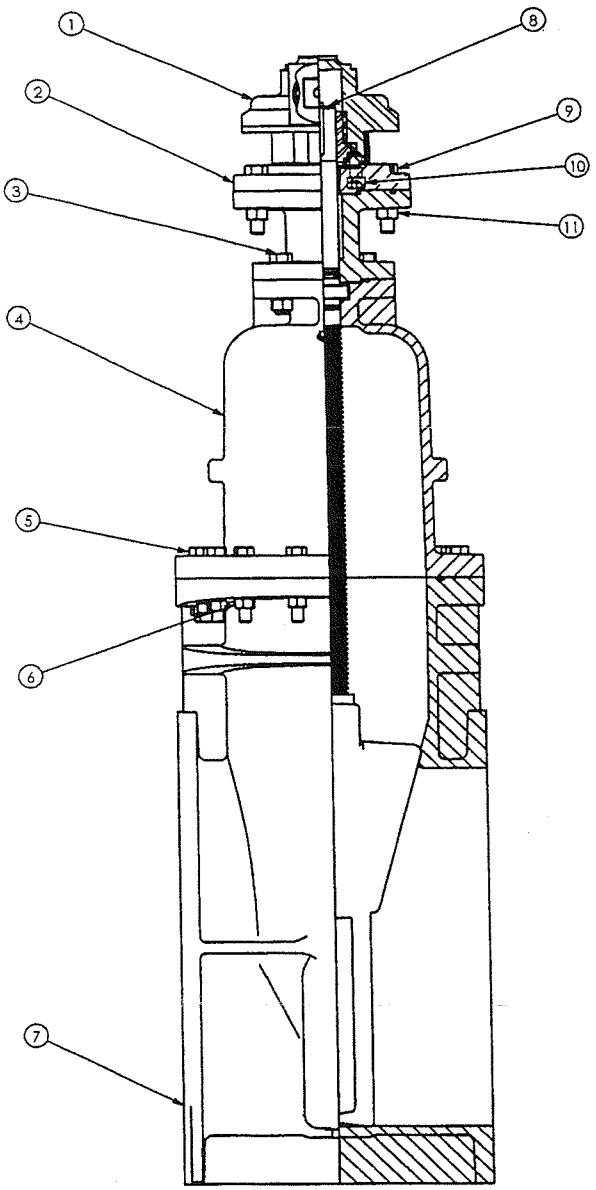
**RECOMMENDED SPARE PARTS

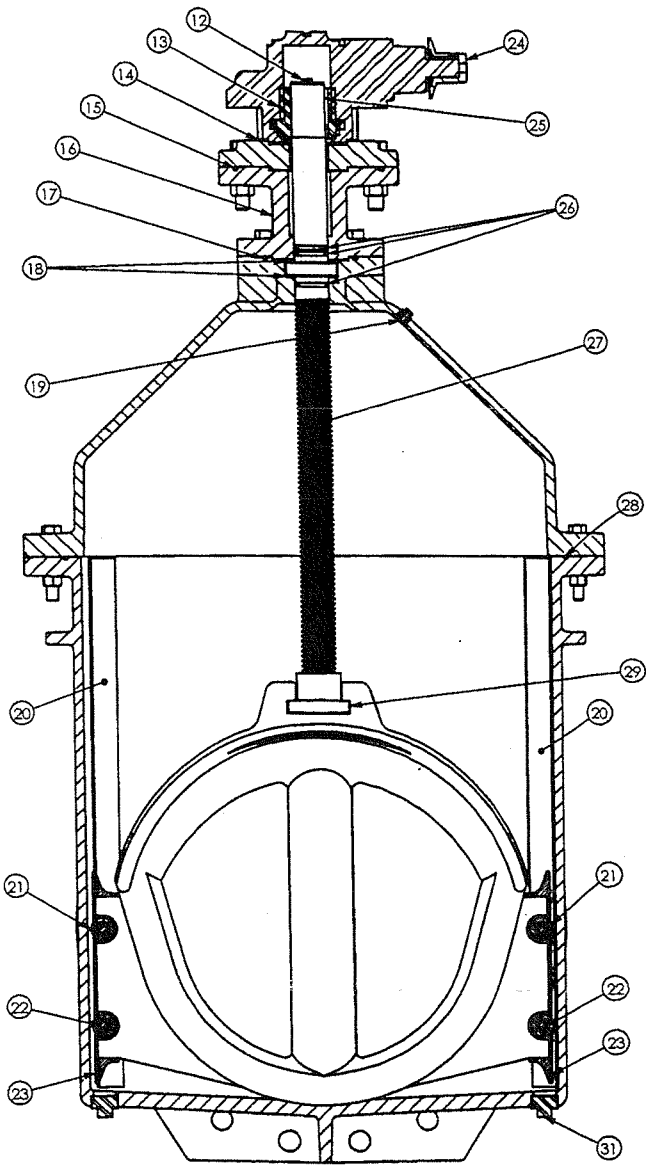
2638-84
D 1/09

24" R/W RTS Bevel Gear Parts List

CLOW VALVE COMPANY

MODEL 2638





ITEM NO.	DESCRIPTION	MATERIAL	MATERIAL SPECIFICATIONS
1	Exeeco IB7.3:1 Actuator	-	-
2	Adaptor Plate	Ductile Iron	ASTM A536 65-45-12
3	Hex Head Bolt	Stainless Steel	ASTM F593 304
4	Cover	Ductile Iron	ASTM A536 65-45-12
5	Hex Head Bolt	Stainless Steel	ASTM F593 304
6	Hex Nut	Stainless Steel	ASTM F594 304
7	Body - Flange	Ductile Iron	ASTM A536 65-45-12
8	Washer	Steel	-
9	Head Hegd Bolt	Stainless Steel	ASTM F593 304
10	Socket Head Bolt	Stainless Steel	ASTM F593 304
11	Hex Nut	Stainless Steel	ASTM F594 304
12	Hex Head Bolt	Stainless Steel	ASTM F593 304
13	Drive Sleeve	Steel	AISI 1023
14	Actuator Gasket	Rubber	Buna N
15	O-Ring	Rubber	EPDM
16	Extension	Ductile Iron	ASTM A536 65-45-12
17	O-Ring	Rubber	EPDM

ITEM NO.	DESCRIPTION	MATERIAL	MATERIAL SPECIFICATIONS
18	Thrust Washer	Plastic	Delrin
19	Pipe Plug	Stainless Steel	AISI 304
20	Track	Stainless Steel	AISI 316
21	Roller	Bronze	ASTM B148 C954
22	Pin	Stainless Steel	AISI 303
23	Scraper	Bronze	ASTM B148 C954
24	Op Nut	Ductile Iron	ASTM A536 65-45-12
25	Key	Steel	AISI 1018
26	O-Ring	Rubber	EPDM
27	Stem	Bronze	ASTM B584 C86700
28	O-Ring	Rubber	EPDM
29	Stem Nut	Brass	ASTM B584 C83600
30	Wedge	Ductile Iron / Rubber	ASTM A536 65-45-12 / EPDM
31	Pipe Plug	Stainless Steel	AISI 304

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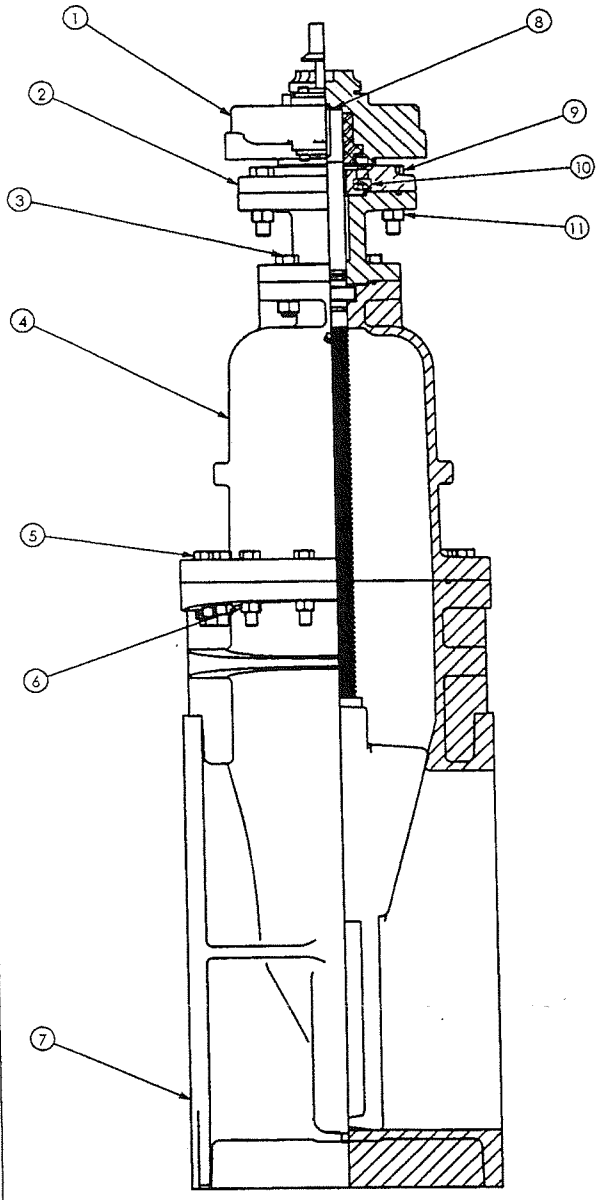
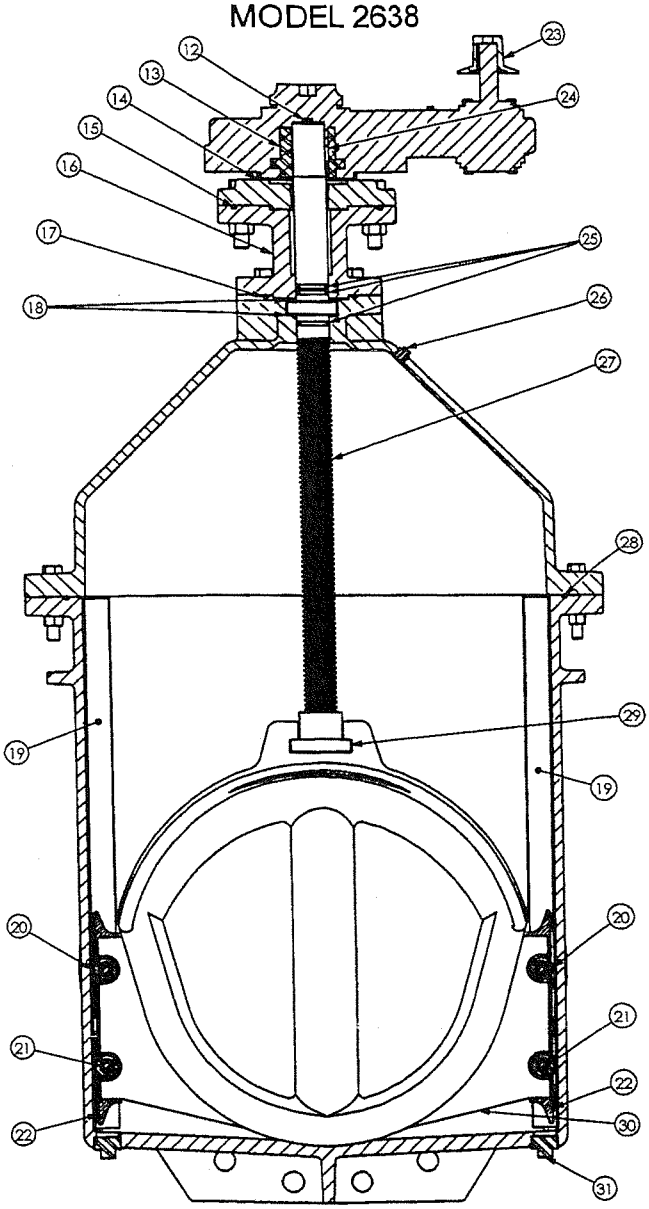
D 01/09

24" R/W RTS Spur Gear
Parts List

CLOW VALVE COMPANY

MODEL 2638





ITEM NO.	DESCRIPTION	MATERIAL	Material Specs
1	Exeeco IS7 3:1 Actuator	-	-
2	Adaptor Plate	Ductile Iron	ASTM A536 65-45-12
3	Hex Head Bolt	Stainless Steel	ASTM F593 304
4	Cover	Ductile Iron	ASTM A536 65-45-12
5	Hex Head Bolt	Stainless Steel	ASTM F593 304
6	Hex Nut	Stainless Steel	ASTM F594 304
7	Body - Flange	Ductile Iron	ASTM A536 65-45-12
8	Washer	Steel	-
9	Head Head Bolt	Stainless Steel	ASTM F593 304
10	Socket Head Bolt	Stainless Steel	ASTM F593 304
11	Hex Nut	Stainless Steel	ASTM F594 304
12	Hex Head Bolt	Stainless Steel	ASTM F593 304
13	Drive Sleeve	Steel	AISI 1023
14	Actuator Gasket	Rubber	Buna N
15	O-Ring	Rubber	EPDM
16	Extension	Ductile Iron	ASTM A536 65-45-12
17	O-Ring	Rubber	EPDM

ITEM NO.	DESCRIPTION	MATERIAL	Material Specs
18	Thrust Washer	Plastic	Delrin
19	Track	Stainless Steel	AISI 316
20	Roller	Bronze	ASTM B148 C954
21	Pin	Stainless Steel	AISI 303
22	Scraper	Bronze	ASTM B148 C954
23	Op Nut	Ductile Iron	ASTM A536 65-45-12
24	Key	Steel	AISI 1018
25	O-Ring	Rubber	EPDM
26	Pipe Plug	Stainless Steel	AISI 304
27	Stem	Bronze	ASTM B584 C86700
28	O-Ring	Rubber	EPDM
29	Stem Nut	Brass	ASTM B584 C83600
30	Wedge	Ductile Iron / Rubber	ASTM A536 65-45-12 / EPDM
31	Pipe Plug	Stainless Steel	AISI 304

Dis-assembly Instructions 14"-24" Geared Valve

Ref; 14"-24" RW Valve Material List (page 5 or 6)

1. Remove 3" NPT plug on top of gear.
2. Remove capscrew and large washer under pipe plug.
3. Remove (4)bolts (20) and (4) nuts (21) between adapter plate (16) and extension.
4. Lift off gear assembly (15) and adapter plate (16). Retain key (22).
5. Remove (4) bolts & nuts (14).
6. Lift off extension (12).
7. Remove stem (6) by turning the stem in the opposite direction of opening the valve.
8. Remove neck flange bolts and nuts (10&11).
9. Lift off cover (2).
10. Grasp stem nut (7) and lift out wedge (3). **Note; Threading stem back into stem nut may make removal of wedge easier.**
11. Reassemble in reverse order replacing cover o-ring (5), extension o-ring (13), and adapter plate o-ring (19) if necessary.

Dis-assembly Instructions 24" Geared Valve

Ref: page 7 or 8 (valve material parts list drawing)

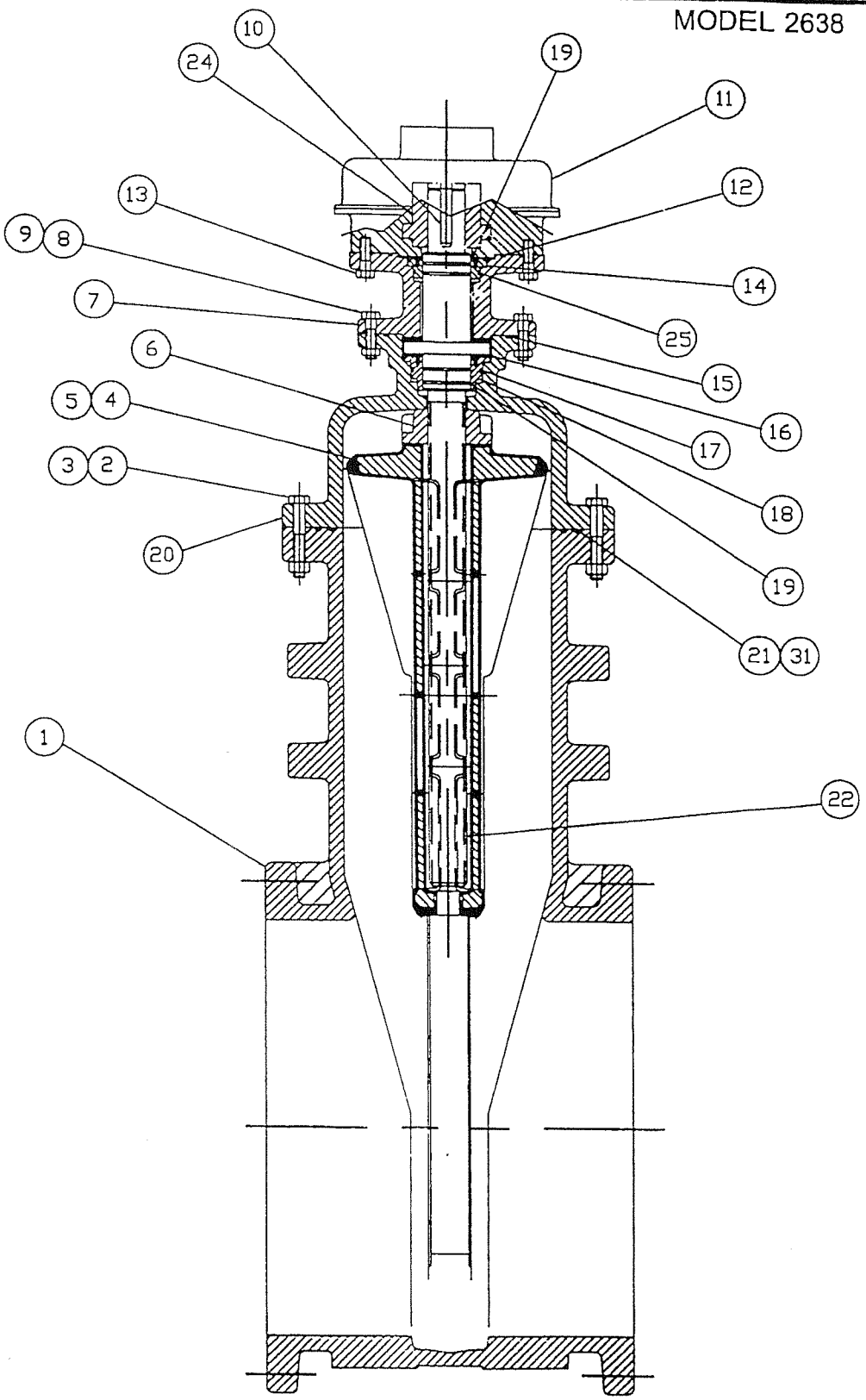
1. Remove 3" NPT plug on top of gear.
2. Remove capscrew and large washer under pipe plug.
3. Remove (40 bolts (9) and (4) nuts (11) between adapter plate (2) and extension.
4. Lift off gear assembly (1) and adapter plate (2). Retain key (25).
5. Remove (4) bolts & nuts (3).
6. Lift off extension (16).
7. Remove stem (27) by turning the stem in the opposite direction of opening the valve.
8. Remove neck flange bolts and nuts (5&6).
9. Lift off cover (4).
10. Grasp stem nut (29) and lift out wedge (31). **NOTE; Threading stem back into stem nut may make removal of wedge easier.**
11. Reassemble in reverse order replacing cover o-ring (28), extension o-ring (17), and adapter plate o-ring (15) if necessary.

2638-50
A 9-23-02

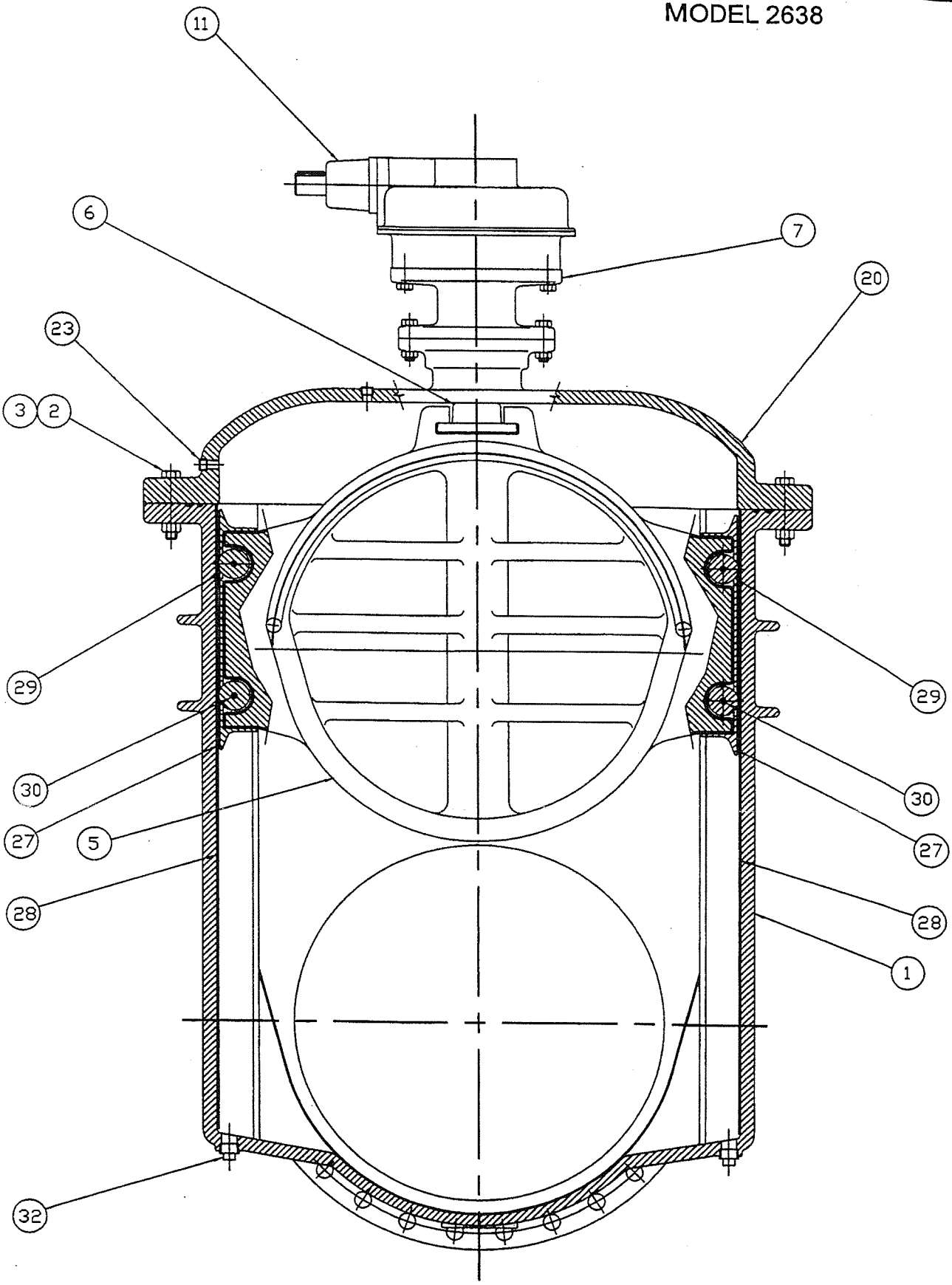
30"-48" R/W VALVE
BEVEL GEAR ASSEMBLY

CLOW VALVE COMPANY

MODEL 2638



30"-48" R/W VALVE
BEVEL GEAR ASSEMBLY
CLOW VALVE COMPANY
MODEL 2638



30"-36" R/W VALVE
BEVEL GEAR PARTS LIST
CLOW VALVE COMPANY
MODEL 2638

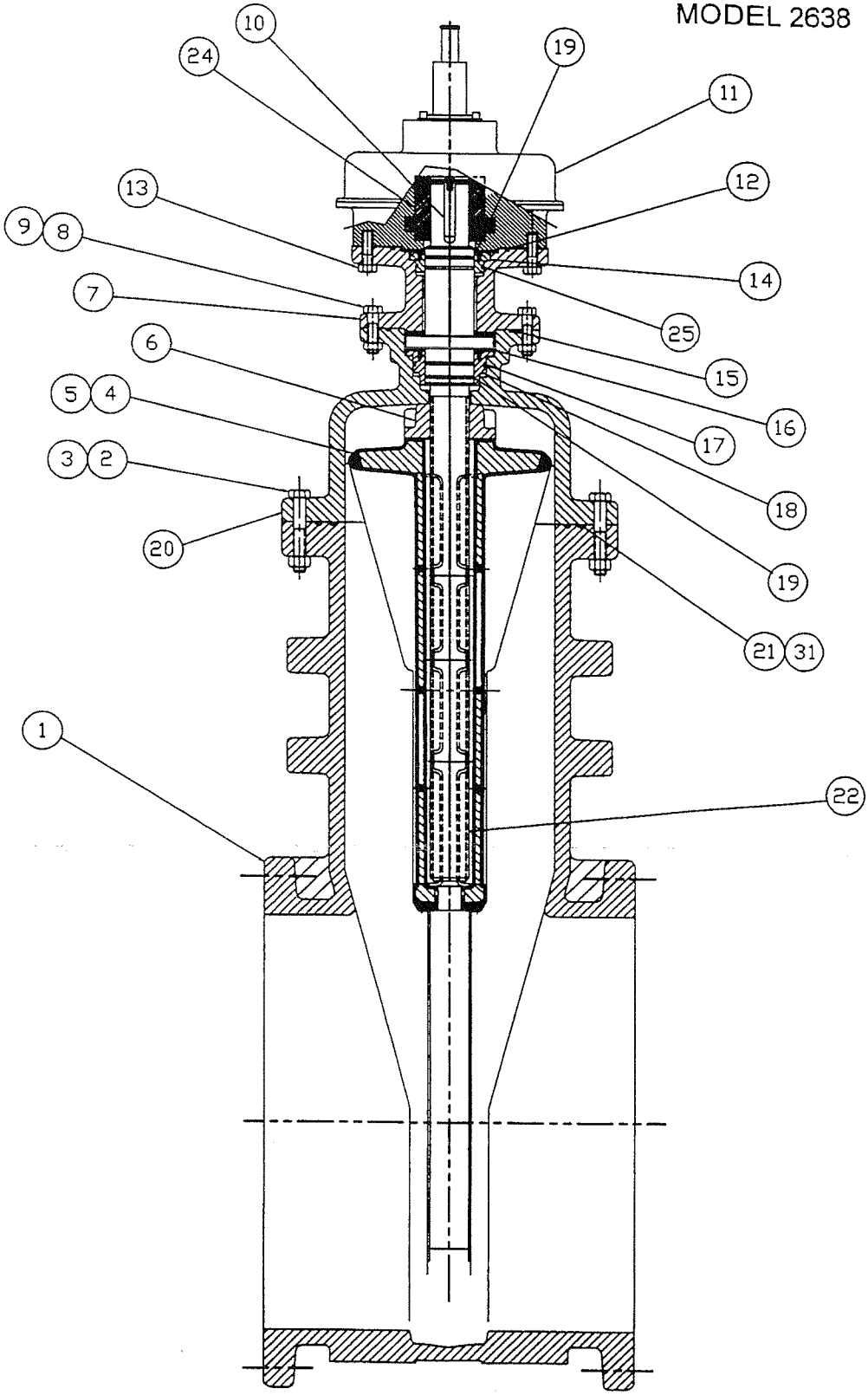
Item	Description	Material
1	Body - Mechanical Joint	ASTM A536 Ductile iron
	Body - Flange	ASTM A536 Ductile iron
	Body - MJ x Flange	ASTM A536 Ductile iron
2	Bolt	AISI 304 Stainless Steel
3	Nut	AISI 304 Stainless Steel
4	Wedge Casting	ASTM A536 Ductile iron
5	Molded Wedge	EPDM
6	Stem Nut	ASTM B763 alloy 995 Brass
7	Extension - actuator	ASTM A536 Ductile iron
8	Bolt	AISI 304 Stainless Steel
9	Nut	AISI 304 Stainless Steel
10	Key	Steel
11	Actuator - bevel gear	
12	O-ring	EPDM
13	Bolt	AISI 304 Stainless Steel
14	Bushing - stem guide	ASTM B584 alloy 836 Brass
15	O-ring	EPDM
16	Thrust Bearing	Nylatron
17	O-ring	EPDM
18	Cover Bushing	ASTM B584 alloy 836 Brass
19	O-ring	EPDM
20	Cover	ASTM A536 Ductile iron
21	O-ring - cover outer	EPDM
22	Stem	ASTM B763 alloy 995 Brass
23	Pipe Plug	AISI 304 Stainless Steel
24	Actuator Drive Bushing	Bronze
25	O-ring	EPDM
27	Scraper	ASTM B148 C954 Al Bronze
28	Track	AISI 316 Stainless Steel
29	Roller	ASTM B148 C954 Al Bronze
30	Pin - roller	AISI 316 Stainless Steel
31	O-ring - cover inner	EPDM
32	Pipe Plug	AISI 304 Stainless Steel

2638-57
A 3-2-04

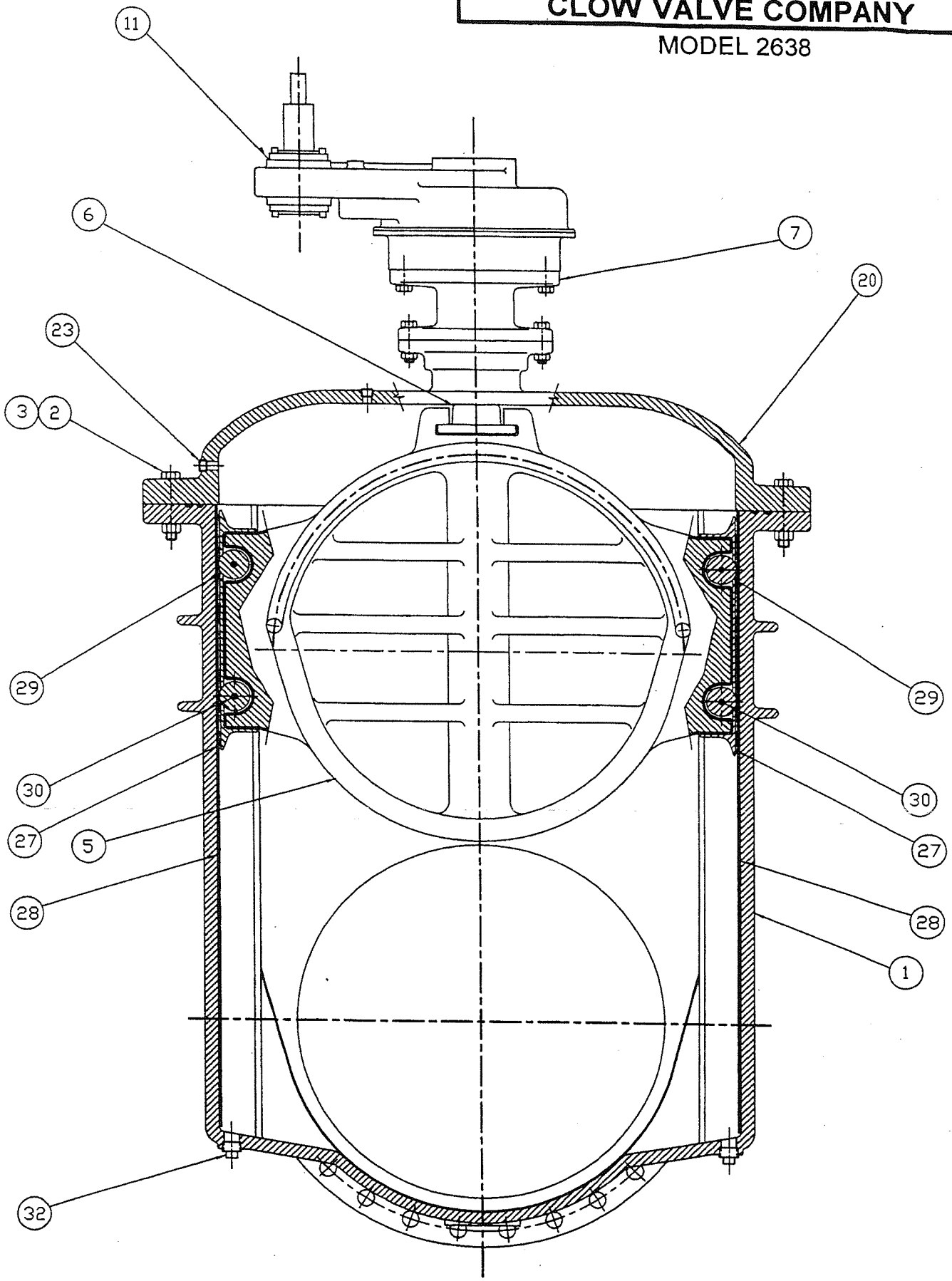
30"-48" R/W VALVE
SPUR GEAR ASSEMBLY

CLOW VALVE COMPANY

MODEL 2638



30"-48" R/W VALVE
SPUR GEAR ASSEMBLY
CLOW VALVE COMPANY
MODEL 2638



30"-48" R/W VALVE
SPUR GEAR PARTS LIST
CLOW VALVE COMPANY
MODEL 2638

Item	Description	Material
1	Body - Mechanical Joint	ASTM A536 Ductile Iron
	Body - Flange	ASTM A536 Ductile Iron
	Body - MJ x Flange	ASTM A536 Ductile Iron
2	Bolt - 7/8-9NC hex hd x 5-1/2 lg	AISI 304 Stainless Steel
3	Nut - 7/8-9NC hex	AISI 304 Stainless Steel
4	Wedge Casting	ASTM A536 Ductile Iron
5	Molded Wedge	EPDM
6	Stem Nut	ASTM B763 alloy 995 Brass
7	Extension - actuator	ASTM A536 Ductile Iron
8	Bolt - 3/4-10NC x 3" lg hex hd	AISI 304 Stainless Steel
9	3/4-10NC hex nut	AISI 304 Stainless Steel
10	Key	Square Seel Keystock
11	Actuator - spur gear	
12	O-ring	EPDM
13	Bolt - 3/4-10NC x 2-1/2 lg hex hd	AISI 304 Stainless Steel
14	Bushing - stem guide	ASTM B584 alloy 836 Brass
15	O-ring	EPDM
16	Thrust Bearing	Nylatron
17	O-ring	EPDM
18	Cover Bushing	ASTM B584 alloy 836 Brass
19	O-ring #236	EPDM
20	Cover	ASTM A536 Ductile Iron
21	O-ring - cover outer	EPDM
22	Stem	ASTM B584 alloy 867 Brass
23	Pipe Plug - 3/4 NPT w/ square hd	AISI 304 Stainless Steel
24	Actuator Drive Bushing	Bronze
25	O-ring	EPDM
27	Scraper	ASTM B148 C954 Al Bronze
28	Track	AISI 316 Stainless Steel
29	Roller	ASTM B148 C954 Al Bronze
30	Pin - roller	AISI 316 Stainless Steel
31	O-ring - cover inner	EPDM
32	Pipe Plug	AISI 304 Stainless Steel

Dis-assembly 30"-48" Geared Valve

Ref. 30"-48" RW GV ASSEMBLY DRAWINGS PAGES 10-15

1. Remove NPT pipe plug from top of gear.
2. Remove capscrew and large washer under pipe plug.
3. Remove (8) capscrews (13) from underside of gear.
4. Lift off gear assembly (11) retain key (10).
5. Remove (8) bolts & nuts (8&9) between extension (7) and cover (20).
6. Lift off extension (7).
7. Remove stem (22) by turning the stem in the opposite direction for opening the valve.
   Note; Lifting device will be required for disassembly.
8. Remove neck flange bolts and nuts (2&3) .
9. Lift off cover (20).
10. Thread stem (22) back into stem nut (6). Lift out wedge (5).
11. Reassemble in reverse order replacing cover o-ring (7) and follower o-ring (2) if necessary.

Troubleshooting
RW GV'S

Possible Malfunction	Symptoms – Causes	Corrective Action
Joint Leakage	*Bolt Tension Relaxing*	*Tighten Bolts*
Seat Leakage	*Foreign material caught in seat*	*Operate valve to flush Out debris.*
	Seats Dirty/Carroded	*Flush or dis-assemble & clean.*
	Seats Damaged	*Inspect-repair or Replace*
Leak Past Stem	*Bolts loose*	*Tighten Bolts*
	(NRS) Orings worn/damaged	*Inspect/replace*
	(OS&Y) Packing worn/damaged	*Inspect/replace*

Inspection for the above should be done semi/annually at the minimum.
There are no lubrication requirements other than;
*OS&Y valves should have the exposed stem **lubricated at each inspection.*
*** Food grade grease similar to Mystic FG2*

For Parts and Service Contact mfg's rep:

INSTRUCTIONS FOR USE

BEVEL GEAR OPERATORS

Bevel Range Specification:
Installation, Operating and Maintenance Instructions:
Assembly and Dismantling Instructions:
Spare Parts List and Recommended 5 Years Holding List:

Rotork Gears,

ROTORK GEARS BEVEL RANGE SPECIFICATION

Component	Material Specification
Gearcase	Cast Iron as standard, optional SG Iron, Carbon Steel or Stainless Steel.
Baseplate	SG Iron as standard, optional Cast Iron, Carbon Steel or Stainless Steel.
Input Housing	Cast Iron as standard, optional SG Iron, Carbon Steel or Stainless Steel.
Bevel Gear	SG Iron or Carbon Steel.
Pinion Gear & Shaft	Carbon Steel as standard, optional Stainless Steel.
Spigot Ring	SG Iron as standard, optional Cast Iron.
Screws	High Tensile Steel Metric Standard to BS3692 & 4168 as standard, optional Stainless Steel.
Bearings	Input Shaft - Ball type. Thrust Output - Needle roller type with thrust washers (with the exception of size 14, which has cylindrical roller thrust bearings and RAB range, which have taper roller bearings).
Output Sleeve A1 (for non rising valve spindles)	Steel.
Output Sleeve A2 (for rising valve spindles)	Aluminium Bronze.
Finish	PA 24 Grey Primer (Standard). Primer and Enamel Gloss (Optional). Other finishes available on request.
Lubricant	CL-X2 (Standard) max temp 120°C: Ignition temperature > 250°C LX-EP2 (High temp) max temp 160°C: Ignition temperature > 250°C MHF-H1 (Food) max temp 177°C: Ignition temperature > 260°C MO2 (Graphite) max temp 120°C: Flash point > 200°C G110 (Nuclear) max temp 150°C: Flash point > 200°C G130 (Nuclear) max temp 150°C: Flash point > 200°C
Seals	Nitrile (Standard) max temp 150°C: Ignition temperature > 300°C Viton (High temp/ Nuclear) max temp 200°C: Ignition temperature > 315°C Fluorosilicone (Low temp) max temp 225°C: Ignition temperature > 300°C Silicone sealant max temp 200°C: Ignition temperature > 450°C

Gearbox Detail	Gearbox Specification
Gearbox design Life	850 hours (20 minutes a day for 7 years)
Gears	Designed basically to BS545.
Gearbox type	Indicated on the nameplate
Gearbox ratio	Indicated on the nameplate
Maximum output torque	Indicated in the Rotork Gears catalogue
Maximum thrust	Indicated in the Rotork Gears catalogue
Gearbox duty specification	Indicated on the nameplate
Nameplate Explosion Marking and Category	According to 94/9/EC and indicated on the nameplate
Maximum speed for the input shaft	350 rpm
Maximum bending moment on the input flange	F10: 66Nm F14: 178Nm F16: 210Nm F25: 700Nm F30: 770Nm
Maximum operating temperature	Indicated on the nameplate
Gearbox weight	Indicated on the nameplate

INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTIONS FOR BEVELS AND SPURS GEAR OPERATORS

The Rotork Gears Spur and Bevel Range Specification sheets indicate the materials of construction and information for putting the equipment into service. The gearbox is marked according to 94/9/EC with the temperature class and explosion group on the equipment and this shall be observed when installing and operating the equipment. The user alone is responsible for the appropriate use of the gearbox in consideration of the basic conditions existing at the plant.

This range of gearboxes is supplied to suit the order requirements but, unless specifically requested at the ordering stage, the output sleeve will be supplied blank and must be machined to suit the equipment to be operated. NTB gearboxes do not have a removable output sleeve.

A thrust element retention device is normally fitted to the baseplate for transporting purposes and MUST be removed to access the output sleeve. The output sleeve can be easily removed from the gearbox by first removing the loose piece spigot ring from the baseplate. It is imperative that the thrust bearings in the output are re-assembled correctly, along with the output sleeve and the spigot ring - That is: models that use needle roller thrust bearings **MUST** have a thrust washer at each side of the needle race. A bearing / washer assembly **MUST** be fitted at each side of the output sleeve thrust shoulder. Models with taper roller bearings **MUST** be assembled with the bearings correctly orientated. All thrust elements and bearing cavities must be packed with grease of the correct specification.

NOTES FOR MOUNTING TO THE VALVE

1. The valve spindle must be greased before assembly of the gearbox to the valve.
2. Thrust element retention device to be removed prior to assembly to the valve.
3. Do not pack the spindle cover tube with grease as this can lead to pressure build up in the gearbox.
4. Flanges to be sealed on assembly with silicone sealant.
5. Spindle cover tubes and plugs to be sealed with suitable sealant.

If the gearbox has been supplied with a handwheel, it is recommended that this be fitted to the gearbox before mounting on the valve. This will make it easier to rotate the gearing to pick up the start of a thread or key location.

On a keyed valve shaft, once the key and keyway are lined up, the gearbox can be lowered onto the mounting flange and bolted down.

On a screwed valve shaft, rotating the handwheel will cause the gearbox to screw itself down the spindle. Once in the correct position it can be bolted down.

For large gearboxes, IB8 to IB14 and IS7 to IS20, we recommend fitting the thrust elements onto the valve prior to fitting the gearbox. The spigot ring and one set of thrust washers and bearings can be placed onto the valve first, then the output sleeve can be screwed down or fitted onto the spindle key, depending on the valve spindle design. The second set of thrust washers and bearings are then fitted. The gearbox then can be lowered onto the valve, taking care that the splines in the output gear and output sleeve do not get damaged.

When bolting the valve to the gearbox we recommend using at least grade 8.8 fasteners, and these **MUST** be torque tightened dependent upon the grade and size used.

If an electric actuator is fitted to the gearbox, a suitable input adaptor will have been supplied. After mounting the actuator to the to the gearbox, the limit and torque switch settings must be made in accordance with the manufacturer's instructions. The maximum permitted bending moment on the input adaptor of the gearbox is indicated on the gearbox specification sheet.

HANDLING

Combined valve, actuator and gearbox must NOT be slung from the gearbox.

MAINTENANCE

All gear cavities are lubricated and sealed for life and the type of grease and seals used within the gearbox is indicated on the nameplate and shown in the material specification. The required maintenance intervals depend on the respective application and will therefore have to be determined by the user dependent on the conditions of use. Annual inspection of the gearbox is recommended, but under normal operating conditions no maintenance is required for the gearbox, but should the valve be taken out of service for overhaul, the gearbox baseplate may be removed and the grease renewed. The baseplate must be sealed using silicone sealant on re-assembly, unless fitted with an O ring. Below is a table for the recommended tightening of screws.

	HEXAGON HEAD GRADE 8.8		HEXAGON HEAD GRADE 8.8 WITH NORDLOCK WASHER		SOCKET HEAD GRADE 12.9		SOCKET HEAD GRADE 12.9 WITH NORDLOCK WASHER		DURLOK GRADE 12.9 SCREW GRADE 12 NUT	
SCREW SIZE	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)
M4	2	2	3	2	4	3	5	4		
M5	5	4	6	4	8	6	10	7	11	8
M6	9	6	10	8	14	11	17	13	19	14
M8	21	15	25	18	35	26	42	31	45	33
M10	41	30	49	36	69	51	83	61	86	64
M12	71	53	86	63	121	89	145	107	152	112
M16	177	131	213	157	299	221	359	265	372	274
M20	346	255	415	306	584	431	701	517	717	529
M24	598	441	718	529	1009	744	1211	893		
M30					2006	1480			Note: Once fully torque tightened Durlok fasteners must not be re used on Nuclear gearboxes.	
M36					3508	2587				
Copy of QC 40-2										

NB. All thrust elements and bearing cavities must be re-greased and refitted in the correct order.

SPARES

Spare parts must be selected from the spare parts lists and a recommended spares holding for 5 years is shown on the spare parts list.

PROCEDURE FOR
DISMANTLING / RE-ASSEMBLY OF BEVEL GEAR OPERATORS

1. **PURPOSE:** To provide dismantling / re-assembly instructions.

2. **SCOPE:** Rotork Gears range of bevel gearboxes

3. **DEFINITION:** Sequence of instructions to dismantle and re-assemble Rotork Gears bevel gearboxes.

4. **PROCEDURE:** Refer to spare parts list for item numbers.

4.1 Dismantling

4.1.1 Remove the key (17) from the input shaft (5).
4.1.2 Remove the 4 off socket head cap screws (20), which secure the input housing (3) to the gearcase (1).
4.1.3 Remove the input housing from the gearcase complete with the input shaft, bearings (10) and spacer (11) where applicable.
4.1.4 Remove the input shaft from the housing.
4.1.5 Remove the 8 off socket head cap screws (21), which secure the baseplate (2) to the gearcase.
4.1.6 Remove the baseplate from the gearcase. The bevel gear (4) will probably remain on the splines of the output sleeve (6) for IB, RAB and HOB gearboxes.
4.1.7 Remove the bevel gear from the output sleeve on the IB, RAB or HOB, or from the baseplate or gearcase of the NTB gearbox.
4.1.8 Remove the spigot ring (7), bearings (8), thrust washers (9), where applicable, and output sleeve from the baseplate of the IB, RAB or HOB gearbox.

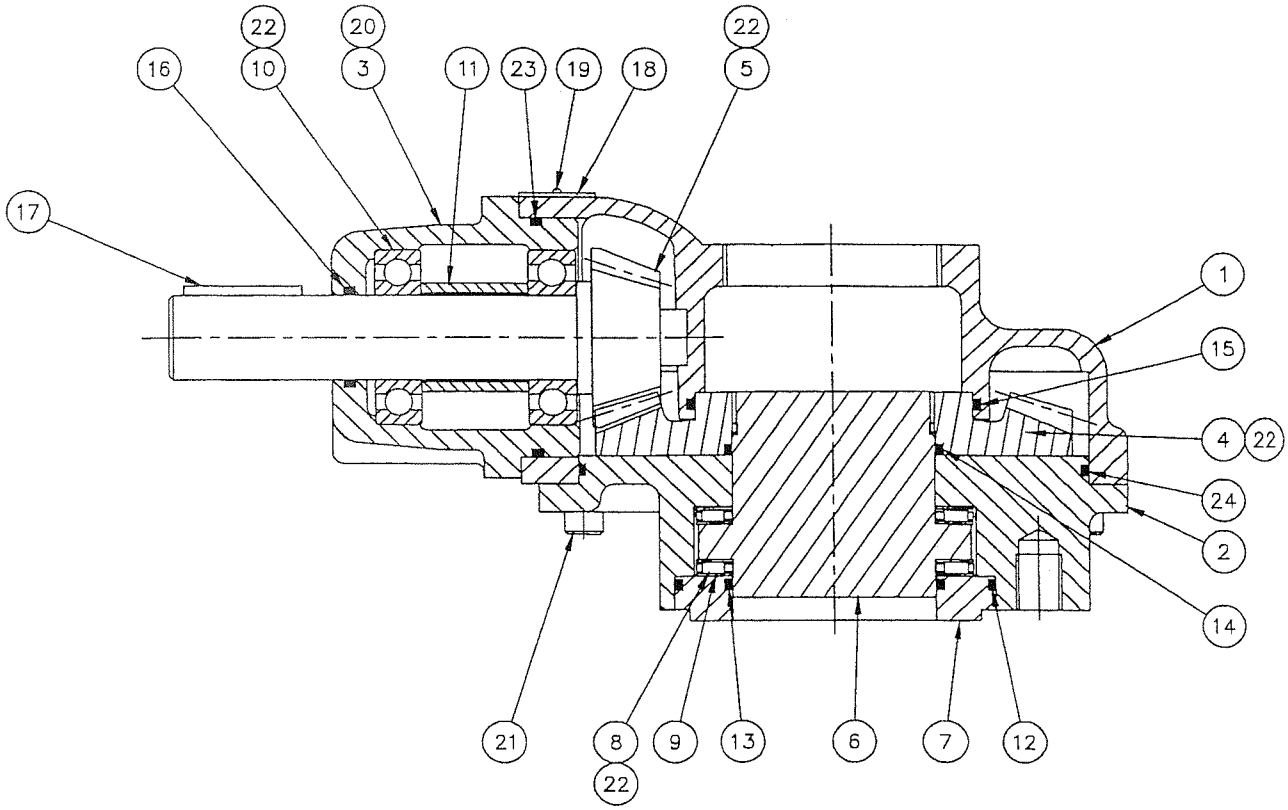
4.2 Re-assembly

4.2.1 Ensure the bevel gear and baseplate are free from dirt and bruising and then fit the 'o' ring (14) to the bevel gear.
4.2.2 Fit the 'o' ring (15) to the gearcase and re-pack the gearcase with grease (22).
4.2.3 Re-fit the output gear into the gearcase ensuring that the 'o' ring (15) remains undamaged.
4.2.4 Grease the back face of the bevel gear before re-fitting the baseplate.
4.2.5 Fit the 'o' ring (24) to the baseplate and re-fit the baseplate into the gearcase. For the NTB gearbox also fit the 'o' ring (13) onto the output gear prior to fixing the baseplate.
4.2.6 Re-secure the gearcase to the baseplate using the existing screws (21) using a diagonal tightening movement.
4.2.7 Reassemble the input housing sub assembly with the input shaft, spacer and bearings ensuring are parts are clean and repack the housing with grease. Fit the 'o' rings (16 and 23) in the housing.
4.2.8 Re-fit the input housing sub-assembly into the gearcase ensuring that the input shaft gear locates into the bevel gear.
4.2.9 Secure the input housing to the gearcase with the existing screws (20) using a diagonal tightening movement.
4.2.10 Re-fit the key to the input shaft.
4.2.11 For IB, RAB and HOB gearboxes apply grease to the thrust bearings and washers, where applicable, and re assemble the output sleeve and spigot assembly into the baseplate. Ensure that the 'o' ring (14) remains undamaged.
4.2.12 Test the gearbox for free rotation.

5. **DOCUMENTATION**

Spare parts list for range of bevel gear actuators:	Bevel Part List.doc
Torque tightening figures.	Document No QC 40-2

SPARE PARTS LIST FOR RANGE OF BEVEL GEAR OPERATORS



ITEM	DESCRIPTION	QUANTITY
1	GEARCASE	1
2	BASEPLATE	1
3	INPUT HOUSING	1
4	BEVEL GEAR	1
5	INPUT SHAFT & GEAR	1
6	OUTPUT SLEEVE	1 (IB, RAB & HOB only)
7	SPIGOT RING	1 (IB, RAB & HOB only)
* 8	THRUST BEARING	2 (IB, RAB & HOB only)
* 9	THRUST WASHER	4 (IB1-13, & HOB only)
*10	BALL BEARING	2 for IB & RAB (1 for HOB & NTB)
11	BEARING SPACER	1 (IB & RAB only)
*12	'O' RING	1 (IB, RAB & HOB only)
*13	'O' RING	1
*14	'O' RING	1 (IB, RAB & HOB only)
*15	'O' RING	1
*16	'O' RING	1
17	KEY	1
18	NAMEPLATE	1
19	NAMEPLATE RIVET	2
20	SOCKET HEAD CAP SCREW	4
21	SOCKET HEAD CAP SCREW	8
22	GREASE	
*23	'O' RING	1
*24	'O' RING	1

Note: items marked * are the recommended spares holding for 5 years operation.

INSTRUCTIONS FOR USE

SPUR GEAR OPERATORS

Spur Range Specification:
Installation, Operating and Maintenance Instructions:
Assembly and Dismantling Instructions:
Spare Parts List and Recommended 5 Years Holding List:

Rotork Gears,
Regina House,
Bramley,
Leeds,
LS13 4ET,
England.

ROTORK GEARS SPUR RANGE SPECIFICATION

Component	Material Specification
Gearcase	Cast Iron as standard, optional SG Iron, Carbon Steel or Stainless Steel.
Baseplate	SG Iron as standard, optional Cast Iron, Carbon Steel or Stainless Steel.
Input Housing	Cast Iron as standard, optional SG Iron, Carbon Steel or Stainless Steel.
Output Gear	SG Iron as standard or Carbon Steel.
Pinion Gear & Shaft	Carbon Steel as standard, optional Stainless Steel.
Spigot Ring	SG Iron as standard, optional Cast iron.
Screws	High Tensile Steel Metric Standard to BS3692 & 4168 as standard, optional Stainless Steel.
Bearings	Input Shaft - Ball Type. Thrust Output – Needle roller type with thrust washers (with the exception of sizes 14, 16, 18, 19 & 20 which have cylindrical roller thrust bearings).
Output Sleeve A1 (for non rising valve spindles)	Steel.
Output Sleeve A2 (for rising valve spindles)	Aluminium Bronze.
Finish	PA 24 Grey Primer (Standard). Primer and Enamel Gloss (Optional). Other finishes available on request.
Lubricant	CL-X2 (Standard) max temp 120°C: Ignition temperature > 250°C LX-EP2 (High temp) max temp 160°C: Ignition temperature > 250°C MHF-H1 (Food) max temp 177°C: Ignition temperature > 260°C MO2 (Graphite) max temp 120°C: Flash point > 200°C G110 (Nuclear) max temp 150°C: Flash point > 200°C G130 (Nuclear) max temp 150°C: Flash point > 200°C
Seals	Nitrile (Standard) max temp 150°C: Ignition temperature > 300°C Viton (High temp and Nuclear) max temp 200°C: Ignition temperature > 315°C Fluorosilicone (Low temp) max temp 225°C: Ignition temperature > 300°C Silicone sealant max temp 200°C: Ignition temperature > 450°C

Gearbox Detail	Gearbox Specification
Gearbox design Life	850 hours (20 minutes a day for 7 years)
Gears	Designed basically to BS436.
Gearbox type	Indicated on the nameplate
Gearbox ratio	Indicated on the nameplate
Maximum output torque	Indicated in the Rotork Gears catalogue
Maximum thrust	Indicated in the Rotork Gears catalogue
Gearbox duty specification	Indicated on the nameplate
Nameplate Explosion Marking and Category	According to 94/9/EC and indicated on the nameplate
Maximum speed for the input shaft	350 rpm
Maximum bending moment on the input flange	F10: 66Nm F14: 178Nm F16: 210Nm F25: 700Nm F30: 770Nm
Maximum operating temperature	Indicated on the nameplate
Gearbox weight	Indicated on the nameplate

INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTIONS FOR BEVELS AND SPURS GEAR OPERATORS

The Rotork Gears Spur and Bevel Range Specification sheets indicate the materials of construction and information for putting the equipment into service. The gearbox is marked according to 94/9/EC with the temperature class and explosion group on the equipment and this shall be observed when installing and operating the equipment. The user alone is responsible for the appropriate use of the gearbox in consideration of the basic conditions existing at the plant.

This range of gearboxes is supplied to suit the order requirements but, unless specifically requested at the ordering stage, the output sleeve will be supplied blank and must be machined to suit the equipment to be operated. NTB gearboxes do not have a removable output sleeve.

A thrust element retention device is normally fitted to the baseplate for transporting purposes and **MUST** be removed to access the output sleeve. The output sleeve can be easily removed from the gearbox by first removing the loose piece spigot ring from the baseplate. It is imperative that the thrust bearings in the output are re-assembled correctly, along with the output sleeve and the spigot ring - That is: models that use needle roller thrust bearings **MUST** have a thrust washer at each side of the needle race. A bearing / washer assembly **MUST** be fitted at each side of the output sleeve thrust shoulder. Models with taper roller bearings **MUST** be assembled with the bearings correctly orientated. All thrust elements and bearing cavities must be packed with grease of the correct specification.

NOTES FOR MOUNTING TO THE VALVE

1. The valve spindle must be greased before assembly of the gearbox to the valve.
2. Thrust element retention device to be removed prior to assembly to the valve.
3. Do not pack the spindle cover tube with grease as this can lead to pressure build up in the gearbox.
4. Flanges to be sealed on assembly with silicone sealant.
5. Spindle cover tubes and plugs to be sealed with suitable sealant.

If the gearbox has been supplied with a handwheel, it is recommended that this be fitted to the gearbox before mounting on the valve. This will make it easier to rotate the gearing to pick up the start of a thread or key location.

On a keyed valve shaft, once the key and keyway are lined up, the gearbox can be lowered onto the mounting flange and bolted down.

On a screwed valve shaft, rotating the handwheel will cause the gearbox to screw itself down the spindle. Once in the correct position it can be bolted down.

For large gearboxes, IB8 to IB14 and IS7 to IS20, we recommend fitting the thrust elements onto the valve prior to fitting the gearbox. The spigot ring and one set of thrust washers and bearings can be placed onto the valve first, then the output sleeve can be screwed down or fitted onto the spindle key, depending on the valve spindle design. The second set of thrust washers and bearings are then fitted. The gearbox then can be lowered onto the valve, taking care that the splines in the output gear and output sleeve do not get damaged.

When bolting the valve to the gearbox we recommend using at least grade 8.8 fasteners, and these **MUST** be torque tightened dependent upon the grade and size used.

If an electric actuator is fitted to the gearbox, a suitable input adaptor will have been supplied. After mounting the actuator to the to the gearbox, the limit and torque switch settings must be made in accordance with the manufacturer's instructions. The maximum permitted bending moment on the input adaptor of the gearbox is indicated on the gearbox specification sheet.

HANDLING

Combined valve, actuator and gearbox must <u>NOT</u> be slung from the gearbox.

MAINTENANCE

All gear cavities are lubricated and sealed for life and the type of grease and seals used within the gearbox is indicated on the nameplate and shown in the material specification. The required maintenance intervals depend on the respective application and will therefore have to be determined by the user dependent on the conditions of use. Annual inspection of the gearbox is recommended, but under normal operating conditions no maintenance is required for the gearbox, but should the valve be taken out of service for overhaul, the gearbox baseplate may be removed and the grease renewed. The baseplate must be sealed using silicone sealant on re-assembly, unless fitted with an O ring. Below is a table for the recommended tightening of screws.

	HEXAGON HEAD GRADE 8.8		HEXAGON HEAD GRADE 8.8 WITH NORDLOCK WASHER		SOCKET HEAD GRADE 12.9		SOCKET HEAD GRADE 12.9 WITH NORDLOCK WASHER		DURLOK GRADE 12.9 SCREW GRADE 12 NUT	
SCREW SIZE	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)	TORQUE TIGHTNESS (Nm)	TORQUE TIGHTNESS (lbsft)
M4	2	2	3	2	4	3	5	4		
M5	5	4	6	4	8	6	10	7	11	8
M6	9	6	10	8	14	11	17	13	19	14
M8	21	15	25	18	35	26	42	31	45	33
M10	41	30	49	36	69	51	83	61	86	64
M12	71	53	86	63	121	89	145	107	152	112
M16	177	131	213	157	299	221	359	265	372	274
M20	346	255	415	306	584	431	701	517	717	529
M24	598	441	718	529	1009	744	1211	893		
M30					2006	1480			Note: Once fully torque tightened Durlok fasteners must not be re used on Nuclear gearboxes.	
M36					3508	2587				
										Copy of QC 40-2

NB. All thrust elements and bearing cavities must be re-greased and refitted in the correct order.

SPARES

Spare parts must be selected from the spare parts lists and a recommended spares holding for 5 years is shown on the spare parts list.

PROCEDURE FOR DISMANTLING / RE-ASSEMBLY OF SPUR GEAR OPERATORS

1. **PURPOSE:** To provide dismantling / re-assembly instructions.

2. **SCOPE:** Rotork Gears range of spur gearboxes

3. **DEFINITION:** Sequence of instructions to dismantle and re-assemble Rotork Gears spur gearboxes.

4. **PROCEDURE:** Refer to spare parts list for item numbers.

4.1 Dismantling

4.1.1 Remove the key (28) from the input shaft (8).
4.1.2 Remove the 4 off socket head cap screws (25), which secure the input housing (4) to the gearcase (1). The endcap, where used, can also be removed.
4.1.3 Remove the input housing from the gearcase complete with the input shaft, bearings (17) and the spacer (12) where applicable.
4.1.4 Remove the input shaft from the housing. Remove the input gear (9) and key (30) where applicable.
4.1.5 Remove the 8 off socket head cap screws (26), which secure the baseplate (2) to the gearcase.
4.1.6 Remove the baseplate from the gearcase. The output gear (5) will probably remain on the splines of the output sleeve (11).
4.1.7 Remove the output gear from the output sleeve and the output hub (5) from the output gear where applicable.
4.1.8 Remove the spigot ring (10), bearings (16), thrust washers (15) and output sleeve from the baseplate..
4.1.9 Remove the hexagonal head screw (27) where applicable and remove idler shaft (6) from the gearcase.
4.1.10 Remove the idler gear (7) from the gearcase and remove the bearings (18) from the idler gear.
4.1.11 The input gear can be removed from the gearcase if not removed in 4.1.4.

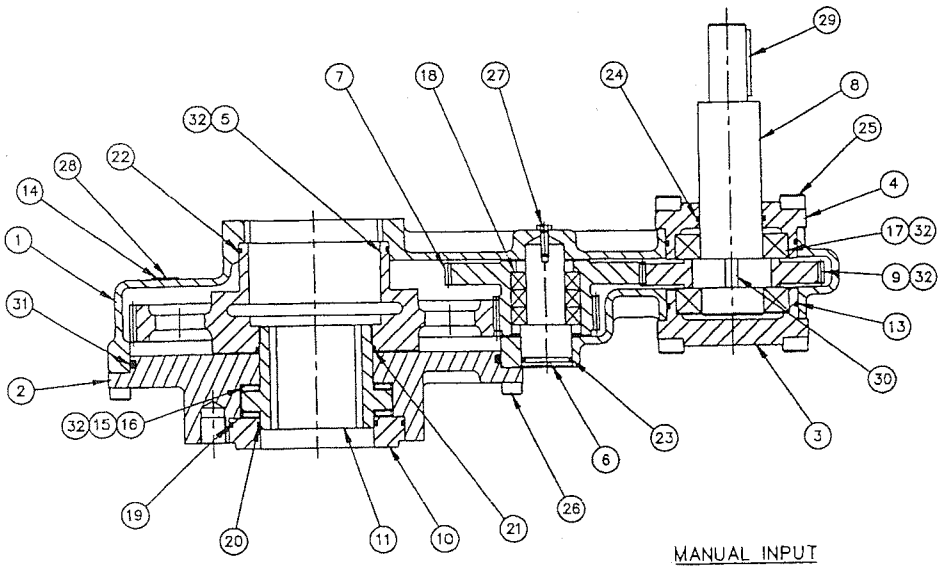
4.2 Re-assembly

4.2.1 Position the input gear in the gearcase if removed in 4.1.10.
4.2.2 Grease and fit the bearings into the idler gear and position in the gearcase.
4.2.3 Fit the 'o' ring (23) to the idler shaft and re-fit the idler shaft into the gearcase and the idler gear. Re-secure the hexagonal head screw where applicable.
4.2.4 Ensure that the output gear and baseplate are free from dirt and bruising and then fit the 'o' rings (21 and 22) to the output gear.
4.2.5 Re-pack the gearcase with grease.
4.2.6 Fit the output gear and output hub, where applicable, into the gearcase and locate with the idler gear.
4.2.7 Fit the 'o' ring (31) to the baseplate and re-secure the baseplate to the gearcase using the existing screws (26) by using a diagonal tightening movement.
4.2.8 Reassemble the input housing sub assembly with the input shaft, input gear, key spacer and bearings ensuring are parts are clean and repack the housing with grease. Fit 'o' rings (13 and 24) to the housing.
4.2.9 Re-fit the input housing sub-assembly into the gearcase ensuring that the input gear locates with the idler gear.
4.2.10 Secure the input housing to the gearcase with the existing screws (25) using a diagonal tightening movement.
4.2.11 Re-fit the key to the input shaft.
4.2.12 Apply grease to the thrust bearings and washers and re assemble the output sleeve and spigot ring assembly into the baseplate. Ensure that the 'o' ring (21) remains undamaged.
4.2.13 Test the gearbox for free rotation.

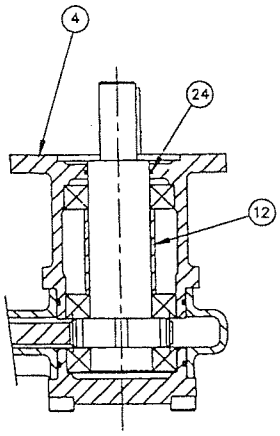
5. **DOCUMENTATION**

Spare parts list for range of spur gear actuators:	Spur Part List.doc
Torque tightening figures.	Document No QC 40-2

SPARE PARTS LIST FOR RANGE OF SPUR GEAR ACTUATORS



MANUAL INPUT



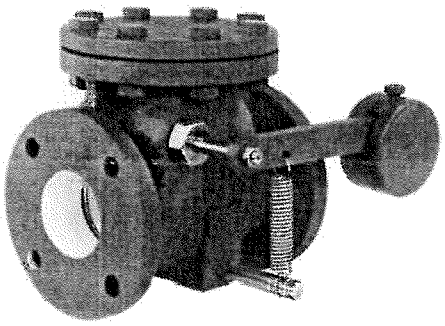
FLANGE INPUT

ITEM	DESCRIPTION	QUANTITY
1	GEARCASE	1
2	BASEPLATE	1
3	ENDCAP (BLANK)	1 (not used on IS2 to IS5)
4	INPUT HOUSING	1
5	OUTPUT GEAR	1 (IS15-20 has additional Output Hub)
6	IDLER SHAFT	1 (IS6, 7, 10–20 has additional Spacer)
7	IDLER GEAR	1
8	INPUT SHAFT	1 (can be combined with items 9 & 30)
9	INPUT GEAR	1 (can be combined with items 8 & 30)
10	SPIGOT RING	1
11	OUTPUT SLEEVE	1
12	SPACER	1
13	O RING	2 (1 for IS2 to IS5)
14	NAMEPLATE	1
*15	THRUST WASHER	4 (not used on IS14, 16, 18, 19, 20)
*16	THRUST BEARING	2
*17	BALL BEARING	2 (Manual input) or 3 (Flange Input)
*18	BALL BEARING	2 (2-7), 3 (8-11), 4 (12-16), 6 (17-20)
*19	O RING	1
*20	O RING	1
*21	O RING	1
*22	O RING	1
*23	O RING	1
*24	O RING	1
25	SOCKET HEAD CAP SCREW	8 (4 for IS2 to IS5)
26	SOCKET HEAD CAP SCREW	8
27	HEXAGON HEAD SCREW	1 for IS6 & IS7 only
28	RIVET	2
29	KEY	1
30	KEY	1 (can be combined with items 8 & 9)
*31	O RING	1
32	GREASE	

Note: items marked * are the recommended spares holding for 5 years operation.

MILLIKEN
VALVE COMPANY

MILLIKEN
AWWA SWING CHECK VALVE
OPERATION AND MAINTENANCE MANUAL



Milliken Valve Company
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Fax: (610) 861-8094
Website: www.millikenvalve.com

MILLIKEN AWWA SWING CHECK VALVES

STORAGE

Valves should be stored in a suitable sheltered place to prevent contamination by weather, dirt or dampness. Valves should remain with original shipping containers or skids, or valves stored on a flat surface with valve weight supported evenly by the flange face. Do not store valves on the shaft ends or bushing housing.

RECOMMENDED STORAGE
NOT MORE THAN (2) UNITS IN HEIGHT

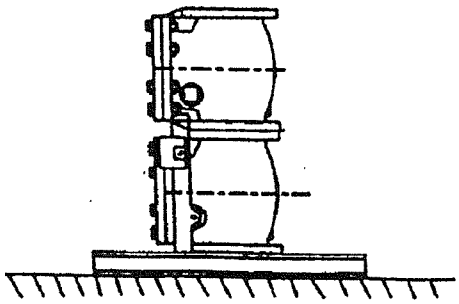


FIGURE #1

OPERATIONS

GENERAL

All valves require checking before being put into operation.

a. Visually inspect valve to insure it has been properly installed.
b. Are gaskets properly installed between flanges?
c. Does valve move smoothly during operations?
d. If furnished with dashpot, "dampener" fluid level should be checked.
e. No fluid leakage should be visible.

In addition, regular inspection is recommended during operation. Prompt attention should be given when trouble arises. As a general rule valves should be subjected to scheduled maintenance or inspection.

OPERATION

Lubrication of valves with optional dampeners or lever operated systems and lubrication fittings should be performed frequently, at least every six months.

INSTALLATION

End protectors must be removed and connections checked for cleanliness before installing a check valve. Any visible foreign matter must be removed from the end connections of the piping system. The valve should be flushed with water and seat checked for damage.

Special Instructions for Check Valve Types

Check type valves much be installed with the inlet in direction of arrow and with the hinge horizontal and disc vertical. This has to be checked carefully before installing the valve. The placing of a check valve in the opposite direction to the flow will prevent the disc from swinging free and, therefore prevent normal operation of the valve.

Make sure the correct gaskets and bolting are available before beginning installation. Keep the valve weight supported by the hoist and align the flange gaskets and install bolting. Pipe must be adequately supported in the valve site to prevent pipe loads from being transmitted to the valve.

The valve should not be installed between pipe flanges that do not align with the valve. Do not attempt to correct misalignment by tightening of flange bolting, as this will place excessive stress on the valve assembly.

Tighten the bolting by the "cross sequence method" to provide uniform seating of the flange gasket (see Figure #3).

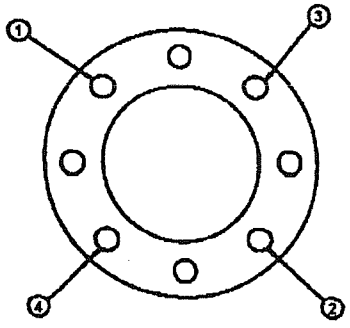


FIGURE #3

MAINTENANCE

TROUBLESHOOTING CHART

TABLE #1

AREA	PROBLEM	PROCEDURE FOR REPAIR
Packing leakage	Packing worn	Replace O-Ring packing
Valve seat	Leakage past seat Damaged seat	Disc seat adjustment Disc seat replacement
Dampener or lever operated options	Difficulty operating	Check for obstruction in line Dampener misalignment Disc or seat adjustment Worn bearings – contact Service Representative
Vibrations and noise	Flow rate greater than anticipated Using valve outside its normal operation range Loose disc pin connection Loose damper or lever to valve mounting	Tighten
Gasket leakage	Pipe misalignment Unsupported pipe loads Improper gasket or installation Uneven torques applied during bolting	See installation

Body/Bonnet & Body/Cover Leakage

GENERAL

It is essential that sufficient bolt tension exist at all times by having the proper torque on the nuts. The original torque might be lost due to vibration, relaxation of material caused by frequent temperature and pressure fluctuation or by creep in high temperature application. We recommend that the joint bolt tension be checked at approximately one-year intervals.

TORQUING PROCEDURE

1. Clean all studs and nuts. Visually inspect all threads to ensure removal of all foreign matter, rust, corrosion, burrs and previous lubricants.
2. Liberally cover tile stud threads and surface under the nut head with Felpro, type C5A Hi-tempo anti-seize compound or equal. Also, lubricate the female threads of the nuts and wipe off any excess lubricant.
3. Follow the bolt tightening sequence shown in Figure #4. This sequence is dependent upon the number of bolts employed and the sketch is only an illustration as to possible tightening sequence. The bolts shall be torqued to recommended values in Table 2.

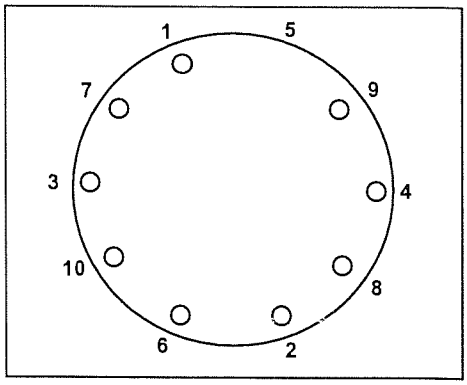


FIGURE #4

APPLICATION OF TORQUES

Each bolt should be torqued in steps of approximately 20% of the final torque. It will be found that as the final torque is approached, the required step will become much less than 20%.

PRECAUTION:

1. The tightening sequence must be followed to ensure that the gasket will be compressed evenly.
2. Do not over-torque as this can cause deformation of the bonnet or cover flange.
3. Impact wrenches that are not properly calibrated will result in improper tightening of the connection.

TORQUE VALUES

TABLE #2

TORQUE VALUES (FT/LB)		
STUD SIZE	BOLTING MATERIAL	
	B7.630	660
	100%	100%
3/8-16UNC	20	20
7/16-14UNC	30	30
1/2-13UNC	50	45
9/16-12UNC	70	62
5/8-11UNC	95	85
3/4-10UNC	170	150
7/8-9UNC	270	240
1-8UNC	410	360
1-1/8-8UN	600	535
1-1/4-8UN	845	750
1-3/8-8UN	1150	1020
1-1/2-8UN	1520	1350
1-5/8-8UN	1955	1740
1-3/4-8UN	2475	2200
1-7/8-8UN	3075	2735
2-8UN	3765	3345
2-1/8-8UN	4500	4045
2-1/4-8UN	5440	4835
2-1/2-8UN	7545	6710

SEAT LEAKAGE

GENERAL

Valve seat leakage may be the result of a distorted seat caused by improper installation of the valve into the pipeline.

Seats may be "fluid cut." When the valve fails to close tightly, this can be caused by debris, pit marks or other surface irregularities on the mating faces.

DISC REPAIRS

1. Disassemble valve as described in Section 500 and inspect the disc for scratches or damages.
2. Polishing with very fine emery cloth on a perfectly flat surface can sometimes restore scratched seating faces.
3. Deep scratches or pits will require the disc be lapped. However, only slight pitting, grooving or indentations not deeper than .005" can be removed by lapping. Defects that cannot be corrected by lapping must be ground and then lapped. We recommend that a maximum of only .005" be removed per side.
4. A flat plate, preferably cast iron, should be used and an abrasive lapping compound (150 grit) Mixed with light oil evenly distributed over the plate surface. A light even pressure should be applied on the plate, lifting the disc as often as possible to prevent accumulation of particles in one area and to allow for proper distribution of lapping compound. The lapping plate position should be turned slightly every few strokes to keep a flat surface. The part should be lapped until seating faces are smooth.
5. Thoroughly clean off the lapping compound with a suitable cleaning fluid, such as acetone or alcohol. Do not use chloride or fluoride bearing solvents.

SEAT REPAIRS

Swing Check / Machine Repair

Automatic grind and lapping machines are available such as the following:
a) Dexter Gate Valve Reseater
b) Unislip Gate and Parallel Slide Valve Grinders

These machines can be mounted directly onto a valve, which is already installed in the pipeline. Both machines automatically set themselves to the correct seat surface angle. These two types of machines are available for different sizes of valves.

SWING CHECK / ALTERNATE REPAIR

Seat faces must be repaired by using a lapping plate when an automatic grinding and lapping machine is not available. A plate of cast iron that is large enough to cover the face of the seat is required. Apply lapping compound mixed with light oil and evenly distribute on plate. Lap seat by moving lapping plate in a circular motion on seat face. Lift the plate as often as possible to prevent accumulation of particles in one area and to allow for proper distribution of the lapping compound. Lap until both seats have smooth faces and then clean off the lapping compound very thoroughly with a suitable cleaning fluid, such as acetone or alcohol.

FITTING

Repaired Parts – Swing Check

The seating faces of the discs or seats much be checked with "Machinist Bluing" before reassembly. A bluing ink should be placed smoothly and equally over the full circumferential surface of both sides of the disc. Place the marked up side of the disc together with the marked tip side of the seat. Slowly lower the part into the body and find the correct mating point of the faces. Contact points should be shown along entire seating surface.

Fitting of New Disc – Swing Check Valves

Damage on the disc seating face, which cannot be removed by grinding or lapping, indicates the disc must be replaced. All new discs coming from the factory are already ground and should be lapped before installation. See installation procedures described in "Reassembly of Swing Check" in this section.

BEARINGS

The bearings used in our check valves are self-lubricating and require no additional lubrication. Occasionally, a customer may have specified optional lubrication fittings. When lube fittings are encountered, we recommend maintenance every six months.

DISASSEMBLY / REASSEMBLY

DISASSEMBLY

General Disassembly

There are two basic methods by which valves can be disassembled:

a. Total disassembly.

b. Partial disassembly to allow access to the area which requires maintenance.

The decision on which method to use depends on the nature of the problem and the space availability.

First determine where the problem lies. Maintenance problems for these valves can be divided into two major areas.

1. Valve internal problems: gasket, disc, seat, etc.

2. Valve top works: dampener or lever

CAUTION: ALL PRESSURE MUST BE RELIEVED FROM BOTH SIDES OF THE VALVE BEFORE ANY SPECIFIC DISASSEMBLY WORK IS STARTED.

REASSEMBLY

General Reassembly

1. The reassembly procedures are not as detailed as the disassembly procedures since, in most cases, the reverse procedure is required.

2. The most important fact to be considered is the cleanliness of all parts. All rust and dirt should be removed from all parts with a wire brush or emery cloth. Oil and grease should have been removed with suitable solvents.

3. All threaded parts (cap screw, nuts, studs) should be well lubricated. The stem and yoke nut threads should be clean of old grease before a new application of grease is applied to the threads. Recommended lubricants are silicone-based grease.

4. Repaired or replacement parts must be checked to see if all repair procedures have been done and that all replacement parts (e.g., packing rings, gasket, etc.) have been checked for size so to insure they will fit the valve being serviced.

5. All orientation marks assigned during disassembly must be observed so that correct orientation is maintained.

Reassembly of Check Valves

1. Hold disc in place on valve seat in body. Insert hinge pin through plugholes in body and then disc hinge. On units with keys and key-ways, make sure key is aligned with key-way slot on pin during reassembly.

2. Check the rotation of the disc on the hanger and the alignment between the disc and seat. After installation is completed, movement should be free and unobstructed.

3. Install new gasket on cover; apply lubrication (a light coat of oil).

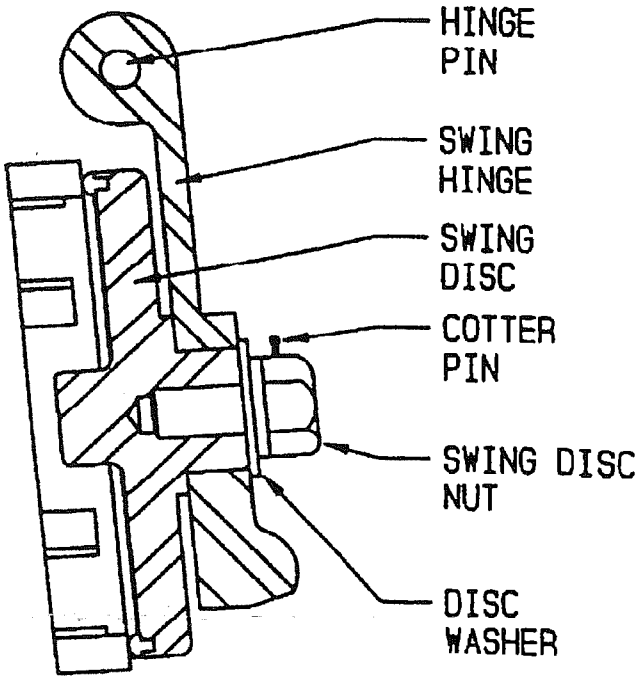
4. Line up the cover with the body and lower onto the body.

5. Apply the recommended lubricant to the body cover studs and then install the body cover nuts. Tighten in strict accordance with torquing procedure.

AWWA SWING CHECK VALVES

CAUTION:

Do not, under any circumstances, use the indicator shaft or pointer on series RCH style valves to cycle the valve or override disc movement. This shaft is not designed to withstand full weight of the disc.



APPENDIX B-4
ELECTRIC MOTOR (PUMP 1)

Vertical High Thrust Motors

Part NO. 835172

Installation, Operation, and Maintenance

EMERSON. CONSIDER IT SOLVED.

SAFETY FIRST

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

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

2. Avoid contact with rotating parts.

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

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

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

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

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

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

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

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

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

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

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

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

†All non Emerson Electric Co. marks shown within this document are properties of their other respective owners.

INSTALLATION AND MAINTENANCE

Table of Contents

Shipment, Handling & Storage

I. SHIPMENT

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

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

II. HANDLING

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

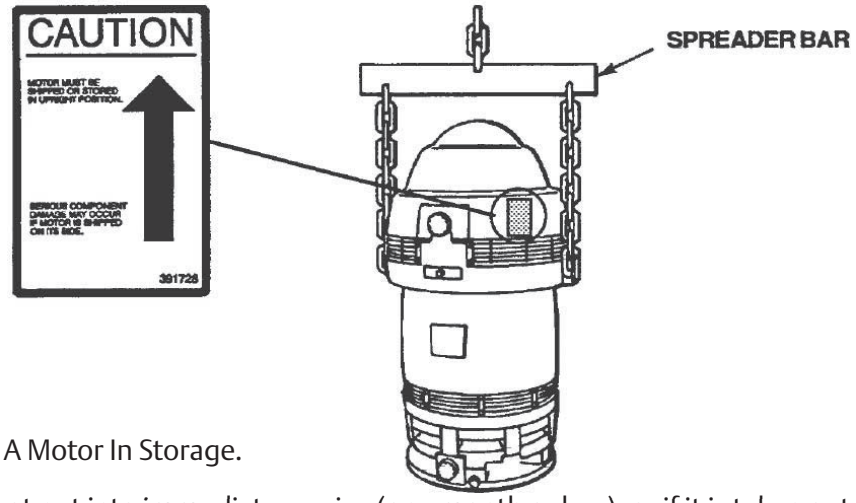
⚠ WARNING

Lifting the motor by other means may result In damage to the motor or injury to personnel.

⚠ CAUTION

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

FIGURE 1



III. STORAGE

1. When To Put A Motor In Storage.

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

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

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

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

2. Storage Preparation.

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

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

NOTICE

Immediately remove any shrink wrap used during shipping. Never wrap any motor in plastic for storage. This can turn the motor into a moisture trap causing severe damage not cover by Emerson Motor Company's limited warranty.

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

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

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

F. Bearings:

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

⚠ CAUTION

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

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

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

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

3. Periodic Maintenance.

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

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

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

D. Insulation Testing:

Two tests are used to evaluate the condition of the winding insulation.The first of these is the one minute insulation resistance test (IR_1) and the second is the polarization index test (PI), which can also be referred to as a dielectric absorption test. The results of either of these tests can be skewed by factors such as the winding temperature and its relation to the dew point temperature at the time the test was conducted . The PI test is less sensitive to these factors than the IR_1 test, but its results can still be affected significantly. Due to these factors, the most reliable method for evaluating the condition of the winding insulation is to maintain a record of periodic measurements, accumulated over months or years of service, for one or both of these tests. It is important that these tests be conducted under similar conditions of winding temperature, dew point temperature, voltage magnitude and duration, and relative humidity. If a downward trend develops in the historical data for either test, or if the readings from both tests drop below a minimum acceptable value, have an authorized electrical apparatus service shop thoroughly clean and dry the winding, and retreat, if necessary.

1. The recommended procedure for the IR_1 test is as follows:

(1) Disconnect all external accessories or equipment that have leads connected to the winding and connect them to a common ground. Connect all other accessories that are in contact with the winding to a common ground.

> ⚠ ***WARNING***
> ***Failure to have accessories grounded during this test can lead to the accumulation of a hazardous charge on the accessories.***

(2) Using a megohmmeter, apply DC voltage at the level noted below for 1 minute and take a reading of the insulation resistance between the motor leads and ground.

Rated Motor Voltage	Recommended DC Test Voltage
UP to 1000 (inclusvie)	500 VDC
1001 to 2500 (inclusive)	500 to 1000 VDC
2501 to 5000 (inclusive)	500 to 2500 VDC
5001 and up	500 to 5000 VDC

> ⚠ ***WARNING***
> ***Follow appropriate safety procedures during and after high voltage testing. Refer to the instruction manual for the test equipment. Make sure the winding insulation is discharged before beginning the test. The winding insulation will retain a potentially dangerous charge after the DC voltage source is removed, so use proper procedures to discharge the winding insulation at the end of the test. Refer to IEEE 43 Standard for additional safety information.***

(3) The reading should be corrected to a 40^0C base temperature by utilizing the formula:

$$R_{40C} = K_T R_T$$

Where:
R_{40C} = insulation resistance (in megohms) corrected to 40^0C
K_T = insulation resistance temperature coefficient at temperature T^0C
R_T = measured insulation resistance (in megohms) at temperature T^0C

The value of K_T can be approximated by using the formula:

$$K_T = (0.5)^{(40-T)/10}$$

Where:
T = the winding temperature in ^{O}C that the insulation resistance was measured at

The recommended procedure for the PI test is as follows:

(1) Perform steps 1 and 2 from the IR_1 test procedure. Heed the safety warnings given in the IR_1 test procedure.

(2) With DC voltage still being applied by the megohmmeter, taken an additional reading of insulation resistance between the motor leads and ground 10 minutes after the DC voltage was initially applied. To minimize measurement errors, the variation in winding temperature between the 1 minute and 10 minute readings should be kept to a minimum.

(3) Obtain the polarization index by taking the ratio of the 10 minute resistance reading to the 1 minute resistance reading.

If historical data from previous IR_1 and / or PI tests is available, then a comparison of the present test result to previous tests can be used to evaluate the condition of the insulation. To minimize error, all readings that are compared should be taken at test voltages, winding temperatures, dew point temperatures, and relative humidities that are similar as possible. If a downward trend in the readings develops over time, have an authorized electrical apparatus service shop thoroughly clean and dry the winding and, if necessary, retreat the winding. Then, repeat the test and re-check results before returning the motor service.

If historical data from previous IR_1 or PI tests is not available, then compare readings from the present test to the recommended minimum values listed below. If the readings from both tests fall below the minimum, have an authorized electrical apparatus service shop thoroughly clean and dry the winding and, if necessary, retreat the winding. Then. repeat the tests and re-check results before returning the motor to service.

The recommended minimum value for the 1minute insulation resistance reading corrected to 40^0C is:

Rated Motor Voltage	**Minimum Insulation Resistance**
Up to 999 (inclusive)	5 Megohms
1000 and up	100 Megohms

The recommended minimum value for the polarization index is 2.0. if the 1 minute insulation resistance reading corrected to 40^0 C is above 5000 megohms, however, the polarization index may not be meaningful. In such cases, the polarization index may be disregarded as a measure of insulation condition.

Refer any question to the Emerson Motor Company Product Service Department.

For more information, refer to the IEEE ®† 43 Standard.

4. Start-up Preparations After Storage.

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

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

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

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

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

IV. INSTALLATION LOCATION

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

1. The location should be clean, dry, well ventilated, properly drained, and provide accessibility for inspection, lubrication, and maintenance. Ambient vibration should be kept to a minimum. Outdoor installations on open driproof motors require protection from the elements.

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

3. Temperature rise of a standard motor is based upon operation at an altitude not exceeding 3300 feet (1000 meters) above sea level, and a maximum ambient temperature of 40^0C unless specified otherwise on nameplate. See NEMA® MG-1 20.28 for usual service conditions.

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

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

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

7. Recommended Minimum Installation Clearances

This is a general guide and cannot cover all circumstances. Unusual arrangments should have inquiries to Emerson Motor Co. Product Service Department. Unusual arrangements might include high ambient, limited ventilation, or a large number of motors in a confined space. The distance to the wall is at the side or end of the motor. The distance to another motor is considered as surface to surface and for side-by-side arrangements. This recommendation considers all motors to be mounted in the same orientation (e.g. all main conduit boxes facing east).

Speed	Distance to Wall	Distance to Another Motor
3600 RPM	2 x Motor Width	2 x Motor Width
1800 RPM or Less	1 x Motor Width	

V. INITIAL INSTALLATION

1. General

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

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

2. Shaft Alignment

On HOLLOSHAFT® motors, the pump shaft and motor coupling must be aligned within .003" TIR. On solid shaft motors, the motor and pump shafts must be aligned within .002" TIR.

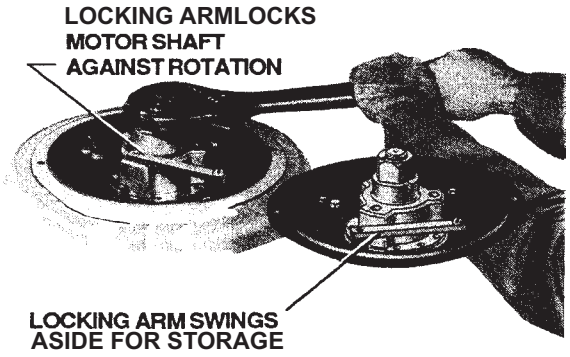
3. Pump Shaft Adjustment (HOLLOSHAFT® motors only)

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

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

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

FIGURE 2



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

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

4. Drive Coupling (HOLLOSHAFT® units only).

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

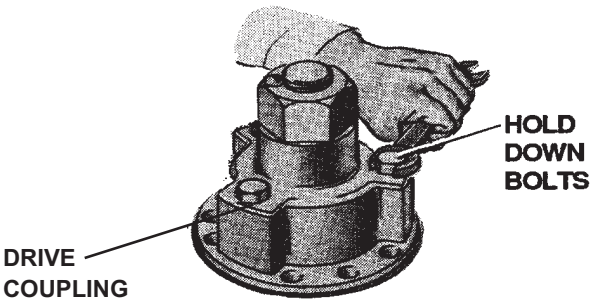
A. Bolted type (Figure 3) - Hold down bolts are installed (some motors require removal of driving pins to allow installation of hold down bolts) in the drive coupling to prevent upward movement of the pump shaft. This will allow momentary upthrust from the pump to be taken by the motor's guide bearing.

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

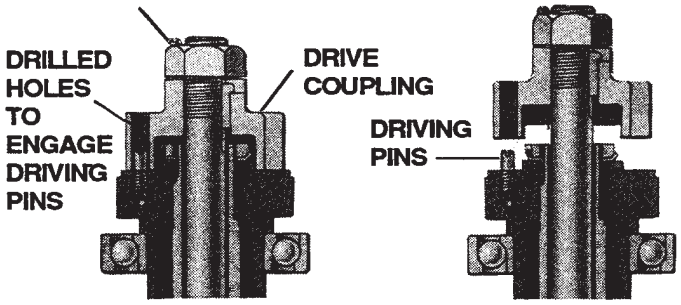
WARNING

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

BOLTED COUPLING
FIGURE 3



SELF RELEASE COUPLING
FIGURE 4



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

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

WARNING

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

5. Water Cooling For Bearing Oil Reservoir.

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

6. Electrical Connection.

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

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

7. Direction Of Rotation.

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

⚠ CAUTION

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

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

8. Spring-Preloaded Thrust Bearings.

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

⚠ CAUTION

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

9. Initial Start.

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

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

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

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

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

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

F. Motors are tested with oil at our manufacturing facility then drained prior to shipment. Note: A small amount of residual oil and rust inhibitor will remain in the oil sump. This residual oil and rust inhibitor is compatible with Turbine Type Mineral Oils and Synthetic, PAO (Poly Alpha Olefin) based oils listed in this manual. It is not necessary to drain this residual oil when adding new oil for operation. Check oil lubricated units to be certain that bearing housings have been filled to between the "MAX" and "MIN" levels on the sight gauge windows with the correct lubricant. Refer to **Section IX "LUBRICATION"** for proper oils.

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

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

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

⚠ WARNING

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

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

VI. NORMAL OPERATION

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

1. General Maintenance.

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

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

B. Systematic records which contain at least the following:

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

2. Inspection and Cleaning

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

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

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

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

⚠ CAUTION

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

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

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

VII. NON-REVERSE RATCHET

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

VIII. ENDPLAY ADJUSTMENT

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

⚠ CAUTION

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

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

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

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

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

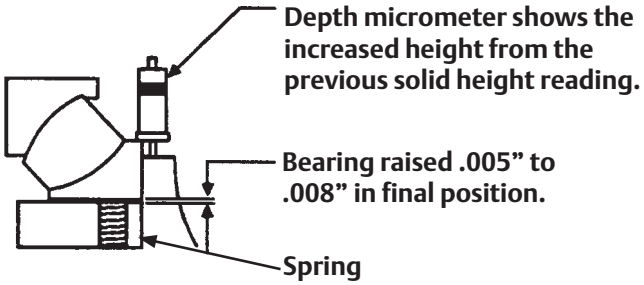
   C. Add .005 to .008 inches to the recorded dimension to obtain the correct endplay range for the unit.

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

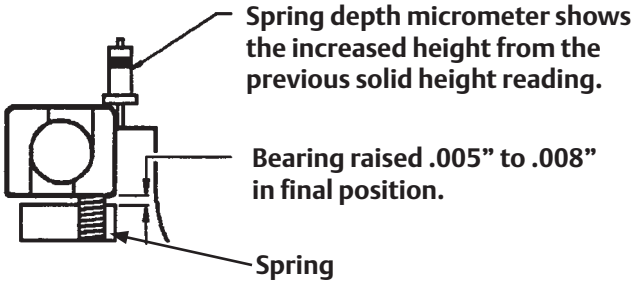
   NOTE: Certain motor builds require removal of the fabricated steel or cast aluminum oil baffle to provide access for depth micrometer measurements.

FIGURE 5

SPHERICAL ROLLER THRUST BEARING



ANGULAR CONTACT BEARING



2. Angular Contact Ball Bearings (Without Springs)

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

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

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

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

ENDPLAY ADJUSTMENT METHODS

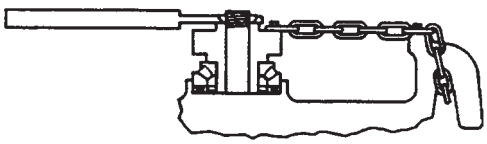
1. Method 1 (refer to Figures 6 & 7)

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

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

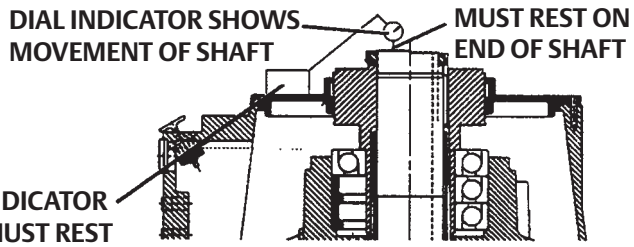
Special equipment required:
- Locking bolts
- Dial indicator
- 3/4" chain
- Depth micrometer
- Spanner wrench with extension

FIGURE 6 (METHOD 1)



MOUNTING SPRINGS ARE COMPRESSED AND ROTOR IS LIFTED BY LOCKNUT

FIGURE 7 (METHOD 1 & 3)



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

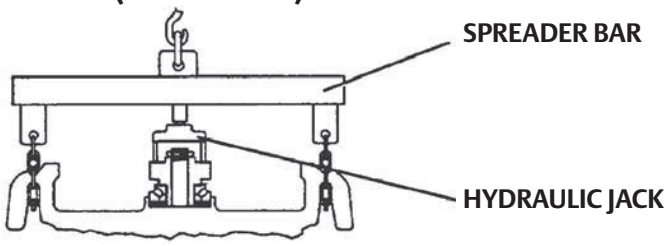
This method utilizes a spreader bar and chains to wrap around lifting lugs, a hydraulic jack (five ton), and crane to lift the spreader bar. The hydraulic jack is supported by two steel blocks of equal thickness on top of the bearing mounting with the jack pushing against the spreader bar. On large motors,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

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

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

FIGURE 8 (METHOD 2)

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



3. Method 3 (refer to Figure 9)

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

⚠ CAUTION

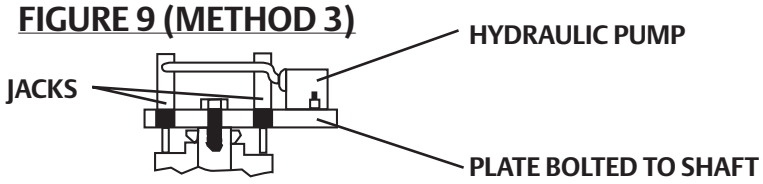
Use of excessive hydraulic pressure can damage bearings.

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

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

FIGURE 9 (METHOD 3)

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



⚠ CAUTION

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

IX. LUBRICATION

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

1. Oil Lubricated Bearings.

Motors are tested with oil at our manufacturing facility then drained prior to shipment. A small amount of residual oil and rust inhibitor will remain in the oil sump. This residual oil and rust inhibitor is compatible with Turbine Type Mineral Oils and Synthetic, PAO (Poly Alpha Olefin) based oils listed in this manual. It is not necessary to drain this residual oil when adding new oil for operation.

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

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

2. Grease Lubricated Bearings.

A. Relubrication of Units in Service

Grease lubricated bearings are pre-lubricated at the factory and normally do not require initial lubrication. Relubricating interval depends upon speed, type of bearing and service. Refer to Table 1 or suggested regreasing intervals and quantities. Note that operating environment and application may dictate more frequent lubrication. To relubricate bearings, remove the drain plug. Inspect grease drain and remove any blockage (caked grease or foreign particles) with a mechanical probe, taking care not to damage bearing.

⚠ WARNING

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

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

⚠ CAUTION

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

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

⚠ CAUTION

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

B. Change of Lubricant

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

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

Table 1
Recommended Grease Replenishment Quantities & Lubrication Intervals

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

Refer to motor nameplate for bearings provided on a specific motor. For bearings not listed in Table 1, the amount of grease required may be calculated by the formula:

$G = 0.11 \times D \times B$

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

Table 2
Recommended Greases

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

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

Table 3
Emerson Motor Co. Recommended Oil Viscosities

Angular Contact Thrust Bearing (7XXX Series)					
Motor Enclosure	**Frame Size**	**Speed (RPM)**	**Ambient Temperature**	**ISO VG**	**Base Oil Type**
Open Dripproof or Weather Protected	324 and Larger	All	-15C thru 40C (5-104F)	32	Mineral or Synthetic
			41C thru 50C (105-122F)	68	Synthetic Only
Totally Enclosed or Explosion proof	404 thru 447		-15C thru 40C (5-104F)	32	Mineral or Synthetic
			41C thru 50C (105-122F)	68	Synthetic Only
	449 thru 5811	1801 - 3600	-15C thru 40C (104F)	32	Synthetic Only
		1800 & Below		68	Synthetic Only
		All	41C thru 50C (105-122F)	Refer to Office	
Spherical Roller Thrust Bearing (29XXX Series)					
Motor Enclosure	**Frame Size**	**Speed (RPM)**	**Ambient Temperature**	**ISO VG**	**Base Oil Type**
Open Dripproof or Weather Protected	444 and Larger	1800 and Below	-15C thru 25C (5-77F)	68	Mineral or Synthetic
			6C thru 40C (42-104F)	150	
			41C thru 50C (105-122F)		Synthetic Only
Totally Enclosed or Explosion proof	449 and Larger		-15C thru 25C (5-77F)	68	Mineral or Synthetic
			6C thru 40C (42-104F)	150	Synthetic Only
			41C thru 50C (105-122F)	Refer to Office	

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

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

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

Table 5
Approximate Oil Sump Capacities

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

X. FUNDAMENTAL TROUBLESHOOTING - PROBLEM ANALYSIS

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

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

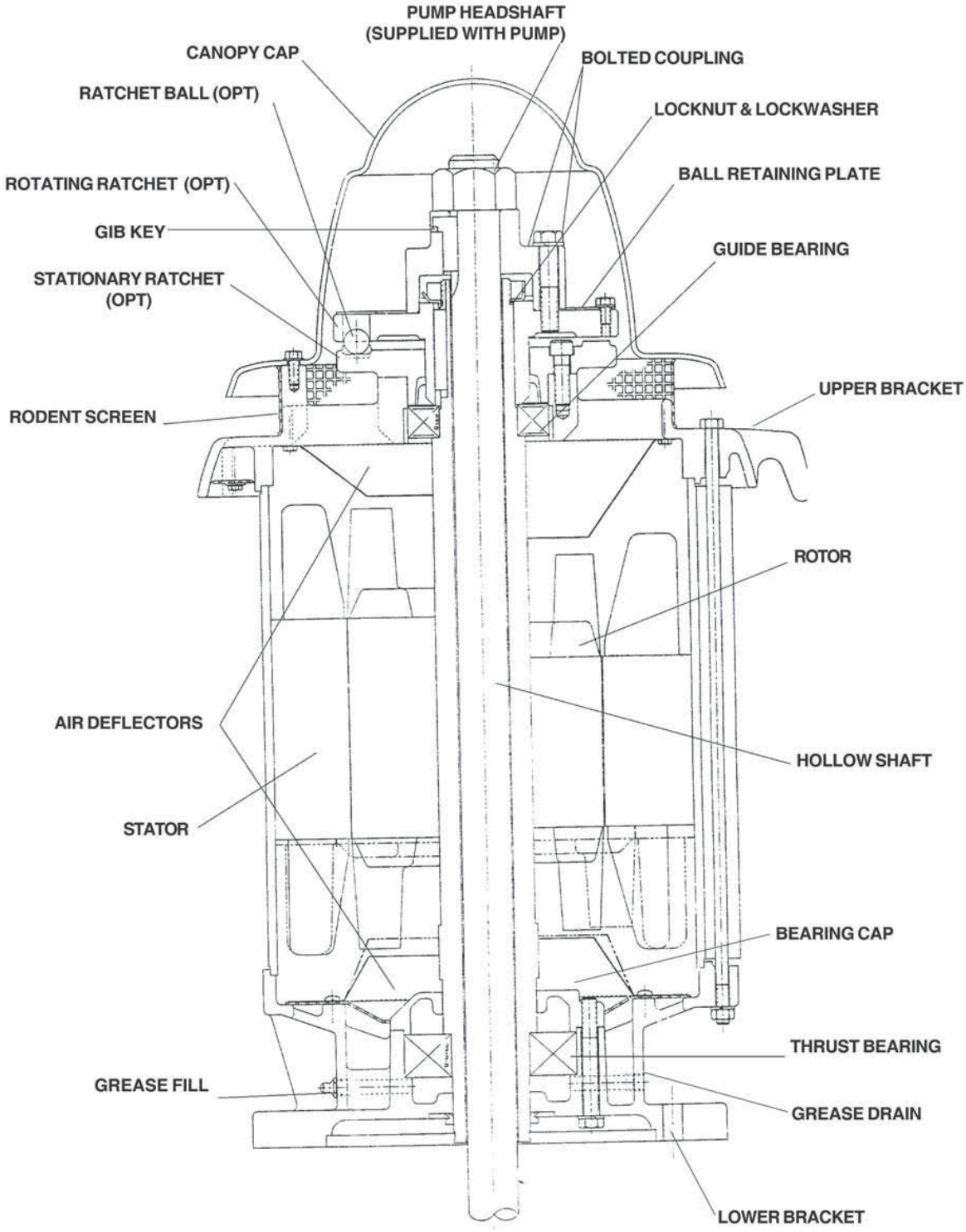
SYMPTOM	POSSIBLE CAUSE	ANALYSIS
Motor overheating (Check with thermo-couple or by resistance methods. Do not depend on hand.)	Overload	Measure load and compare to nameplate rating. Check for excessive friction in motor or in complete drive. Reduce load or replace motor with greater capacity motor. Refer to Appendix C.
	Motor intake or exhaust blocked or clogged.	Clean motor intake and exhaust areas. Clean filters or screens if motor is so equipped.
	Unbalanced voltage	Check voltage to all phases. Refer to Appendix A.
	Open stator windings	Disconnect motor from load. Check idle amps for balance in all three phases. Check stator resistance in all three phases.
	Over / Under Voltage	Check voltage and compare to nameplate voltage.
	Ground	Locate with test lamp or insulation tester and repair.
	Improper Connections	Recheck connections.
Bearing Overheating Generally, bearing temperatures (as measured by a tipsensitive RTD or thermocouple touching the bearing outer race) should not exceed 90^0C when using mineral-based lubricants or 120^0C when using synthetic-based lubricants.	Misalignment	Check alignment.
	Incorrect oil, or oil level too high or too low.	Refill with proper oil. Verify oil level is correct.
	Excessive thrust.	Reduce thrust from driven machine.
	Bearing over-greased.	Relieve bearing cavity of grease to level specified in lubrication section.
	Motor overloaded	Measure load and compare to nameplate rating. Check for excessive friction in motor or in complete drive. Reduce load or replace motor with greater capacity motor. Refer to Appendix C.
	Motor intake or exhaust blocked or clogged	Clean motor intake and exhaust areas. Clean filters or screens if motor is so equipped.
Bearing oil leeking around the drain plug.	Insufficient sealant applied to drain plug threads.	Remove drain plug and drain existing oil from sump. With a clean cloth, wipe excess oil from the plug threads and the threads in the drain hole. Apply Gasolia Thread Sealant P/N SS08 to the threads of the plug and replace. Fill sump with new oil to the proper level.

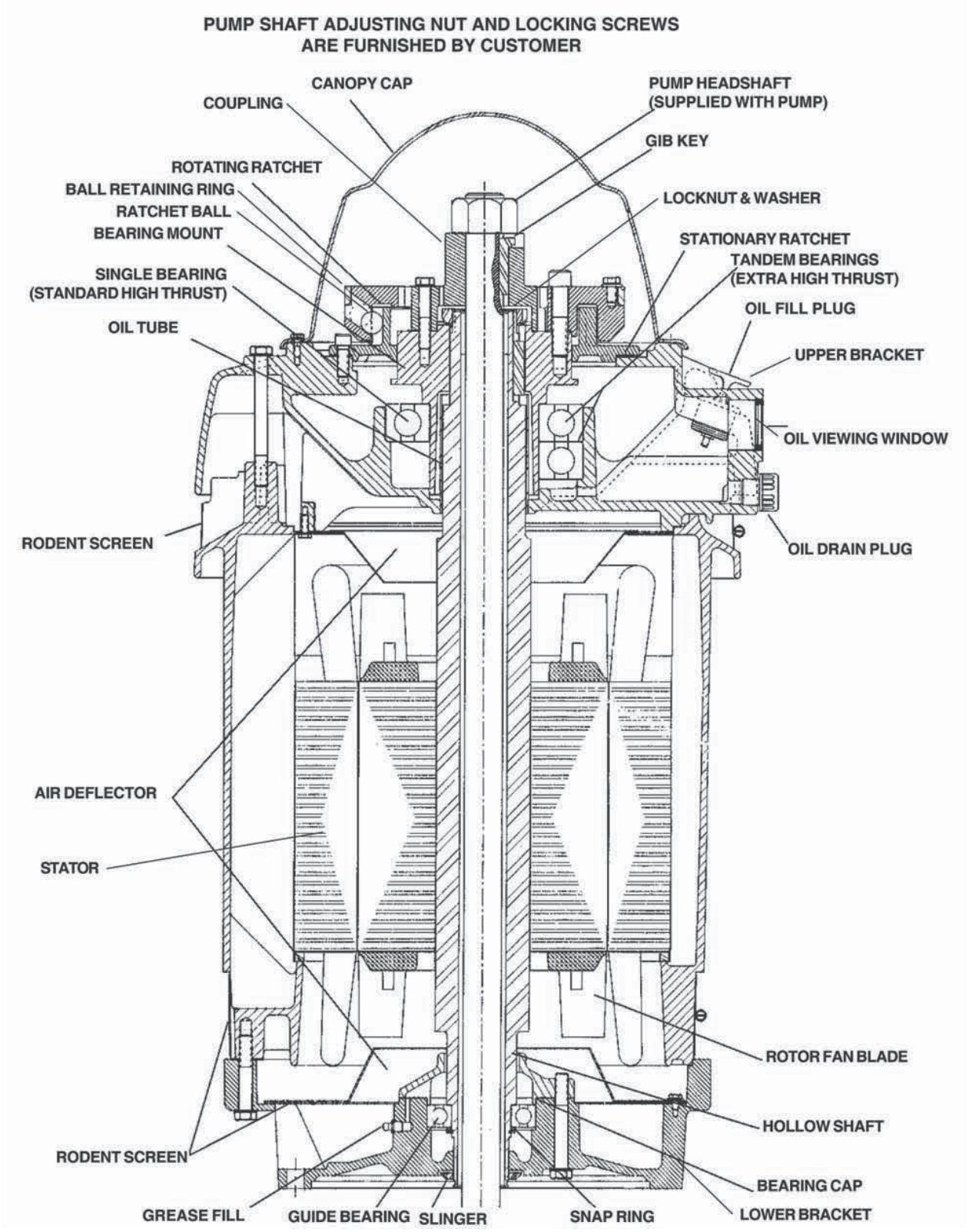
XI. SPARE PARTS

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

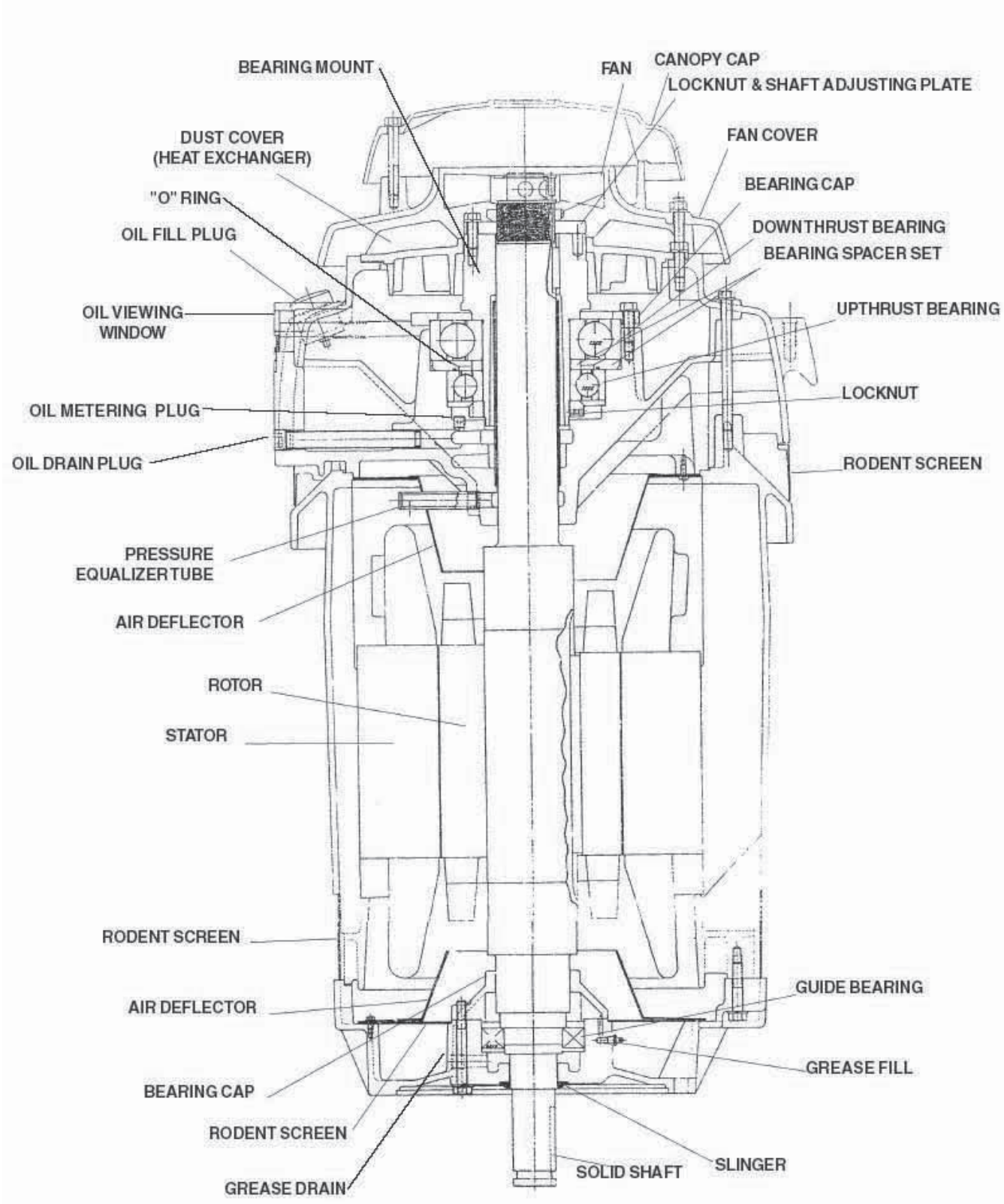
Emerson Motor Co.
710 Venture Drive
Suite 100
Southaven, MS 38672
Phone (662) 342-6910
Fax (662) 342-7350

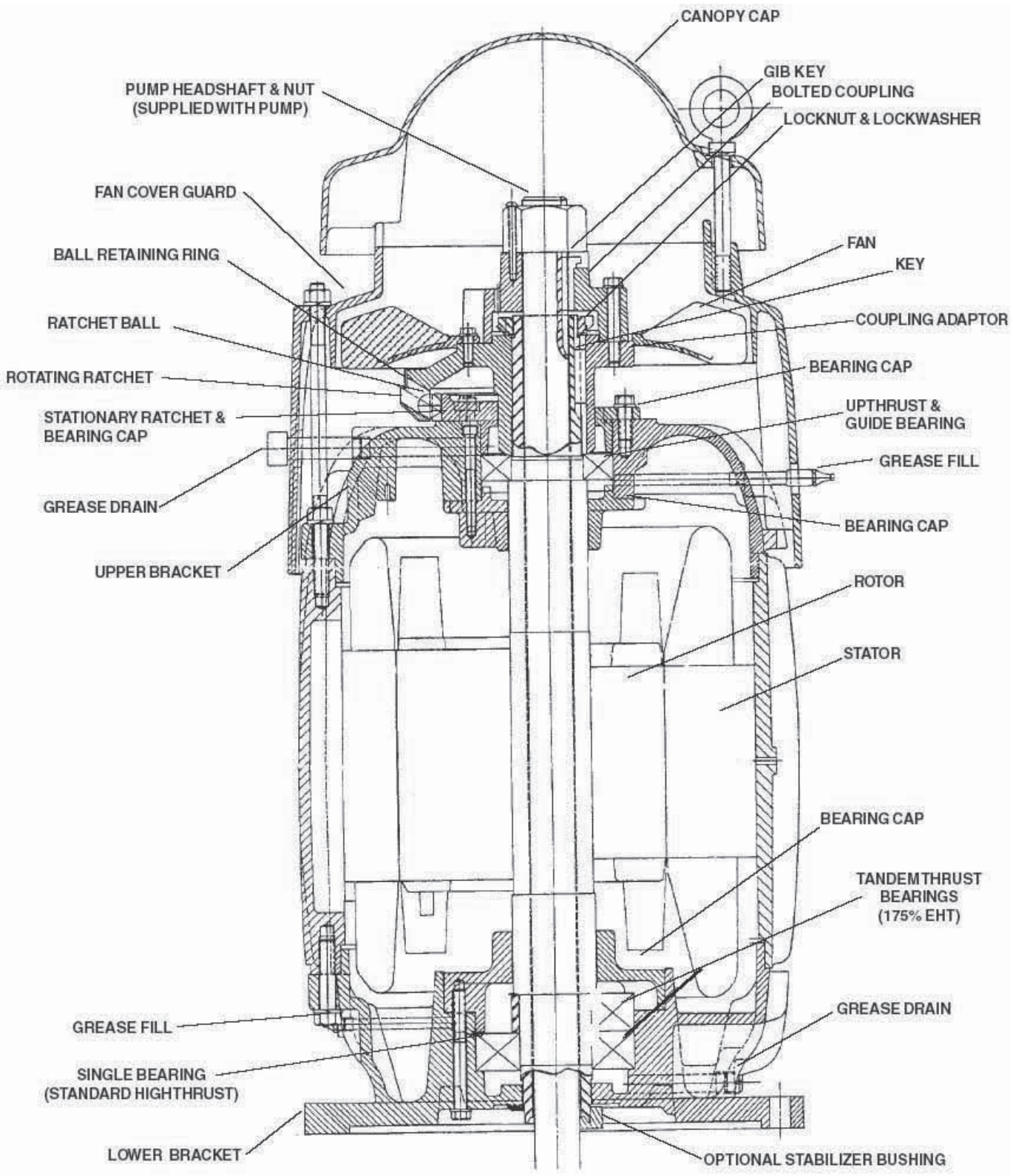
Drawings for many standard designs are supplied on the following pages. Most of the parts should be easy to identify. If however, there is some deviation from your machine, consult the factory for assistance.

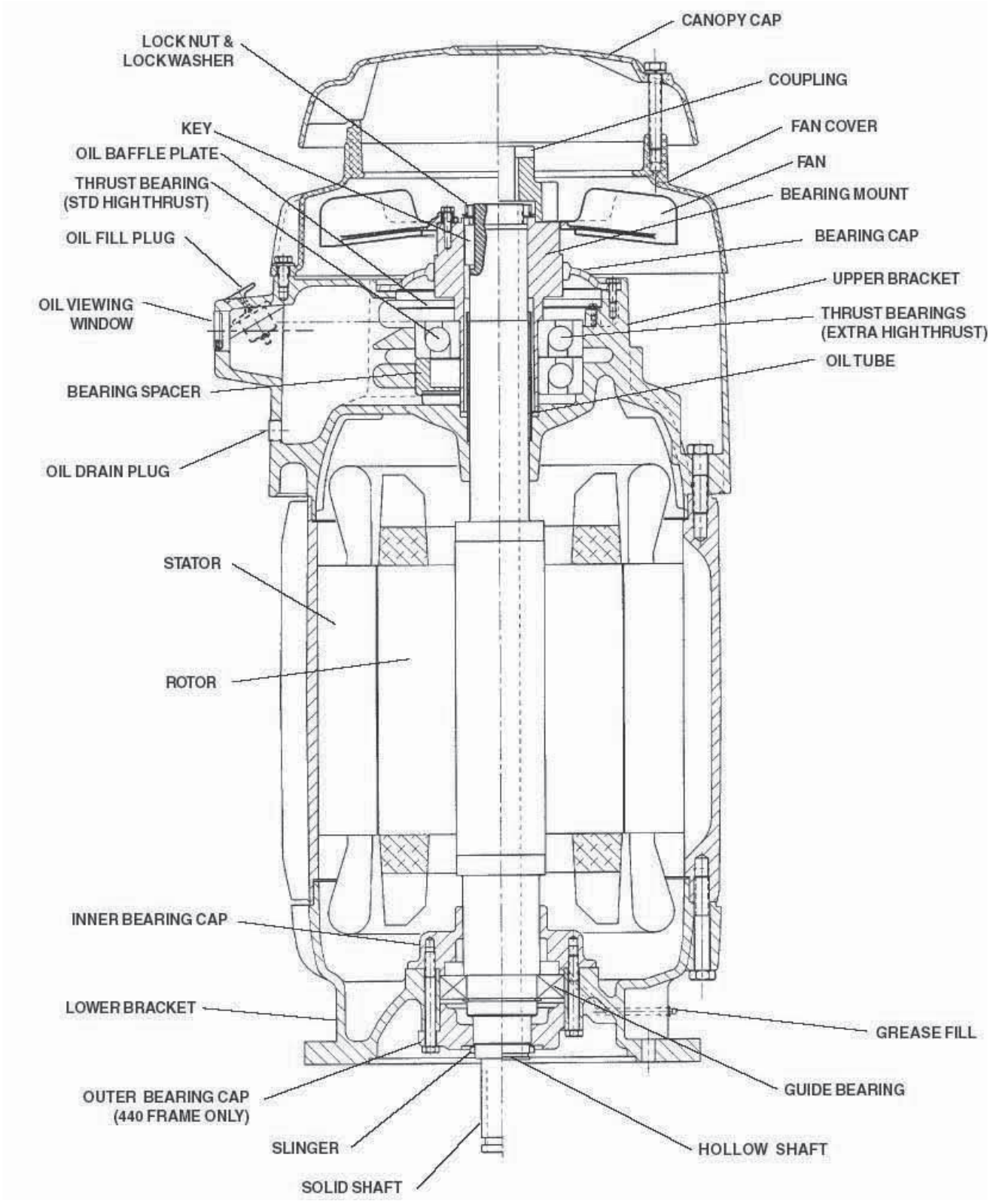

PUMP HEADSHAFT
(SUPPLIED WITH PUMP)
CANOPY CAP
BOLTED COUPLING
RATCHET BALL (OPT)
LOCKNUT & LOCKWASHER
ROTATING RATCHET (OPT)
BALL RETAINING PLATE
GIB KEY
GUIDE BEARING
STATIONARY RATCHET
(OPT)
UPPER BRACKET
RODENT SCREEN
ROTOR
AIR DEFLECTORS
HOLLOW SHAFT
STATOR
BEARING CAP
THRUST BEARING
GREASE FILL
GREASE DRAIN
LOWER BRACKET

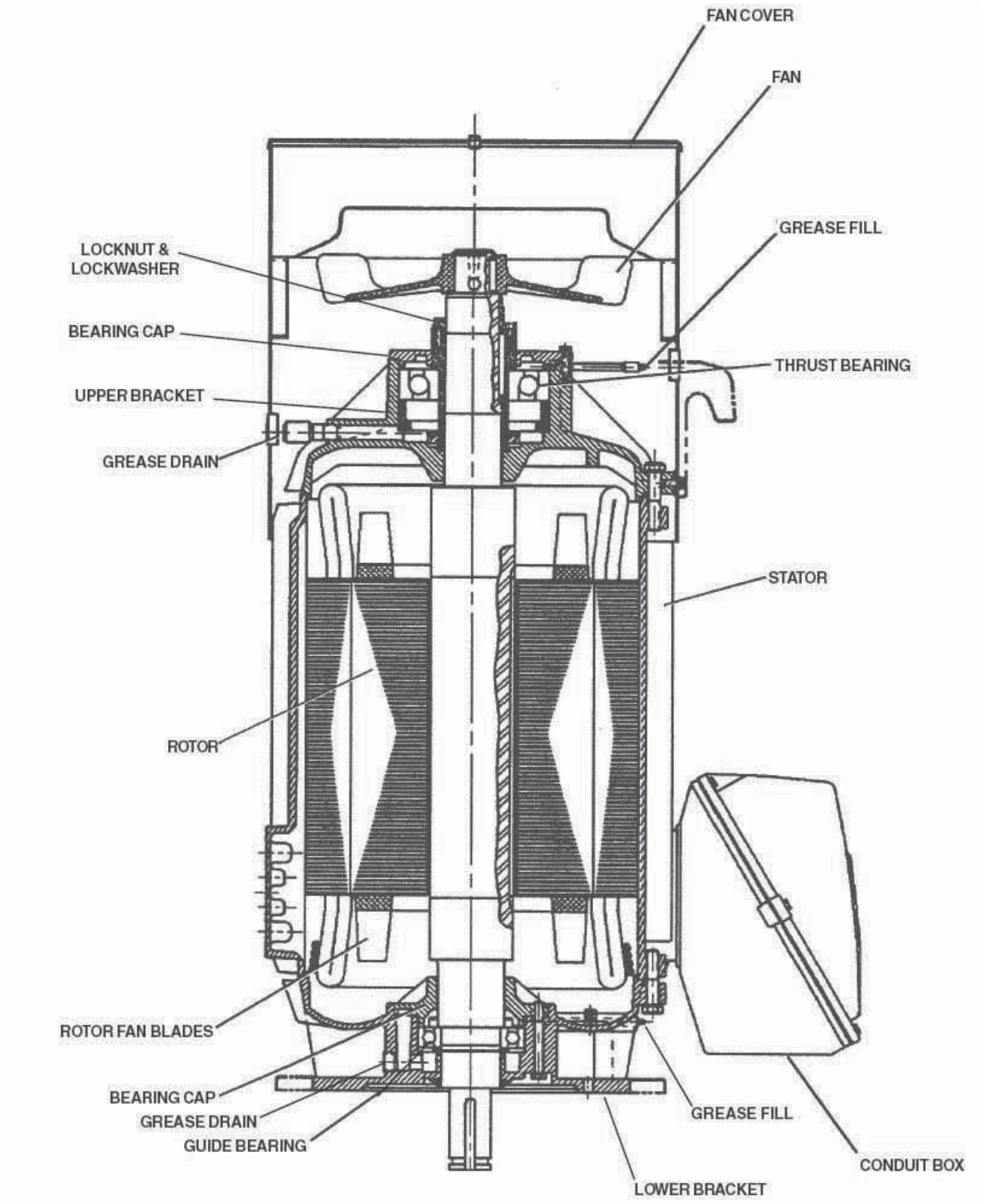

PUMP SHAFT ADJUSTING NUT AND LOCKING SCREWS
ARE FURNISHED BY CUSTOMER
CANOPY CAP
COUPLING
PUMP HEADSHAFT
(SUPPLIED WITH PUMP)
GIB KEY
ROTATING RATCHET
BALL RETAINING RING
RATCHET BALL
BEARING MOUNT
LOCKNUT & WASHER
STATIONARY RATCHET
TANDEM BEARINGS
(EXTRA HIGH THRUST)
SINGLE BEARING
(STANDARD HIGH THRUST)
OIL FILL PLUG
OIL TUBE
UPPER BRACKET
OIL VIEWING WINDOW
RODENT SCREEN
OIL DRAIN PLUG
AIR DEFLECTOR
STATOR
ROTOR FAN BLADE
HOLLOW SHAFT
RODENT SCREEN
BEARING CAP
GREASE FILL
GUIDE BEARING
SLINGER
SNAP RING
LOWER BRACKET

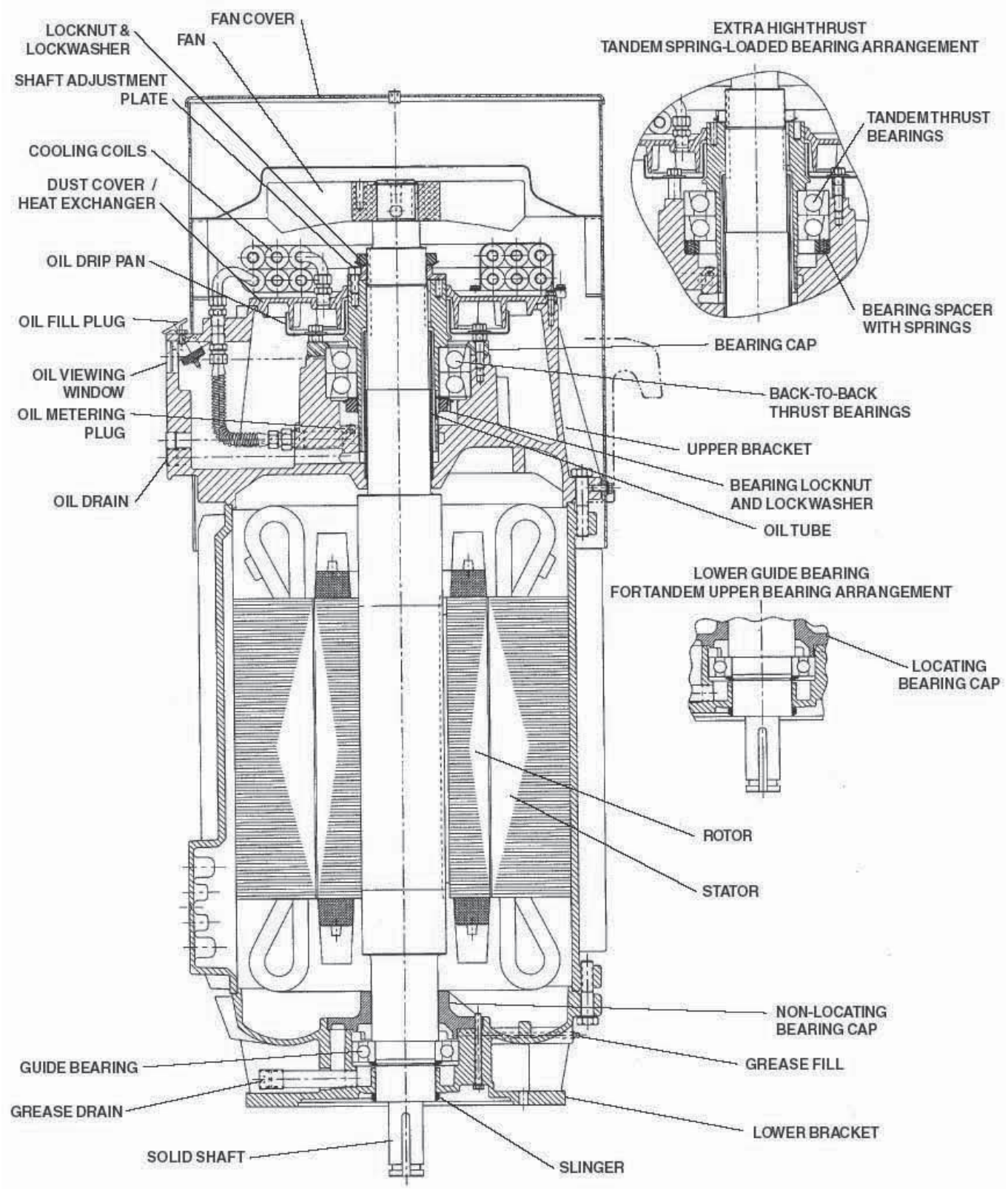
Spare Parts
440 Frame, Type RV-4 (2 Pole)




CANOPY CAP
GIB KEY
BOLTED COUPLING
LOCKNUT & LOCKWASHER
PUMP HEADSHAFT & NUT
(SUPPLIED WITH PUMP)
FAN COVER GUARD
BALL RETAINING RING
FAN
KEY
RATCHET BALL
COUPLING ADAPTOR
ROTATING RATCHET
BEARING CAP
STATIONARY RATCHET &
BEARING CAP
UPTHRUST &
GUIDE BEARING
GREASE FILL
GREASE DRAIN
BEARING CAP
UPPER BRACKET
ROTOR
STATOR
BEARING CAP
TANDEM THRUST
BEARINGS
(175% EHT)
GREASE FILL
GREASE DRAIN
SINGLE BEARING
(STANDARD HIGHTHRUST)
LOWER BRACKET
OPTIONAL STABILIZER BUSHING

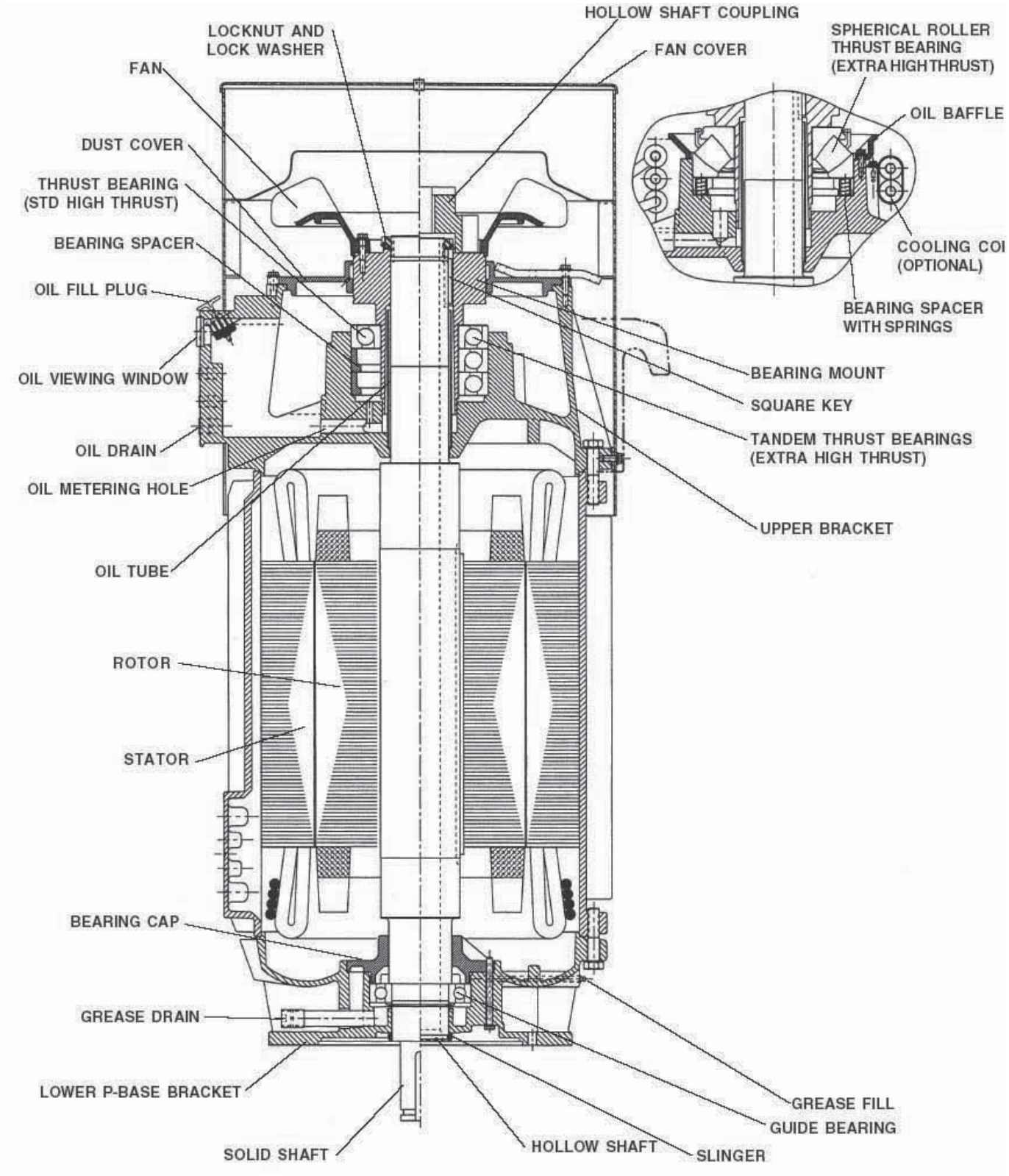

CANOPY CAP
LOCK NUT & LOCKWASHER
COUPLING
KEY
FAN COVER
OIL BAFFLE PLATE
FAN
THRUST BEARING (STD HIGH THRUST)
BEARING MOUNT
OIL FILL PLUG
BEARING CAP
UPPER BRACKET
OIL VIEWING WINDOW
THRUST BEARINGS (EXTRA HIGH THRUST)
OIL TUBE
BEARING SPACER
OIL DRAIN PLUG
STATOR
ROTOR
INNER BEARING CAP
LOWER BRACKET
GREASE FILL
GUIDE BEARING
OUTER BEARING CAP (440 FRAME ONLY)
SLINGER
HOLLOW SHAFT
SOLID SHAFT

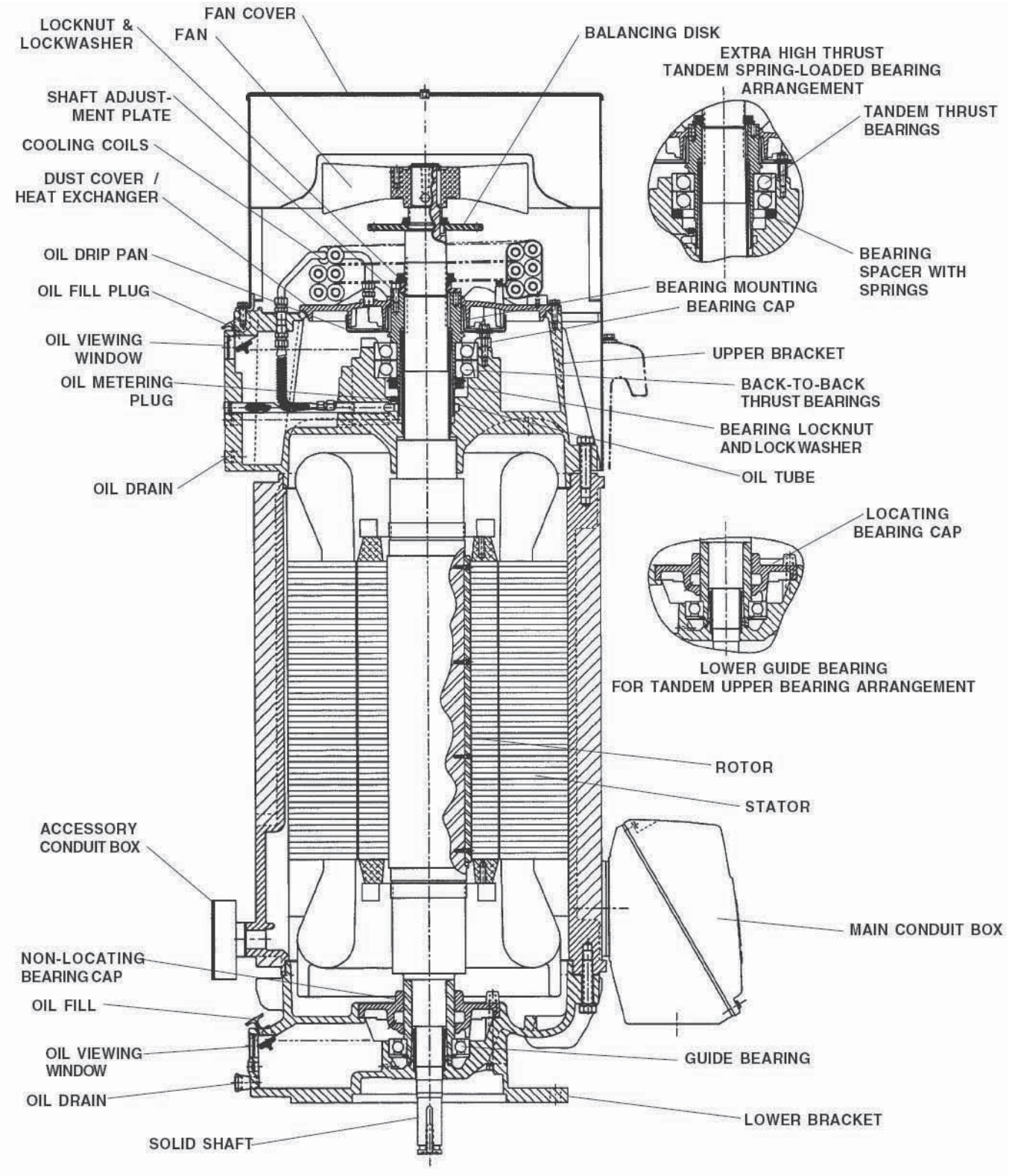

FAN COVER
FAN
GREASE FILL
LOCKNUT &
LOCKWASHER
BEARING CAP
THRUST BEARING
UPPER BRACKET
GREASE DRAIN
STATOR
ROTOR
ROTOR FAN BLADES
BEARING CAP
GREASE DRAIN
GUIDE BEARING
GREASE FILL
CONDUIT BOX
LOWER BRACKET


LOCKNUT & LOCKWASHER
FAN
FAN COVER
SHAFT ADJUSTMENT PLATE
COOLING COILS
DUST COVER / HEAT EXCHANGER
OIL DRIP PAN
OIL FILL PLUG
OIL VIEWING WINDOW
OIL METERING PLUG
OIL DRAIN
EXTRA HIGH THRUST TANDEM SPRING-LOADED BEARING ARRANGEMENT
TANDEM THRUST BEARINGS
BEARING SPACER WITH SPRINGS
BEARING CAP
BACK-TO-BACK THRUST BEARINGS
UPPER BRACKET
BEARING LOCKNUT AND LOCKWASHER
OIL TUBE
LOWER GUIDE BEARING FOR TANDEM UPPER BEARING ARRANGEMENT
LOCATING BEARING CAP
ROTOR
STATOR
NON-LOCATING BEARING CAP
GREASE FILL
GUIDE BEARING
GREASE DRAIN
LOWER BRACKET
SOLID SHAFT
SLINGER

Spare Parts

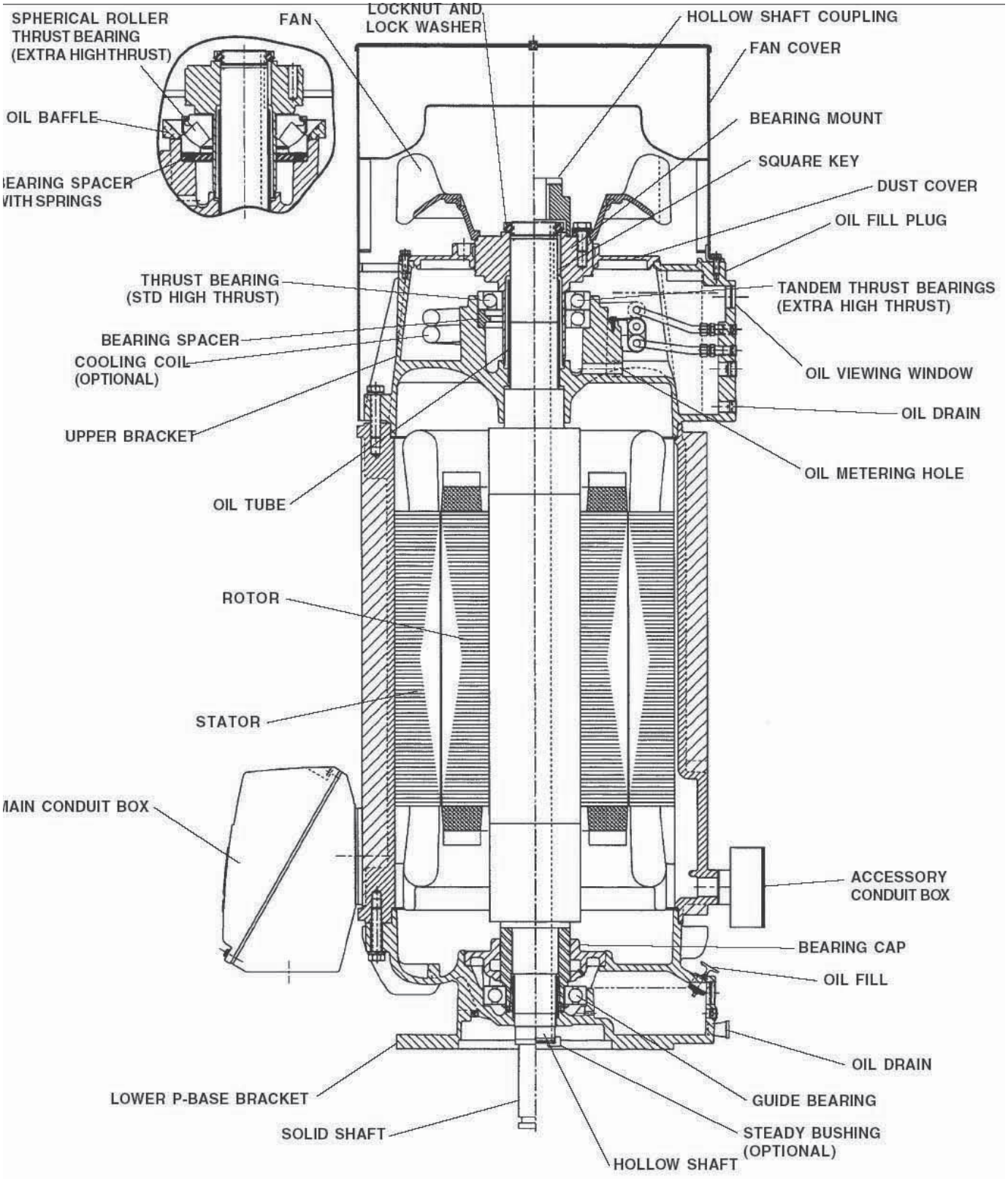
449 Frame
Type JU and JV-4
(4 Pole & Slower)

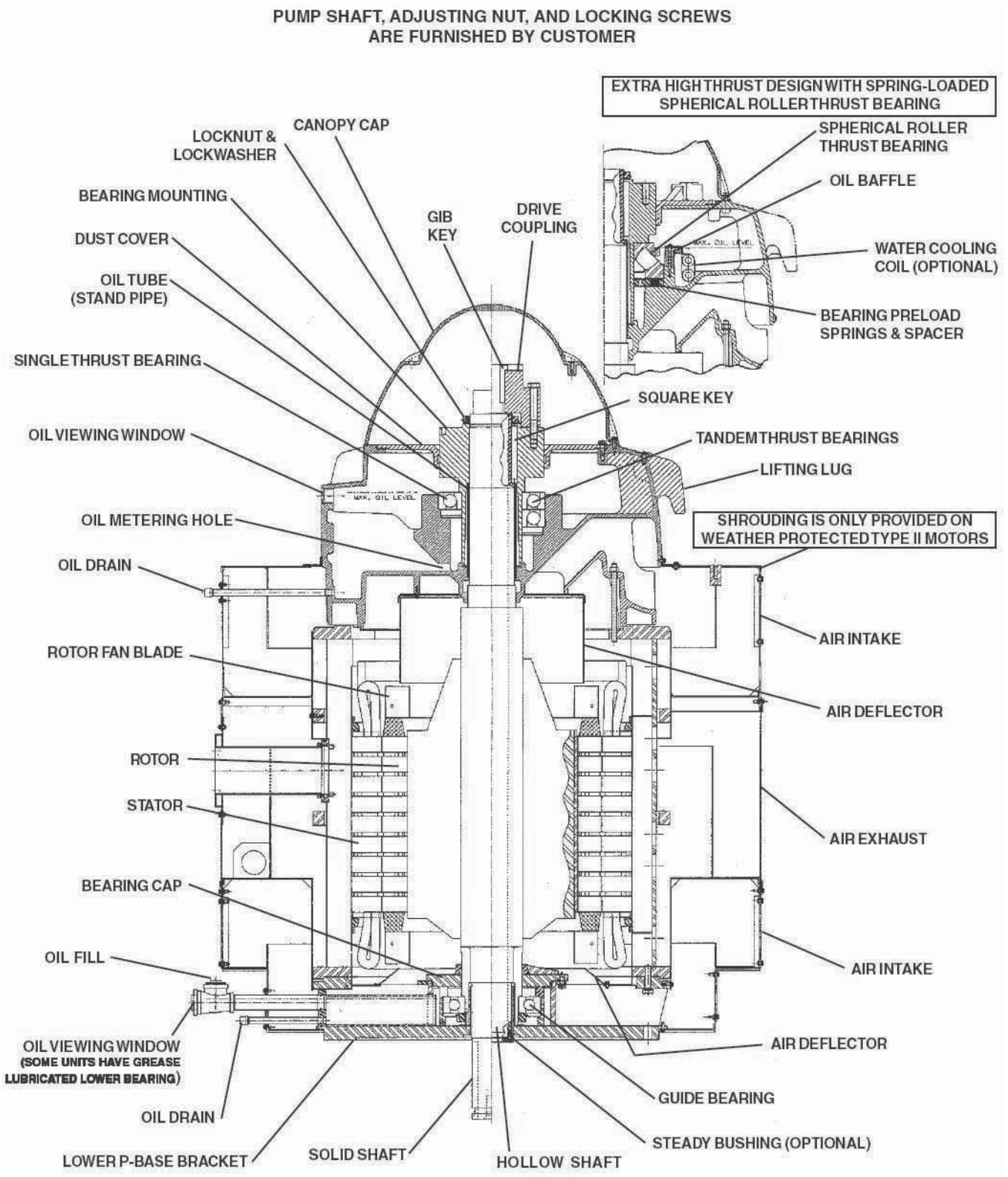



FAN COVER
LOCKNUT & LOCKWASHER
FAN
BALANCING DISK
EXTRA HIGH THRUST TANDEM SPRING-LOADED BEARING ARRANGEMENT
SHAFT ADJUST-MENT PLATE
TANDEM THRUST BEARINGS
COOLING COILS
DUST COVER / HEAT EXCHANGER
BEARING SPACER WITH SPRINGS
OIL DRIP PAN
OIL FILL PLUG
BEARING MOUNTING
BEARING CAP
OIL VIEWING WINDOW
UPPER BRACKET
OIL METERING PLUG
BACK-TO-BACK THRUST BEARINGS
BEARING LOCKNUT AND LOCKWASHER
OIL TUBE
OIL DRAIN
LOCATING BEARING CAP
LOWER GUIDE BEARING FOR TANDEM UPPER BEARING ARRANGEMENT
ROTOR
STATOR
ACCESSORY CONDUIT BOX
MAIN CONDUIT BOX
NON-LOCATING BEARING CAP
OIL FILL
OIL VIEWING WINDOW
GUIDE BEARING
OIL DRAIN
LOWER BRACKET
SOLID SHAFT

Spare Parts

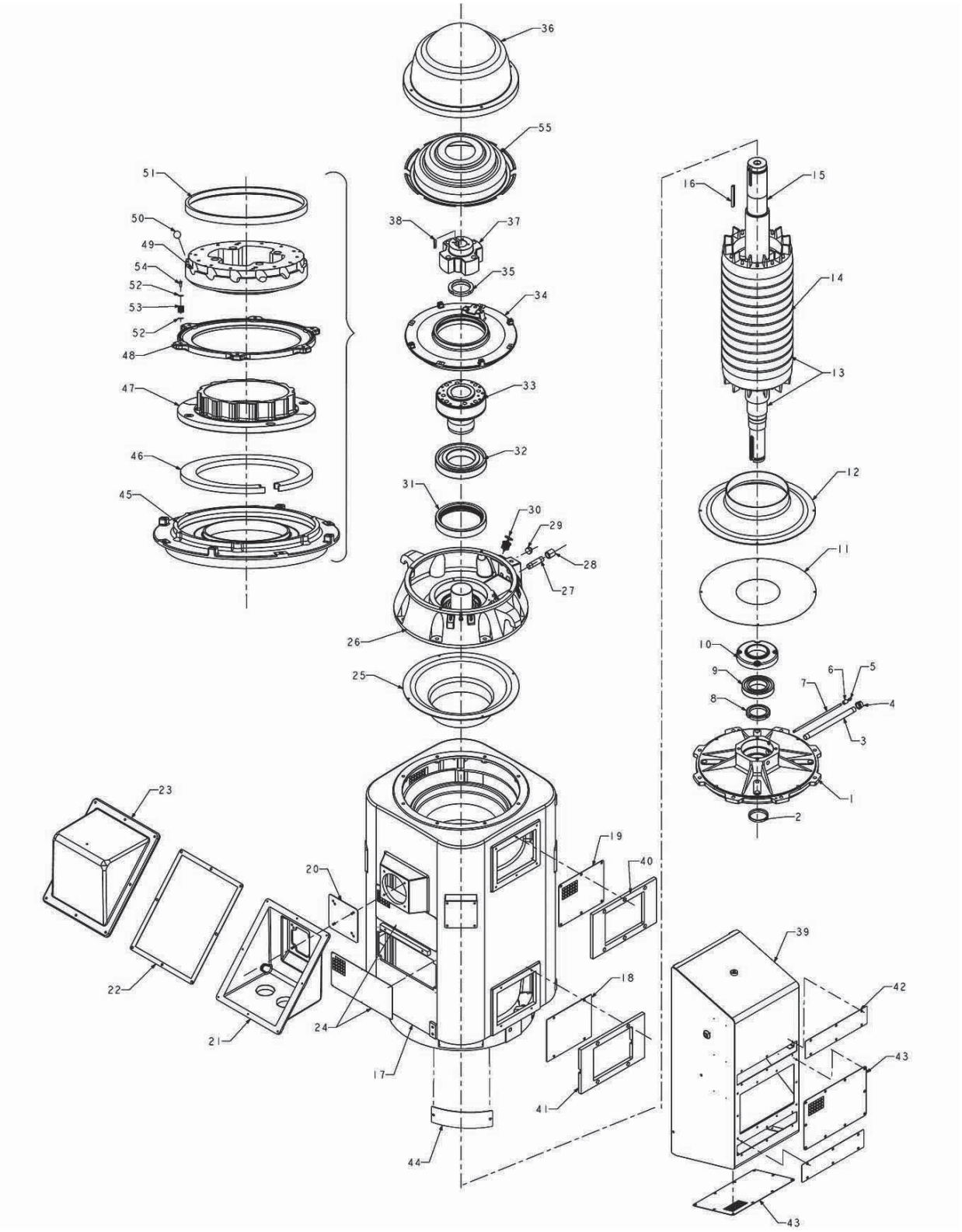
5800 Frame
Type JU, and JV-4, EU, EV-4
(4 Pole & Slower)




PUMP SHAFT, ADJUSTING NUT, AND LOCKING SCREWS
ARE FURNISHED BY CUSTOMER
EXTRA HIGH THRUST DESIGN WITH SPRING-LOADED
SPHERICAL ROLLER THRUST BEARING
SPHERICAL ROLLER
THRUST BEARING
OIL BAFFLE
WATER COOLING
COIL (OPTIONAL)
BEARING PRELOAD
SPRINGS & SPACER
LOCKNUT &
LOCKWASHER
CANOPY CAP
BEARING MOUNTING
DUST COVER
OIL TUBE
(STAND PIPE)
GIB
KEY
DRIVE
COUPLING
SINGLE THRUST BEARING
SQUARE KEY
OIL VIEWING WINDOW
TANDEM THRUST BEARINGS
LIFTING LUG
OIL METERING HOLE
SHROUDING IS ONLY PROVIDED ON
WEATHER PROTECTED TYPE II MOTORS
OIL DRAIN
AIR INTAKE
ROTOR FAN BLADE
AIR DEFLECTOR
ROTOR
STATOR
AIR EXHAUST
BEARING CAP
OIL FILL
AIR INTAKE
AIR DEFLECTOR
OIL VIEWING WINDOW
(SOME UNITS HAVE GREASE
LUBRICATED LOWER BEARING)
GUIDE BEARING
OIL DRAIN
STEADY BUSHING (OPTIONAL)
LOWER P-BASE BRACKET
SOLID SHAFT
HOLLOW SHAFT

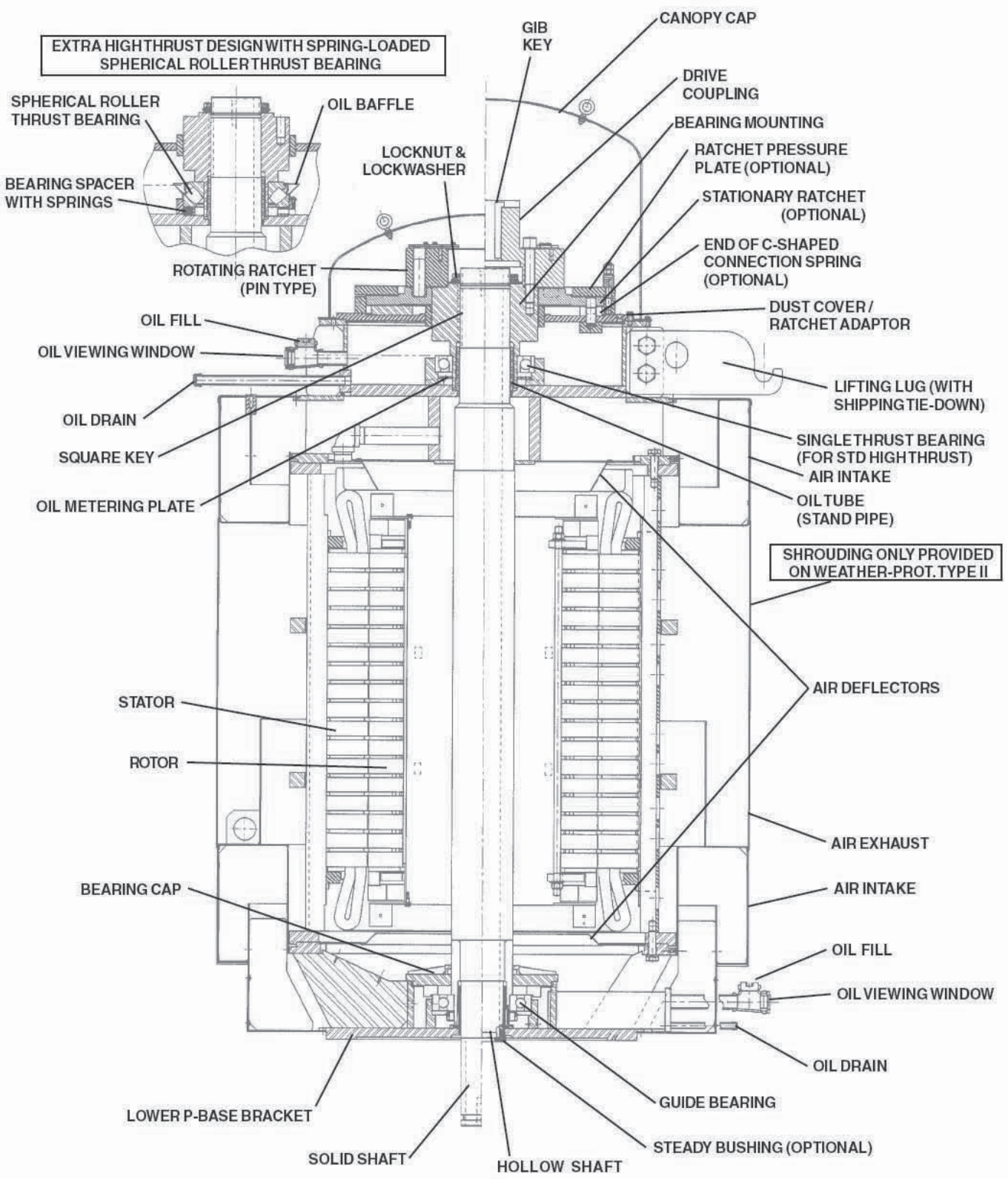
Spare Parts

5000 Frame
Type RU and RV-4



ITEM NO.	QTY	NAME OF PART
1	1	Lower Bracket
2	1	Shaft Water Slinger
3	1	Pipe Nipple (Lower Grease Drain)
4	1	Pipe Cap (Lower Grease Drain)
5	1	Grease Zerk Fitting
6	1	Pipe Coupling (Lower Grease Fill)
7	1	Pipe Nipple (Lower Grease Fill)
8	1	Locknut and Lockwasher (Lower Bearing)
9	1	Lower Bearing
10	1	Lower Bearing Cap
11	1	Lower Intake Screen (Only on WP-1)
12	1	Lower Air Deflector
13	1	Rotor Assembly
14	1	Rotor Core
15	1	Rotor Shaft
16	1	Square Key (Bearing Mounting to Shaft)
17	1	Stator Assembly
18	2	Lower Air Intake Cover (Only on WP-1)
19	2	Upper Air Intake Screen (Only on WP-1)
20	1	Gasket (Outlet Box Base to Stator)
21	1	Outlet Box Base
22	1	Gasket (Outlet Box Cover to Base)
23	1	Outlet Box Cover
24	2-(5008) 4-(5012)	Exhaust Screen
25	1	Upper Air Deflector
26	1	Upper Bracket
27	1	Pipe Nipple (Oil Drain)
28	1	Pipe Cap (Oil Drain)
29	1	Oil Sight Gauge Window

ITEM NO.	QTY	NAME OF PART
30	1	Oil Fill Plug (Expanding)
31	1	Bearing Spacer (or Tandem Thrust Bearing)
32	1	Upper Thrust Bearing
33	1	Bearing Mounting
34	1	Dust Cover (Only on Units Without Ratchet)
35	1	Locknut and Lockwasher (Brg Mtg to Shaft)
36	1	Canopy Cap
37	1	Thrust Coupling (Only on Hollowshaft)
38	1	Gib Key (Only on Hollowshaft)
39	2	WP2 Intake Box (Only on WP-2)
40	2	Upper Adapter Flange (Only on WP-2)
41	2	Lower Adapter Flange (Only on WP-2)
42	4	Filter Access Cover (Only on WP-2)
43	4	Intake Screen (Only on WP-2)
44	4	Cover (Flange Access) (Only on WP-2)
45	1	Ratchet Adaptor (Only on Units With Ratchet)
46	1	Connection Spring (Only on Units With Ratchet)
47	1	Stationary Ratchet (Only on Units With Ratchet)
48	1	Pressure Plate (Only on Units With Ratchet)
49	1	Rotating Ratchet (Only on Units With Ratchet)
50	12-(5008) 14-(5012)	Ratchet Ball (Only on Units with Ratchet)
51	1	Ball Retaining Ring (Only on Units With Ratchet)
52	4-(5008) 12-(5012)	Plain Washer (Only on Units With Ratchet)
53	4-(5008) 6-(5012)	Die Spring (Only on Units With Ratchet)
54	4-(5008) 6-(5012)	Screw (Only on Units With Ratchet)
55	1	Pressurization Baffle


EXTRA HIGH THRUST DESIGN WITH SPRING-LOADED SPHERICAL ROLLER THRUST BEARING
SPHERICAL ROLLER THRUST BEARING
OIL BAFFLE
BEARING SPACER WITH SPRINGS
GIB KEY
CANOPY CAP
DRIVE COUPLING
BEARING MOUNTING
LOCKNUT & LOCKWASHER
RATCHET PRESSURE PLATE (OPTIONAL)
STATIONARY RATCHET (OPTIONAL)
END OF C-SHAPED CONNECTION SPRING (OPTIONAL)
ROTATING RATCHET (PIN TYPE)
DUST COVER / RATCHET ADAPTOR
OIL FILL
OIL VIEWING WINDOW
LIFTING LUG (WITH SHIPPING TIE-DOWN)
OIL DRAIN
SINGLE THRUST BEARING (FOR STD HIGH THRUST)
SQUARE KEY
AIR INTAKE
OIL TUBE (STAND PIPE)
OIL METERING PLATE
SHROUDING ONLY PROVIDED ON WEATHER-PROT. TYPE II
AIR DEFLECTORS
STATOR
ROTOR
AIR EXHAUST
BEARING CAP
AIR INTAKE
OIL FILL
OIL VIEWING WINDOW
OIL DRAIN
GUIDE BEARING
LOWER P-BASE BRACKET
STEADY BUSHING (OPTIONAL)
SOLID SHAFT
HOLLOW SHAFT

Installation Record

NAMEPLATE AND INSTALLATION INFORMATION

SERIAL NUMBER OR MODEL NUMBER..... _____
HORSEPOWER ..... _____
MOTOR RPM..... _____
PHASE ..... _____
FREQUENCY ..... _____
AMPS ..... _____ **AT** _____ **VOLTS**
DESIGN ..... _____
FRAME ..... _____
DATE PURCHASED ..... _____ **P.C. NUMBER** _____
DATE INSTALLED ..... _____
LOCATION OF JOB SITE ..... _____
MACHINE OR INSTALLATION NUMBER ..... _____
PURCHASED FROM ..... _____
MOTOR RESISTANCE LINE TO LINE AT TIME OF INSTALLATION ..... _____

INSULATION TO GROUND READING AT TIME OF INSTALLATION .....

RECORD OF MAINTENANCE

GRADE AND TYPE OF LUBRICANT USED .....

DATE OF LAST RELUBRICATION	INSULATION RESISTANCE		OVERHAUL OR REPAIR	
	DATE	MEGOHMS	DATE	ACTION

Table 6
Threaded Fastener Torque Requirements

All threaded fasteners used for rigid joints (cast iron and low carbon steel) in products of Emerson Motor Co., are to be tightened to the torque values listed in the following tabulation. Values are based upon dry assembly.

Diameter of Fastener	Number of Threads Per Inch	Grade 5 Fasteners	Grade 2 Fasteners
#6	32	16 lb.-in.	10 lb.-in.
	40	18	12
#8	32	30	19
	36	31	20
#10	24	43	27
	32	49	31
#12	24	66	37
	28	72	40
1/4”	20	96	66
	28	120	76
5/16”	18	16 lb.-ft.	11 lb.-ft.
	24	18	12
3/8”	16	29	20
	24	34	23
7/16”	14	46	30
	20	52	35
1/2”	13	70	50
	20	71	55
9/16”	12	102	
	18	117	
5/8”	11	140	
	18	165	
3/4”	10	249	
	16	284	
7/8”	9	401	
	14	446	
1”	8	601	
	14	666	
1-1/8”	7	742	
	12	860	
1-1/4”	7	1046	
	12	1196	
1-3/8”	6	1371	
	12	1611	
1-1/2”	6	1820	
	12	2110	

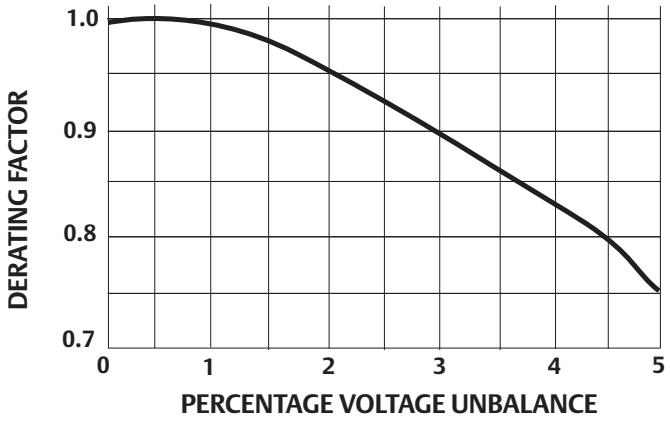
The above torque limits are not to be used when a drawing or specification lists a specific torque.

Effects of Unbalanced Line Voltage.

A potential cause of premature motor failure is unbalanced line (supply) voltage. Three phase motors produce useful work when they efficiently convert electrical energy into mechanical energy. This is accomplished when each phase of the supply voltage is of equal strength and works in harmony to produce a rotating magnetic field within the motor.

When the value of supply voltage leg to leg is not equal (e.g. 460-460-460), the risk of unbalanced line voltage is present. If this voltage unbalance exceeds about 1%, excessive temperature rise will result. Unless the motor HP capacity is derated to compensate, the motor will run hot resulting in degredation of the insulation system and bearing lubricant.

From NEMA MG-1, 14.36: Derating factors due to unbalanced line voltage



Example: Field ratings of Phase A - 480 v, Phase B = 460 v, Phase C = 450 v

As a rule of thumb, the percentage increase in temperature rise will be about two times the square of the percentage voltage unbalance. In this case the average voltage (480 + 460 + 450) is equal to 463 volts. The maximum deviation between legs is 17 volts (480 - 463 volts).

The Percentage voltage unbalance is determined as follows: 17 / 463 x 100 = 3.7%. The temperature rise will then increase $(3.7)^2$ x 2 = 27%. This condition will reduce the typical life of your motor to less than 25% of its design life. Should this condition be present, call your electric utility and resolve your unbalanced supply condition.

Other areas of motor performance will also be affected - e.g., loss of torque capacity, change in full load RPM, greatly unbalanced current draw at normal operating speed. Refer to NEMA MG-1 section 14.36 for details.

Motors Applied to Variable Frequency Drives (VFD's)

Electric motors can be detrimentally affected when applied with variable frequency drives (VFD's). The non-sinusoidal waveforms of VFD's have harmonic content which causes additional motor heating; and high voltage peaks and short rise times, which result in increased insulation stress, especially when long power cable lengths are used. Standard motors utilized with VFD's must be limited to those application consderations defined in **NEMA MG-1 Part 30.**

NEMA MG-1 Part 31 defines performance and application considerations for Definite-Purpose Inverter Fed motors. To insure satisfactory performance and reliability, Emerson Motor Co. offers and recommends nameplated inverter duty motor products which meet the requirements of NEMA MG-1 Part 31. The use of non-inverter duty motors may result in unsatisfactory performance or premature failure, which may not be warrantable under the Terms and Conditions of Sale. Contact your Emerson Motor Co. Field Sales Engineer for technical assistance in motor selection, application and warranty details.

ELECTRIC MOTOR LOAD TEST USING THE WATT HOUR METER

In the analysis of electric motors it is sometimes desirable to conduct an accurate load check on a particular installation to determine whether the motor is operating within the rating and horsepower for which it was designed. Since most pumps installations have their own watt hour power meters, accurate readings will permit a load check via the following formula:

K = Disc constant (watts per revolution of disc per hour). This is typically found on the meter face.

R = Revolutions of disc in watt meter within the time of the test.

T = Time of test, in seconds.

Transformer ratio = Stated on meter face. Must be included where current transformers are used with watt meters.

To obtain input kilowatts:

$$\text{Input KW} = \frac{K \times R \times 3.6}{T}$$

To obtain input horsepower:

$$\text{Input HP} = \frac{K \times R \times 4.83 \times \text{Transformer Ratio}}{T}$$

The watt hour meter measures power consumed over a period of time. It is necessary to establish the rate at which power is being consumed by the work being done. We establish this rate by counting the revolutions of the disc in a given time. Here is a typical example of a load check:

GIVEN

- Pump motor to be load checked is rated 100 HP, 1800 RPM, 3-phase, 60 Hz, 1.15 service factor, 91.0 Percent Efficiency.
- Disc constant (K) found on face of meter = 40.
- Transformer ratio found on face of meter = 3.

DATA FOUND FROM TESTS
With stop watch, disc was observed to revolve 10 times in exactly 49 seconds. Therefore, R = 10; T = 49.

THUS

$$\text{Input HP} = \frac{40 \times 10 \times 4.83 \times 3}{49} = 118.29$$

Output HP = Input HP x Motor Efficiency
Output HP = 118.29 x 91% = 107.54

CONCLUSION
The output HP (107.54) is greater than output HP shown on nameplate (100 HP) but is well within the 1.15 service factor which applies to this motor.

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Motor Technologies

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Emerson trademarks followed by the ® symbol are registered with the U.S. Patent and Trademark Office.

EMERSON. CONSIDER IT SOLVED.™

EMERSON
Motor Technologies

EMERSON MOTOR COMPANY
8100 WEST FLORISSANT AVE.
ST. LOUIS, MO 63136

DATE: 10/6/2010

P.O. NO.: 139952
Order/Line NO.: 20087036 SO 100

TO: AMERICAN-MARSH PUMPS
3269 EAST NORTH
BLDG D
FRESNO, CA, 93725
ATTN: JOHN WRIGHT

PO 139952 TAG: NOR CAL

Model Number: NA
Catalog Number: NA
Submittals
CONF,LLC,SUBMITTALS

REVISIONS:
(NONE)

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY US ELECTRICAL MOTORS.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Features:

HOLD PRODUCTION
Horsepower ..... 00075.00~00000.00 ~ KW: 55.95
Enclosure ..... WPI
Poles ..... 08~00 ~ RPM: 900~0
Frame Size ..... H444~VP
Phase/Frequency/Voltage.. 3~060~460 ~ Random Wound
Service Factor 1.15
Insulation Class ..... Class "F" ~ Insulife 2000
Altitude In Feet (Max) .. 3300 Ft.(1000 M)
Ambient Ir Degree C (Max) +50 C
Efficiency Class ..... Premium Efficiency
Application ..... Vertical Centrifugal Pump
Customer Part Number ....
16.5" Base
Non-Reverse Ratchet
Pricebook Thrust Value (lbs).. 12500
Customer Down Thrust (lbs) ... 12500
Customer Shutoff Thrust (lbs).
Up Thrust (lbs): ~
Inverter Duty Rating:
Load Type (Base Hz & Below) . Variable Torque
Speed Range (Base Hz & Below) 10:1
"AK" Dimension (Inches).. NA
Shaft Dimensions:~U=2.125 ~ AH/V=4.500
KEYWAY=0.500 ~ ES=3.030
Temperature Rise (Sine Wave): "B" Rise @ 1.0 SF (Resist)
NEMA Design ..... B
Starting Method ..... Direct-On-Line Start
Duty Cycle ..... Continuous Duty
Efficiency Value ..... 93.0 % ~ Guaranteed
Sound Level Value (dBa).. 80 dBa @ 1M Sound Pressure
Load Inertia (lb-ft2): NEMA ~ NEMA Inertia: 1814.00 ~ 1.00
Number Of Starts Per Hour: NEMA
Motor Type Code RVI4
Rotor Inertia (LB-FT²) 55.5 LB-FT²
Qty. of Bearings PE (Shaft) 1
Qty. of Bearings SE (OPP) 1
Bearing Number PE (Shaft) 6215-J

Bearing Number SE (OPP) 7322 BEM

EMERSON
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8100 WEST FLORISSANT AVE.
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Model Number: NA
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Submittals
CONF,LLC,SUBMITTALS

REVISIONS:
(NONE)

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY US ELECTRICAL MOTORS.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

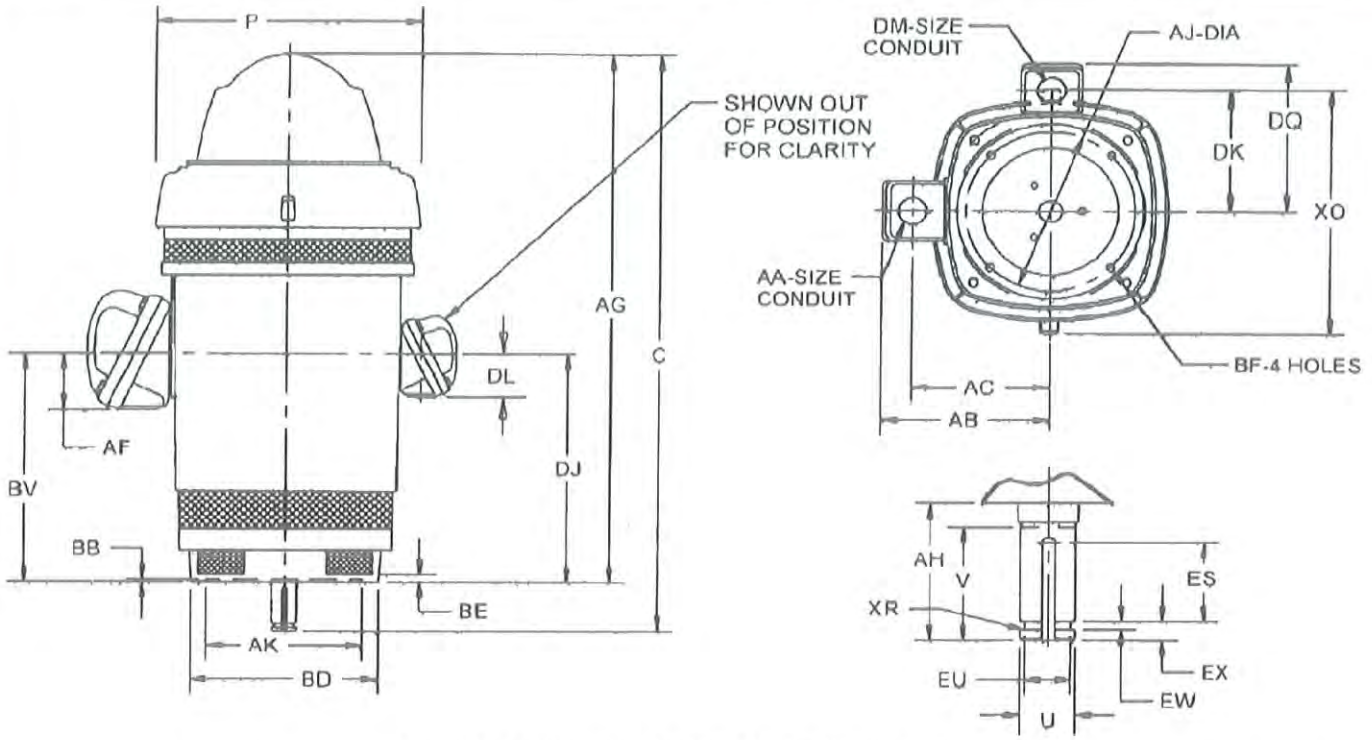
Accessories:

Corro-Duty Paint Job
Counter CW Rotation FODE
Ground Lug In Conduit Box
Insul Bearings- Both Brackets
Screens - Standard Material
115 Volt Space Heaters
Stainless Steel Hardware
Thermostats - Normally Closed
VFD Duty
Conduit Box Information: ~ Size 2.0 - Cast Iron
Conduit Opening Size (AA) .. 3.5" NPT
1 Conduit Opening ~ Bottom Of Conduit Box
Q-1 Accessory Outlet Box ~ Same Side As Main O/B
3/4" NPT Conduit Opening

USE THE DATA PROVIDED BELOW TO SELECT THE APPROPRIATE DIMENSION PRINT

Horsepower	75
Pole(s)	08
Voltage(s)	460
Frame Size	H444VP
Shaft U Diameter	2.125
Outlet Box AF	8.06
Outlet Box AA	3.5
Accessory Outlet Box DM	0.75

EFFECTIVE: 17-MAR-09	VERTICAL MOTORS O/S (#2) MAIN & SEP O/B FRAME: H440VP, VPA TYPE: RV-4, RVE-4, RVI-4, RVS-4	PRINT: 09-2676-04
SUPERSEDES: NEW		SHEET: 1 OF 1



ALL DIMENSIONS ARE IN INCHES AND MILLIMETERS

UNITS	C	P [2]	U -.001	V MIN	AA	AB	AC	AF	AG	AH	AJ	AK +.005	BB MIN	BE
IN	54.56	23.38	2.125	4.50	3-1/2 NPT	21.56	15.94	8.06	50.06	4.50	14.750	13.500	.25	.75
MM	1386	594	53.98	114		548	405	205	1272	114	374.65	342.80	6	19

UNITS	BF	BV	DJ	DK	DL	DM	DQ	ES MIN	EU -.005	EW +.002	EX -.006	XO	XR	SQ KEY
IN	.69	21.19	21.19	11.56	1.81	3/4 NPT	13.88	3.03	1.750	.375	.750	27.50	.03	.500
MM	18	536	536	294	46		353	77	44.45	9.53	19.05	699	1	12.70

FRAME	UNITS	BD MAX
440VP	IN	16.50
	MM	419
440VPA	IN	20.00
	MM	508

TOLERANCES	
FACE RUNOUT	.007 F.I.R
PERMISSIBLE ECCENTRICITY OF MOUNTING RABBET	.007 F.I.R
PERMISSIBLE SHAFT RUNOUT	.002 F.I.R
SPECIAL SHAFT RUNOUT (WHEN SPECIFIED)	.001 F.I.R

1. ALL ROUGH DIMENSIONS MAY VARY BY .25" DUE TO CASTING AND/OR FABRICATION VARIATIONS.
2. LARGEST MOTOR WIDTH.
3. CONDUIT OPENINGS MAY BE LOCATED IN STEPS OF 90° REGARDLESS OF LOCATION. STANDARD AS SHOWN WITH CONDUIT OPENING DOWN.
4. TOLERANCES SHOWN ARE IN INCHES ONLY.

09-2676

EMERSON. Motor Technologies

US MOTORS

NAMEPLATE DATA

CATALOG NUMBER				NAMEPLATE PART #	422707-005		
MODEL		FR	H444VP	TYPE	RVI4	ENCL	WPI
SHAFT END BRG	6215-J - QTY 1			OPP END BRG	7322 BEM - QTY 1		
PH	3	MAX AMB	50 C	ID#	(ref: Order#: 20087036, Type: SO, Line#: 100)		
INSUL CLASS	F	Asm. Pos.		DUTY	CONT		

HP	75	RPM	890	HP		RPM			
VOLTS	460			VOLTS					
FL AMPS	95.0			FL AMPS					
SF AMPS	109.0			SF AMPS					
SF	1.15	DESIGN	B	CODE	G	SF		DESIGN		CODE	
NEMA NOM EFFICIENCY	94.1	NOM PF	78.1	KiloWatt	55.950	NEMA NOM EFFICIENCY		NOM PF			
GUARANTEED EFFICIENCY	93.0	MAX KVAR		HZ	60	GUARANTEED EFFICIENCY		MAX KVAR		HZ	

UL DATA (IF APPLICABLE):

DIVISION		CLASS I		GROUP I	
TEMP CODE		CLASS II		GROUP II	

VFD DATA (IF APPLICABLE):

VOLTS	460		
AMPS	99.8		
TORQUE 1	441.8LB-FT	TORQUE 2	
VFD LOAD TYPE 1	VT/PWM	VFD LOAD TYPE 2	
VFD HERTZ RANGE 1	6-60	VFD HERTZ RANGE 2	
VFD SPEED RANGE 1	90-900	VFD SPEED RANGE 2	
SERVICE FACTOR	1.00	FL SLIP	
NO. POLES		MAGNETIZING AMPS	
VECTOR MAX RPM		Encoder PPR	
Radians / Seconds		Encoder Volts	

TEAO DATA (IF APPLICABLE):

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

ADDITIONAL NAMEPLATE DATA:

Decal / Plate	WD=499495	Customer PN	
Notes		Non Rev Ratchet	NRR
Max Temp Rise	70C RISE/RES@1.00SF	OPP/Upper Oil Cap	5.5 QT/5.2 L
Thermal (WDG)	OVER TEMP PROT 2	SHAFT/Lower Oil Cap	GREASE
Altitude			
EPACT Note		EPACT Compliance	
COS		Marine Duty	
Balance	0.06 IN/SEC	Arctic Duty	
3/4 Load Eff.	94.6	Inrush Limit	
Motor Weight	1500	Direction of Rotation	
Sound Level	80 DBA @ 1M	Special Note 1	
Vertical Thrust	12500	Special Note 2	
Thrust Percentage	100% HT	Special Note 3	
Bearing Life		Special Note 4	
Starting Method		Special Note 5	
Number of Starts		Special Note 6	
200/208V 60Hz Max Amps		SH Max. Temp.	
190V 50 hz Max Amps		SH Voltage	SH VOLTS=115V
380V 50 Hz Max Amps		SH Watts	SH WATTS=192W
NEMA Inertia		Load Inertia	
Sumpheater Voltage		Sumpheater Wattage	
Special Accessory Note 1		Special Accessory Note 16	
Special Accessory Note 2		Special Accessory Note 17	
Special Accessory Note 3		Special Accessory Note 18	
Special Accessory Note 4		Special Accessory Note 19	
Special Accessory Note 5		Special Accessory Note 20	
Special Accessory Note 6		Special Accessory Note 21	
Special Accessory Note 7		Special Accessory Note 22	
Special Accessory Note 8		Special Accessory Note 23	
Special Accessory Note 9		Special Accessory Note 24	
Special Accessory Note 10		Special Accessory Note 25	
Special Accessory Note 11		Special Accessory Note 26	
Special Accessory Note 12		Special Accessory Note 27	
Special Accessory Note 13		Special Accessory Note 28	
Special Accessory Note 14		Special Accessory Note 29	
Special Accessory Note 15		Special Accessory Note 30	

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Motor Technologies

EMERSON MOTOR COMPANY
ST. LOUIS, MO

MOTORS

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

MOTOR PERFORMANCE

MODEL NO.	CATALOG NO.	PHASE	TYPE	FRAME
NA	NA	3	RVI4	H444VP

ORDER NO.	20087036	LINE NO.	100

MPI:	135752
HP:	75
POLES:	8
VOLTS:	460
HZ:	60
SERVICE FACTOR:	1.15
EFFICIENCY (%):	
S.F.	93.7
FULL	94.1
3/4	94.6
1/2	94.2
1/4	91.2
POWER FACTOR (%):	
S.F.	79
FULL	78.1
3/4	74.4
1/2	65.2
1/4	44.6
NO LOAD	3.7
LOCKED ROTOR	31.8
AMPS:	
S.F.	109
FULL	95
3/4	75
1/2	57
1/4	43
NO LOAD	37.8
LOCKED ROTOR	531.4
NEMA CODE LETTER	G
NEMA DESIGN LETTER	B
FULL LOAD RPM	890
NEMA NOMINAL EFFICIENCY (%)	94.1
GUARANTEED EFFICIENCY (%)	93
MAX KVAR	25.6
AMBIENT (°C)	50
ALTITUDE (FASL)	3300
SAFE STALL TIME-HOT (SEC)	30
SOUND PRESSURE (DBA @ 1M)	70
TORQUES:	
BREAKDOWN(% F.L.)	206
LOCKED ROTOR(% F.L.)	150
FULL LOAD(LB-FT)	441.8

The Above Data Is Typical, Sinewave Power Unless Noted Otherwise

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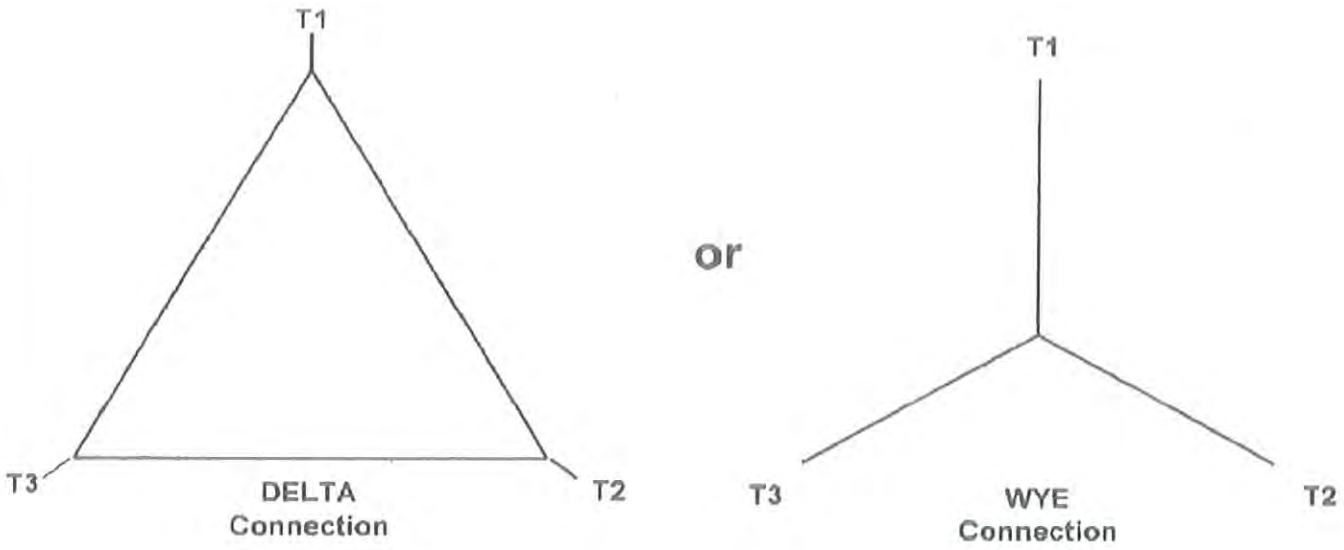
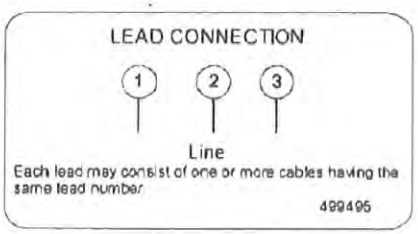
EMERSON MOTOR COMPANY
ST. LOUIS, MO

MOTORS

499495

Motor Wiring Diagram





To reverse direction of rotation interchange connections L1 and L2.

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

EFFECTIVE 2/27/96
SUPERCEDES: X736618, 96441, 179979, 284136
Connection Plate: 499495
Connection Decal: 912113

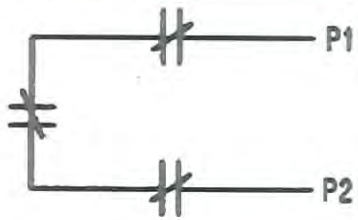
ALT. C | 834066 | A

THERMOSTATS

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

2. THERMOSTATS MUST NOT BE USED TO SWITCH ABOVE 18 AMPS AT 24 VDC OR 12 AMPS AT 230 VAC.

N. C. THERMOSTATS



ACCESSORY LISTING
QTY-3 N.C. THERMOSTATS

ALT LET	CHANGE NOTICE NO.	DESCRIPTION OF CHANGE
A	-----	REDRAWN ON CAD 10/28/91
B	MOD	8-NOV-95 UPDATE TEXT
C	MOD	6-JUN-00 UPDATED

U.S. ELECTRICAL MOTORS
DIVISION OF EMERSON ELECTRIC CO.
ST. LOUIS, MISSOURI

TITLE: CUSTOMER CONNECTION DIAGRAM

SCALE: NONE | UNITS: IN

DRWN 24-APR-80, DLH
RVSD 6-JUN-00, RWK
APPD 6-JUN-00, REP

MATERIAL: ---

PARTS: --- | FRAME: -----

CSTGS: --- | TYPE: -----

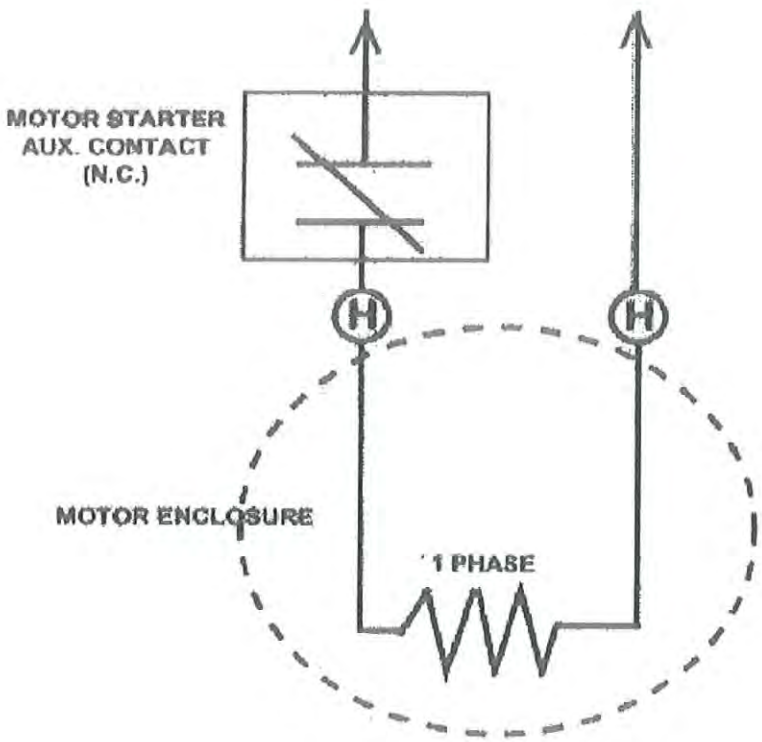
SHEET 1 of 1 | PREFIX: CDG

ALT. C | 834066 | A

970798

SPACE HEATER CONNECTION DIAGRAM

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



THIS EQUIPMENT IS SUPPLIED WITH ANTI-CONDENSATION HEATERS. HEATERS SHOULD BE ENERGIZED WHEN EQUIPMENT IS NOT OPERATING TO PROTECT UNIT BY PREVENTING INTERNAL CONDENSATION. CONNECT THE "H" OR HEATER LEADS TO	
115V VOLTS	**192W** WATTS RATING

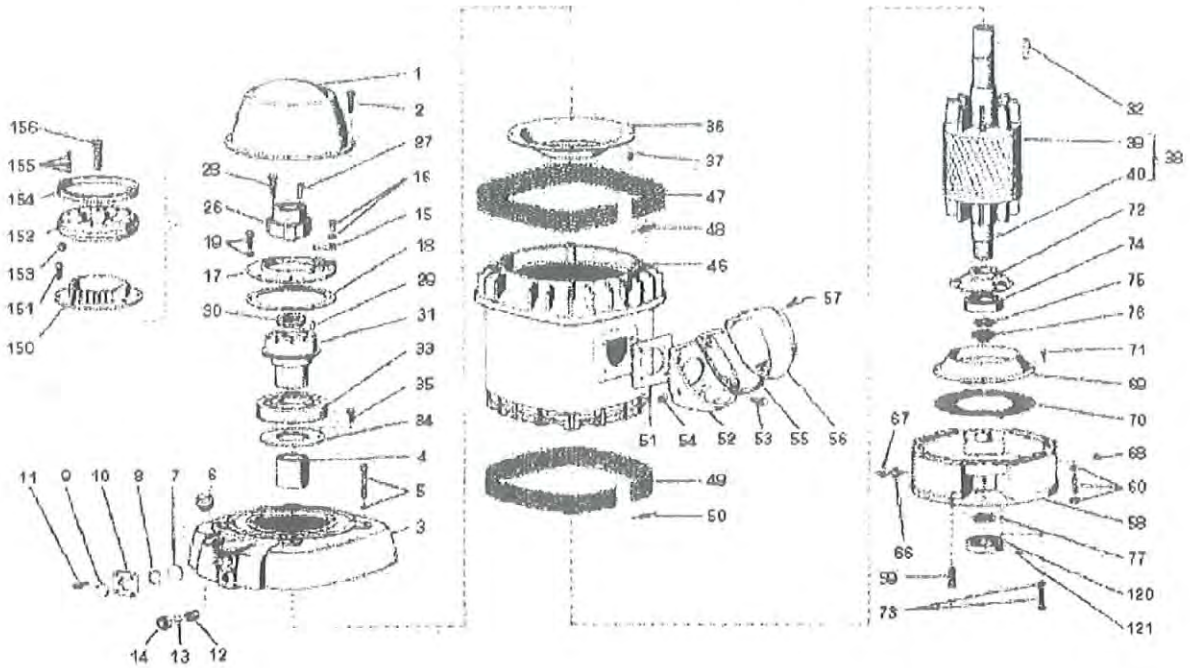
SPACE HEATER NAMEPLATE (ON MOTOR)

Revision: 7/30/2008
Mike Cullen

RENEWAL PARTS

FRAMES 324 THRU 445 - OPEN DRIPPROOF MOTORS
TYPES: RU, RUE, RUI, RUS, RUSI, RV, RV4, RVE, RVE4, RVI, RVI4, RVS, RVS4

HIGH THRUST - WEATHER PROTECTED TYPE 1 - P BASE
HOLLOSHAFT & SOLIDSHAFT MOTORS



ITEM NO.	QTY	NAME OF PART
1	1	Canopy Cap
2	3	Hex Head Cap Screws (Canopy Cap)
3	1	Upper Bracket Assembly
4	1	Oil Retaining Tube
5	4	Hex Head Cap Screw & Lockwasher (Bracket to Stator)
6	1	Special Plug
7	1	Reflector Disc
8	2	Gasket - Sight Gauge
9	1	Sight Gauge Window
10	1	Sight Gauge Housing
11	4	Oval Head Screw (Sight Gauge)
12	1	Nipple Fitting (Oil Drain)
13	1	Gasket or "O" Ring

ITEM NO.	QTY	NAME OF PART
14	1	Drain Cap
15	1	Locking Arm
16	1	Hex Head Cap Screw & Lockwasher
17	1	Dust Ring
18	1	Gasket (Dust Ring)
19	3	Hex Head Cap Screw & Lockwasher
20-25	-	NOT USED THIS ASSEMBLY
26	1	Coupling (RU & RUE only)
27	1	Gib Key
28	3	Hex Head Cap Screw & Lockwasher (Bearing Mounting)

29	3	Spring Pin
30	1	Locknut / Lockwasher

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

BEARINGS:
Refer to motor nameplate for the bearing numbers.

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

reference: Renewal Parts Section 700, Pages 149 & 150

RENEWAL PARTS

FRAMES 324 THRU 445 - OPEN DRIPPROOF MOTORS
TYPES: RU, RUE, RUI, RUS, RUSI, RV, RV4, RVE, RVE4, RVI, RVI4, RVS, RVS4

HIGH THRUST - WEATHER PROTECTED TYPE 1 - P BASE
HOLLOSHAFT & SOLIDSHAFT MOTORS

ITEM NO.	QTY	NAME OF PART
31	1	Bearing Mounting
32	1	Square Key
33	1	Ball Bearing (Upper) (Refer to Section 775)
34	1	Metering Plate (Used on 444 & 445 frames only)
35	1	Hex Head Cap Screw & Lockwasher (Used on 444 & 445 frames only)
36	1	Air Deflector (Upper)
37	7	Self-Tapping Screw (Air Deflector) Use Qty. 8 on 404 & 405 frame & Qty. 6 on 444 & 445 frame
38	1	Rotor Assembly (Includes items 39 & 40)
39	1	Rotor Core
40	1	Rotor Shaft
41-45	-	NOT USED THIS ASSEMBLY
46	1	Wound Stator Assembly
47	1	Grill (Upper Fame)
48	1	Expansion Spring
49	1	Grill (Lower Frame)
50	1	Expansion Spring
51	1	Gasket (Outlet Box Base)
52	1	Outlet Box Base
53	4	Hex Head Cap Screw
54	1	Hex Head Countersunk Pipe Plug
55	1	Gasket (Outlet Box Cover)
56	1	Outlet Box Cover
57	4	Hex Head Cap Screw (Outlet

ITEM NO.	QTY	NAME OF PART
61-65	-	NOT USED THIS ASSEMBLY
66	1	Grease Fitting
67	1	Plastic Cap (Used on frames 404, 405, 444 & 445 only)
68	1	Pipe Plug
69	1	Lower Air Deflector
70	1	Lower Screen
71	4	Hex Head Cap Screw & Lockwasher (Qty. 8 on 404 & 405 frames, Qty. 6 on 444 & 445 frames)
72	1	Lower Bearing Cap
73	3	Hex Head Cap Screw / Lockwasher
74	1	Ball Bearing (Lower) (Refer to Section 775)
75	1	Bearing Spacer (Lower)
76	1	Snap Ring
77	1	Water Deflector
FOR UNITS WITH STABILIZER BUSHINGS, OMIT ITEM NO. 77 & ADD THE FOLLOWING:		
120	1	Stabilizer Bushing
121	2	Socket Set Screws
FOR UNITS WITH NON-REVERESE RATCHETS, OMIT ITEM NO.'s 15, 17 & 19 AND ADD THE FOLLOWING:		
150	1	Stationary Ratchet
151	3	Socket Head Cap Screws
152	1	Rotating Ratchet
153	12	Steel Balls

57	4	Box Cover)
58	1	Lower Bracket "P" Base
59	4	Hex Head Cap Screw (Not used on 404 & 405 frames)
60	4	Stud / Nut & Washer (Used on 404 & 405 frames only)

153	12	Steel Balls
154	1	Ball Retaining Ring
155	6	Round Head Machine Screws, Lockwasher & Plain Washers
156	3	Hex Head Cap Screws

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

BEARINGS:
Refer to motor nameplate for the bearing numbers.

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

reference: Renewal Parts Section 700, Pages 149 & 150

TYPICAL REED CRITICAL FREQUENCY DATA

USEM MODEL NO: NA
USEM CATALOG NO: NA

Frame: H444VP Type: RVI4

REED CRITICAL FREQUENCY:	33	HZ
CENTER OF GRAVITY:	21	IN
DEFLECTION @ CENTER OF GRAVITY:	0.0090	IN
UNIT WEIGHT:	1600	LBS
BASE DIAMETER:	ALL	IN
MAXIMUM MOTOR DIAMETER:	23.13	IN.
DATE:	10/6/2010	

Home Email

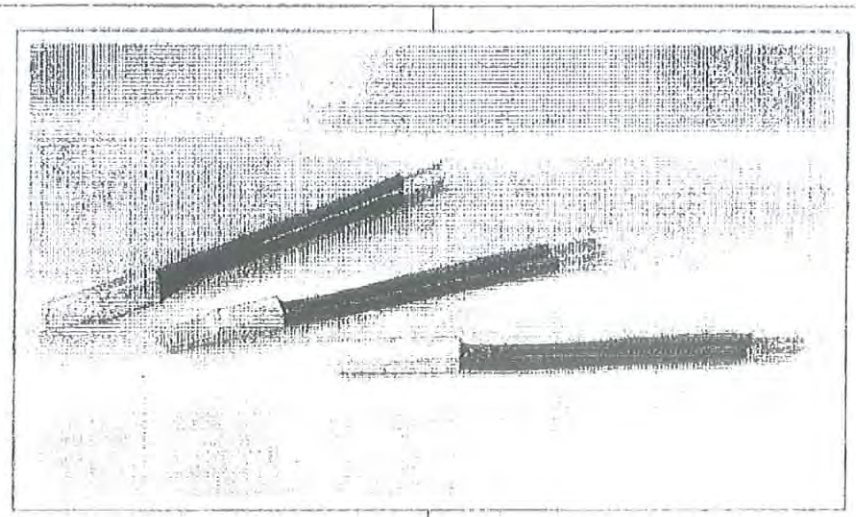
TEXAS INSTRUMENTS 9700 ON-WINDING MOTOR PROTECTOR

As a world market leader in appliance motor protection Texas Instruments builds the 9700 to meet almost any application in this market. This compact motor protector provides locked rotor and overload protection in a wide range of industrial and domestic appliances.

Design and operating principles

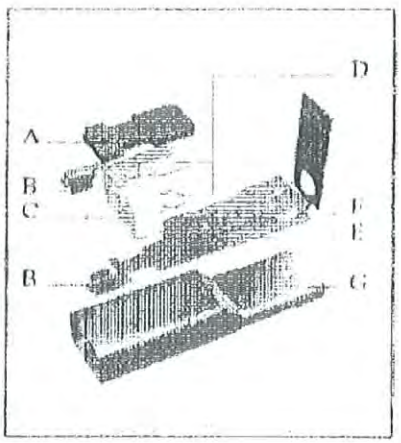
The 9700 design consists of a sealed tin-plated steel can that holds and protects the inner components against penetration of dirt and varnish as well as mechanical forces. The standard 9700 model is supplied with two insulated leads and with shrinkable sleeves as an option. The steel terminal inside the can contains the calibrated Klixon® disc, carrying a contact of fine silver. Another contact is placed on the opposite side, separated from the terminal by an insulator.

The operating principle of the 9700 is both simple and effective. A current flows through the resistive Klixon® bimetal disc. When a fault condition occurs, the increased current and ambient temperature cause the bimetal disc to snap open the contacts. The contacts close again automatically as the device cools down to a safe running temperature.



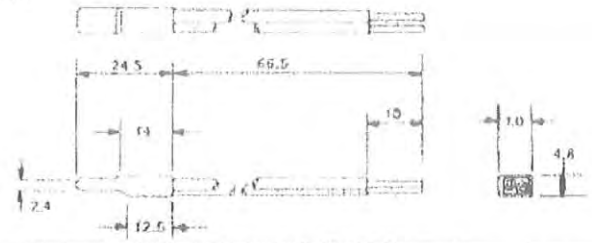
Applications

The 9700 operates as a sensitive power cut-out for applications like single and three-phase motors, choke coils, solenoid valves and transformers. In single-phase motors, it can be mounted directly in the main circuit to serve as an on-winding protector. Its compact size assures ease of installation, even in small spaces. At this time there is practically no motor the 9700 cannot protect against overheating and overloading. Texas Instruments' 9700 provides you with a cost-effective solution in terms of maximum quality and reliability.

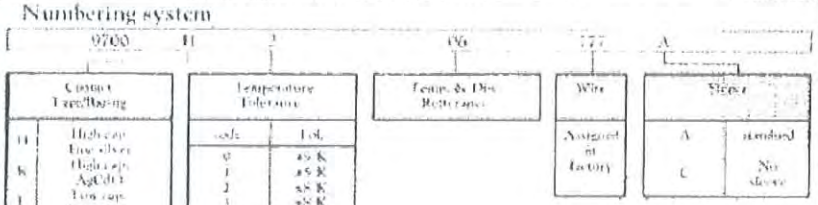


A : Insulator
B : Crimp terminals for insulated leads
C : Insulator
D : Contacts
E : Steel terminal
F : Calibrated Klixon® snap action disc
G : Tin plated steel can

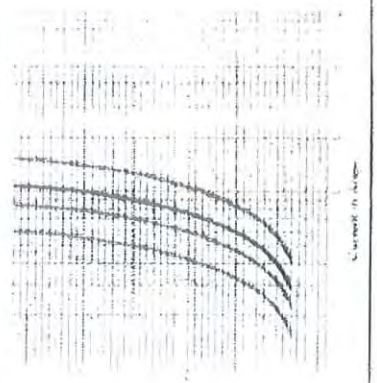
Dimensions (mm)



Numbering system



Ultimate trip current vs ambient temperature



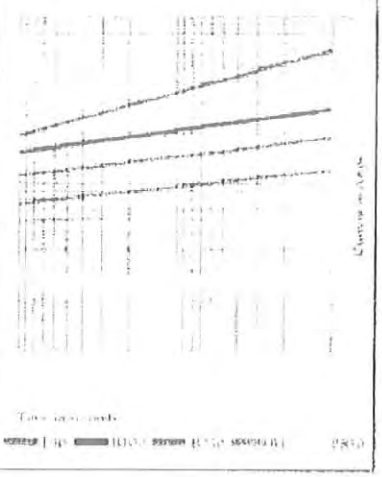
Specifications

Standard temperature range	
Max. ambient temperature	
Tolerance on open temperature	

Maximum contact rating (10,000 cycles)

Type	AMPS				
	24VDC	115VAC	230VAC	380VAC	600VAC
9700H	16	16		13	9
9700K	18	20	12		

Average first cycle tripping time vs current 25°C ambient



Certifications

Agency	File number

ISO 9001
KEMA CERT. NR. 19110

Note

Texas Instruments provides customer assistance in a variety of technical areas. However, since TI does not have full access to the data concerning all of the uses and applications of customers' products, TI does not assume any responsibility for customer product design or for any infringements of patents or rights of others which may result from TI's assistance.

TEXAS INSTRUMENTS

KLIXON®

This product is manufactured in:

MALAYSIA
Texas Instruments Malaysia Sdn Bhd
1, Lintang Enggang 33
Ampang / Ulu Klang
54200 KUALA LUMPUR
Tel.: 03-45.02296 Fax: 03-45.60214

SILICONE RUBBER HEATERS

Rugged, Thin, Lightweight and Flexible...Limited Only By Your Imagination

Rugged, yet thin, lightweight, and flexible ... the use of Watlow silicone rubber heaters is limited only by your imagination. With these heaters, you can put the heat where it's needed and, in the process, improve heat transfer, speed warm-ups and decrease wattage requirements.

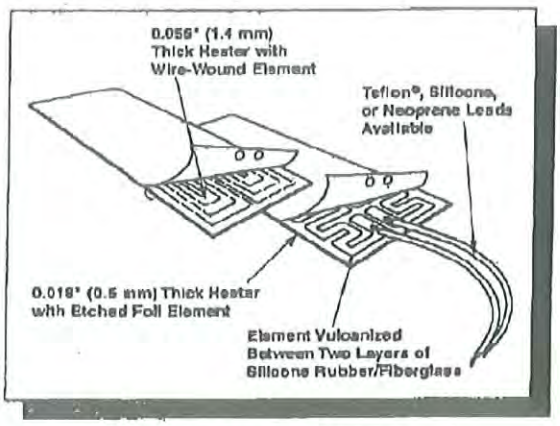
Fiberglass-reinforced silicone rubber gives your heater dimensional stability without sacrificing flexibility. Because very little material separates the element from the part, heat transfer is rapid and efficient.

Performance Capabilities

- Operating temperatures to 500°F (260°C)
- Watt densities to 80 W/in² (12.5 W/cm²) dependent upon application
- 0.055 inch (1.4 mm) thick with a wire-wound element; only 0.018 inch (0.5 mm) with an etched foil element

Applications

- Freeze protection and condensation prevention for many types of instrumentation and equipment
- Medical equipment such as blood analyzers, test tube heaters, etc.
- Computer peripherals such as laser printers
- Curing of plastic laminates
- Photo processing equipment



Features and Benefits

Designed in the exact shape and size you need

- Conforms to your equipment

More than 80 designs available immediately from stock

- Reduces down time

UR®, cUR®, and VDE recognitions

- Available on many designs

Moisture and chemical-resistant silicone rubber material

- Provides longer heater life

Vulcanizing adhesives or fasteners available

- Heaters bond easily to your part

WATLOW
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e-mail: www.watlow.com

SILICONE RUBBER HEATERS

Standard Silicone Rubber Specifications

Maximum width x maximum length:
- Wire-wound: 36 x 120 inches (915 mm x 3050 mm)
- Etched foil: 20 x 30 inches (510 mm x 760 mm)

Thickness (standard):
- Wire-wound: 0.055 inch (1.4 mm)
- Etched foil: 0.018 inch (0.5 mm)

Weight (standard):
- Wire-wound: 8 oz./ft² (0.24 g/cm²)
- Etched foil: 3 oz./ft² (0.09 g/cm²)

Maximum operating temperature:
- 500°F (260°C)

Maximum temperature for UL® Recognition:
- 428°F (220°C)

Minimum ambient temperature:
- -80°F (-62°C)

Maximum voltage:
- 600V~(ac)

Maximum wattage:
- Consult watt density graph on page 170 of the Watlow Heater's catalog.

Lead size:
- Sized to load

Lead length:
- 12 + 1½ - ½ inches (305 mm + 40 mm - 15 mm)

Wattage tolerance:
- Wire: ± 5 percent
- Foil: + 5 percent -10 percent

Dimensional tolerances:
- 0 to 6 inches (0 to 150 mm): ±1/16 inch (1.6 mm)
- 6 to 18 inches (150 to 455 mm): ±⅛ inch (3.2 mm)
- 18 to 36 inches (455 mm to 915 mm): ± 3/16 (4.8 mm)
- Over 36 inches (915 mm): ± 1 percent

How to Order

To order stock silicone rubber heaters, specify the Watlow code number (from the Watlow Heater's catalog) and the quantity. To order a heater with options, specify the code number, quantity and options desired (see page 165 in the Watlow Heater's catalog). Consult Watlow before combining options.

Made-to-Order: Consult factory

For made-to-order units, Watlow will need the following application information from you:
- Size (dimensions)
- Voltage
- Wattage/watt density
- Operating temperature
- Options (leads, thermostats, attachment techniques, etc.)
- Will heater be subject to flexing?
- Element type, if you have a preference
- Agency approvals
- Quantity

Availability

- Stock: Same day shipment of orders received by 11:00 a.m. CST.
- Stock with Options: Shipment in five working days or less. Not all options are available with stock heaters.