

**Installation and Maintenance**  
**SERIES 1160**  
**Low Lift Direct Coupled**  
**Mixed Flow Turbine Pumps**



**AURORA PUMP**

A UNIT OF GENERAL SIGNAL

P.O. BOX 1332 • CITY OF INDUSTRY, CA • 91744

## RECOMMENDATIONS FOR STORAGE AURORA VERTI-LINE PUMPS

Aurora Verti-Line Pumps are carefully prepared for shipment from the factory. Skids and boxes are intended to resist mechanical damage from normal handling and preservatives are used to protect critical surfaces from routine conditions of weather and corrosion in transit. Effective life of factory-applied protection, however, can vary widely under different circumstances and should be considered adequate only to secure the equipment during shipment and installation. If installation and operation cannot be effected within a reasonably short time after delivery to jobsite, the product is assumed to be in storage and subject to precautionary procedures as described below.

With common sense as the best guide, store the equipment off the ground in an indoor location where it will not be exposed to excess moisture or humidity, extreme weather conditions, blowing dust corrosive fumes, or other harmful factors. If storage must be outdoors, provide at least a roof shelter and cover all pieces securely with six mil polyethylene sheet or equivalent.

Inspect pump periodically to assure that factory-applied preventives remain intact. With the first sign of deterioration, renew the protective measure in question. If rust spots appear on machined surfaces, clean with fine emery cloth and apply approved rust preventive.

If pump is assembled, it should remain on skids just as delivered. Packing rings and/or mechanical seals if assembled in place should be removed from the pump and stored in a box. If pump is unassembled, inner column joints should be nested inside suction column pipe to save space as well as to provide greater protection. All threads must be covered with wrapping and tape or with suitable caps. Never stack anything on top of column joints.

Electric motors and right angle gear drives must be handled vertically at all times. See individual manufacturer's storage instructions for motors, gears, IC engines, universal shafts, other appurtenances and accessories.

For long term storage, but not to exceed 36 months, the following additional precautions should be observed:

- Air dry hydraulic portion of pump to remove any residual liquid.
- Cover and seal with pressure sensitive waterproof tape all openings into flowstream areas.
- Wrap shaft extension with pressure sensitive waterproof tape.
- Coat rabbet fit on driver and pump head with heavy grease, along with any other exposed machined surfaces.
- Completely cover upper part of motor and seal with tape. Consider providing space heaters for motors if stored under damp or humid conditions.
- Fill any external lubrication piping or flush lines with rust preventive.
- Store all parts in a clean dry area with ambient temperature reasonably constant between 40 and 100 degrees F.

Upon removing a pump from any type of storage, proceed as follows:

- Consider contracting with the pump manufacturer for the services of a factory trained field service engineer or technician.
- Remove all covers and tape from openings, drivers, and threads.
- Remove grease and rust preventive from mating fits and running surfaces.
- Clean all threads and mating fits thoroughly.
- Assemble packing and/or mechanical seal if applicable, using appropriate instructions.
- Flush any external lubrication piping to remove rust preventive.
- Follow individual manufacturer's instructions regarding driver and other appurtenances.
- Inspect all visible parts.
- Install pump and start up in accordance with applicable instruction manual.

Occasionally, a pump is stored in its installed position for protracted periods while related equipment is made ready or perhaps simply in seasonal shutdown. In this event, pump and driver shaft must be rotated manually once a week or the unit may be power run every two weeks, using proper startup procedures at each start.

These procedures are offered as a guide to assist users and may not be construed to amend, to extend, or to modify in any way the AURORA Pump warranty.

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## SECTION 1

### A WORD TO THE OWNER

Efficient performance. Satisfactory operation. Dependable service.

We know these are the things you want from your Aurora Verti-Line vertical mixed flow pump and we've designed it accordingly. We've prepared this booklet to help you assure continuance of these features by implementing a careful and proper installation and maintenance program. If you want further assistance, you might consider contracting for the services of an experienced Aurora service representative to supervise your installation and/or startup.

Because of variations in jobsite environments and installation requirements, we've had to be somewhat general. However, we have listed what we believe are the most important guidelines. Your installer must still use sound judgement to adapt the methods we've outlined to the specific site circumstances and pump design features in each particular installation. It is in your interest that he does, since failure to comply with recommended procedures may void your warranty.

If any question should arise during the course of the work, we urge you to see your local Aurora representative immediately. Please be able to identify the unit by its serial number. We stamp the number on the nameplate that can be found on the discharge head.

Figures 1 and 2 will show you the relationship of all the parts after installation is complete. The nomenclature we've used here will identify the items throughout the instructions. Before starting the installation procedure, please read through the entire process we've described in this book, omitting material not applicable to your particular pump. Study in detail the precautionary directions emphasized in Section 15.

Then, when you do start the work, refer to the instructions for each individual step. After the equipment is in operation, we suggest you keep a manual available at the site for future use in maintenance programs. It can be used in conjunction with the Aurora disassembly, assembly and troubleshooting manual.



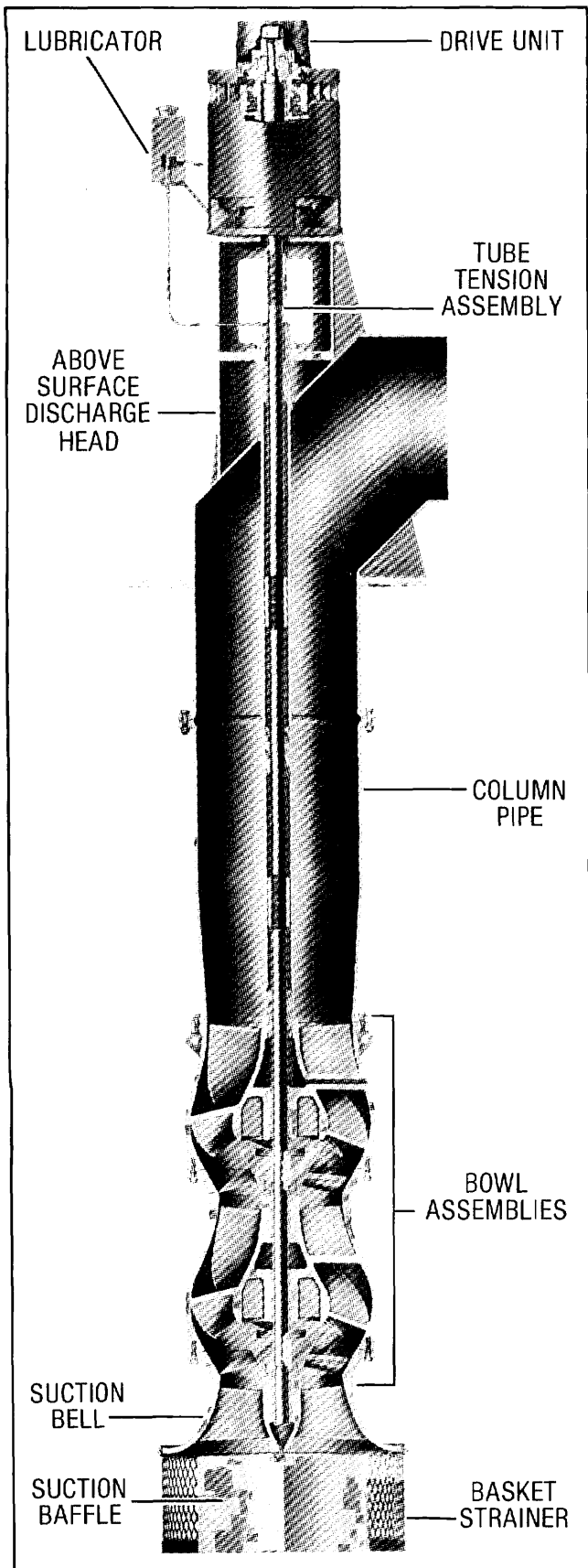


Figure 1. Mixed Flow Low Lift Pump with Above Surface Discharge

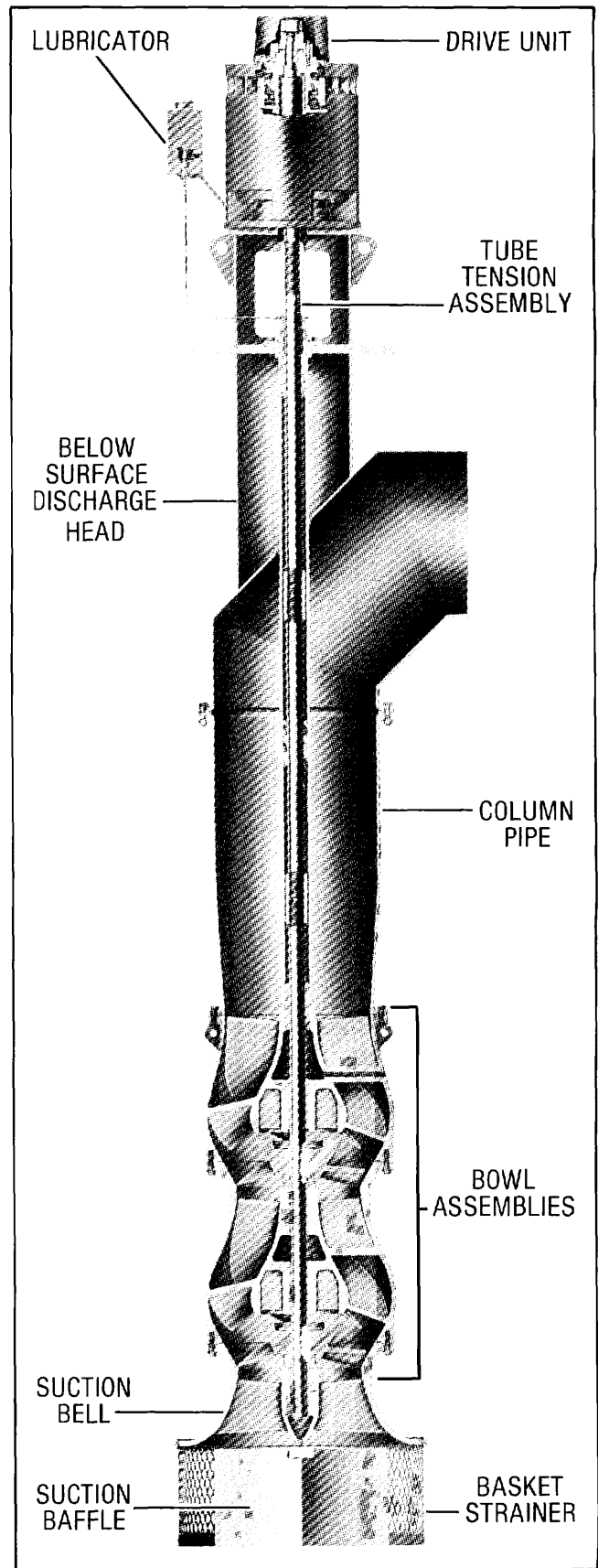


Figure 2. Mixed Flow Low Lift Pump with Below Surface Discharge

## SECTION 2

### THE SUMP

The sump you provide can influence both the mechanical and hydraulic performance of your pump. The intake configuration should be designed to deliver an evenly distributed flow of water to the pump suction since uneven flow patterns tend to create vortices. Vortexing can be submerged and completely invisible or it can appear on the surface. It can introduce air into the pump, can increase or decrease power consumption, can influence submergence requirement, and can produce objectionable noise and vibration, among other things.

It's easy to be misled by low calculated average velocities across an intake channel, but keep in mind these figures can often mean absolutely nothing. It's the localized velocities that start the vortex. Actually, vortices are more easily sustained in flows of lower average velocities where a calm slowly moving surface does nothing to interfere with a gradual buildup in vortex size. A more turbulent surface can tend to break up these disturbances before they grow large enough to cause harm.

The Standards of the Hydraulic Institute offers certain guidelines for good pit design and we subscribe to these general principles. However, we recommend you put your sump design questions in the hands of an experienced sump design engineer who can match intake configuration with pump requirements in the plant design phase and make it possible for you to realize optimum performance from each.

Before starting installation, inspect the completed sump carefully. You'll want to make sure it's dimensionally adequate to receive the pump. You'll also want to see that it has been cleared of all trash and debris. Your inspection should include any pipelines or conduits feeding into the pit. It's a good idea to have the basin screened to prevent future entrance of foreign material which can damage or clog the pump, possibly even rendering it inoperative.

### SECTION 3

## THE MOUNTING BASE

Your Aurora Verti-Line mixed flow pump requires a foundation suitable for the weight of the entire pump when full of water. While the preferred material is solid reinforced concrete, you can use adequate fabricated steel framework as long as you keep deflections to an absolute minimum. Regardless of material, the supporting base must be properly engineered, structurally sound and stable, able to withstand and prevent objectionable vibration.

Most mixed flow pump designs feature relatively large suction bell diameters. The opening in the foundation through which you'll install the unit must allow working clearance. If you've elected to use a below base discharge configuration, the opening must also accommodate passage of the discharge elbow. We advise you to verify these clearances before starting installation.

You'll undoubtedly want to provide anchor bolts to secure the discharge head to the mounting base. We prefer the sleeve bolt design shown in Figure 3 and you probably will too since it's easy to use. Alternate bolts are illustrated, however, for your consideration.

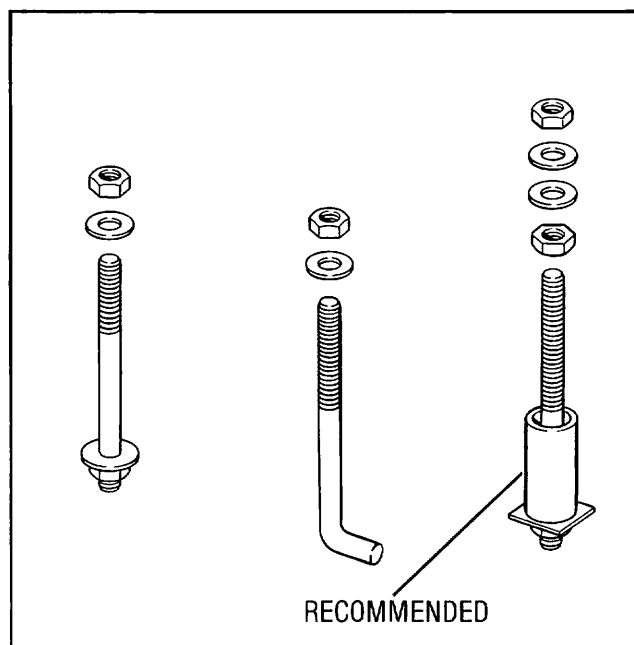


Figure 3. Foundation Anchor Bolts

## SECTION 4 THE EQUIPMENT

The material and equipment you'll need for installation may vary with the size of pump and the type of job. We'll offer the following suggestions as a guide but you will want to remember the primary tool to be used at all times is **SAFETY FIRST**.

You can use a portable derrick or tripod, but we recommend a boom crane of adequate capacity or a properly designed pump setting rig similar to that shown in Figure 4. Whatever you choose, your lifting device must allow the load hook to be raised at least two feet higher than the total length of your assembled pump. Your hook should be of the safety type with a good easy working swivel and you must have sufficient reach to center it over the installation position.

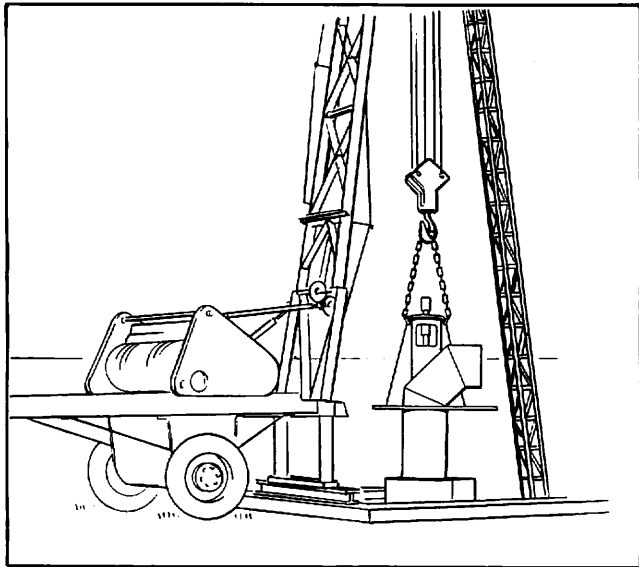


Figure 4. Pump Installation Rig

In most cases, your Aurora Verti-Line mixed flow pump will be delivered to you in an assembled condition, ready to lower in place and to accept the driver plus some miscellaneous parts. We've described this situation in Section 7. If you've elected to receive it un-assembled due to its size, jobsite headroom limitation, or some other compelling reason, we've provided information in Section 8 for you.

For the usual installation, we suggest the following miscellaneous tools and material but you may want to vary them to suit the peculiarities of your individual project:

Lifting equipment (See Figure 4)

\*Steel beam clamps (See Figure 5)

Chain or cable sling about 10 feet long of adequate size for job (See Figure 6)

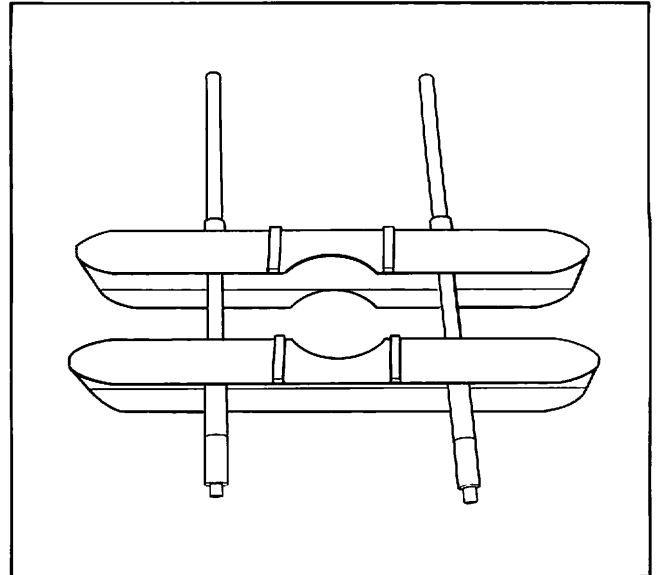


Figure 5. Beam Clamps

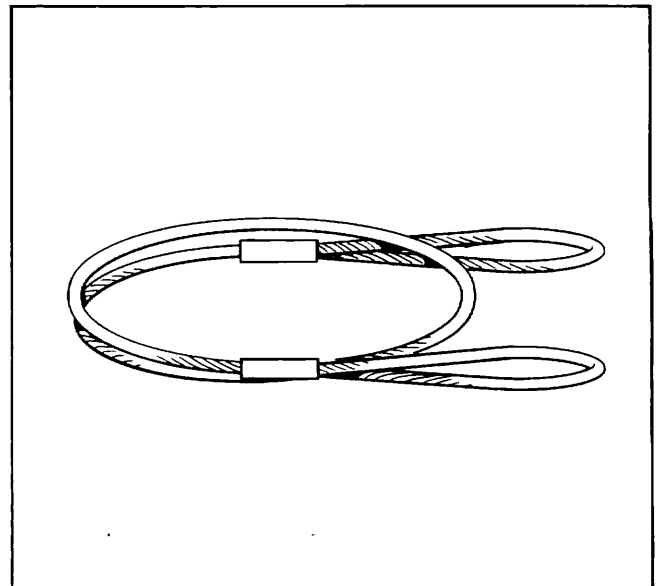


Figure 6. Cable Sling



Chain tongs

\*Tube tension wrench (See Figure 7)

Medium size pipe wrenches

12 foot length 3/4 inch rope

Ordinary set of mechanics tools (See Figure 8)

Large crescent wrench

Wire brush

Assortment of files

\*Cover for bowl unit and column sections

Clean rags

Thread compound -- Use anti-galling type for stainless steel parts

Solvent -- in recommended containers

Special lubricants as required

Shims and wedges

Non-shrink grouting material

**Note**

All combustible materials must be kept in approved safety containers and handled carefully, away from any flame, sparks, exhaust, or any other possible source of ignition.

\*Required only for installation of unassembled pumps

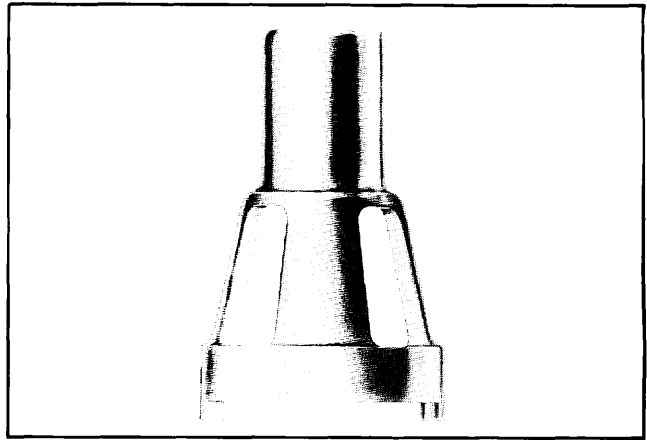


Figure 7. Tube Tension Wrench

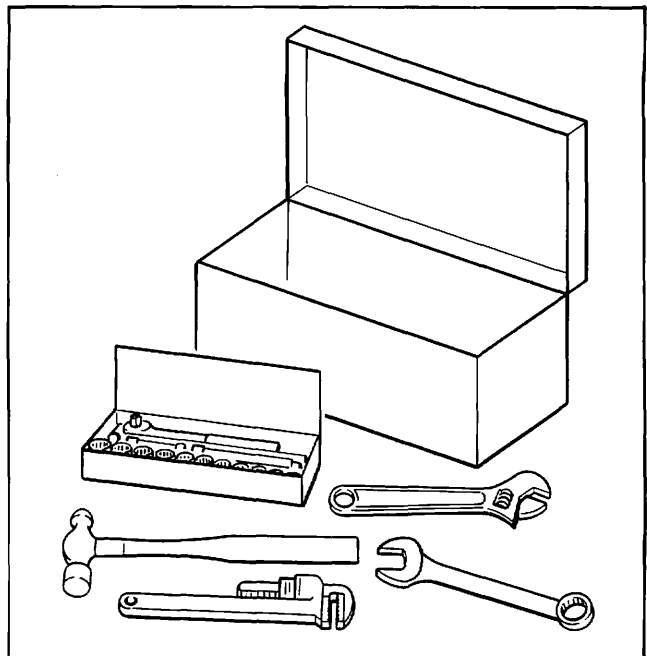


Figure 8. Ordinary Set of Mechanics Tools

## SECTION 5

### RECEIVING THE PUMP

Your Aurora Verti-Line mixed flow pump was inspected on the carrier just prior to leaving the factory. When you receive it at your jobsite, look it over carefully for any visible damage to parts, skids, boxes, or dunnage. If shaft is crated, open the crate carefully to inspect and make a count but leave the shaft in the box for protection until ready for installation. Take inventory on the

truck or during the unloading process. We don't want you to sign for damaged or incomplete shipments unless you take the appropriate exceptions. Report such instances immediately to the Aurora sales office and to the transportation company involved giving full particulars and confirming all verbal understandings in writing.

## SECTION 6

### UNLOADING THE PUMP

We cannot urge you too strongly to exercise extreme care in handling and installing all parts. All items are precision machined for proper alignment and, if dropped, banged, sprung, or mistreated in any way, misalignment and malfunction will undoubtedly result. Parts which are too heavy to be lifted from the transporting car or truck, as shown in Figure 9, should be skidded slowly and carefully to the ground so as to prevent harm. We ask you never to unload by dropping parts directly from the carrier to the ground. Never use crates in which parts were shipped for skids.

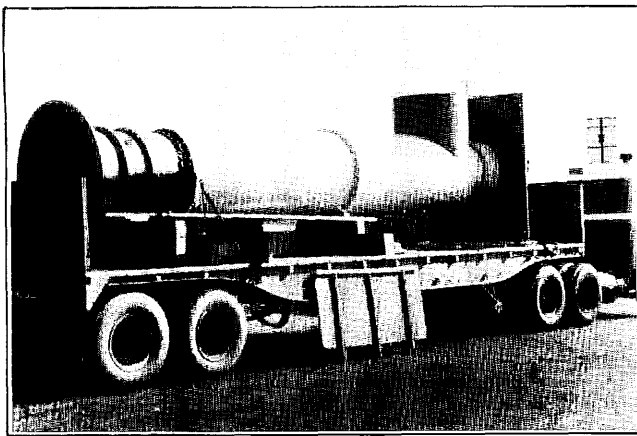


Figure 9. Transported via Truck Carrier

If you can't begin installation within a very few days after delivery, it's a good idea to segregate and identify all components comprising your Aurora shipment so you won't lose them in the midst of other equipment arriving at the jobsite. Under these conditions, refer to the Recommendations for Storage located on the inside front cover of this publication. Read and follow the instructions carefully because care of the pump during storage can be as important as maintenance after operation has begun.

If your jobsite conditions permit, you may be able to install directly from the truck that brought the pump to you. If not, and if you've received your pump unassembled, lay out the column pipe and bowl assembly on suitable timbers or staging to keep all material out of the dirt. Figure 10 illustrates an acceptable method of laying out a pump. Inner column joints consisting of shafting and tubing with couplings and lineshaft bearings will have been preassembled for you at the Aurora factory into proper lengths to match the column pipe. Insert these assemblies into the mating pipe sections with the projecting lineshaft coupling and bearing

if any pointing toward the installation position. See Figure 11 for enclosed lineshaft and Figure 12 for open lineshaft.

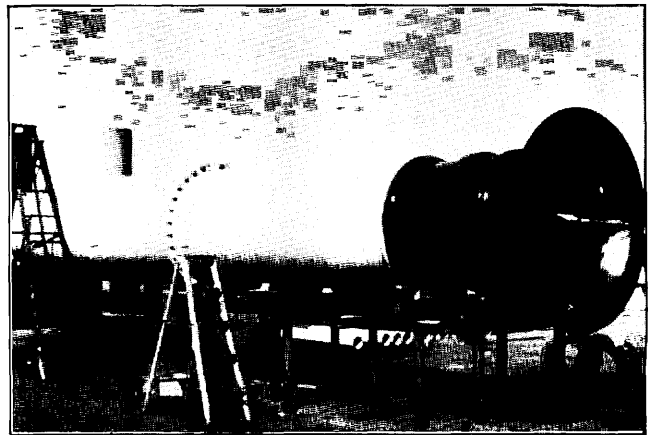


Figure 10. Properly Layed Out Pump

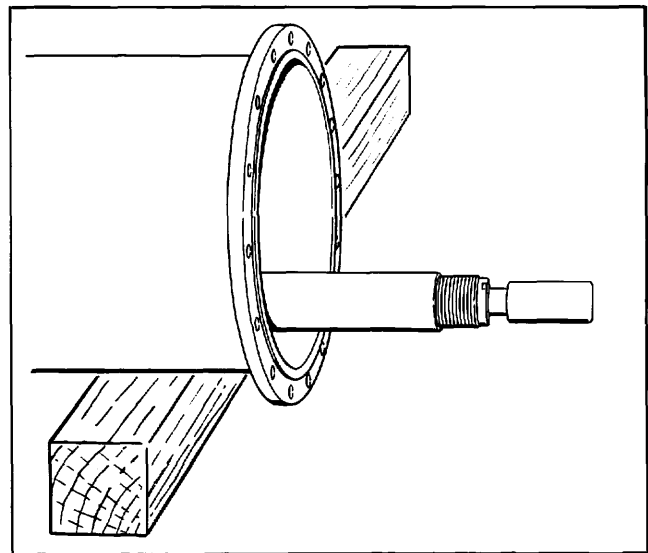


Figure 11. Enclosed Lineshaft

Examine the tube faces to see that they are free from burrs or nicks and, in the process, wipe them clean. Your installer should check for tightness those sections that were assembled at the factory to insure none have loosened in transit. He should also inspect each joint for straightness as a bent tube cannot be used. Keep ends covered until each piece is ready for installation.

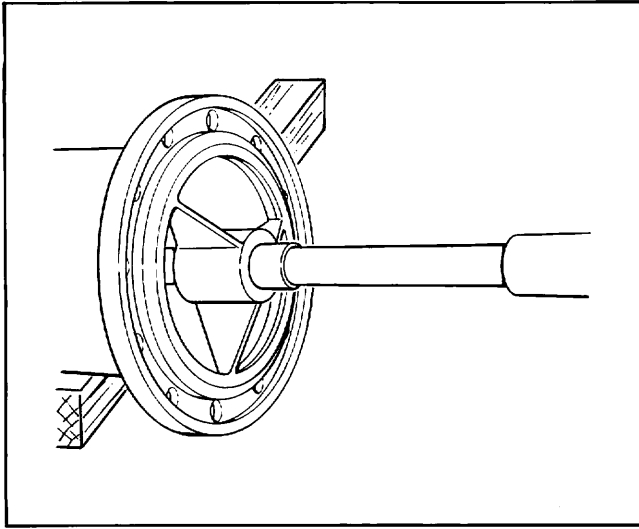


Figure 12. Open Lineshaft

If your lineshaft was shipped to you in a crate, we suggest you handle it directly from the crate. If not, place each length on timbers and clean with solvent to remove rust preventive, oil, or slushing compound. In either case, inspect each joint to make sure the faces are undamaged and that the piece is absolutely straight. Each was straightened before shipment from the factory and, if any were bent in transit, they cannot be used. Insert each piece into the proper pipe section and keep ends covered until installation.

All other parts should be cleaned and laid out on a suitable surface in the order in which you'll want to use them. Again, check against your packing list to be sure none are missing. It's much better to find out now than during the actual installation.

If you received your pump in the assembled condition, go right on to Section 7. If unassembled, skip Section 7 and follow directions in Section 8.

## SECTION 7

### INSTALLING THE PUMP

#### FACTORY ASSEMBLED UNIT

You're now ready to start actual installation. Clear the work area at and around the mounting position so installers can move freely and with maximum safety. This will also decrease the chances for foreign material or objects to enter the pump as it is lowered into position and secured.

During the course of the work, you must never lose sight of the fact that you are handling precision components no matter how awkward they may be to manipulate. All threads should be engaged by hand and checked before tightening. Damage resulting from cross threading or dirt must be repaired with a file before applying force. If not repairable, the part must be replaced so it's clearly worth your while to use the utmost care.

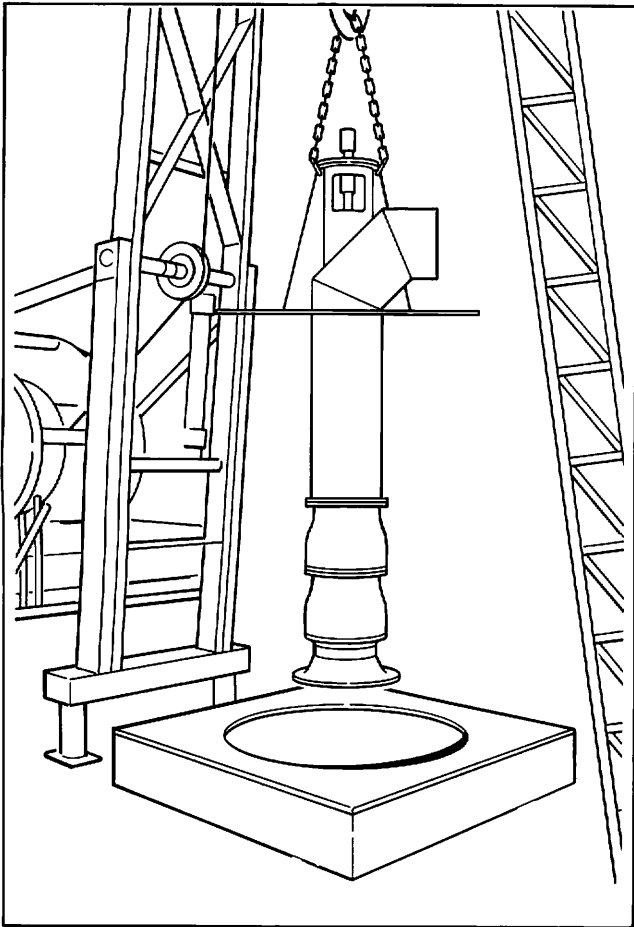


Figure 13. Raising Unit Over Mounting Position

Using the lifting lugs on the discharge head only, raise the unit as shipped to a vertical position over its mounting base. Figure 13. Take care to avoid putting any strain on the column or any exposed shafting. Also be careful not to damage the strainer, if used, during the lifting operation. Clean the bottom of the pump base and, if the base is to be grouted, apply a heavy coat of grease. Lower the assembly gently into place in its operating position with full contact, base to mounting surface. Assemble anchor bolt nuts very loosely.

If your pump has been constructed with a shaft enclosing tube, you will find the tubing terminates in a tension nut assembly in the discharge head. See Figure 14. Since this part is assembled at the factory where the proper tension has already been applied to the tube, there is nothing for you to do here except to connect the lubricating system. We'll tell you all about that in Section 9.

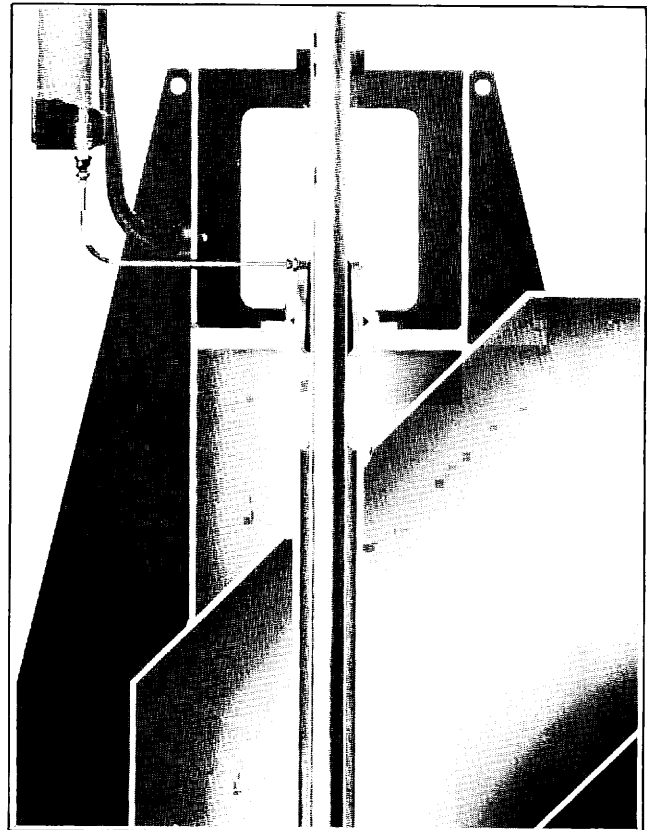


Figure 14. Tube Tension Assembly

Meanwhile, if there is ever any reason for you to relieve the tension on the tube, be sure to mark the position of the nut flange with respect to its mounting surface in the head. With this as an indicator, you can reload the tubing to the same tension when you reassemble.

If your pump is of open lineshaft construction, it will be furnished with a packing box, Figure 15, instead of a tension nut. The box is completely assembled and installed at the factory. Before first startup, see Section 13 for run in procedure and directions for maintenance and repacking when necessary.

Examine the position of the pump. The suction bell must hang the proper distance from the sump bottom and be unobstructed. Piping connections must be in the right orientation with respect to jobsite plumbing. The whole unit must hang plumb and true; if not, use wedges and/or shims until it does.

When you're satisfied with the position of the equipment, skip Section 8 and go on to the appropriate portion of Section 9.

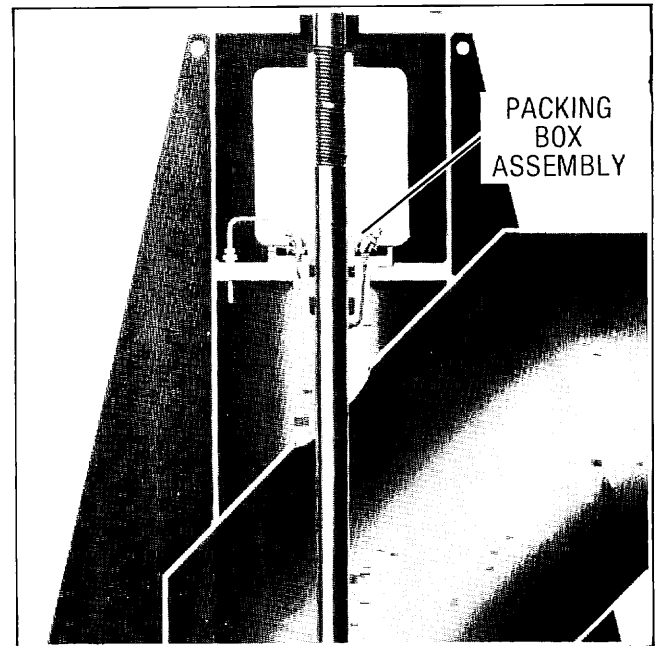


Figure 15. Packing Box Assembly



## SECTION 8

### INSTALLING THE PUMP

#### UNASSEMBLED UNIT

You're now ready to start actual installation. Clear the work area at and around the mounting position so installers can move freely and with maximum safety. This will also decrease the chances for foreign material or objects to enter the pump as it is lowered into position and secured.

During the course of the work, you must never lose sight of the fact that you are handling precision components no matter how awkward they may be to manipulate. All threads should be engaged by hand and checked before tightening. Damage resulting from cross threading or dirt must be repaired with a file before applying force. If not repairable, the part must be replaced so it's clearly worth your while to use utmost care.

#### a. Enclosed Lineshaft Construction

Examine the bowl assembly to determine that all stage connecting nuts or capscrews have been taken up securely. Inspect the bypass ports in discharge bowl to make sure they are open clear through to the shaft and

not plugged in any way. This may be done by probing a wire into the port and through the passage. See Figure 16.

Determine the amount of bowlshaft endplay and record it. You can do this by pushing the shaft all the way into the bowls and mark it where it emerges from the top fitting. Then pull the shaft out manually as far as it will go and measure the distance your mark has travelled. This is endplay or bowl lateral. We'll want to check your record later.

Using elevators under the top flange or properly sized eyebolts through the flange, raise the bowl assembly as illustrated in Figure 17, controlling the lower end with a rope drag line. If you have a strainer, this is the time to attach it to the suction bell. Suspend the load directly over the mounting position and lower until the elevators or the flange rest securely on the beam clamps, as shown in Figure 18. Never lift the assembly with the cast lugs, if any, on the individual bowl casings. These are adequate only for handling the dis-assembled part by itself.

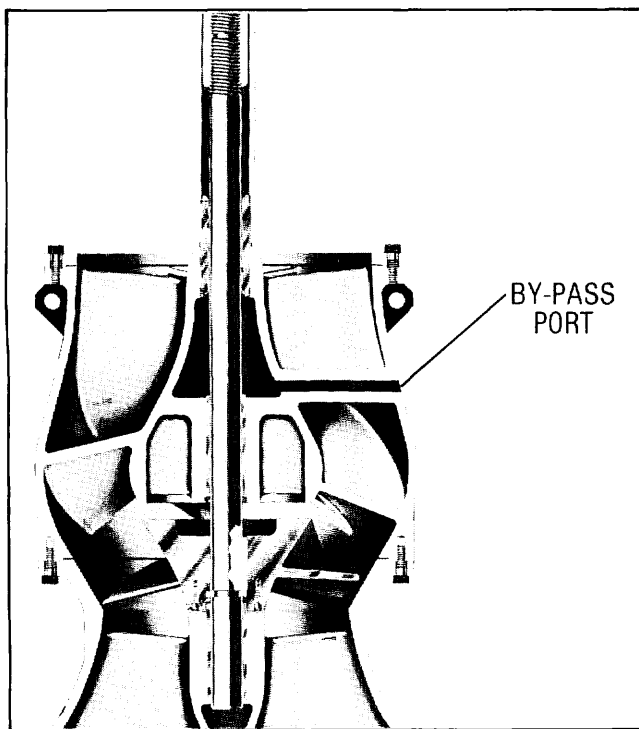


Figure 16. Inspecting By-Pass Port

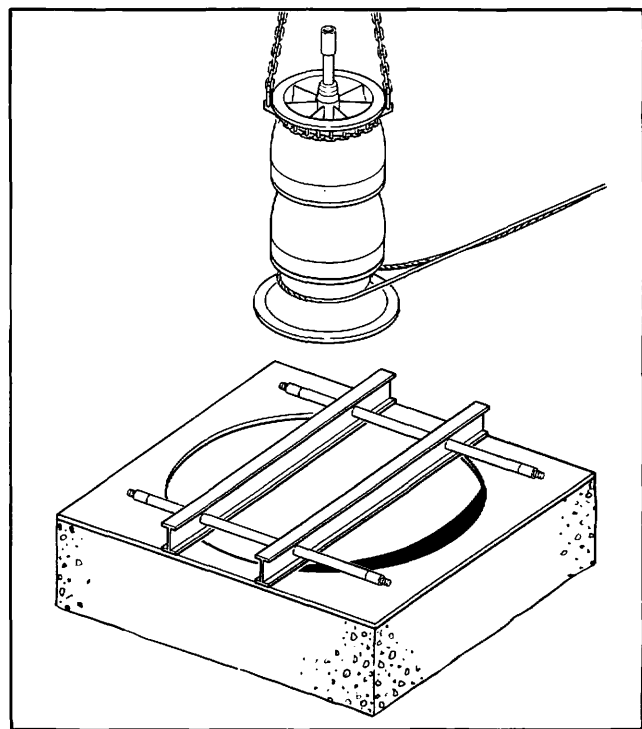


Figure 17. Raising Bowl Assembly Over Well

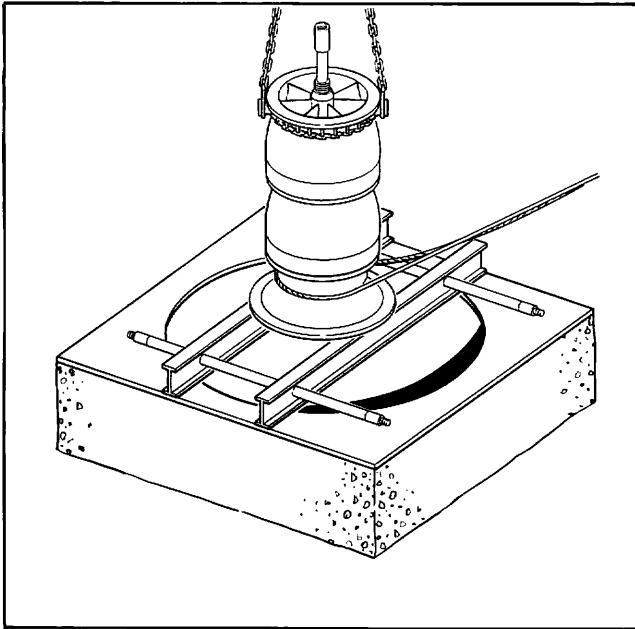


Figure 18. Bowl Assembly Resting on Beam Clamps

Remove the shaft protector tube, shown in Figure 19, from the top of the bowl assembly. Clean and inspect all exposed threads and faces. The tube adapter should project exactly half its length from the discharge bowl hub unless it has a shoulder to butt solidly against the hub. Do not attempt to handle the assembly by the shaft, now or at any other time.

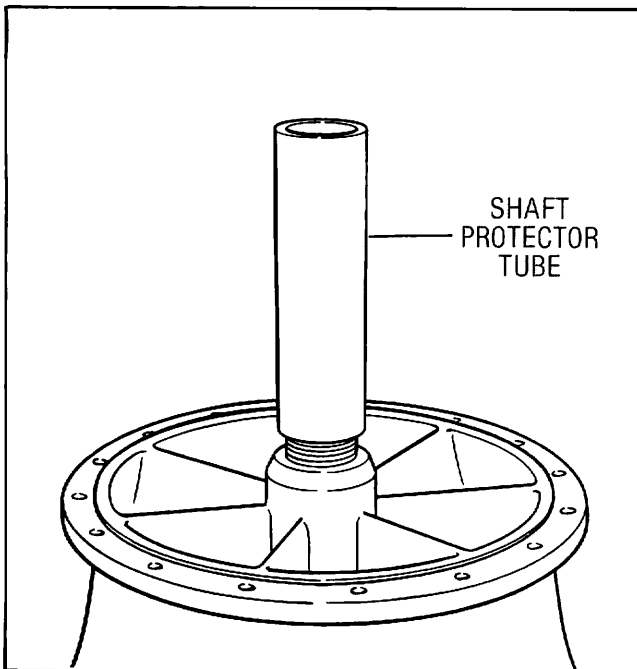


Figure 19. Shaft Protector Tube

If something is dropped into the pump at any time during the installation, you must retrieve it before going any farther. You might even have to return everything to the surface to do this. This is why we caution you to keep the open end of the pump covered at all times. Stuff sacking into the opening or use a cover designed specifically for the purpose. Stuff a clean rag into the open end of the shaft coupling. Remember of course to remove all this as the joint is made up.

Secure the elevators to the bottom column assembly below the flange. Again you may use proper eyebolts through the flange if you prefer. Using a hemp rope, secure a timber hitch knot around the pipe about one foot from the end away from the mounting position. Place a double half hitch knot around the tubing, and a reverse double half hitch knot around the shaft and over the threads to prevent slipping. This is illustrated in Figure 20.

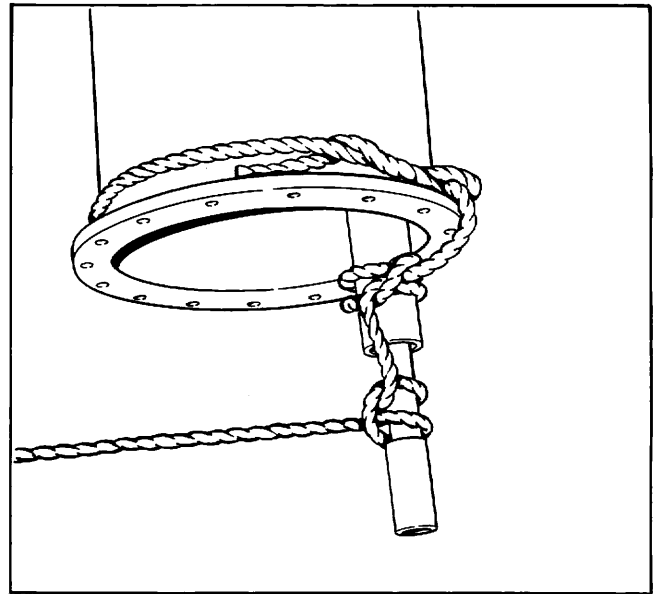


Figure 20. Securing Enclosed Lineshaft Assembly

Hoist the column assembly into place above the mounting position as shown in Figure 21. You must keep the free end of the tail rope taut at all times to prevent dropping the shaft. A soft board or pipe dolly should be laid out for the end of the pipe to slide in on, restrained by the tail rope, so that the flange face will not be damaged as the section is being raised. Clean all the threads and inspect the faces of the pipe, shaft, and tube to be sure there are no burrs, nicks, or dirt. Paint the shaft and tube threads with thread lubricant. If parts are stainless steel, use only an approved anti-galling compound.

Lower the parts until the shaft sits firmly on its coupling and start threading it in by hand. Remove the rope from shaft only and continue threading the shaft

in until it butts solidly, remembering the threads are left hand. Make sure the shaft ends are together but don't use undue force. As shown in Figure 21, lock shafts firmly with two small pipe wrenches, using one wrench on the coupling and the other on the shaft just above the thread with the wrench handles parallel to avoid pulling shaft off center. Never apply wrench jaws to threads or to any area that might run in a bearing or packing. Do not allow coupling to ride up on last scratch or imperfect thread. Both shafts should expose an equal length of thread above and below the coupling, indicating that the shaft butt is in the exact center. If unusual power is required, stop and look for damaged or dirty threads since forcing may cause misalignment and eventual malfunction.

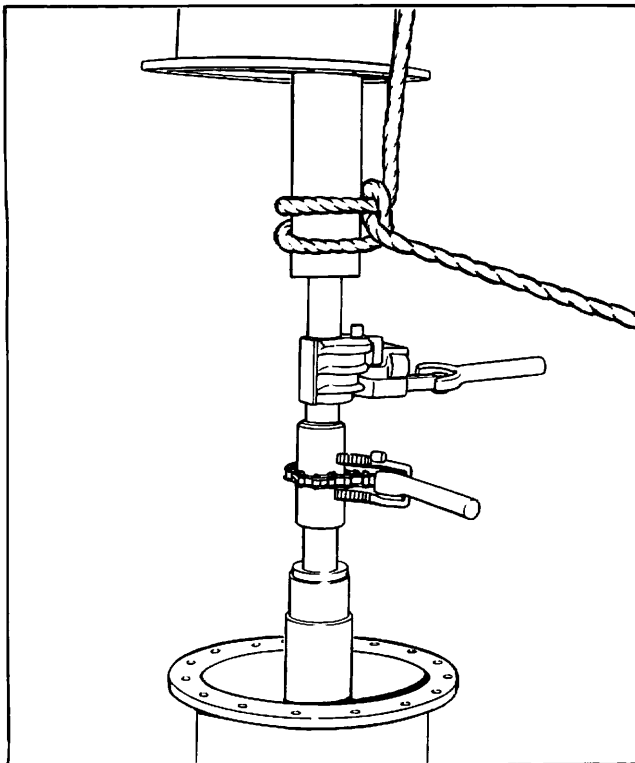


Figure 21. Connecting Enclosed Lineshaft Assembly

Lower the enclosing tube to the tube adapter and start the threads on by hand. Remove the rope and continue threading the enclosing tube on with a small pipe wrench or chain tong, remembering these are right hand threads. On the following tube sections, two wrenches or tongs should be used. One is to hold the lower tube stationary while the other tightens the upper section into place onto the projecting lineshaft bearing. Keep the wrench handles parallel. Remove the cover material.

Now you can lower the column pipe, engaging the registers and seating the flange faces firmly. Insert all bolts not obstructed by the elevators or eyebolts and

tighten the nuts uniformly. When you have enough bolts to carry the weight of the assembly safely, remove the lower elevators and assemble the rest of the bolts, making sure all holes are filled and that all nuts are secure. Lower the pump until it again rests on the beam clamps.

You may repeat this procedure for each succeeding column section. In working with flanged column pipe and pieces with similar configuration, be particularly conscious of the pulloff effect where the chains or sling bear against the flange rim. Scoring or chafing will reduce the strength of your sling considerably and must be avoided.

The discharge elbow/mounting base section is usually shipped to you with the tension nut, seen in Figure 22, assembled. Remove this assembly and store in a clean safe place except for the long tube connector, Item 254, which you may now assemble to the top tube parcel as another tubing joint. If a lock collar, Item 258, is furnished, it must be in position on the connector before the connector is joined to the tubing. Leave the lock collar setscrews loose at this time. Find the top lineshaft and insert it into the tube assembly.

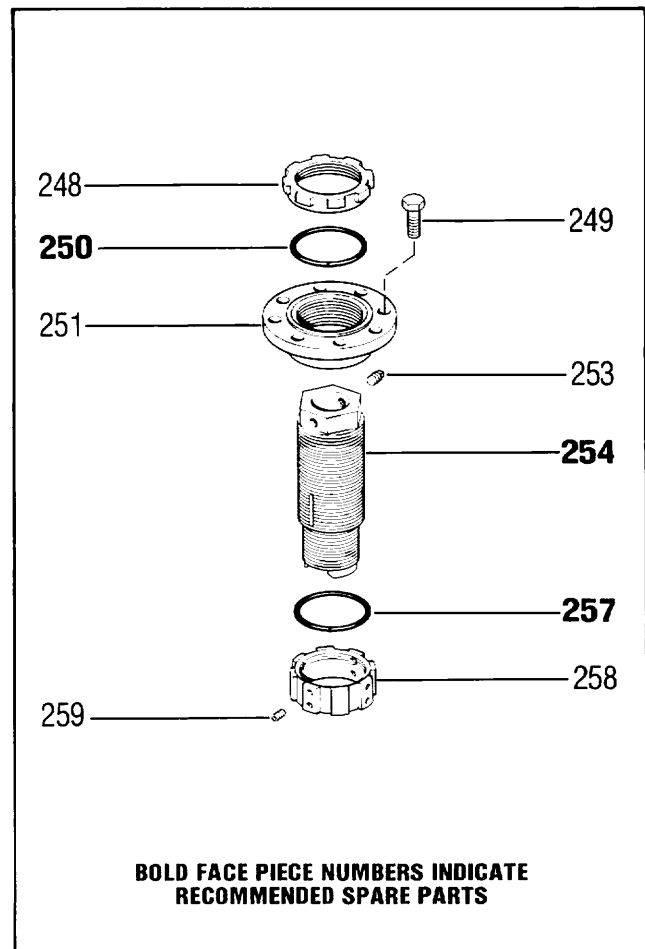


Figure 22. Tube Tension Assembly

Slide the top inner column assembly into the elbow/mounting base section and join the bottom end to the pump column in the manner described for all column joints. From this point on, the pump must be handled with the lifting lugs on the discharge head, as depicted in Figure 13. Never lift with eyebolts tapped into the holes for securing the driver. They're inadequate to support the weight.

Clean the bottom face of the mounting plate and, if the pump is to be grouted, apply a heavy coat of grease to the underside. Raise the load a few inches to remove the beam clamps and elevators, then let it down slowly and carefully, positioning the base with respect to the discharge piping system, if any, and engaging the anchor bolts, if used. Continue to lower until the base contacts the foundation and the weight of the pump is transferred to the mounting structure. Effect this transfer very gradually without a bump. Be sure the pump is in a plumb vertical position with full contact base to mounting surface. Assemble the nuts loosely to anchor bolts.

The projecting tube connector and headshaft will probably have sagged to one side of the opening through the head. Make sure you can center them easily by hand. Examine and clean threads and flange surfaces of tension nut, Item 251, Figure 22. Inspect the mating face in the discharge head for any burrs, rough spots, or projections, especially at the location of the tapped holes. Clean with a file where necessary. Apply thread lubricant and grease flange face. Thread the tube tension nut, Item 251, down over the connector, Item 254, and into position firmly, engaging register fit. You may have to remove the pipe bushing and plug, Item 253, from the ports at the top of the tube connector to do this. If so, lay them aside in a safe place for the time being. During this phase of work with the tubing, protect the protruding shaft at all times.

Slip the tube tension wrench Figure 7 carefully down over the shaft and tube until the wrench pins engage two capscrew holes in the tension nut flange. With chain tongs around the wrench body, turn the nut clockwise one sixth of a turn for each ten feet of tubing, thus effectively stretching the tube assembly, forcing it to remain straight and taut.

When the tension nut is properly seated, oil the capscrews, Item 249, and thread them firmly into position to secure the flange to the discharge head. If your pump is furnished with a tubing lock collar, Item 258, back it down the connector, Item 254, far enough to insert the packing ring, Item 257, working through the discharge opening in the head. Then screw the collar back up on the connector until it butts against the tension nut, Item 251. Back the collar off very slightly until the setscrews, Item 259, line up with the first keyway on the connector. Tighten the setscrews securely.

You may now place the packing ring, Item 250, in the chamfer in the top of the tension nut around the con-

necter threads. Assemble the tubing locknut, Item 248, with its chamfered face down and tighten by hand very carefully so the packing ring remains properly seated as the nut is brought down against it. The final tightening of the nut may be done with a spanner wrench or by tapping the nut with a block of wood and a hammer. Never tap the nut with a metallic object.

Your tubing joint is now complete. You may reassemble the pipe bushing and plug, Item 249, in the oil ports in the position most convenient for the oil line from the reservoir.

You have also completed this phase of the installation. Skip Section 8b and go on to Section 9 for the next procedure.

#### b. Open Lineshaft Construction

Examine the bowl assembly to determine that all stage connecting nuts or capscrews have been tightened securely. Inspect bypass ports in discharge bowl to make sure they are closed. Refer to Figure 23.

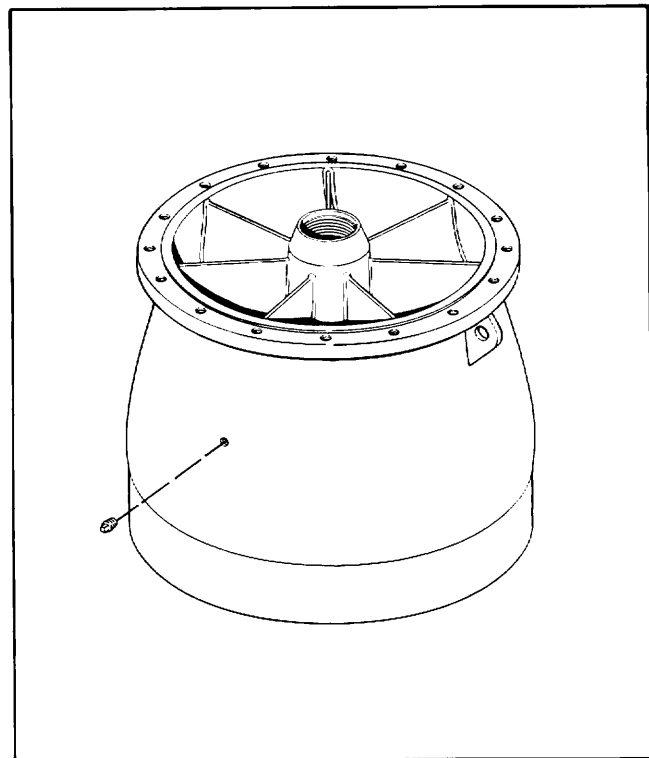


Figure 23. Mixed Flow Bowl Assembly

Establish the amount of bowlshaft endplay and record it. You can do this by pushing the shaft all the way into the bowls and mark it where it emerges from the top fitting. Then pull the shaft out manually as far as it will go and measure the distance your mark has travelled. This is endplay or bowl lateral. We'll want to refer to your record later.

Using elevators under the top flange or properly sized eyebolts through the flange, raise the bowl assembly as illustrated in Figure 24, controlling the lower end with a rope drag line. If you have a strainer, this is the time to attach it to the suction bell. Suspend the load directly over the mounting position and lower until the elevators or the flange rest securely on the beam clamps. See Figure 18. Never lift the assembly by using the cast lugs, if any, on the individual bowl casings. These are adequate only for handling the disassembled part by itself.

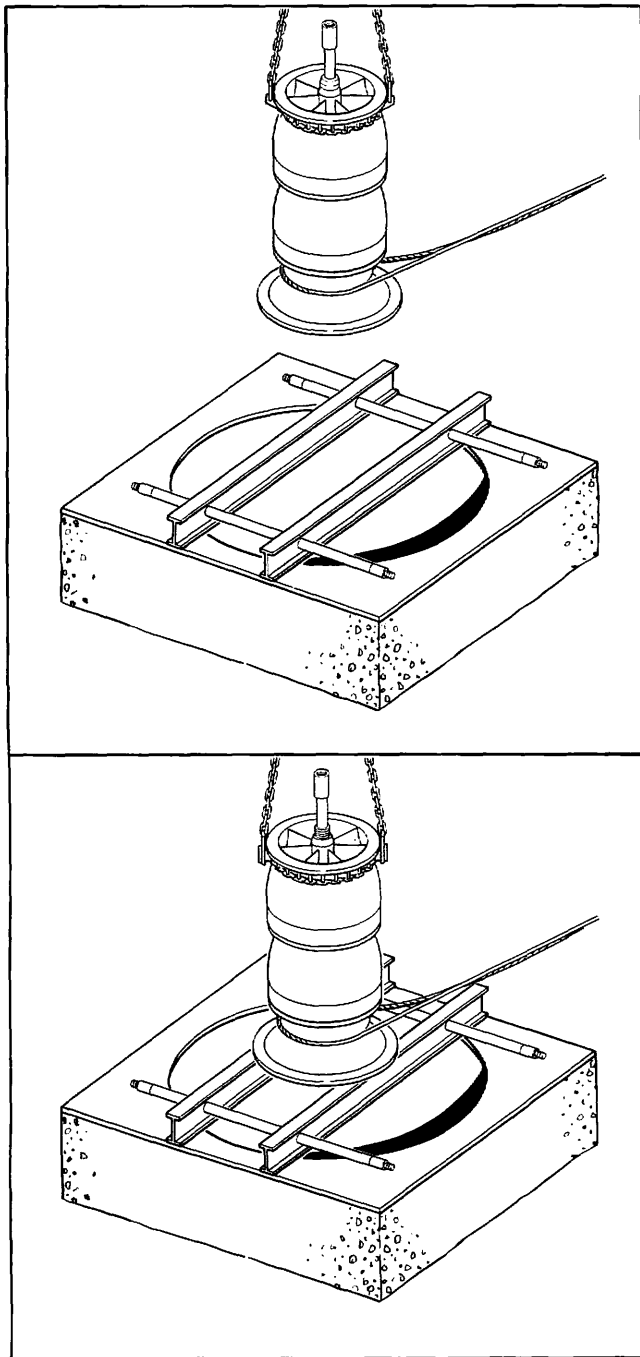


Figure 24. Positioning Bowl Assembly

If something is dropped into the pump at any time during the installation, you must retrieve it before going any farther. You might even have to return everything to the surface to do this. That's why we caution you to keep the open top of the pump covered at all times. Stuff sacking in the opening or use a cover specifically designed for the purpose. Stuff a clean rag into the open top of the shaft coupling. Remember of course to remove all this just before the joints are made up.

Secure the elevators to the bottom column assembly, below the flange. Again you may use proper eyebolts through the flange if you prefer. Using a hemp rope, secure a timber hitch knot around the pipe about one foot from the end, away from the mounting position and a reverse double half hitch knot around the shaft over the threads to prevent slipping. This is illustrated in Figure 25.

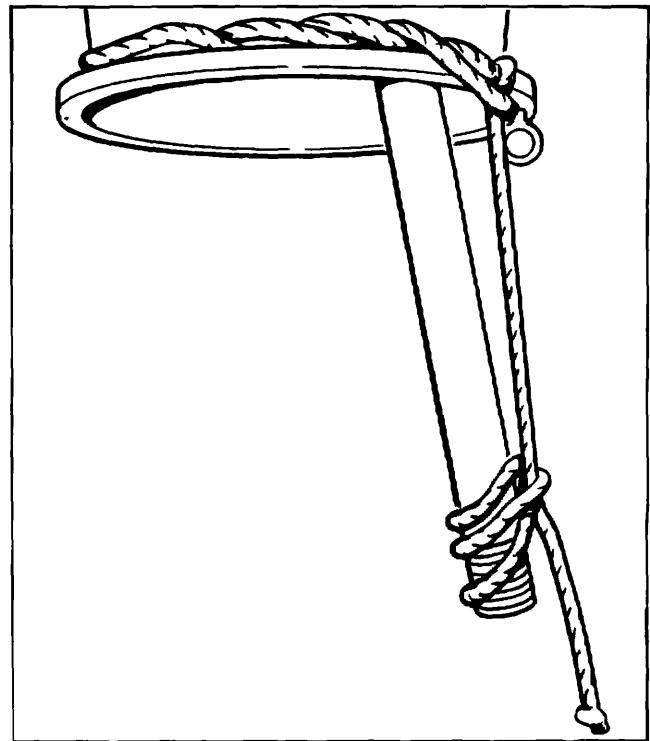


Figure 25. Securing Open Lineshaft Assembly

Hoist the column assembly into place above the installation position. You must keep the free end of the tail rope taut at all times or you'll drop the shaft. A soft board or pipe dolly should be laid out for the end of the pipe to slide in on, restrained by the tail rope, so that the flange face will not be damaged as the section is being raised. Clean the shaft threads and inspect the faces of shaft and pipe flanges to be sure there are no burrs, nicks, or dirt. Paint the shaft threads with a thread lubricant. If parts are stainless steel, use only an approved anti-galling compound.

Lower the parts until the shaft sits firmly on its coupling, as shown in Figure 26. Start the threads in by hand, keeping in mind they are left hand. Remove the rope and continue threading the shaft in until it butts solidly. Make sure the ends are firmly together but don't use undue force. As in Figure 27, lock the shafts securely with two small pipe wrenches, one on the coupling and the other on the shaft just above the thread, with the handles parallel to avoid pulling shaft off center. Never apply wrench jaws to the threads or to any area of shafting that might run in a bearing or packing. Don't allow the coupling to ride up on last scratch or imperfect thread. Both shafts should expose an equal length of thread above and below the coupling, indicating that you have the shaft butt in the exact center. If unusual power is required, stop and look for damaged or dirty threads since forcing may cause misalignment and eventual malfunction.

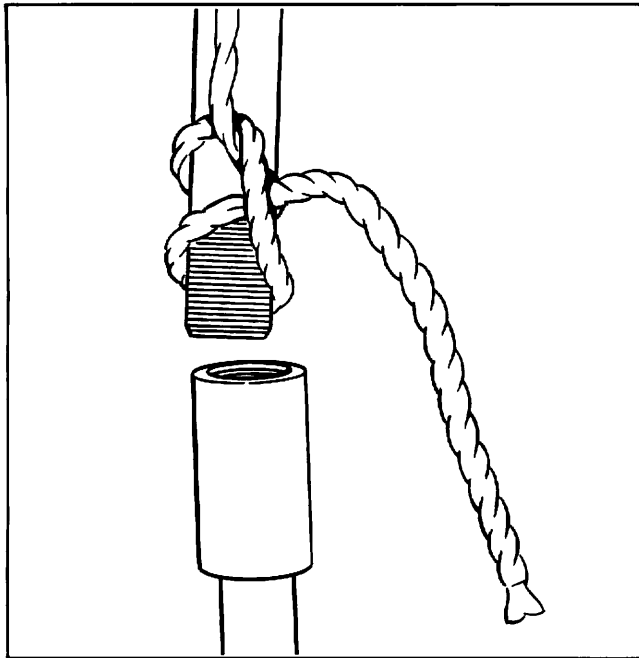


Figure 26. Joining Open Lineshaft

Now you can lower the column pipe, engaging the registers and seating the flange faces evenly. Insert all bolts not obstructed by elevators or eyebolts and tighten the nuts uniformly. When you have enough bolts to carry the weight of the assembly safely, remove the lower elevators and assemble the rest of the bolts, making sure all holes are filled and that all nuts are secure. Lower the assembly until again it rests on the beam clamps.

Wipe the upper end of the shaft clean of oil to a point several inches below the journal. After this point on the way in, don't let oil run down the shaft or into the pipe as it will deteriorate the rubber lineshaft bearing. If the

lineshaft bearings in your pump are secured in a hub fastened to the column pipe by welded ribs, Figure 28, the bearings will install as part of the pipe assembly.

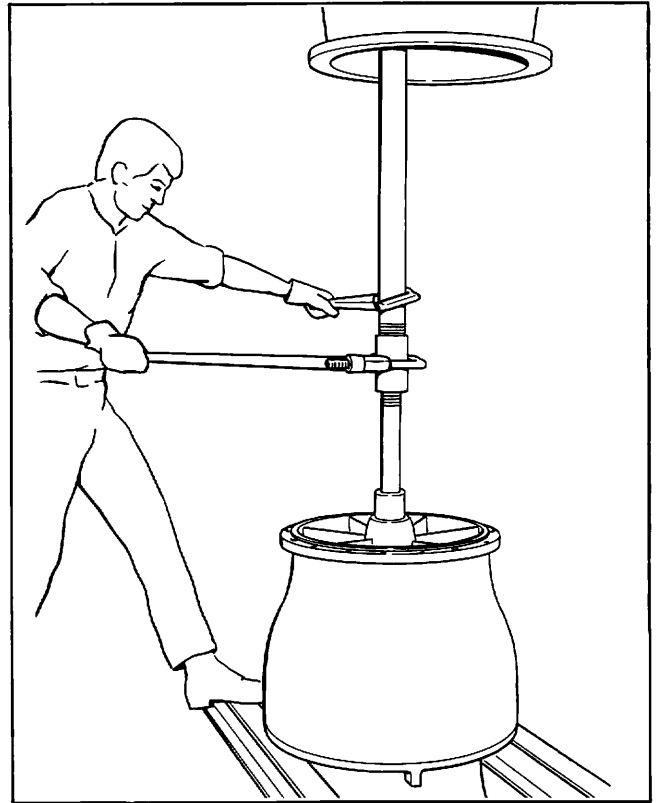


Figure 27. Connecting Open Lineshaft Assembly

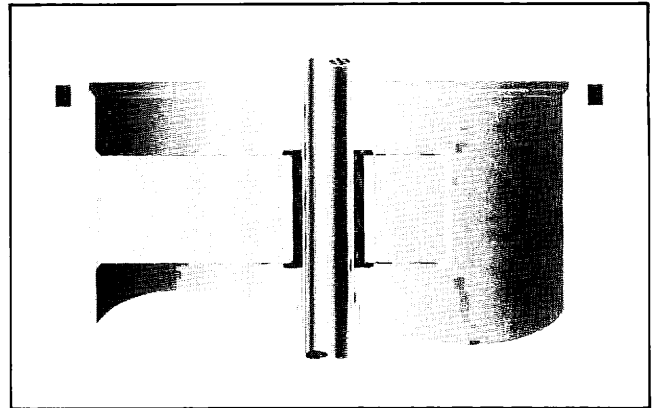


Figure 28. Open Lineshaft Bearing Welded Configuration

However, if your lineshaft bearings are assemblies separate from the pipe, Figure 29, you must install them in the top of each pipe joint. Place a lineshaft bearing over the projecting end of the shaft. Slide the parcel down until the retainer rim seats solidly in the column flange register. Check to see that the rubber bearing is located properly over the shaft journal. It should be possible to center the shaft so as to insert the



spider rim into the register with little or no force. If the shaft bears heavily to one side, investigate immediately for cause before proceeding. Never continue with installation if shaft does not center freely at bearing retainer as this indicates a misaligned column pipe or bent shaft, either of which will eventually cause trouble.

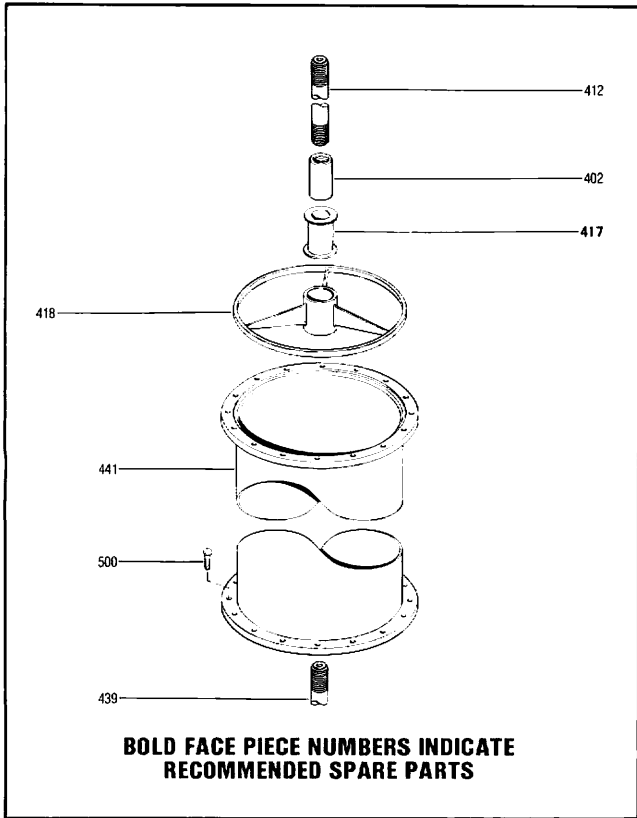


Figure 29. Open Lineshaft Bearing, Separate Configuration

When all is centered properly and the journal location is acceptable, cover the open pipe end and proceed with installation of the next column section. Repeat the same procedures with all additional sections. Note, with the separate bearing retainer assembly, the pipe flanges must clamp the retainer rim securely.

The discharge elbow/mounting base section is usually sent to you with the packing box, seen in Figure 15, assembled. Remove this assembly complete with its gasket and capscrews and store in a clean safe place. Insert the top lineshaft into the elbow/base section and join the bottom end of the resulting assembly to the pump column in the manner described for all column joints. From this point on, the pump must be handled by the lifting lugs on the discharge head shown in Figure 22. Never lift with eyebolts tapped into the holes for securing the driver. They're inadequate to support the weight. Clean the bottom face of the mounting plate and, if pump is to be grouted, apply a heavy coat of grease to the underside.

Raise the unit a few inches to remove the beam clamps and elevators, then let down slowly and carefully, positioning the base with respect to the discharge piping system, if any, and engaging the anchor bolts if used. Continue to lower until the base contacts the foundation and the weight of the pump is transferred to the mounting structure. Effect this transfer very gradually without a bump. Be sure the pump is in a plumb vertical position with full contact base to mounting surface.

Retrieve the packing box assembly, shown in Figure 30. Place the gasket, Item 246, in position on the mounting flange in the discharge elbow. Loosen the gland, Item 224, by backing off the gland nuts, Item 222, slightly. Slip the box very slowly and cautiously down over the shaft and into place in the elbow with the flange seated firmly and evenly. The shaft should center and allow the box to enter the register without forcing. Oil the capscrews, Item 234, and use them to secure the flange evenly.

Before first startup, study the run in procedure described in Section 13. Again check the installation to make sure the pump hangs plumb and that the shaft is easily centered without force. It should be possible to correct deviation in either of these areas by proper use of wedges and/or shims under the base.

When all is satisfactory, go on to Section 9 for the next procedure.

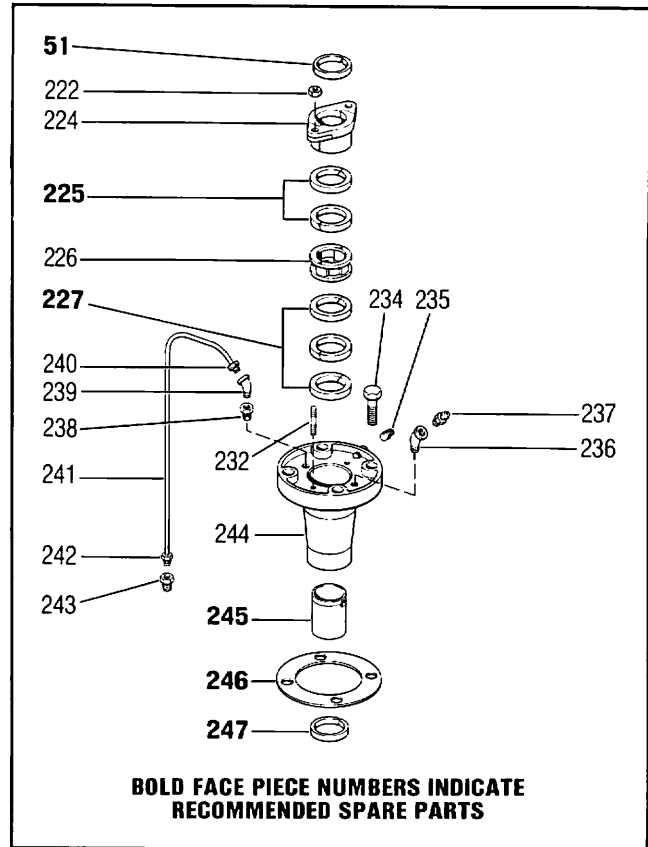


Figure 30. Packing Box Assembly

## SECTION 9

### LUBRICATING THE PUMP

#### a. Gravity Flow Oil

If your pump is designed for gravity oil lubrication with an enclosing tube around the lineshaft, examine the oil reservoir and the oil feed line, making sure they are clean and without obstruction. Figure 31 will show you the parts involved. Attach the reservoir assembly, Item 204, to the driver pedestal by its bracket, using cap-screws, Item 218, and placing dampener gasket, Item 219, between bracket and mounting surface. If may be necessary to interchange the sight gauge assembly with the oil line fittings to make the routing to the tube connector in the most convenient way.

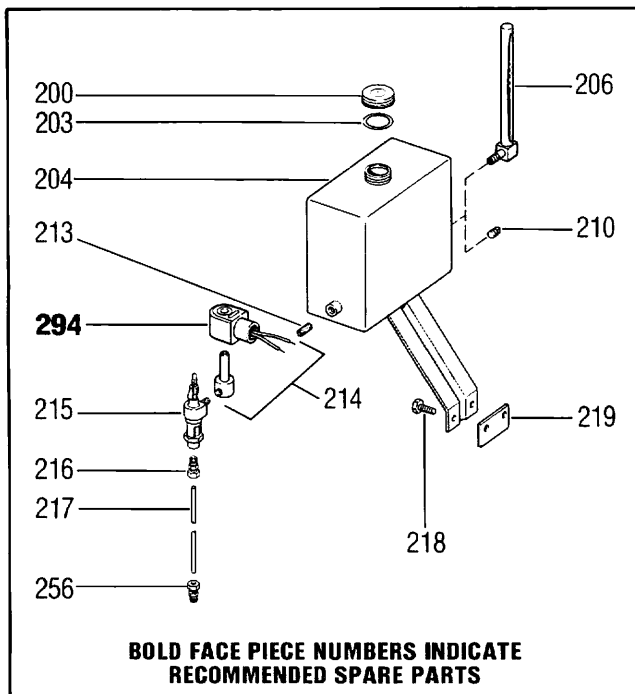


Figure 31. Lubricator

If your lubrication system is automatic, you will have Item 294, as shown in Figure 31. If system is manual, this part is not needed. Keep the cover assembly on the reservoir at all times to prevent entrance of foreign material.

Connect up lubrication system as illustrated in Figure 32 using the parts depicted in Figure 31. Adjust the lubricator valve, Item 215, to permit oil to drip at the rate of approximately one drop per second. With automatic lubricators, you'll have to complete the electrical connections to the solenoid valve, Item 294, so it can be operated to allow flow of oil to the lubricator valve, Item 215.

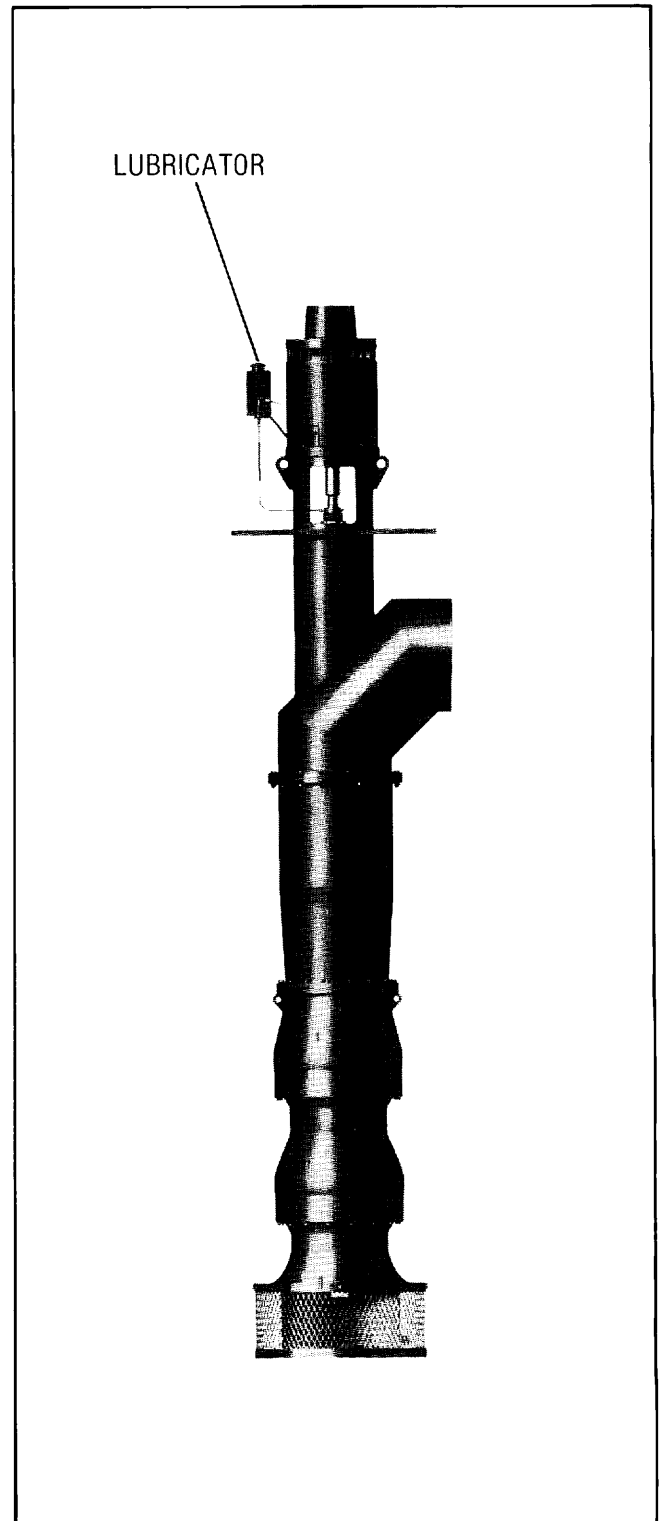


Figure 32. Lubricator Location

If it isn't practical to energize the solenoid at this time, you'll have to prelubricate the pump manually. Remove the pipe plug in the top of the tube connector and fill the upper cavity with approved turbine oil at least three times so the oil will run down into the enclosing tube.

Before first start, verify that the oil reservoir is full and that the lubricant can flow freely into the enclosing tube. Allow oil to drip for fifteen minutes while checking all related procedures to be sure all is ready for startup. After starting, be sure the oil continues to drip into the pump during operation. You may find it necessary to apply a small amount of oil from a can to the point where the shaft emerges from the tubing in the discharge head. This should only be required during the first few minutes of operation.

After logging about one half hour running time, adjust the flow on the manual lubricator to about thirty drops per minute and run at this rate for the first ten operating hours. When a solenoid control is not furnished, shut off manual lubricator during idle periods. After running successfully for about ten hours, reduce oil flow rate to eight drops per minute maximum for permanent operation.

#### b. Pumped Liquid

If your unit is designed to be lubricated by the pumped liquid, there is little if anything for you to do since the pump is, in effect, self lubricating. All it requires is an adequate supply of cool, non-aerated liquid, free from suspended solids or gases in solution. All you need do before installation is to make sure the bypass ports in the discharge bowl are closed as described in Section 8b.

If your pump must be idle for any prolonged period, the shaft should be rotated by hand once a week. If you prefer, you can instead spin the shaft under power once a week provided you have adequate liquid over the pump suction.

Your packing box has a grease fitting in the top. It is not often necessary to use this fitting and you can usually ignore it. If you use it to lube the box bearing at all, apply the grease sparingly. Too much will interfere with cooling water flow through the box.

If the fluid you are to handle is something other than water, or if you expect temperature to be higher than normal, we will have furnished bearings suited specifically to that kind of service provided we knew about it. However, if your pump has been designed for a given application, we can't recommend your switching it to a different environment without first checking with the factory or your Aurora representative.

#### c. External Source Pressure Lubrication

You may have ordered your Aurora Verti-Line mixed flow pump equipped for connection to an external source of pressurized lubricating liquid. If so, refer to this subsection and Figure 33. In our description here, we'll deal with water as the lubricant, though any suitable lubricating fluid will do so long as it's compatible with your bearing material. Be sure to use the lubricant for which your pump was originally designed.

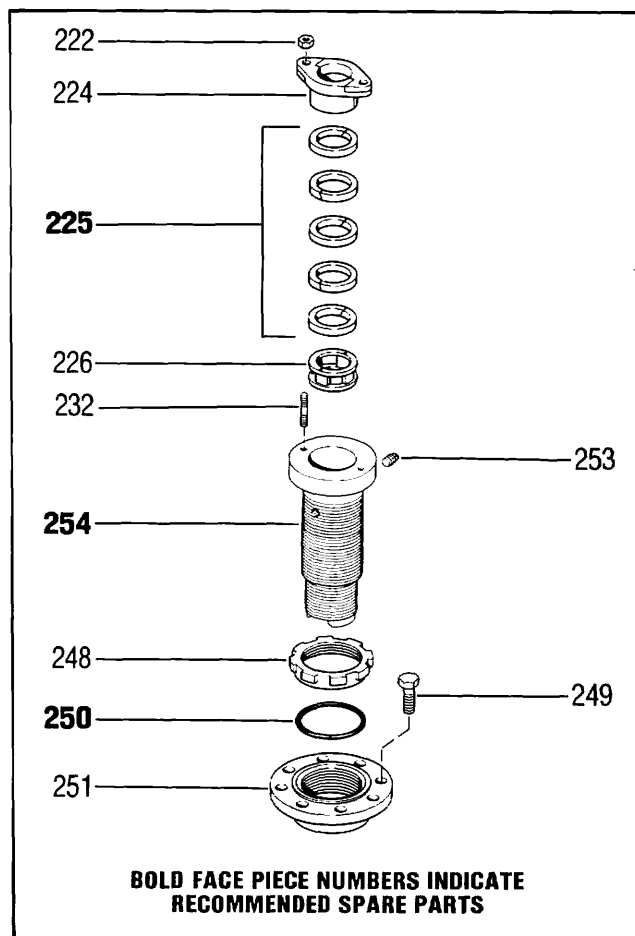


Figure 33. Packed Tube Tension Assembly

This construction usually features a shaft enclosing tube terminating in a tension nut assembly in the discharge head. Like a similar part described in subsection 8a, this assembly is usually installed at the factory where the proper tension has already been applied to the tube for you. However, as you can see in Figure 33 the tube connector, Item 254, has a packing chamber at the bottom of which is placed a lantern ring, Item 226, ported to receive the lubricating water and direct it down the tube to the line shaft bearings. Above the lantern cage are rings of packing, Item 225, in sufficient number to locate the gland, Item 224, properly in the top of the container.

As a tension nut, this assembly is treated the same as we suggested in subsection 8b. If there is ever any

reason for you to relieve the tension on the tube, be sure to mark the position of the nut, Item 251, with respect to its mounting surface in the head. With this, you can reload the tubing to the same tension magnitude when you reassemble. As a packing box, the connector will respond to the same general treatment we'll describe in Section 13.

If your external lubrication system is of the low pressure variety, make sure the bypass ports in the discharge bowl are open before you install the pump. For most applications, you'll need to furnish three to five gallons per minute of lubricating water at 40 to 50 PSIG source pressure to lubricate and cool the lineshaft bearings. This flow is injected into a port on the side of the connector, Item 254. A pressure gauge on your source will only indicate system backpressure so it may not show the forty pound value we've mentioned. We recommend you have this much available should you need it.

If your system is a high pressure design, the bypass ports in the discharge bowl will be plugged. You should verify this before installation of the pump. In this design, lubricating water must be admitted to the tubing under heads greater than that generated in the bowl assembly. Higher pressures will of course necessitate more frequent maintenance of packing. Do not exceed 125 PSIG injection pressure without first checking with the factory.

In either the low or the high pressure systems, we recommend you incorporate a positive indicating flowmeter and an alarm arrangement to warn of any interruption in flow of lubricating water. If flow stops, the pump must be shut down immediately until the malfunction is cleared. Otherwise, serious damage will result.

#### d. Fresh Water Flush

If you're going to pump fluids containing abrasive particles, you'd be well advised to inject clean liquid directly into the journal areas to provide lubrication and cooling as well as to prevent entrance of abrading material into bearing zones. If you ordered your pump equipped for this service, we will have provided means for you to flush bearings continuously with clean or filtered water.

As in subsection 9c, we recommend very strongly you incorporate a positive indicating flowmeter and an alarm arrangement to warn of any interruption in flow anywhere in the lubricating system. If flow to any journal area stops, the pump must be shut down immediately until the malfunction is cleared. Otherwise serious damage may result.

Although this option is referred to as a fresh water flush system, you can use any approved lubricant that is compatible with the pumped liquid and with your bearing material, and so long as flow and pressure

conditions permit. In general, for water, you should be prepared to furnish about one gallon per minute for each journal to be served up through one inch shaft diameter; you'll need two GPM for each journal from one through two inch, nearly 5 GPM per journal through three inch. Above these sizes, it's best to consult the factory.

Figures 34 and 35 will give you an idea what to expect in the way of external piping for this system. Figure 34 illustrates the bowl assembly in which the suction case is provided with a port in the bottom of the hub through which flush water may be injected. The bowls themselves may be cast with a port leading from the outside through a flow directing vane into the bearing area. Obviously such bowl assemblies must be ordered in this condition so the necessary porting will be provided. Assembled units are usually shipped with the piping in place as in Figure 35 but occasionally it may be required for you to install at the jobsite. When you handle these units with external piping, take care to avoid damage to pipe or tubing. Pinching or perforating a line could render the lubrication system inoperative.

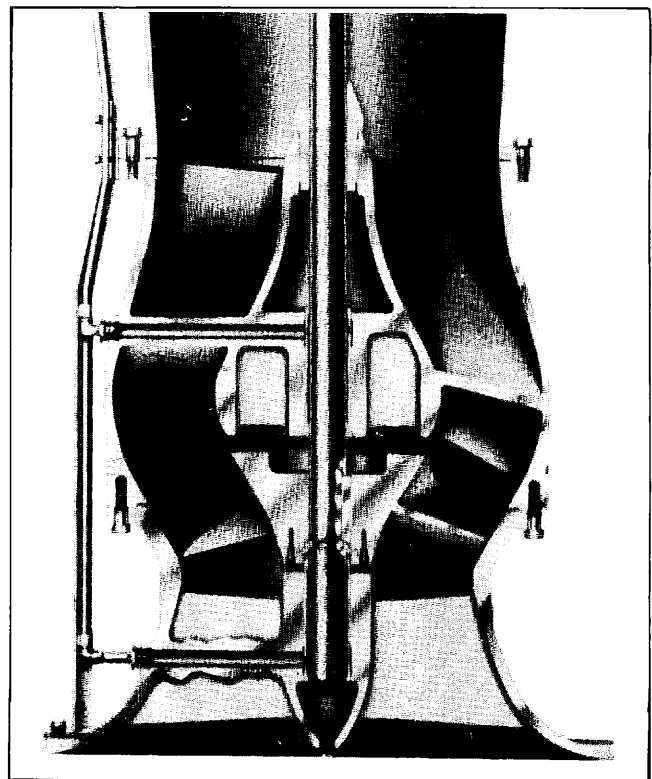


Figure 34. Bowl Assembly Lubrication

The flushing liquid must be free from abrasives and other foreign particles, must have adequate lubricating properties to do the job, and should be kept below 85° F in temperature. The liquid must be injected at a pressure in excess of that existing across the journal area

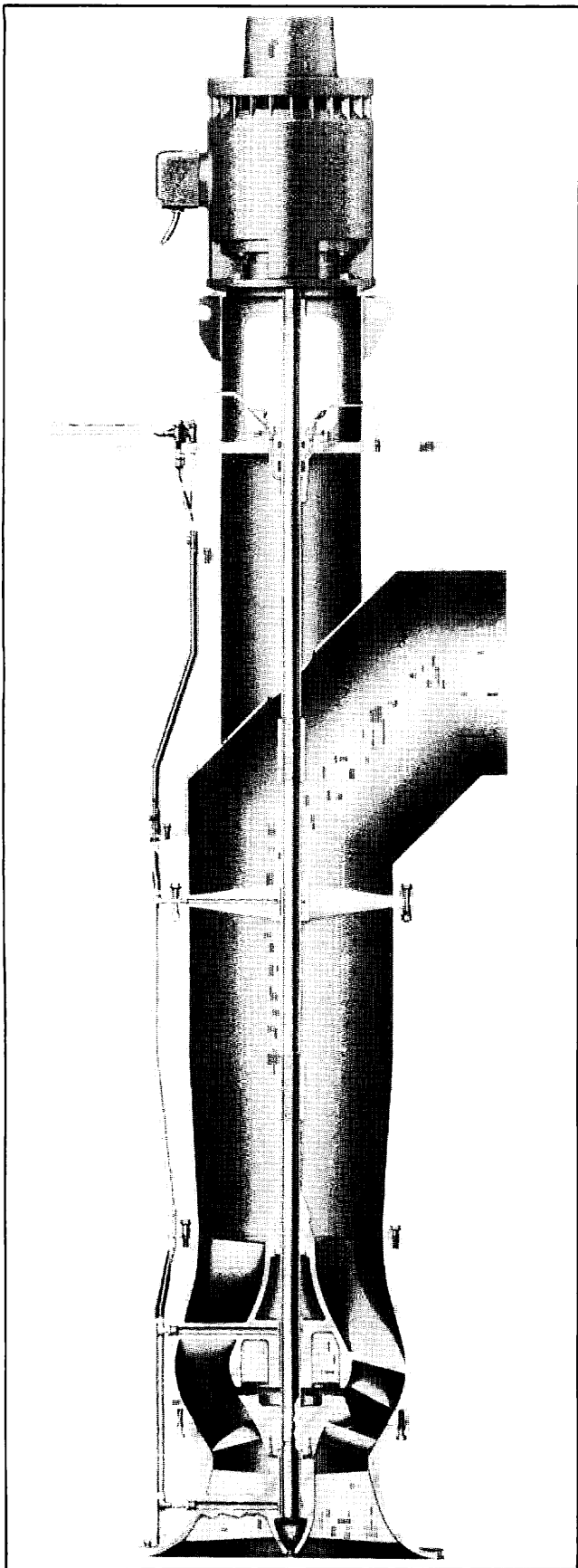


Figure 35. Complete Pump Lubrication -  
Open Lineshaft

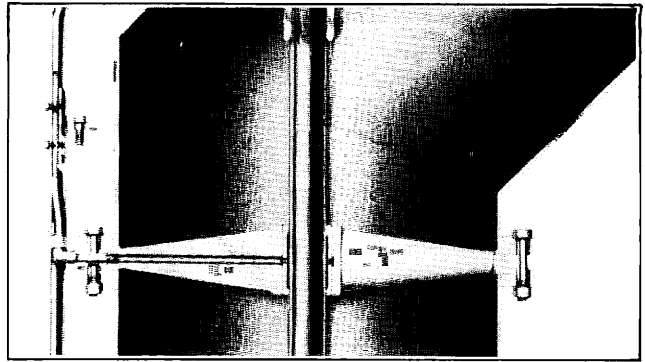


Figure 36. Open Lineshaft Bearing Lubrication

to which it is ported. This usually means something greater than the total discharge head against the pump.

Open lineshaft bearings, if necessary, may be protected in much the same way as illustrated in Figure 36. Again piping is connected as shown and run to bearing from surface source of supply. Flush water must be injected into bearing at a pressure in excess of that existing in the column pipe at that point.

Flushing at the packing box may be accomplished in a manner as depicted in Figure 37. You can make similar arrangements for mechanical seals, Figure 38. Occasionally, you may want to use a water flush design in connection with tube enclosed construction and you may accomplish this by an extension of the system described in subsection 9c.

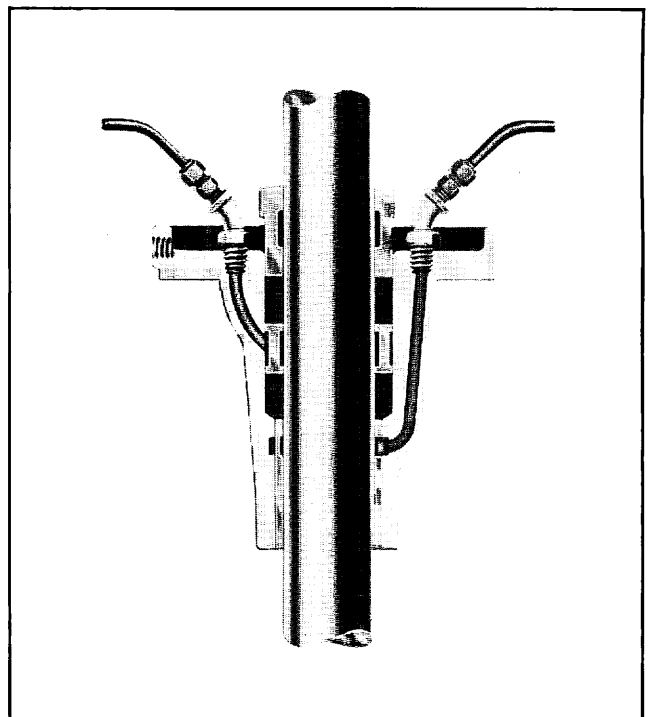


Figure 37. Packing Box Flush Provision

If you choose oil as your lubricant, you can reduce the recommended capacities or flow rates slightly. If you use this type of system to feed grease to your bearings, it is only necessary to keep the piping full and under adequate pressure at all times during operation. Here again, an alarm system may save you much trouble.

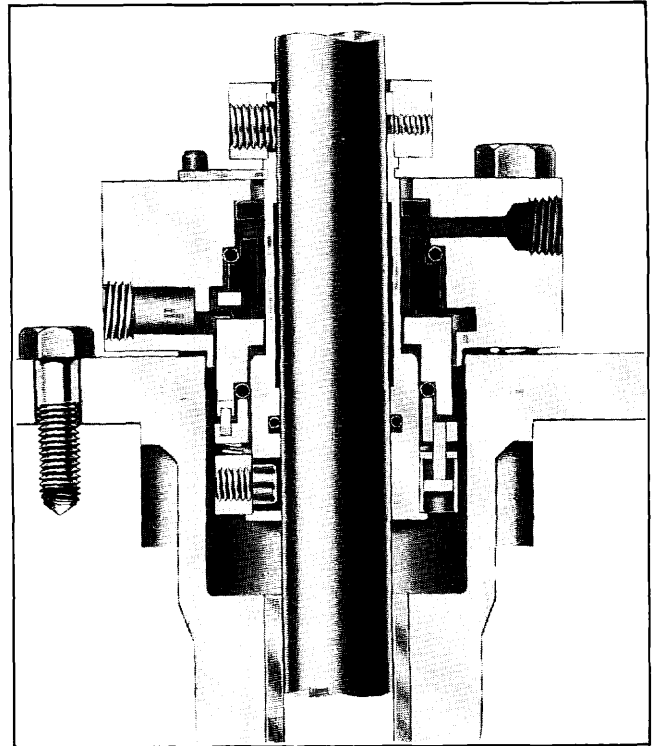


Figure 38. Typical Mechanical Seal -  
Ported for Flush System



## SECTION 10

### INSTALLING THE DRIVER

Uncrate the driver but leave it attached to the bottom skid on which it arrived. Move it to a convenient location beside the pump head, keeping it vertical at all times. Set down on firm and level footing.

When ready for installation, raise the driver off its skid to a comfortable working height, lifting it with the lugs provided on the frame.

#### WARNING

Stand beside the load as it hangs in the sling, never under it. Inspect and clean the mounting flange and register. If you find any burrs or nicks, set the driver on two beam supports and repair with a file.

#### WARNING

Don't work under the load while it's hanging from the hoist. Clean the top of the pump head and inspect it also, making any necessary repairs.

If your pump is equipped with a vertical hollowshaft driver, illustrated in Figure 39, continue right on here

with subsection 10a. If you have a solid shaft driver as in Figure 40, skip this portion and be guided by subsection 10b.

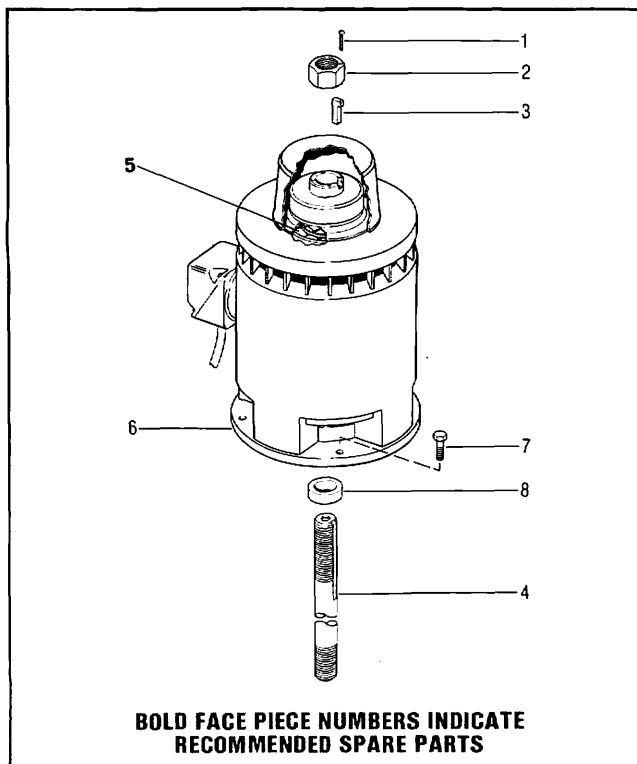


Figure 39. Vertical Hollow Shaft Driver

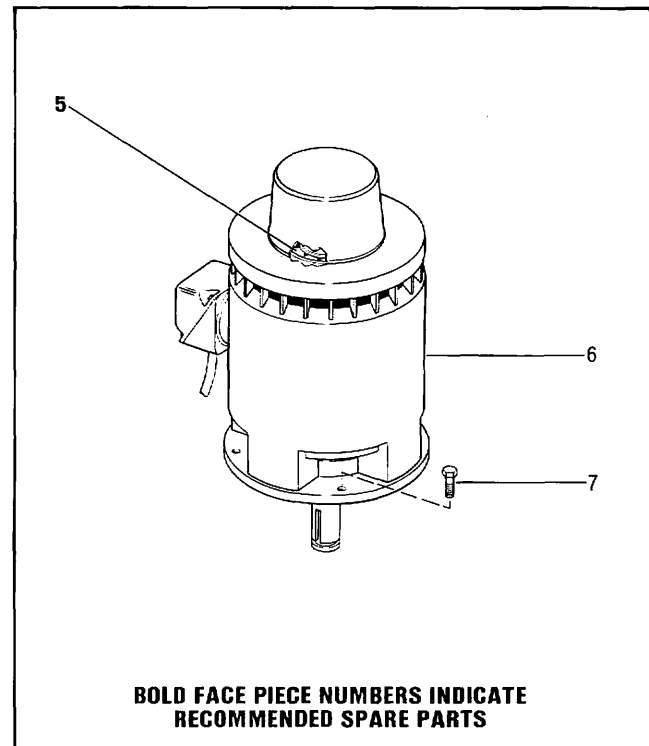


Figure 40. Vertical Solid Shaft Driver

#### a. Vertical Hollow Shaft

Remove the driver cover cap screws and the canopy itself. See Figure 41. Remove the drive coupling and any other parts packed in the top for shipment. Place them in a clean safe place for later use. Cover all openings in the top to prevent anything from dropping into the driver. If this should happen, the object must be retrieved before proceeding.

Lower the driver slowly to the head until the register fit is engaged but with the weight still on the hoist. In the case of an electric motor, swing it around so the junction box is in the desired orientation. If you have a gear drive, as depicted in Figure 42, your positioning criterion is the horizontal input shaft. Align the mounting holes and start the attaching cap screws in by hand. Transfer the weight gently from hoist to head and secure the cap screws, tightening them uniformly.

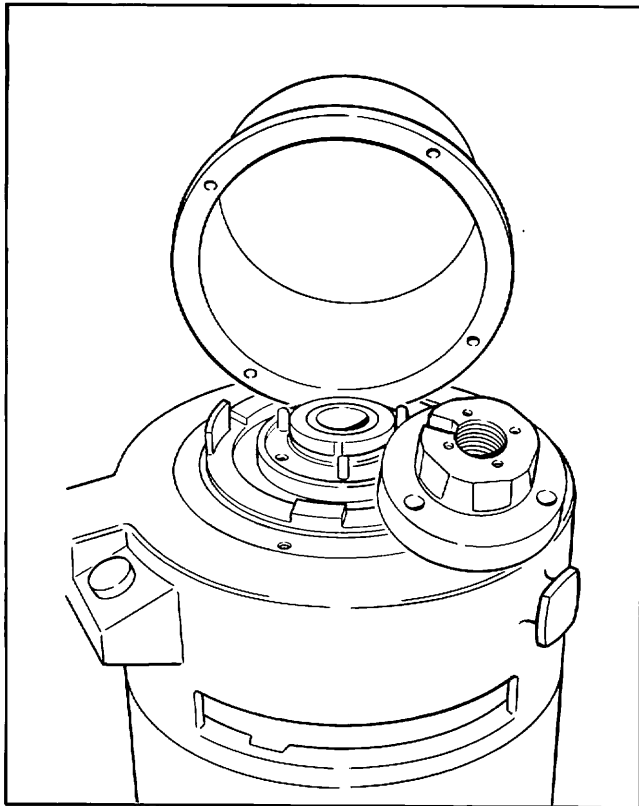


Figure 41. Removing Driver Canopy

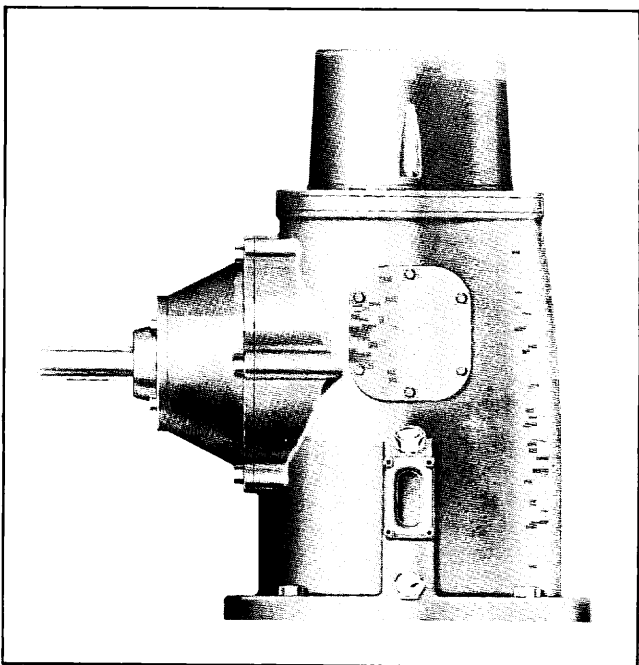


Figure 42. Right Angle Gear Drive

Please note that the lifting lugs on the driver are for handling the driver only. Never attempt to use these lugs to hoist the pump. The pump must be handled with its own lifting trunnions.

If you have a VHS electric motor, depicted in Figure 39, to deal with, open the main breaker or pump disconnect switch and make a temporary connection between the motor terminals and the leads from the starter panel. Since many electric motors are built as dual voltage machines, it is important that proper connections be made to suit the voltage of your power source. Therefore, you must check both power characteristic and motor rating for compatibility, then see the motor nameplate for correct wiring hookup.

While scanning the nameplate, determine the type of thrust bearing with which you've been furnished. If it's a spherical roller bearing, proceed with utmost caution as it must never be run at normal speed without an appreciable thrust load. For this reason, when establishing rotation as we're about to do, be very careful to just bump or tap the switch. Never close it fully until the pump is completely operational.

Otherwise, you may now energize the starter panel and buzz start the motor by switching it very quickly on and off, observing for direction of rotation and watching to see that it spins freely and is in apparent balance. Driver shaft must turn counterclockwise when viewed from the top. If rotation is clockwise, kill the power to the starter panel and interchange any two leads on three phase motors. With single phase machines, follow manufacturer's instructions.

After reconnection, energize the starter and again buzz start the motor. When you're sure you have counterclockwise rotation, mark the motor terminals and the leads from the starter box to match. De-energize the starter at the main breaker or pump disconnect switch and make the permanent power connections. Naturally, these connections must be made in accordance with all applicable electrical codes and regulations.

If your pump is equipped with a right angle gear drive, as shown in Figure 42, instead of an electric motor, the rotation check must wait until later when the pump is completely installed and connected to the prime mover. At that time, rotation is verified in a manner similar to that just described with allowances for the type of power equipment. Match up the rotation arrows on the gear and the prime mover to determine compatibility, at least as far as the nameplates are concerned.

Your headshaft was probably shipped to you in a separate box. Find it and clean it thoroughly throughout its length, threads, keyway, and end faces. Now slide it down through the driver hollow shaft without bumping or scraping, keyway end up. If you were furnished with a slinger ring, assemble it to the shaft as the shaft bottom end emerges from the bottom of the driver. With the coupling already assembled to the top lineshaft, join the headshaft to the lineshaft, snapping the two to a firm butt.

Looking down on the driver, check to see that the headshaft stands in the center of the hollowshaft and that the driver shaft rotates freely by hand. If the shaft stand to one side of the quill, rotate the shaft from below. If the top of the bar moves around the quill, you have a bent shaft or a bad coupling joint. If, however, the shaft remains in the same off center spot during rotation, the problem is with one of the stationary parts, perhaps the column or head assembly or, just as likely, the mounting structure. Whatever it is, it must be rectified before proceeding. If in doubt, call your Aurora representative.

When all is well, retrieve the drive coupling and other parts you set aside, together with the pump parts shown in Figure 39. Try the drive key, Item 3, in both headshaft and drive coupling keyways. They should produce a sliding fit. If necessary, dress the key until a free but not loose fit is obtained. Don't file the keyways. Slide the drive coupling over the headshaft, Item 4, into proper position onto its register, firmly seated perfectly flat without cocking. It should slide easily and smoothly without tendency to drag or hang up when lowered or rotated.

Insert the drive key, Item 3. Again it should be a free, but not loose, fit. If necessary dress the key but never the keyways. The top of the key must be below the adjusting nut seat when in place.

Thread the adjusting nut, Item 2, onto headshaft keeping in mind the left hand threads, and raise the shaft until all its weight is on the nut. This is the break-free point. With a very slight lowering, the impeller vanes are felt to drag on the bowl. Mark the breakfree point, adjusting nut to driver coupling.

Now turn the nut counterclockwise to raise the shaft, counting the turns, until the top of the impeller hub is felt to contact the bowl. Measure the distance the shaft moved out of the nut. This dimension should correspond to the endplay dimension you recorded in Section 8. Now back the nut off clockwise until you are approximately one turn above the breakfree point. For finer adjustments refer to Section 14. Assemble the lockscrew, Item 1, Figure 39. The top of your driver now looks like Figure 43.

Replace the driver canopy and secure the capscrews. Keep it that way all the time you aren't actually working under the cover. Check your driver lubricant and follow manufacturer's directions. If your driver requires provision for coolant flow, take necessary measures as instructed. Don't run equipment until all these conditions have been satisfied. Leave the power circuit open to the starter panel while performing remaining work except when you require pump operation.

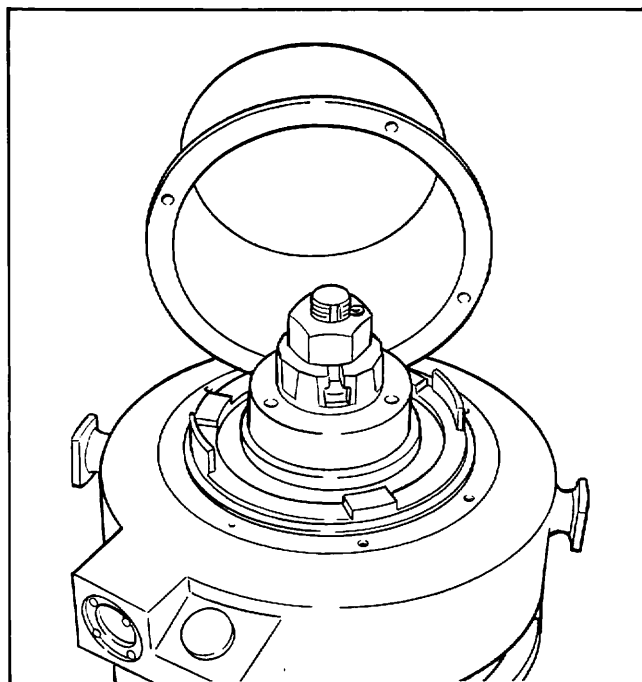


Figure 43. Driver Top

#### b. Vertical Solid Shaft

Lower your vertical solid shaft driver to a firm and stable position atop a pair of beams or blocks placed on the discharge head to provide ample clearance between driver shaft and pump shaft. If you have an electric motor to deal with, secure it firmly against reactive torque with chain or cable restraints. Open the main breaker or pump disconnect switch and make a temporary connection between the motor terminals and the leads from the starter panel. Since many electric motors are built as dual voltage machines, it is important that proper connections be made to suit the voltage of your power source. Therefore you must check both power characteristic and motor rating for compatibility, then see the motor nameplate for correct wiring hookup.

While scanning the nameplate, determine the type of thrust bearing with which you've been furnished. If it's a spherical roller bearing, proceed with utmost caution as it must never be run at normal speed without an appreciable thrust load. For this reason, when establishing rotation as we're about to do, be very careful to just bump or tap the switch. Never close it fully until the pump is completely operational.

Otherwise you may now energize the starter panel and buzz start the motor by switching it very quickly on and off, observing for direction of rotation and watching to see that it spins freely and is in apparent balance. Driver shaft must turn counterclockwise when viewed from the top. If rotation is clockwise, kill

the power to the starter panel and interchange any two leads on three phase motors. With single phase machines, follow manufacturer's instructions.

After reconnection, energize the starter and again buzz start the motor. When you're sure you have counter-clockwise rotation, mark the motor terminals and the leads from the starter box to match. De-energize the starter at the main breaker or pump disconnect switch and remove the temporary power connections from the motor.

If your pump is equipped with a right angle gear drive, as shown in Figure 44, instead of an electric motor, the rotation check must wait until later when the pump is completely installed and connected to the prime mover. At that time, rotation is verified in a manner similar to that just described with allowances for the type of power equipment involved. Match up the rotation arrows on the gear and the prime mover to determine compatibility, at least as far as the nameplates are concerned.

While the driver is sitting on the blocks, examine the protruding drive shaft for any nicks or burrs. If necessary, repair very cautiously with a small file. Clean the shaft and oil it very lightly. Find the shaft coupling parts, Figure 45, and clean them all thoroughly.

Try the drive shaft key, Item 101, in both driver shaft and upper coupling half, Item 103, keyways. You should find a very close sliding fit. If necessary, dress the key but not the keyways until you obtain a free but not loose fit. Now try the thrust collar, Item 105, in the shaft groove. It too should be a very close fit and may be dressed to obtain this if necessary. Try the coupling half, Item 103, on the shaft.

When you have the proper fits and while the driver still sits on the blocks, insert the key, Item 101, in the shaft keyway and slide the coupling half, Item 103, up on the shaft flange face down. With the flange above the drive shaft ring groove, assemble both halves of the thrust collar, Item 105, in the groove and slide the coupling back down until it rests firmly on the thrust collar, retaining the collar halves in place in the coupling recess. Assemble and tighten setscrew, Item 104, securely.

If your coupling is furnished with a spacer spool, Item 106, assemble the spacer to the driver coupling half, Item 103. If parts are matchmarked, install them accordingly. Use only the nuts and bolts shipped with the pump as some couplings are balanced as assemblies. Tighten all flange bolts securely and uniformly throughout the coupling.

Inspect and clean pump shaft threads, painting lightly with good thread lubricant. If parts are stainless steel, be sure to use an approved anti-galling thread compound. After trying keys and parts as described above, insert key, Item 114, in pump shaft keyway and slip

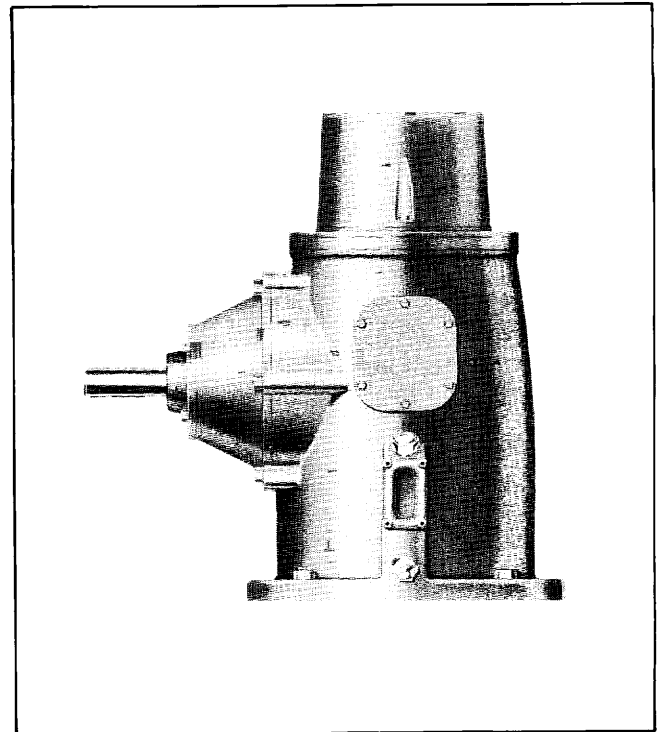


Figure 44. Right Angle Gear Drive

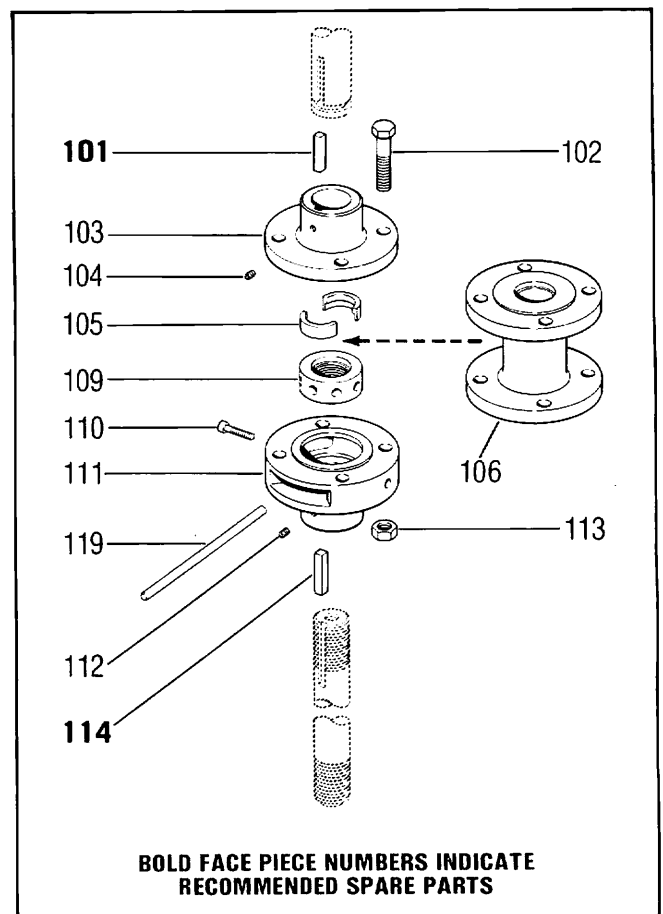


Figure 45. Flanged Adjustable Shaft Coupling

pump shaft coupling half, Item 111, well down over shaft, flange face up, leaving shaft threads projecting above coupling. Screw adjusting nut, Item 109, onto pump shaft with the rimmed end up, turning counter-clockwise until pump shaft protrudes through threaded portion of nut by at least two threads. Remove the capscrews securing the packing box or tension nut flange.

Raise the driver just enough to remove the blocks, then lower it slowly to the head until the register fit is engaged but keeping the weight on the hoist. In the case of an electric motor, swing it around so the junction box is in the desired orientation. If you have a gear drive, Figure 44, your positioning criterion is the horizontal input shaft. Align the mounting holes and start the attaching capscrews in by hand. Transfer the weight gently from hoist to head and secure the capscrews, tightening them uniformly.

Please note the lifting lugs on the driver are for handling the driver only. Never attempt to use these lugs to hoist the pump. The pump must be handled with its own lifting trunnions.

With the pumpshaft all the way down, screw the adjusting nut 109 up by turning clockwise until its outer shoulder is approximately one tenth of an inch below the face of the driver coupling flange, Item 103, or spacer, Item 106, lower flange, if you have a spacer spool. Pull the pump coupling, Item 111, up and insert flange bolts, Item 108, through both flanges. Assemble nuts, Item 113, and run up by hand until they are snug, using a light machine oil on the bolt threads.

Check for shaft alignment at the outer edges of all the flanges. They must meet evenly both at the faces and at the outer circumferences. True alignment can be further verified by using dial indicators on both the

driver and the pump shafts. If you cannot obtain alignment within 0.003 inches T. I. R., call your local Aurora representative.

When satisfactory alignment is achieved, put all bolts under uniform tension, using a torque wrench if available. Five hundred inch pounds should be sufficient torque; i.e., a fifty pound pull on a ten inch wrench or the equivalent. Make sure pump shaft key, Item 114, is flush with coupling hub and tighten set-screw, Item 112, securely to lock the key in place.

Move the adjusting nut, Item 109, very slightly if necessary to line up the nearest hole with the tapped hole in the outer circumference of the pump coupling flange. The nut may be rotated by inserting a bar, Item 119, through the slot in the coupling into one of the holes in the outer surface of the nut. Insert the socket head capscrew, Item 110, making certain it projects into a hole in the adjusting nut, then tighten securely. Now replace the packing box or tension nut flange capscrews. Tighten them uniformly and securely.

You may now make the permanent power connections to the electric motor, if that's what you have, checking of course to see that the power circuit to the starter panel is still open. Naturally these connections must be made in accordance with all applicable codes and regulations.

Check the driver lubricant and follow manufacturer's directions. If your driver requires provision for coolant flow, take the necessary measures as instructed. Don't attempt to run the equipment until all these considerations have been satisfied. Leave the power circuit open to the starter panel while performing remaining work except when the procedure requires pump operation.

## SECTION 11

### OPTIONAL EQUIPMENT

Your Aurora Verti-Line mixed flow pump may be furnished with a variety of optional features to your specification. Some of the available options will be described in this manual. Please refer to those sections applicable to the construction of your unit, disregarding those that don't apply. Check your shipment for any drawings and/or special instructions that may have been included to cover items not described in this manual.

#### a. Flanged Non-Adjustable Shaft Coupling

In Section 10b, we described for you the installation of a Flanged Adjustable Shaft Coupling to join a solid shaft driver to the pump shaft. The Flanged Non-Adjustable Shaft Coupling is used almost exclusively to connect a hollowshaft electric motor with a hollowshaft gear drive in a combination drive assembly.

In such an assembly, the gear is mounted on the pump head and carries a yoke on its top. The electric motor sits atop the yoke and thus we attain a combination electric and internal combustion drive, usually for insurance against loss of operation due to power failure. The Flanged Non-Adjustable Shaft Coupling is located in the gear drive yoke and joins the gear drive shaft to the motor drive shaft. See Figure 46.

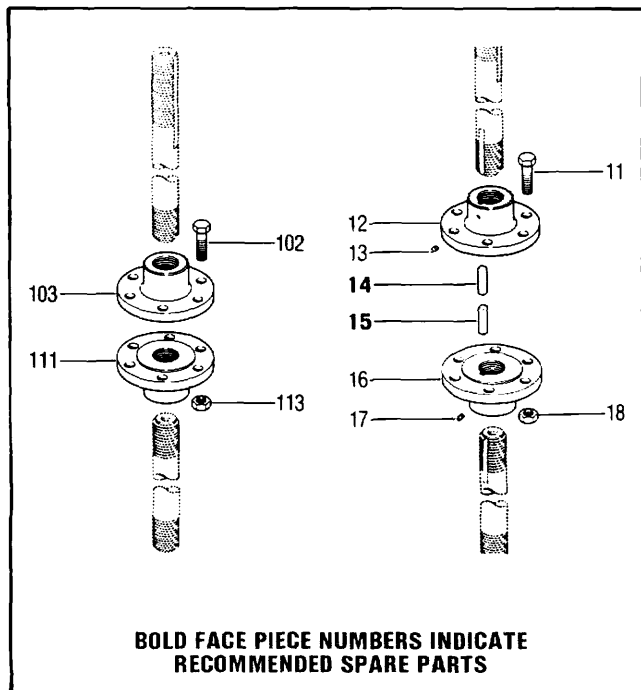


Figure 46. Flanged Non-Adjustable Shaft Coupling

If your pump is equipped with a combination drive, assemble it complete up to and including the gear drive with its shaft and adjusting nut. The shaft will protrude upward out of the gear drive coupling with threads and a keyway exposed. Clean all the parts and paint the threads with lubricant. If the parts are stainless steel, use only an approved anti-galling compound. Thread the lower coupling half, Item 16, onto the gear shaft so that the end face of the shaft terminates about one thread below the flange face. Note: that's the flange face, not the register face. Line up the keyways and insert the key, Item 15. If necessary dress the key but not the keyways to a free but not loose fit. Tighten the setscrew, Item 17, securely.

In a similar manner, assemble the upper coupling half, Item 12, to the motor drive shaft, leaving the endface of the shaft about one thread below the flange face as before. Again, assemble the key, Item 14, and the setscrew, Item 13.

Now raise the electric motor and insert the motor shaft into the motor hollowshaft from the bottom with the shaft coupling flange facing down. Thread the adjusting nut on the top of the motor shaft to support the shaft weight while you lower the motor carefully into place atop the gear yoke. Orient the motor properly with respect to the junction box and secure the attaching capscrews.

Insert the bolts, Item 11, through the flanges and run the nuts, Item 18, up by hand until they're snug against the flange, using a light weight machine oil on the bolt threads. After all the nuts are drawn up and you're satisfied the flanges meet evenly, put all the bolts under uniform tension with a torque wrench if you have one.

Assembly of the motor shaft adjusting nut, the adjustment of the impeller, and other procedures may now be completed as described in Section 10a.

#### b. Below Base Discharge

Mixed flow pumps are so constructed that the discharge elbow may be either above or below the mounting base. Up to now in this manual, we've dealt primarily with an above base discharge configuration. We're including this subsection covering the below base arrangement, as shown in Figure 47, in case that's the way you ordered your pump.

In most cases, the discharge elbow, mounting base, and motor pedestal are all combined to make a one

piece section from which any additional column may be suspended. This is true regardless of whether the discharge is above or below base. Essentially, the installation procedures are identical, even when the elbow is in a separate piece of column farther down, well below the mounting plate. There are, however, several considerations worthy of your attention and we'll discuss them here.

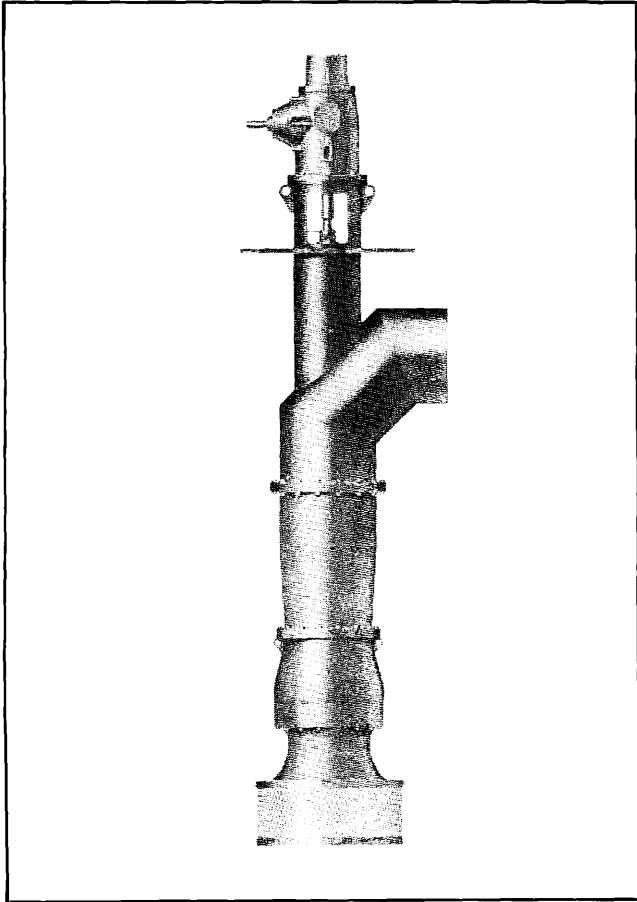


Figure 47. Below Base Discharge

Because your column pipe in effect deadends above your discharge, it's possible to entrap air in the upper cavity. Therefore we furnish all arrangements of this type with a port from which the air may be released. The port may be in the pedestal or in the column itself, depending on details of construction. We recommend you make provisions for either automatic or manual exhaust. Release should occur continuously during operation but at least at each startup.

Another point of difference: since the discharge is somewhat removed from the base and the tie down bolts, the moment imposed on the column by the discharge pressure can be appreciable, even in low head pumps like yours. When this becomes a factor, we must require restraints to oppose the horizontal thrust forces acting at the tee. Such forces must not be allowed to produce misalignment in the column.

As you can see in Figure 47, the elbow must pass through the foundation. Because of the large size of the discharge, this sometimes complicates the structural design of the mounting base.

### c. Suction Umbrella

When indicated by submergence or inflow conditions, you may want to order your low lift pump equipped with a suction umbrella. These parts are of unusually large diameter, probably too large to pass through the hole in the foundation where you'll install the rest of the pump. The umbrella is usually, therefore, assembled after the pump is installed.

If clearances will permit its entry into the sump, you can use a single piece umbrella as illustrated in Figure 48. If the pump is large, the umbrella will be large and you may want to go to a two piece split design as shown in Figure 49. In either case, the parts are taken into the sump below the pump and installed from there, using the clips, Item 734, washers, Item 735, and nuts, Item 736, in connection with the studs on the umbrella itself. With the split arrangement, the two pieces, Items 730 and 731 must also be joined, using washers, Items 732 and nuts 733. For the big parts, it is best to block the items up under the suction bell so they don't have to be muscled up from the sump floor.

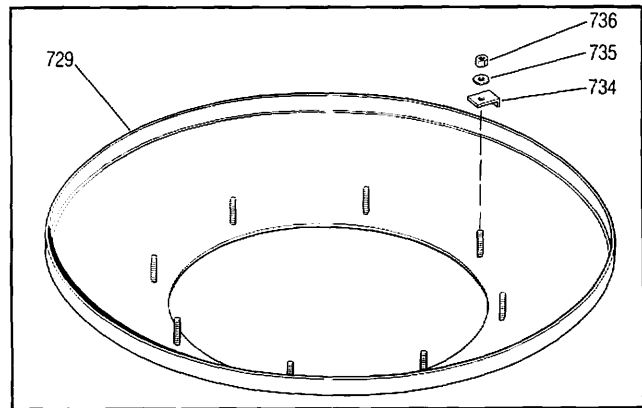


Figure 48. Suction Umbrella, Single Piece Design

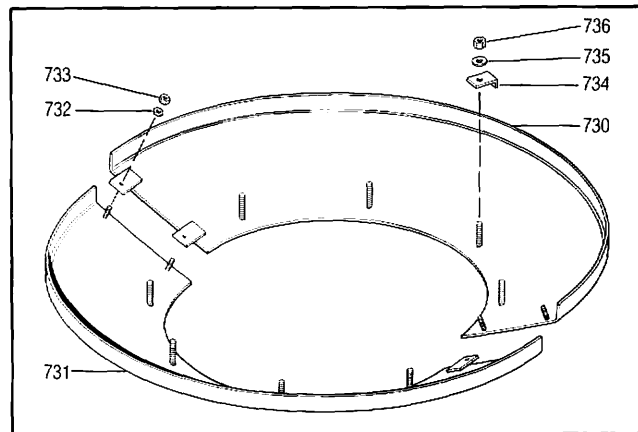


Figure 49. Suction Umbrella, Two Piece Split Design

## SECTION 12

### CONNECTING THE PIPING

You will be connecting your Aurora Verti-Line mixed flow pump to your piping of course, since the pump is there to energize your system. Whatever your particular piping system is, it must be independently supported. It must not be allowed to impose stress on the pump due to weight, thermal expansion, misalignment, or any other condition.

When bolting system flanges to the pump flanges, determine that the flanges fit face to face and hole to hole before inserting bolts. Don't draw the flanges together with the flange bolts.

One way you can avoid stressing the pump parts with the system piping is to incorporate couplings designed to absorb some misalignment and vibration. Dresser type, as shown in Figure 50 and, to a lesser extent, victaulic type couplings, as shown in Figure 51, will give you a little more tolerance in fashioning your piping grids. Keep in mind, however, that there is a thrust load across such couplings that may require restraining ties. You may have some small pipes or tubes to accommodate if you are supplying coolant to the driver, for example. In such cases, it is well to protect the small lines from vibration by using hose connections at strategic locations.

If it is your intent to grout the pump base in place and you haven't already done it, this is the time to do so. After the grout has cured sufficiently, secure the anchor bolt nuts firmly and proceed with Section 13.

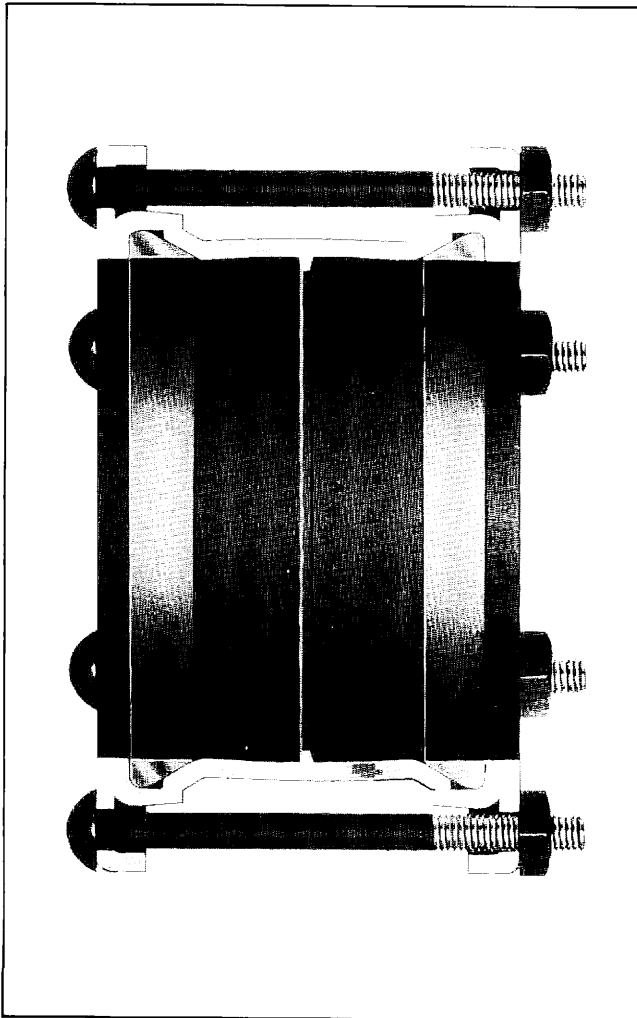


Figure 50. Dresser Type Coupling

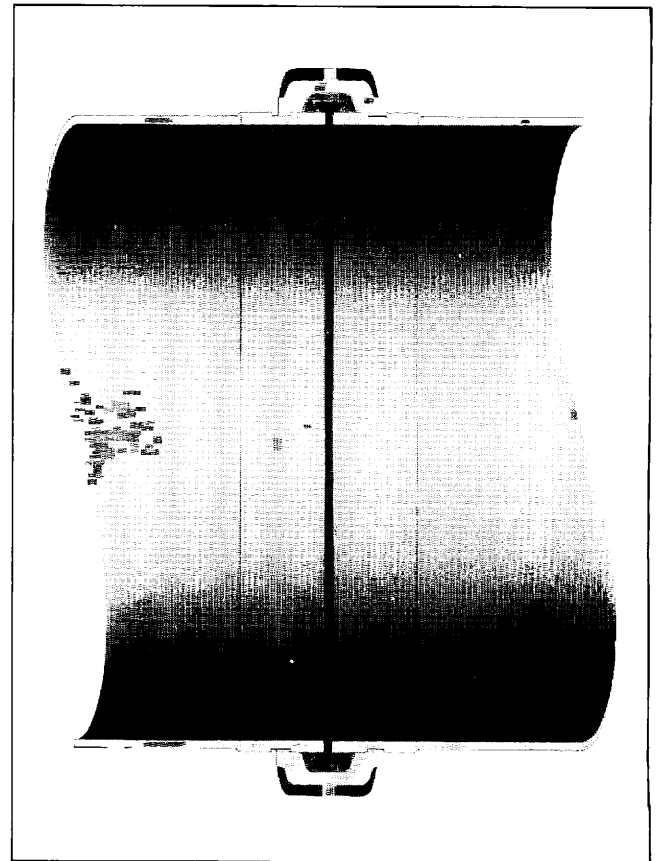


Figure 51. Victaulic Type Coupling



## SECTION 13

### STARTING THE PUMP

Before starting a new pump for the first time, you must establish the status of the following items:

- \* Driver lubrication levels must be adequate.
- \* Driver cooling system, if used, must be operative.
- \* Driver wiring has been carefully checked.
- \* Driver connection to power source is complete and adequately guarded.
- \* Pump lubrication system is operative with adequate levels.
- \* Pump has been through a proper prelubrication cycle.
- \* All accessible connections are tight.
- \* Pump is properly adjusted according to Section 10.
- \* Pump rotation is counterclockwise when viewed from top.
- \* Suction bell is properly submerged.
- \* System is in condition to deliver and accept full flow.
- \* All covers and guards are in place.
- \* All personnel are clear of equipment.

When all these conditions are satisfied, start the pump and observe the operation closely. If there is excessive vibration, unusual or excessive noise, or if the driver draws noticeably more power than expected, stop the pump. Research the cause and correct the problem before attempting a restart.

If your pump is tube enclosed and leaks at the tension nut, check the locknut and packing ring at the top. If this isn't the cause, it may be necessary to apply more tension on the tube. Stop the pump and move the tension nut flange around to the next capscrew hole, working through the access openings in the discharge head.

With an open lineshaft pump, give your attention to the packing box. Let the pump run for ten to fifteen minutes while you allow the packing gland, Item 224 in Figure 30, to leak at least one hundred drops per minute. If the leakage rate slows during this period, loosen the gland nuts, Item 222, to maintain constant flow. Gland tem-

perature should level off and then drop slightly toward the end of the run. You may then draw up the nuts about one sixth of a turn every five minutes until leakage is minimized. If, during this procedure, the gland heats up so that it will vaporize water, back off the nuts and repeat the run in process as described until the temperature stays down after the gland is finally adjusted.

During the first four hours of operation, you may find it necessary to tighten the gland gradually as the packing rings, Items 225 and 227, are broken in and formed to fill the chamber. You must always allow a small trickle to flow through the top of the gland. During this time, check frequently to see that the box is not overheating. Should this occur, slacking off on the gland nuts, Item 222, may be all you need do. If excess heat continues, inspect the bypass line from the drain port and make sure there is substantial flow through it.

The grease fitting, Item 237, channels into the throttle bearing. Only a very small amount of standard water pump grease should be injected for startups only, otherwise not at all. Too much grease can actually interfere with heat transfer in the journal area, producing excessive temperature in the box. It's better to use no grease than too much.

As you repeatedly tighten the gland over long periods of operation, the packing rings will be compressed in the chamber, lowering the gland into the box. Additional rings are often added as required to compensate but you must never add more than two above the lantern ring, Item 226, since you will block the drain port. After adding any packing, probe the drain port with a wire to see that it has not become plugged.

When you eventually find it necessary to repack the box, you must first remove the remains of the old packing with packing hooks, cleaning the chamber thoroughly. The lantern cage, Item 226, is provided with #10-24 tapped holes in the face so that you can lift it out using appropriate machine screws or similar means. You'll find the gland, Item 224, easy to remove because of its split design. You can secure the lantern ring up out of the way during repacking by tying a couple turns of string around the shaft.

At the time of repacking, always check the shaft alignment and surface finish. The finish should be smooth without burrs, grooves, or scratches. Avoid shaft runouts over 0.005 inch. You may use butt or diagonal cut packing, but we recommend the latter. We also recommend you use die cut rings for repacking, of the same size and material as the original. If you cut and fit

the rings at the jobsite, be sure to cut them so the ends just barely meet when formed around the shaft. The ring joints should be located 90° to 180° from the cut in rings immediately above and below.

If your pump has been repaired or if it has been shut down for several days or more, follow the same proce-

dures for restarting as above. Refer to our Recommendations for Storage located on the inside front cover of this publication.

If you have any questions, Aurora Pump will be glad to help you. We wish you the best of service from your pumping equipment.

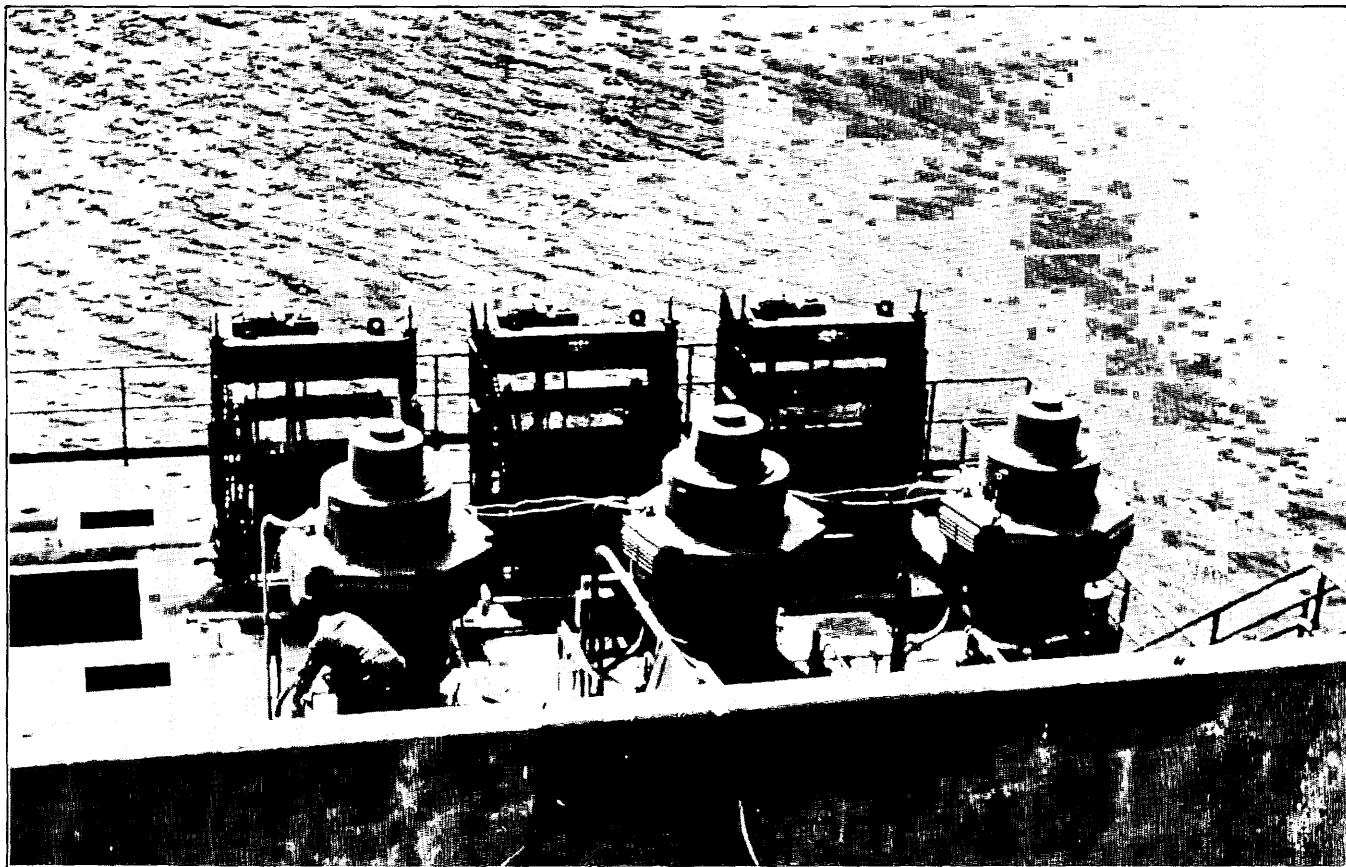


Figure 52. Typical Installation

## SECTION 14

### ADJUSTING THE PUMP

In Section 10, when connecting the driver to the pump shaft, you adjusted your impeller(s) about one turn up off the bowl seat(s). The pump may be operated this way, and often is, at least for an initial period if not longer. However, since your mixed flow impellers are of the semi-open variety, as shown in Figure 53, you'll want to achieve a precision adjustment if you intend to develop optimum hydraulic performance.

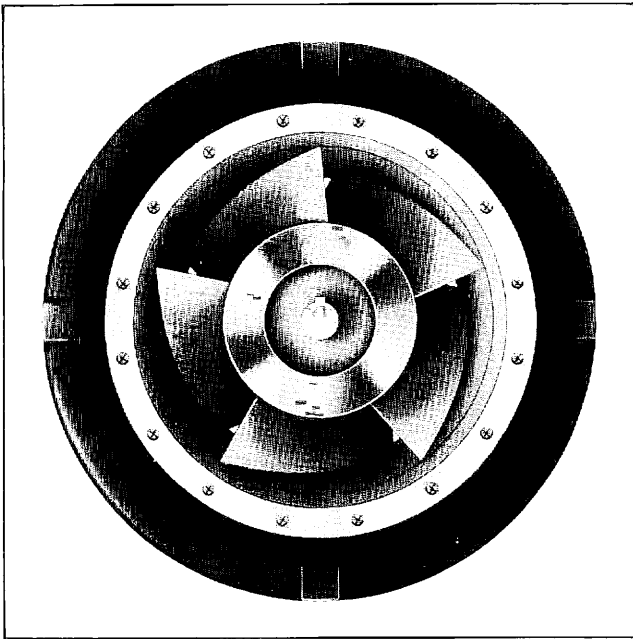


Figure 53. Mixed Flow Impeller

You'll need an ammeter to indicate power behavior. Assuming your power readings were within reason during first operation discussed in Section 13, stop the pump, remove the adjusting nut lock screw, and back the adjusting nut down to the next lock screw hole by turning the nut clockwise. Secure the lock screw and start the pump, observing power behavior on the ammeter. Repeat this, backing up one lock screw hole at a time until the ammeter first displays fluctuating power requirement. This tells you the impellers have contacted the bowl seats.

If the fluctuations are very slight and the power magnitude is acceptable, you've got the optimum setting. After some running time, the fluctuations should disappear as the impellers seat themselves.

If the power deviations are wide and the power peaks too high, the impellers are dragging too heavily. Raise the shaft slightly by turning the adjusting nut counter-clockwise one lock screw hole. Secure the lock screw and run the pump. This is your proper setting.

If the performance of your pump gradually falls off over a period of time and you're unable to find the explanation in the system, readjust the pump as described. If adjustment is the problem, you'll restore your original performance unless other changes have taken place. It's always a good idea to check the adjustment and readjust if necessary before running a performance test on the unit. This will give you a standard of comparison for the life of the equipment.

If you have any questions, your Aurora representative will be glad to help you. We wish you the best of service from your Aurora Verti-Line Mixed Flow Pump.

## SECTION 15

### PRECAUTIONARY INFORMATION

#### a. Responsibilities

There are certain areas in which Aurora Pump has no control and can therefore accept no liability. For instance, unless supervised by an Aurora Pump service engineer, responsibility for installation, start-up and maintenance rightfully belongs to the Owner and his authorized agents. Similarly, the following shall be the Owner's obligation and responsibility:

Suitability of foundation or mounting structure

Suitability of power characteristics

Security and safety of jobsite and site conditions

Placement and maintenance of all appropriate guards and safety devices

Suitability and performance of system to which pump is applied

Aurora Pump cannot be responsible for damages, lost time, or injury resulting from failure to comply with these instructions. Aurora Pump's obligations do not cover damage to the pump due to abrasives, gas, or corrosives in the water. They do not cover harm due to starting pump in a reverse rotation mode; neither do they cover performance when parts not furnished by Aurora are used in the pump.

If you have any question, please call your Aurora representative.

#### b. General Cautionary Notes

Your Aurora Verti-Line pump is an engineered assembly of precision parts and must be treated accordingly even though sometimes the components are heavy and awkward to manipulate. Also, because they may be heavy, they must never be handled carelessly. Normal rules of safety and approved methods of practice as associated with the erection of heavy equipment must be observed in any activity related to your pump.

In addition to general acceptable industrial practice, we emphasize the following twenty precautions:

Don't work on pumps, wiring, or any pump or system components without opening energizing circuits such as at main breaker or pump disconnect switch. This will prevent damage or injury due to "surprise" starts

actuated by automatic control systems. It will also help prevent other possibilities of injury.

Don't work under a suspended load. Rest the load on positive supports when it's necessary to be underneath.

Don't run a spherical roller thrust bearing except under full thrust load. It can fly apart and cause damage to equipment and injury to personnel.

Don't forget that this equipment contains rotating parts. Use CAUTION when working near such parts to avoid injury. Always replace all guards, covers, shields, and other safety devices before startup.

Don't permit smoking in the vicinity of petroleum base solvents. Store solvents in approved containers.

Don't use lubricants that can contaminate your system and cause damage or injury.

Don't start pump while it is still rotating in reverse direction after having shut down. It is advisable to install a time delay relay on electric drives to prevent this. Non-reverse protection in the driver could also be a solution.

Don't put heavier than recommended heaters in your starter if the pump load begins to trip those furnished originally. These are protective devices. Call your Aurora representative for assistance.

Don't add oil to driver while running; check levels only when idle. Don't add grease to grease lubricated driver without removing the relief plug.

Don't drop parts into pump during installation or disassembly. Don't drop parts into driver when canopy is off and top is open. Parts must be recovered immediately.

Don't run pump backward. Clockwise operation (looking down at top of pump) under power can unscrew threaded shaft joints. Power requirements of some designs increase when driven backward and can thus create undesirable overloads. In certain areas of the country prone to phase reversal problems, consider phase protection in your power circuit. Note: these problems do not apply to pumps coasting backward due to return flow from system; overspeed is the circumstance to question then.

Don't allow oil, grease, or thread lubricant to contact rubber bearings or tube stabilizers.

Don't pump anything but water unless your pump has been designed for it

Don't start the pump without proper adjustment.

Don't start a pump in which the shaft appears frozen or locked up. Free the shaft and rotate by hand first.

Don't pull system piping to pump flanges with bolts or capscrews. Install pipelines so that fasteners are used to prevent leakage only.

Don't hang the weight of suction or discharge lines and fittings on pump. Support pipe runs with blocking or concrete saddles according to best piping practice. Use dresser type couplings with thrust ties if necessary whenever possible to eliminate piping strains imposed on pump.

Don't throttle or obstruct the suction of any pump.

Don't tighten shaft packing except in increments. For example, take gland nuts up part of a turn and let pump run five or ten minutes before tightening further. If leakage water is too hot to put on your hand, back gland nuts off a little until water cools, then tighten again. Gland nuts must be adjusted evenly so as to prevent gland from cocking and forcing against shaft.

Don't change pump speed without first checking effect on power, internal pressure, and other conditions. Don't forget that your pump is guaranteed for design conditions only as purchased.

And let us add one more DON'T for the benefit of your pump and your peace of mind:

Don't hesitate to call your Aurora representative or the Aurora factory when you need help or have a question.

#### c. Operation at Shutoff Head

In the usual application of Aurora Verti-Line mixed flow pumps, no harm will result from operation at condition of static flow heads as long as you've prepared for that contingency. The following points should be checked and resolved before putting your equipment into operation at or near shutoff heads.

Impeller adjustment must be made at shutoff head.

Thrust bearing must be adequate.

If prolonged operation at no flow is contemplated, the problem of heat dissipation may become acute since most of the shutoff horsepower is converted to heat in the available liquid. This can be reduced with an adequate recirculation system.

Mixed flow impellers usually have critical power characteristics at low flow rates. Shutoff horsepower requirements should be reviewed for possible driver overload. If your pump will start against a closed valve, you'd better review and compare the speed torque curves of your pump and your driver for complete compatibility.

You must remember that open lineshaft units depend upon pumped liquid for lubrication. Fluid temperatures, if raised excessively due to lack of flow, may impair lubrication efficiency even to the point of destroying the pump.

To summarize, normal designs will easily accommodate most of the considerations listed above. However, to obtain the best possible application, you must notify the factory at the time of purchase if operation at static flow heads will be a possibility. This precaution must be observed to validate any warranty.

#### d. Maintenance Hints

For pump oil lubrication, use a light turbine oil equivalent to Standard Oil O. C. Turbine Oil #32 or a good grade of mineral oil with proper additives having a viscosity equal to SAE #10. Always be sure your lubrication system has plenty of oil and is operating any time the pump is running.

Remove the old oil from your driver at least once a year or according to the driver manufacturer's instructions. Flush with kerosene and refill. Follow manufacturer's directions carefully as to method and type of lubricant. Replace self lubricated driver ball bearings in about five years. It is generally less expensive to replace these before they fail.

Replace all shaft packing on open lineshaft pumps after maintenance has required the addition of no more than two rings. Always let packing box leak slightly at top of gland to protect the shaft and add life to your packing.

Be aware of changing conditions in your system. Any change from the original condition or any variation in the system can create an undesirable reaction in the pump as the energizer of the system. If your system head has increased, for example, check your performance curve, your thrust bearing capacity, and other details for the new conditions.

We recommend you consult your Aurora representative before attempting to remove or repair your pump. If it becomes necessary to work on your equipment, be sure to review all instructions for operation and maintenance. You may want to consider contracting for the services of a trained Aurora service engineer to guide you.

# NOTES

All orders shall be made out to Aurora Pump at North Aurora, Illinois, and shall be subject to acceptance by us at North Aurora.

**1. CONSTRUCTION AND LEGAL EFFECT.** Our sale to you will be solely upon the terms and conditions set forth herein. They supersede and reject any conflicting terms and conditions of yours, any statement in yours to the contrary notwithstanding. Exceptions to any of our terms and conditions must be contained in a written or typed (not printed) statement received from you; we shall not be deemed to have waived any of our terms and conditions or to have assented to any modification or alteration of such terms and conditions unless such waiver or assent is in writing and signed by an authorized officer. No representation of any kind has been made by us except as set forth herein; this agreement conclusively supersedes all prior writings and negotiations with respect thereto and we will furnish only the quantities and items specifically listed on the face hereof; we assume no responsibility for furnishing other equipment or material shown in any plans and/or specifications for a project to which the goods ordered herein pertain. Any action for breach of contract must be commenced within one year after the cause of action has accrued. Our published or quoted prices, discounts, terms and conditions are subject to change without notice.

**2. PRICES.** Unless otherwise noted on the face hereof, prices are net F.O.B. our producing factory, and include standard catalogue literature only. Service time of a factory-trained service man is not included and may be charged extra. The amount of any applicable present or future tax or other government charge upon the production, sale, shipment or use of goods ordered or sold will be added to billing unless you provide us with an appropriate exemption certificate. We may adjust prices to our prices in effect at time of shipment. Purchased equipment such as motors, controls, gasoline engines, etc., will be invoiced at prices in effect at time of shipment in accordance with pricing policy of manufacturer.

**3. DEFECTIVE EQUIPMENT.** Providing Purchaser notifies us promptly, if within one year from date of shipment equipment or parts manufactured by us fail to function properly under normal, proper and rated use and service because of defects in material or workmanship demonstrated to our satisfaction to have existed at the time of delivery, the Company reserving the right to either inspect them in your hands or request their return to us will at our option repair or replace at our expense F.O.B. our producing factory, or give you proper credit for such equipment or parts determined by us to be defective, if returned transportation prepaid by Purchaser. The foregoing shall not apply to equipment that shall have been altered or repaired after shipment to you by anyone except our authorized employees, and the Company will not be liable in any event for alterations or repair except those made with its written consent. Purchaser shall be solely responsible for determining suitability for use and the Company shall in no event be liable in this respect. The equipment or parts manufactured by others but furnished by us will be repaired or replaced only to the extent of the original manufacturer's guarantee. Our obligations and liabilities hereunder shall not be enforceable until such equipment has been fully paid for. Purchaser agrees that if the products sold hereunder are resold by purchaser, he will include in the contract for resale, provisions which limit recoveries against us in accordance with this section. In case of our failure to fulfill any performance representation, it is agreed that we may at our option remove and reclaim the equipment covered by this agreement at our own expense and discharge all liability by repayment to the purchaser of all sums received on account of the purchase price. (THE FOREGOING OBLIGATIONS ARE IN LIEU OF ALL OTHER OBLIGATIONS AND LIABILITIES INCLUDING NEGLIGENCE AND ALL WARRANTIES, OF MERCHANTABILITY OR OTHERWISE, EXPRESS OR IMPLIED BY FACT OR BY LAW, AND STATE OUR ENTIRE AND EXCLUSIVE LIABILITY AND BUYER'S EXCLUSIVE REMEDY FOR ANY CLAIM OF DAMAGES IN CONNECTION WITH THE SALE OR FURNISHING OF GOODS OR PARTS, THEIR DESIGN, SUITABILITY FOR USE, INSTALLATION OR OPERATION.) WE WILL IN NO EVENT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES OR DELAY RESULTING FROM ANY DEFECT WHATSOEVER, AND OUR LIABILITY UNDER NO CIRCUMSTANCES WILL EXCEED THE CONTRACT PRICE FOR THE GOODS FOR WHICH LIABILITY IS CLAIMED.

**4. DELIVERY.** Delivery, shipment and installation dates are estimated dates only, and unless otherwise specified, are figured from date of receipt of complete technical data and approved drawings as such may be necessary. In estimating such dates, no allowance has been made, nor shall we be liable directly or indirectly for, delays of carriers or delays from labor difficulties, shortages, strikes or stoppages of any sort, fires, accidents, failure or delay in obtaining materials or manufacturing facilities, acts of government affecting us directly or indirectly, bad weather, or any causes beyond our control or causes designated Acts of God or force majeure by any court of law, and the estimated delivery date shall be extended accordingly. We will not be liable for any damages or penalties whatsoever, whether direct, indirect, special or consequential, resulting from our failure to perform or delay in performing unless otherwise agreed in writing by an authorized officer.

**5. OPERATING CONDITIONS AND ACCEPTANCE.** Recommendations and quotations are made upon the basis of operating conditions specified by the Purchaser. If actual conditions are different than those specified and performance of the equipment is adversely affected thereby, Purchaser will be responsible for the cost of all changes in the equipment required to accommodate such conditions, and we reserve the right to cancel this order and Purchaser shall reimburse us for all costs and expenses incurred in, and reasonable profit for, performance hereunder. We reserve the right to refuse any order based upon a quotation containing an error. The provisions in any specification or chart are descriptive only and are not warranties or representations; we will certify to a rated capacity in any particular product upon request. Capacity, head and efficiency certifications are based on shop tests and when handling clear, fresh water at a temperature of not over 85°F. Certifications are at this specified rating only and do not cover sustained performance over any period of time nor under conditions varying from these.

**6. SHIPPING.** Unless you specify otherwise in writing, (a) goods will be boxed or crated as we may deem proper for protection against normal handling, and extra charge will be made for preservation, waterproofing, export boxing and similar added protection of goods; (b) routing and manner of shipment will be at our discretion, and may be insured at your expense, value to be stated at order price. On all shipments F.O.B. our producing factory, delivery of goods to the initial carrier will constitute delivery to you and all goods will be shipped at your risk. A claim for loss or damage in transit must be entered with the carrier and prosecuted by you. Acceptance of material from a common carrier constitutes a waiver of any claims against us for delay or damage or loss.

**7. PATENT INFRINGEMENT.** We will not be liable for any claim of infringement unless due to infringement by goods manufactured by us in the form in which we supply such goods to you and without regard to their use by you. If you notify us promptly of any such claim of infringement and, if we so request, authorize us to defend or settle any suit or controversy involving such claim, we will indemnify you against the reasonable expenses of any such suit and will satisfy any judgment or settlement in which we acquiesce, but only to an amount not exceeding the price paid to us for the allegedly infringing goods. If an injunction is issued against the further use of allegedly infringing goods we shall have the option of procuring for you the right to use the goods, or replacing them with non-infringing goods, or modifying them so that they become non-infringing, or of removing them and refunding the purchase price. The foregoing expresses our entire and exclusive warranty and liability as to patents, and we will not be liable for any damages whatsoever, suffered by reason of any infringement claimed, except as provided herein. You will hold us harmless and indemnified against any and all claims, demands, liabilities, damages, costs and expenses resulting from or connected with any claim of patent infringement arising out of the manufacture by us of goods in accordance with a design or specifications which you furnish us.

**8. CANCELLATION AND RETURNED EQUIPMENT.** Orders may be cancelled only with our written consent and upon payment of reasonable and proper cancellation charges. Goods may be returned only when specifically authorized and you will be charged for placing returned goods in saleable condition, any sales expenses then incurred by us, plus a restocking charge and any outgoing and incoming transportation costs which we pay.

**9. CREDIT AND PAYMENT.** Payment for products shall be 30 days net. Pro-rata payments shall become due with partial shipments. A late charge of 1½ percent per month or the maximum permitted by law, whichever is less, will be imposed on all pastdue invoices. We reserve the right at any time to alter, suspend, credit, or to change credit terms provided herein, when in its sole opinion your financial condition so warrants. In such a case, in addition to any other remedies herein or by law provided, cash payment or satisfactory security from you may be required by us before shipment; or, the due date of payment by you under this contract may be accelerated by us. Failure to pay invoices at maturity date at our election makes all subsequent invoices immediately due and payable irrespective of terms, and we may withhold all subsequent deliveries until the full account is settled, and we may terminate this agreement. Acceptance by us of less than full payment shall not be a waiver of any of our rights. You represent by sending each purchase order to us that you are not insolvent as that term is defined in applicable state or federal statutes. In the event you become insolvent before delivery of any products purchased hereunder, you will notify us in writing. A failure to notify us of insolvency at the time of delivery shall be construed as a reaffirmation of your solvency at that time. Irrespective of whether the products purchased hereunder are delivered directly to you, or to a customer of yours, and irrespective of the size of the shipment, we shall have the right to stop delivery of the goods by a bailee if you become insolvent, repudiate, or fail to make a payment due before delivery, or if for any other reason we have a right to withhold or reclaim goods under the applicable state and federal statutes. Where you are responsible for any delay in shipment the date of completion of goods may be treated by us as the date of shipment for purposes of payment. Completed goods shall be held at your cost and risk and we shall have the right to bill you for reasonable storage and insurance expenses.

**10. SPECIAL JIGS, FIXTURES AND PATTERNS.** Any jigs, fixtures, patterns and like items which may be included in an order will remain our property without credit to you. We will assume the maintenance and replacement expenses of such items, but shall have the right to discard and scrap them after they have been inactive for one year without credit to you.

**11. INSPECTION.** Inspection of goods in our plant by you or your representative will be permitted insofar as this does not unduly interfere with our production workflow, provided that complete details of the inspection you desire are submitted to us in writing in advance.

**12. RECORDS, AUDITS AND PROPRIETARY DATA.** Unless otherwise specifically agreed in writing signed by an authorized officer, neither you nor any representative of yours, nor any other person, shall have any right to examine or audit our cost accounts, books or records of any kind or on any matter, or be entitled to, or have control over, any engineering or production prints, drawings or technical data which we, in our sole discretion, may consider in whole or in part proprietary to ourselves.