

2.4 Installation, operation and maintenance

Vertical pumps, when properly installed and operated, and when given reasonable care and maintenance, will operate satisfactorily for a long period of time. The following paragraphs outline the general principles that must be considered to insure trouble-free pump operation.

Vertical pumps are built in a wide variety of designs and for many different services. The manufacturer's instruction book should be studied carefully and followed, as there may be specific requirements for a particular machine or application which cannot be covered in a general discussion.

2.4.1 Pre-installation instructions

2.4.1.1 Unloading/inspecting equipment received

Immediately upon receipt of the pump equipment, check carefully to see that all items have been received and are in undamaged condition. Report any shortage or damage to the transport company handling the shipment and the equipment manufacturer, noting the extent of damage or shortage on the freight bill and bill of lading. This should be done at once. Particular care and close adherence to the manufacturer's recommendations are required when unloading long, slender components such as shafting. Improper placements of slings or chains can result in deformation or other serious damage. Do not leave the unit exposed to weather or construction hazards, which may cause damage to the equipment.

2.4.1.2 Storing equipment at site

2.4.1.2.1 Short-term

The pump and equipment, as shipped, have adequate protection for short-term storage in a covered, dry and ventilated location at the job site prior to installation.

2.4.1.2.2 Long-term

If the equipment will be subject to extended storage conditions prior to installation, then the manufacturer must be advised about storage duration, so that special protection can be provided for the equipment. Periodic rotation of the pump and driver shaft is recommended during long-term storage.

2.4.1.3 Handling equipment and tools for installation

For typical installations, the following equipment must be available at the job site when installing or removing the pump: Suitable overhead lifting equipment of adequate capacity to lift the driver, the entire pump (without driver) or the heaviest subassembly of the pump. Adequate headroom must be provided to accommodate the longest section of the pump to be handled, including rigging.

Properly sized slings, chains and shackles for attaching to the equipment lifting lugs. Eye bolts are required for handling pump sections when lifting lugs are not provided.

I-beams for supporting pump subassemblies at the foundation when it is necessary to install the pump in sections. Common millwright's tools are used for this type of work, including a machinist level to insure proper leveling of the foundation plate.

2.4.1.4 Manufacturer's instructions

The Installation and Service Manual and/or special instructions included in the shipment should be read thoroughly before installing or operating the equipment. All instructions should be retained for reference regarding maintenance and operation.

2.4.1.5 Use of manufacturer's service personnel

It is recommended that the services of a manufacturer's erecting engineer be employed for supervising installation and start-up of the pumping equipment, when such equipment is custom-engineered or of a costly, high-precision type. This is to assure that the machinery is properly installed. The purchaser then also has the opportunity to review and see implemented factory-recommended instructions.

2.4.1.6 Site preparation; protection against elements/environment

A clean, drained area must be provided next to the point of installation, of adequate size for placing the pump components and driver in the sequence in which they will be installed. Protective covers should be left on all pump openings until the time of actual installation, to prevent dirt and foreign objects from entering the pump. Protective coatings should likewise be left on machined

surfaces to prevent rusting. For outdoor installations, the components should be covered with rainproof tarps during the period of installation for protection against the elements. This is particularly important during freezing conditions, to prevent water from collecting in pump cavities and perhaps causing freezing damage.

2.4.1.7 Foundation requirements (forces and mass requirements)

The mass of the foundation must be sufficient, preferably five times that of the rotating element of the pumping equipment, to form a permanent, rigid support for the base plate. This is equally important whether the pump is installed over a pit or over a well. Base plate and foundation bolt sizing is critical, particularly on high-pressure pumps, to adequately restrain reaction forces such as from directional flow change, system transients and sudden valve closure. Foundation bolts should be embedded in the concrete, located by a drawing or template. A pipe sleeve larger than the bolt should be used to allow movement for final positioning of the bolts. (See Figure 2.34).

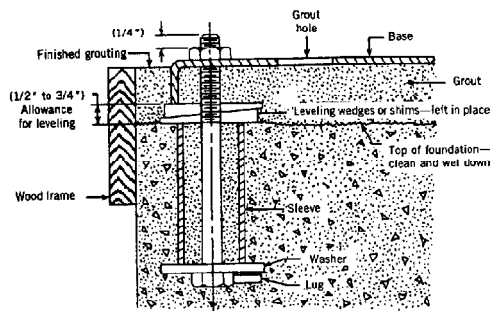


Figure 2.34 — Typical foundation bolt design

2.4.1.8 Access for maintenance and repair

All pumps require regular maintenance. It is therefore important to locate pump discharge piping (and suction piping when applicable), as well as auxiliary equipment, control and starting panels in such a manner that adequate access is provided for maintenance. Adequate floor space and working room must also be provided for repair, including parts placement.

2.4.2 Installation

2.4.2.1 Checking wells

When vertical pumps, either of the lineshaft or submersible type, are to be installed in wells,

consideration must be given to the well before application and installation (See Figure 2.35).

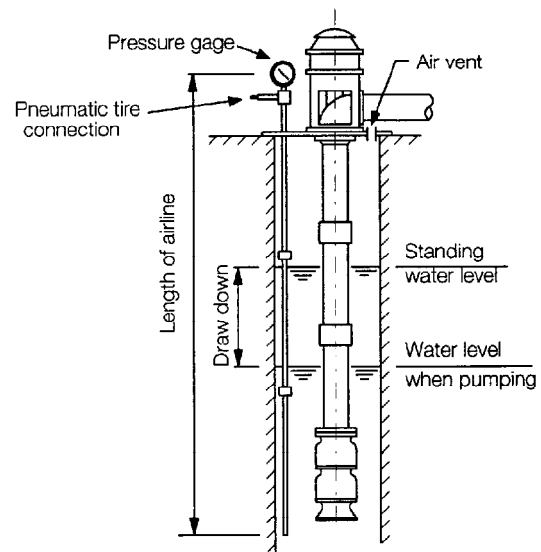


Figure 2.35 — Typical deep well type installation

Installing a unit in a crooked well may bind and distort the pump column or pump-motor assembly with potential resulting malfunction. Well straightness should be within one inch per hundred feet and without double bend. If straightness is in doubt, the well should be "gauged" prior to installation by lowering a dummy assembly, slightly longer and larger on the diameter than the actual pump or pump-motor assembly, on a cable. Gauging is also important when a stepped well casing is used, with the lower part of the well casing having a smaller inside diameter.

Wells that have not been properly constructed or developed, or which produce sand, can be detrimental to a pump. If a well is suspected of producing an excessive amount of sand, a unit other than the production pump should be used to clear the well.

2.4.2.2 Checking wet pits

Before starting the installation of pumps in an open pit, there are several checks that can be made. The configuration of the intake structure is now fixed and should be in conformance with the

general guidelines provided in Paragraph 2.3.5 in the Design and Application section. Dimensional checks should be made as follows to preclude installation and servicing problems.

- 1) Length of pump vs. depth of sump;
- 2) Correct fit of anchor bolts to sole plate and of the sole plate to the pump mounting base;
- 3) Satisfactory angular location of anchor bolts or correct lineup of discharge head to discharge piping;
- 4) Proper conduit location provided for driver;
- 5) Sufficient head room for handling.

2.4.2.3 Locating pump

The pump should be located so that a short, direct discharge pipe, with the least number of elbows and fittings, may be used to minimize head loss from friction. If practical, it should be placed so that it will be accessible for inspection during operation. The equipment selected should be compatible with the environment. Pumps and drivers, other than submersible types, and controls should be protected against flooding.

2.4.2.4 Entrained air

Entrained air reduces pump performance, with amounts as small as 1% by volume affecting radial flow pumps and 3% to 5% of entrained air affecting axial flow pumps. Cascading water causing air entrainment must therefore be avoided. For well pumps, the perforated casing must be located below the pump suction. Return lines into sumps or tanks should terminate a minimum of two pipe diameters below the low liquid level. Undersized or partially blocked intake screens and trash racks result in similar problems, caused by excess pit velocity. Adequate provisions for cleaning rotating screens and trash racks must be made.

2.4.2.5 Pump leveling/plumbness

Vertical lineshaft and submersible pumps are automatically aligned through registered fits. However, on lineshaft pumps, it is recommended to check the alignment of the head shaft to the driver at the time the latter is mounted.

When the base plate has been correctly leveled, it should be supported on rectangular metal blocks and shims or on metal wedges having a small taper. The support pieces should be placed close to the foundation bolts (See Figure 2.36).

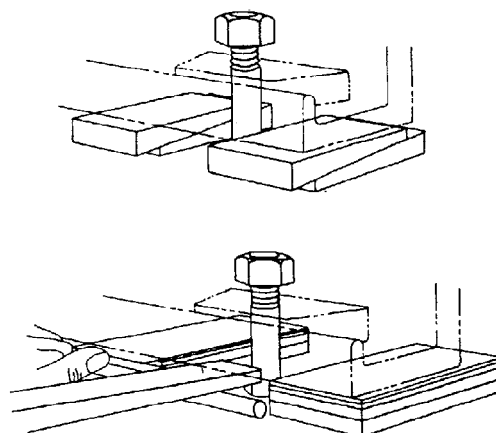


Figure 2.36 — Method of leveling

On large units, small jacks made of cap screws and nuts are often convenient. A gap of about 1 to 2 inches (25 to 50 mm) should be allowed between the base plate and the foundation for grouting.

Submersible pumps do not require special alignment at the foundation. However, solid support must be provided for the surface plate from which the unit is suspended, and a water tight seal may also be required to prevent well contamination.

2.4.2.6 Lining up pump discharge

The leveling or plumbness of a vertical lineshaft pump is established during pump installation. Slightly out of plumb wells or minor out of level foundations require the pumps to be lined up as described in Paragraph 2.4.4.2 of this Section.

The discharge pipe should be brought up to the pump discharge so that a very minimum of pipe strain is transferred to the pump.

2.4.2.7 Grouting

When the alignment is correct, the foundation bolts should be tightened evenly but not too firmly. The unit can then be grouted to the foundation. It is desirable to grout the leveling pieces, shims or wedges in place. Foundation bolts should not be fully tightened until the grout is hardened, usually about 48 hours after pouring.

2.4.3 Suction and discharge piping

2.4.3.1 Pipe supports/anchors/joints

Suction and discharge piping must be anchored, supported and restrained near the pump to avoid application of forces and moments in excess of those permitted by the pump manufacturer.

In calculating forces and moments, the weights of the pipe, contained fluid and insulation, as well as thermal expansion and contraction, must be considered.

If an expansion joint is installed in the piping between the pump and the nearest anchor in the piping, a force equal to the area of the expansion joint times the pressure in the pipe will be transmitted to the pump. Pipe couplings which are not axially rigid have the same effect. This force may be larger than can be safely absorbed by the pump or its support system.

It is therefore recommended that a pipe anchor be installed between an expansion joint and the pump to absorb the axial force.

When proper anchoring cannot be provided, adequate tie rods must be provided and properly adjusted to protect the pump and the expansion joint. Cast iron and nonmetallic pump flanges are usually made with flat faces. To avoid breaking the flange when tightening the bolting, mating pipe flanges should also have flat faces, and a full-face gasket should be used.

2.4.3.2 Suction piping requirements

A vertical pump in a suction barrel performs properly only if it is supplied with a steady flow of liquid arriving at the pump suction flange with sufficient pressure to provide adequate NPSH to the pump and with a uniform velocity profile.

Failure of the suction piping to deliver the liquid to the pump in this condition can lead to noisy operation, swirling of liquid around the suspended pump assembly, premature bearing failure, and cavitation damage to the impeller and inlet portions of the casing.

For pumps operating with suction pressure below atmospheric pressure, or handling fluids near their vapor pressure, the suction line should slope constantly upwards toward the pump to avoid trapping vapor using eccentric reducers where necessary (see Figure 2.37).

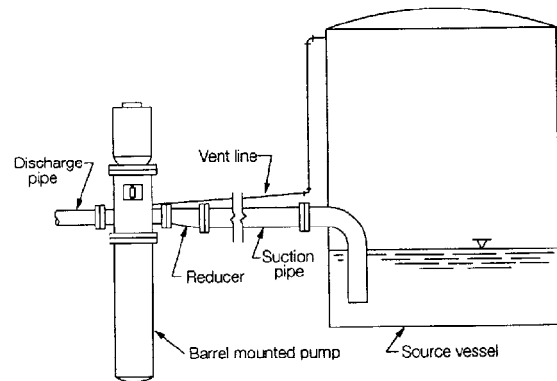


Figure 2.37 — Eccentric reducer

In systems where the suction line is not always kept full of liquid, there is a possibility that a large slug of air or vapor may be swept into the pump during a restart, causing a partial or complete loss of pump prime. Any high point in a suction line will accumulate gas with similar results. Any valves in the suction line should be installed with their shafts horizontal, to avoid air pockets in the valve body.

When it is required to prime the pump before start-up, then the priming connections should be at the high point of the pump suction chamber. A permanent vent line back to the suction source at this point may also be desired for pumps operating in a closed system.

2.4.3.3 Pipe reducers

Reducers are installed just ahead of the pump suction when the pipe is larger than the pump nozzle. Reducers used at the pump suction should be of the conical type and sufficiently long to prevent fluid turbulence. Contour type reducers are not recommended.

With the liquid source below the pump, the reducer must be eccentric and installed with the level side up (see Figure 2.37).

Eccentric or concentric reducers may be used when the liquid source is above the pump and the suction piping is sloping upward towards the source.

2.4.3.4 Suction valves

Check valves used to prevent backflow should not be used in the suction line. They are sometimes used in series-parallel connections to reduce the number of valves which must be operated when changing from one type of operation to the other.

Block valves may be installed in order to be able to isolate the pump for maintenance.

Foot valves are specially designed check valves sometimes used at the inlet to bowl assemblies for well pumps to keep the column water filled and to prevent backspin and well disturbance from rapidly draining water.

2.4.3.5 Strainers

To keep unwanted solids out of the pump, strainers may be installed at the suction bell or in the pump suction piping. The strainer itself usually introduces only a moderate pressure drop, but as debris accumulates, the pressure drop will increase. It is therefore recommended that pipe-mounted strainers be installed with upstream and downstream pressure taps and that the pressure drop be monitored.

Suction bell strainers typically clear themselves by backflow in the pump column when the unit is stopped. For large pumps, trash racks and screens are typically part of the intake structure.

2.4.3.6 Elbow at pump suction

When a straight run of pipe at the pump suction cannot be provided, certain arrangements of fittings must be avoided for vertical pumps installed in suction barrels. When liquid flows through an elbow, or makes a turn through a tee, the exit velocity will be strongly non-uniform. Elbows with a plane perpendicular to the pump can should therefore not be used, since a strong vortex motion can be set up in the fluid in the pump barrel. This could lead to a swirling motion in the suspended pump and result in bearing failure, noisy operation and cavitation damage in the first stage of the pump assembly. Splitters inside the pump barrel can be used to break up the fluid swirl.

2.4.3.7 Suction tanks

In many process applications, a suction line may be taken off the side or bottom of a process or storage vessel. When this is done, it is necessary to ensure that the submergence level over the inlet to the suction pipe is adequate to prevent

vortexing. Figure 2.26 in the Design and Application section indicates reasonable minimum values of submergence over the inlet as a function of capacity. If operating levels of liquid in the vessel cannot provide the required submergence at the planned line velocities, then the size of the inlet must be increased as necessary to reduce the velocity to the point where the submergence is adequate.

2.4.3.8 Discharge valves

A check valve and an isolation valve should be installed in the discharge line. The check valve serves to protect the pump from reverse flow and excessive back pressure. The isolation valve is used in priming, starting and when shutting down the pump. Except on axial flow and mixed flow pumps, it is advisable to close the isolation valve before stopping or starting the pump. If increasers are used on the discharge side of the pump to increase the size of piping, they should be placed between the check valve and the isolation valve. If expansion joints are used, they should be placed between the check valve and pump. (See Figure 2.38)

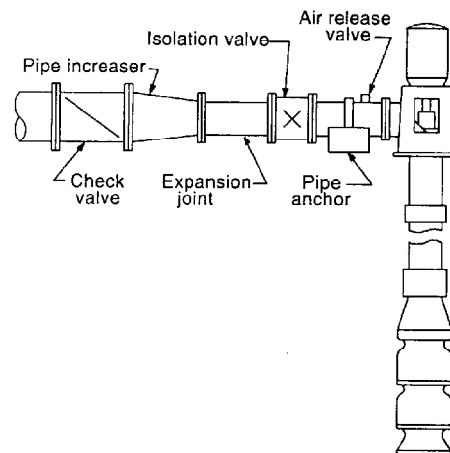


Figure 2.38 — Discharge valve expansion joint

2.4.3.9 Air release valves

For medium and large size vertical wet pit pumps pumping into a pressurized system, an automatic air and vacuum release valve is recommended.

The valve should be located on the pump discharge nozzle or between the pump discharge nozzle and the discharge valve or check valve, whichever is closest.

The release valve prevents a large volume of air from being compressed, and then setting up a severe shock wave when suddenly released, with potential for serious equipment damage. The air release valve also prevents undesirable air from entering the pressurized system.

2.4.3.10 Siphons

When a siphon is used in the pump discharge line, for the purpose of reducing the head requirement for applications such as pumping over a levee, additional equipment requirements are imposed for the system to function satisfactorily.

To clear the siphon of air and make it operational, either a vacuum pump or an air ejector must be provided, or the pump and driver must be suitable for handling the higher head with adequate flow until the siphon is cleared. For high specific speed pumps, this may result in a significant increase in required brake horsepower. Additionally, if the height of the siphon above the discharge water level is substantial, then the flow from the pump at the increased head requirement may not be sufficient to clear the siphon, and a vacuum pump assist is required.

A siphon breaker must be mounted at the high point of the siphon to prevent backflow when the pump is stopped.

2.4.4 Mounting and alignment of drivers

2.4.4.1 Mounting and alignment of vertical solid shaft drivers

Before mounting the driver on the discharge head/driver stand, check the register fit, if furnished, and the mounting face on the driver for acceptable tolerance on runout and squareness respectively, using a dial indicator mounted on the driver shaft. Next, check the squareness of the face of the driver coupling half, mounted on the shaft with a tight fit and seated against a split ring, using a dial indicator on a firm base.

With the driver bolted to the discharge head, mount a dial indicator on the driver shaft above the coupling half and sweep the bore of the stuffing-box. If excess runout exists, some adjustment can be made at the driver mounting fit and the stuffing-box mounting fit. Before installing any

additional coupling parts, check the driver for correct rotation, as given in the manufacturer's installation instructions. Next, mount the pump half coupling, shaft adjusting nut and coupling spacer if applicable, and raise the impeller in accordance with the manufacturer's instructions. Then secure the coupling bolts. Make a final check of the shaft runout below the pump half coupling with a dial indicator. If the runout is within acceptable tolerances, check the tightness of the driver hold-down bolts. If dowels are used to secure the driver location, then it should be noted that redoweling is required after disassembly/reassembly, since tolerance buildup in the multiple vertical joints results in alignment variation.

2.4.4.2 Mounting and alignment of vertical hollow shaft drivers

Remove the clutch or coupling from the top of the hollow shaft, and mount the driver on top of the discharge head/driver stand. For designs requiring the pump head shaft to be installed prior to mounting the driver, lower the hollow shaft driver with care over the head shaft to be sure the latter is not damaged. Check the driver for correct rotation, as given in the manufacturer's installation instructions. Install the head shaft, if not already done, and check it for centering in the hollow shaft. If off-center, check for runout in head shaft, misalignment from discharge head to driver, or out of plumbness of the suspended pump. Shims can be placed under the discharge head to center the head shaft, but shims should not be placed between the motor and the discharge head.

Install the driver coupling or clutch, and check the non-reverse ratchet for operability, if furnished. Install the coupling gib key and the adjusting nut, and raise the shaft assembly with the impeller(s) to the correct running position in accordance with the manufacturer's instructions. Secure the adjusting nut to the clutch, and double-check the driver hold-down bolts for tightness.

Most hollow shaft drivers have register fits. Further centering of these drivers is therefore normally not required, nor are dowels recommended.

2.4.5 Preparing the stuffing-box

2.4.5.1 Packed stuffing-box

The stuffing box may or may not be packed before shipment from the factory. If the stuffing box is not packed, it should be carefully cleaned and packed

once the motor is mounted and connected to the head. Instructions are usually provided with the box of packing. If not, the following may be used as a guide.

Each packing ring should be cut so that the ends come together but do not overlap. Succeeding rings of packing should be placed so that the joints are staggered. Packing rings should be tamped down individually, but not too tightly, as this may result in burning the packing and scoring of the shaft or shaft sleeve. When the pump is first started, the gland should be left fairly loose. Once the pump is operating normally, the gland may be tightened while the pump is running, if the leakage is excessive. A slight flow of liquid, about 60 drops per minute, from the stuffing-box is necessary to provide lubrication and cooling.

When the leakage can no longer be controlled by adjusting the gland, all rings of packing should be replaced. The addition of a single ring to restore gland adjustment is not recommended.

If a pump has been left idle for a long period of time, it is recommended that the packing be replaced.

If the liquid to be pumped is dirty, gritty, toxic or corrosive, sealing liquid should be piped to the lantern ring in the stuffing-box from a clean source of supply in order to prevent damage and/or hazardous conditions. Sealing liquid should be at a pressure sufficient to insure a small flow of clean

liquid into the pump, but not so high as to require excessive tightening of the packing.

When a lantern ring is provided, be sure that sufficient packing is placed below the lantern ring, so that the liquid for sealing is brought in at the lantern ring and not at the packing. The pipe supplying the sealing liquid should be fitted tightly so that no air enters. This is particularly important for vertical barrel pumps mounted in a system where a vacuum must be maintained. (See Figure 2.41).

For applications with suspended abrasives, the lantern ring should be placed at the bottom of the stuffing-box below the packing.

2.4.5.2 Mechanical seals

Pumps handling hazardous or expensive liquids, or where normal leakage from the stuffing-box is objectionable, are often furnished with mechanical seals.

Mechanical seals for vertical pumps are of two basic types, depending on whether mounting is to be external or internal. Externally mounted seals are easily adjusted for correct positioning after the impeller(s) is (are) set for correct running clearance. Mechanical seals mounted internally in the stuffing-box, unless of the cartridge type, must be mounted on a shaft sleeve and the sleeve correctly positioned and locked to the shaft after the impeller(s) is (are) lifted for proper running clearance.

Since mechanical seals are made in a wide variety of designs, the instructions for installing and operating a specific seal must be carefully studied and followed. A mechanical seal is a precision device and must be treated accordingly. Particular attention must be paid to any injection or recirculating piping required.

There are two features that can simplify change-out of worn seals. The first is the use of a spacer coupling in the head shaft of the pump. This allows removal of the seal/sleeve assembly without removing the driver. The second is use of an axially split mechanical seal. Change-out of this design does not require any disassembly of the pump.

2.4.6 Pre-lubrication

2.4.6.1 Primary and secondary drivers

Before running the driver, either separately or connected to the pump, check lubrication require-

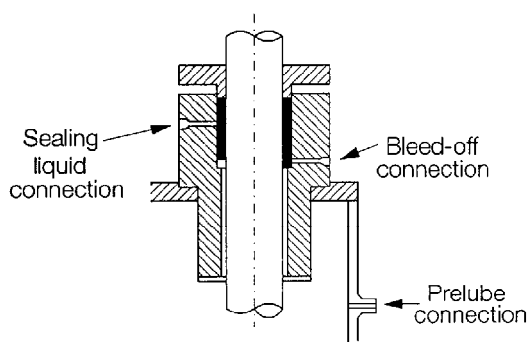


Figure 2.39 — Packed type stuffing box