PUMP CLINIC 7

INSTALLATION AND PIPING

INSTALLATION

Instruction Books

Instruction books are intended to help keep the pumps in an efficient and reliable condition at all times. It is necessary, therefore, that instruction books be available to all personnel involved in this function.

Preparation for Shipment

After a pump has been assembled in the manufacturer's shop, all flanges and exposed machined metal surfaces are cleaned of foreign matter and treated with an anti-corrosion compound, such as grease, Vaseline, or heavy oil. For protection during shipment and erection, all pipe flanges, pipe openings and nozzles are protected by wooden flange covers or by screwed-in plugs.

Usually the driver is delivered to the pump manufacturer, where it is assembled and aligned with the pump on a common baseplate. The baseplate is drilled for driver mounting, but the final dowelling is performed in the field after final alignment. When size and weight permit, the unit is shipped assembled with pump and driver on the baseplate. If drivers are shipped directly to be mounted in the field, the baseplate should be drilled at the job site.

Care of Equipment in the Field

If the pumping equipment is received before it can be used, it should be stored in a dry location. The protective flange covers and coatings should remain on the pumps. The bearings and couplings must be carefully protected against sand, grit and other foreign matter.

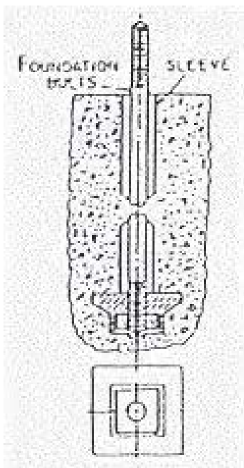
More thorough precautions are required if a pump must be stored for an extended period of time. It should be carefully dried internally with hot air or by a vacuum-producing device to avoid rusting of internal parts. Once free of moisture, the pump internals should be coated with protective liquid such as light oil, kerosene or antifreeze. Preferably, all accessible parts, such as bearings and couplings, should be dismantled, dried and coated with Vaseline or acid-free heavy oil and then properly tagged and stored.

If rust preventive has been used on stored parts, it should be removed completely before final installation and the bearings should be relubricated.

Pump Location

Working space must be checked to assure adequate accessibility for maintenance. Axially-split casing horizontal pumps require sufficient headroom to lift the upper half of the casing free of the rotor. The inner assembly of radially split multistage centrifugal pumps is removed axially. Space must be provided so that the assembly can be pulled out without canting it. For large pumps with heaving casings and rotors, a travelling crane or other facility for attaching a hoist should be provided over the pump location.

Pumps should be located as close as practicable to the source of liquid supply. Wherever possible, the pump centreline should be placed below the level of the liquid in the section reservoir.



(Figure 1 - Foundation bolt)

Foundations

Foundations may consist of any structure heavy enough to afford permanent rigid support to the full area of the baseplate and to absorb any normal strains or shocks. Concrete foundations built up from solid ground are the most satisfactory. Although most pumping units are mounted directly on baseplates, very large equipment may be mounted directly on the foundations by using sole plates under the pump and driver feet. Misalignment is corrected with shims.

The space required by the pumping unit and the location of the foundation bolts is determined from the drawings supplied by the manufacturer. Each foundation bolt should be surrounded by a pipe sleeve three or four diameters larger than the bolt. After the concrete foundations are poured, the pipe is held solidly in place but the bolt may be moved to conform to the corresponding hole in the baseplate.

When a unit is mounted on steelwork or some other structure, it should be placed directly over, or as near as possible to, the main members, beams or walls and should be supported so that the baseplate cannot be distorted or the alignment disturbed by any yielding or springing of the structure, or of the baseplate.

Mounting of vertical wet-pit pumps

A curve ring or soleplate must be used as a bearing surface for the support flange of a vertical wet-pit pump. The mounting face must be machined because the curb ring or soleplate will be used in aligning the pump.

If the discharge pipe is located below the support flange of the pump (belowground discharge), the curb ring or soleplate must be large enough to pass the discharge elbow during assembly. A rectangular ring should be used. If the discharge pipe is located above the support flange (aboveground discharge), a round curb ring or soleplate should be provided with clearance on its inner diameter to pass all sections of the pump below the support flange. A typical method of arranging a grouted soleplate for vertical pumps is shown below.

If the discharge is belowground and an expansion joint is used, it is necessary to determine the movement that may be imposed on the structure. The pump casing should be attached securely to some rigid structural members with tie rods. If vertical wet-pit pumps are very long, some steadying device is required irrespective of the location of the discharge or of the type of pipe connection. Tie rods can be used to connect the unit to a wall, or a small clearance around a flange can be used to prevent excessive displacement of the pump in the horizontal plane.

Alignment

When a complete unit is assembled at the factory, the baseplate is placed on a flat, even surface. The pump and driver are mounted on the baseplate and the coupling halves are accurately aligned using shims under the pump and driver mounting surfaces where necessary. The pump is usually dowelled to the baseplate at the factory, but the driver is left to be dowelled after installation at the site.

The unit should be supported over the foundation by short strips of steel plate or shim stock close to the foundation bolts, allowing a space of ¾ to 2 inches (2 to 5 cm) between the bottom of the baseplate and the top of the foundation for grouting. The shim stock should extend fully across the supporting edge of the baseplate. The coupling bolts should be removed before the unit is levelled and the coupling halves are aligned.

Where possible, it is preferable to place the level on some exposed part of the pump shaft, sleeve, or planed surface of the pump casing. The steel supporting strips or shim stock under the baseplate should be adjusted until the pump shaft is level, the suction and discharge flanges are vertical or horizontal as required, and the pump is at the specified height and location. When the baseplate has been levelled, the nuts on the foundation bolts should be made handtight.

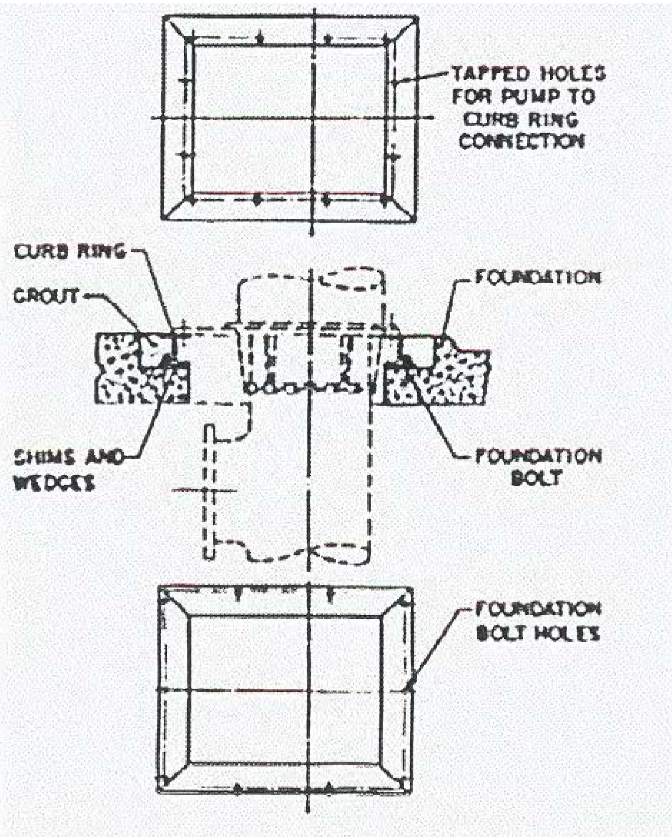


Fig. 2 Rectangular curb ring for belowground discharge vertical pump

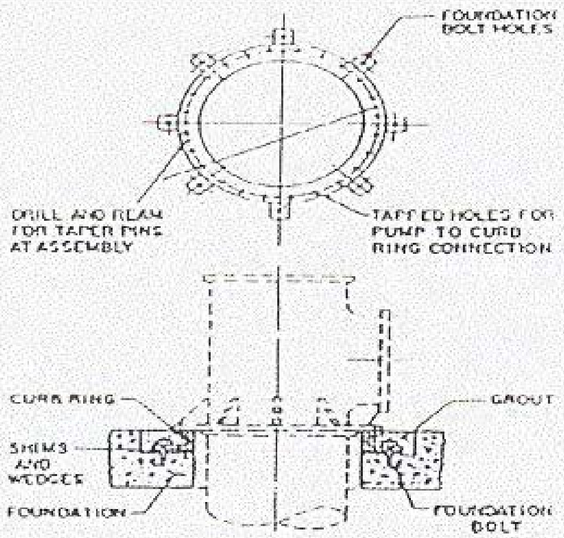


Fig 3 - Round curb ring for aboveground discharge vertical pump

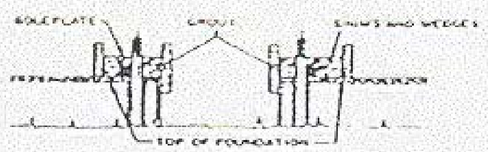


Fig 4 - Grouting form for vertical pump soleplate

During this levelling operation, accurate alignment of the unbolted coupling halves must be maintained. A straightedge should be placed across the top and sides of the coupling, and at the same time, the faces of the coupling halves should be checked with a tapered thickness gauge or with feeler gauges to see that they are parallel. For all alignment checks, including parallelism of the coupling faces, both shafts should be pressed over to one side when taking readings.

When the peripheries of the coupling halves are true circles of equal diameter and the faces are flat and perpendicular to the shaft axes, exact alignment exists when the distance between the faces is the same at all points and when a straightedge lies squarely across the rims at any point. If the faces are not parallel, the thickness gauge or feelers will show variation at different points. If one coupling is higher than the other, the amount may be determined by the straightedge and feeler gauges.

Sometimes coupling halves are not true circles or are not of identical diameter because of manufacturing tolerances. To check the trueness of either coupling half, rotate it while holding the other coupling half stationary and check the alignment at each quarter turn of the half being rotated. Then the half previously held stationary should be revolved and the alignment checked. A variation within manufacturing limits may be found in either of the half-couplings and proper allowance for this must be made when aligning the unit.

A more exact method for checking alignment that is recommended requires the use of a dial indicator. With the indicator bolted to the pump half of the coupling, both radial and axial alignment can be checked. This method is called face-and-rim alignment. With the button resting on the periphery of the other coupling half, the dial should be set at zero and a mark chalked on the coupling half at the point where the button rests. For any check (top, bottom or sides) both shafts should be rotated the same amount, that is all readings on the dial should be made with the button on the chalk mark.

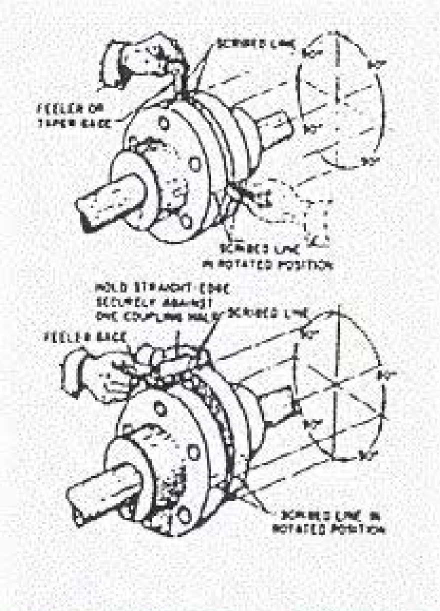


Fig 5 - Coupling alignment using feeler gauges

The dial readings will indicate whether the driver must be raised, lowered, or moved to either side. After any movement, it is necessary to check that the coupling faces remain parallel to one another. For example, if the dial reading at the starting point is set to zero and the diametrically opposite reading at the bottom or sides shows ± 0.202 in (± 0.508 mm) the driver must be raised or lowered by shimming or moved to one side or the other by half of this reading. The same procedure is used to align gear couplings but the coupling covers must first be moved back out of the way and all measurements should be made on the coupling hubs.

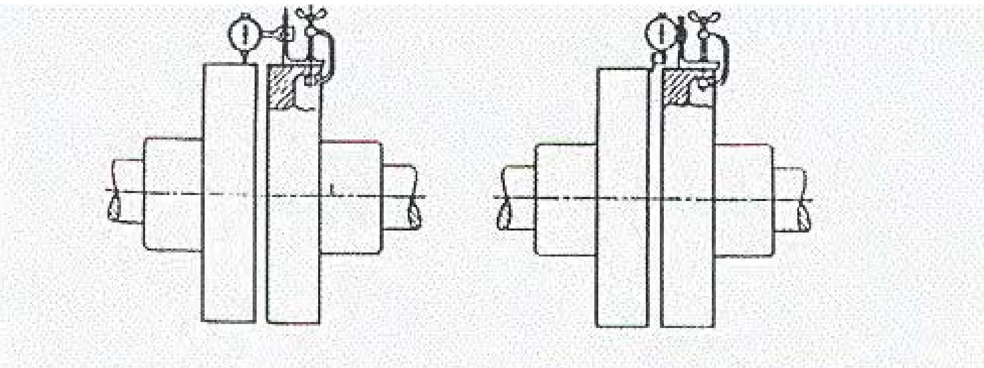


Fig. 6 - Use of dial indicator for face-and-rim alignment of standard coupling

When an extension coupling connects the pump to its driver, a dial indicator should be used to check the alignment. The extension piece between the coupling halves should be removed to expose the coupling hubs. The coupling nut on the end of the shaft should be used to clamp a suitable extension arm or bracket long enough to extend across the space between the coupling hubs. The dial indicator is mounted on this arm, and alignment is checked for both concentricity of the hub diameters and parallelism of the hub faces. Changing the arm from one hub to the other provides an additional check. The dial extension bracket must be checked for sag, and readings must be corrected accordingly.

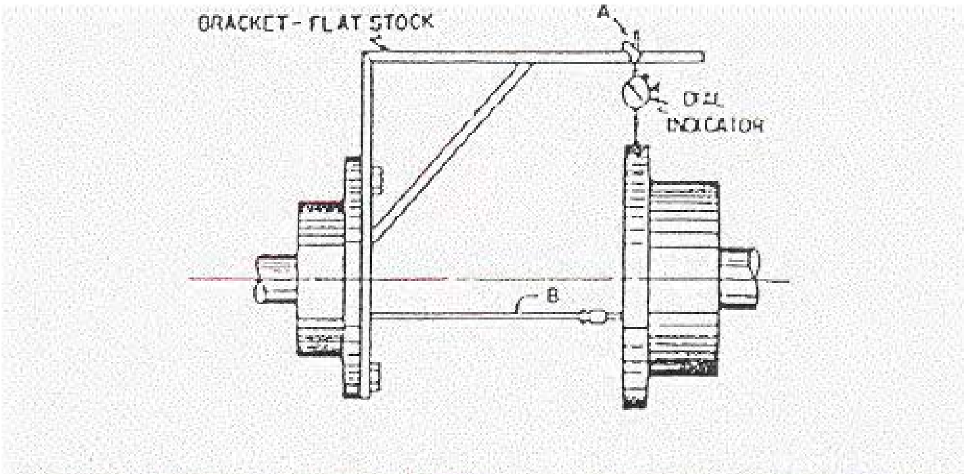


Fig 7 - Use of dial indicator for face-and-rim alignment of extension coupling

The clearance between the faces of the coupling hubs and the ends of the shafts should be such that they cannot touch, rub, or exert a pull on either pump or driver. The amount of this clearance may vary with the size and type of coupling used. Sufficient clearance will allow unhampered endwise movement of the shaft of the driving element to the limit of its bearing clearance. On motor-driven units, the magnetic centre of the motor will determine the running position of the motor half-coupling. This position should be checked by running the motor uncoupled. This will also permit checking the directon of rotation of the motor. If current is not available at the time of installation, move the motor shaft in both directions as far as the bearings will permit and adjust the shaft centrally between these limits. The unit should then be assembled with the correct gap between the coupling halves.

Large horizontal sleeve-bearing motors are not generally equipped with thrust bearings. The motor rotor is permitted to float, and as it will seek its magnetic centre, an axial force of rather small magnitude can cause it to move off this centre. Sometimes it will move enough to cause the shaft collar to contact and possibly damage the bearing. To avoid this, a limited-end float coupling is used between the pump and the motor on all large units to restrict the motor rotor. The setting of axial clearances for such units should be given by the manufacturer in the instruction books and elevation drawings.

When the pump handles a liquid at other than ambient temperature or when it is driven by a steam turbine, the expansion of the pump or turbine at operating temperature will alter the vertical alignment. Alignment should be made at ambient temperature with suitable allowances for the changes in pump and driver centrelines after expansion. The final alignment must be made with the pump and driver at their normal temperatures and adjusted as required before the pump is placed into permanent service.

For large installations, particularly with steam-turbine-driven pumps, more sophisticated alignment methods are sometimes employed using proximity probes and optical instruments. Such procedures permit checking the effect of temperature changes and machine strains caused by piping stresses while the unit is in operation. When such procedures are recommended, they are included with the manufacturers' instructions.

When the unit has been accurately levelled and aligned, the hold-down bolts should be gently and evenly tightened before grouting. The alignment must be rechecked after the suction and discharge piping has been bolted to the pump to test the effect of piping strains. This can be done by loosening the bolts and reading the movement of the pump, if any, with dial indicators.

The pump and driver alignment should be occasionally rechecked, for misalignment may develop from piping strains after a unit has been operating for some time. This is especially true when the pump handles hot liquids as there may be a growth or change in the shape of the piping. Pipe flanges at the pump should be disconnected after a period of operation to check the effect of the expansion of the piping and the adjustments should be made to compensate for this.

Grouting

Ordinarily, the baseplate is grouted before the piping connections are made and before the alignment of the coupling halves is finally rechecked. The purpose of grouting is to prevent lateral shifting of the baseplate to increase its mass to reduce vibration and to fill in irregularities in the foundation.

The usual mixture for grouting a pump baseplate is composed of one part pure Portland cement and two parts building sand, with sufficient water to cause the mixture to flow freely under the base (heavy cream consistency). To reduce settling, it is best to mix the grout and let it stand for a short period then remix it thoroughly before use without adding any more water.

The top of the rough concrete foundation should be well saturated with water before grouting. A wooden form is built around the outside of the baseplate to retain the grout. Grout is added until the entire space under the baseplate is filled to the top of the underside. The grout holes in the baseplate serve as vents to allow the air to escape. A stiff wire should be used through the grout holes to work the grout and release any air pockets.

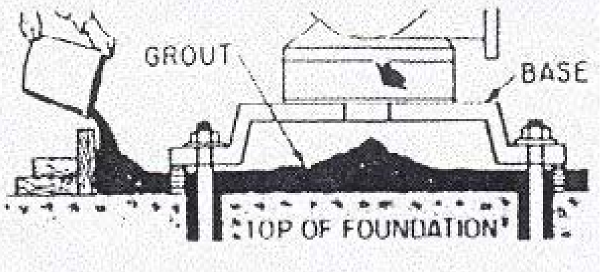


Fig. 8 - Application of grouting. Grout is added until the entire space under the base is filled. Holes in the base (arrow) allow air to escape and permit working of the grout to release air pockets.

The exposed surfaces of the grout should be covered with wet burlap to prevent cracking from too-rapid drying. When the grout is sufficiently set so that the forms can be removed, the exposed surfaces of the grout and foundations are finished smooth. When the grout is hard (72h or longer), the hold-down bolts should be finally tightened and the coupling halves rechecked for alignment.

There is considerable controversy over whether the levelling strips or wedges should be removed after grouting. The best practice is to remove these in all cases for reciprocating machinery because pounding action or vibration will ultimately loosen the unit from the foundation. The space formerly occupied by shims or wedges must be re-grouted. There is less danger is not removing the strips or wedges with rotating machinery, provided care is used in mixing the grout material and there is no shrinkage or drying. The strips or wedges can also be removed from a rotating unit. Erectors can follow their own preference in this matter.

The pump and driver alignment must be rechecked thoroughly after the grout has hardened permanently and at reasonable intervals thereafter.

Dowelling of pump and driver

When the pump handles hot liquids, dowelling of both the pump and its driver should be delayed until the unit has been operated. A final re-check of alignment with the coupling bolts removed and with the pump and driver at operating temperature is advisable before dowelling.

Large pumps handling hot liquids are usually dowelled near the coupling end, allowing the pump to expand from that end out. Sometimes the other end is provided with a key and a keyway in the casing foot and the baseplate.

PIPING

Suction piping

The suction piping should be as direct and short as possible. If a long suction line is required the pipe size should be increased to reduce frictional losses. (The exception to this recommendation is in the case of boiler-feed pumps where difficulties may arise during transient conditions of load change if the suction piping volume is excessive. This is a special and complex subject and the manufacturer should be consulted).

Where the pump must lift the liquid from a lower level, the suction piping should be laid out with a continual rise toward the pump avoiding high spots in the line to prevent the formation of air pockets. Where a static suction head will exist, the pump suction piping should slope continuously downward to the pump.

Flow velocity should be less than 2m per second and the pipe diameter should be calculated accordingly. Generally, the suction line is larger than the pump suction nozzle and eccentric reducers should be used. If the source of supply is above the pump, the straight side of the reducer should be at the bottom. Installing eccentric reducers with a change in diameters greater than 4 inches (10 cm) could disturb the suction flow. If such a change is necessary, it is advisable to use properly vented concentric reducers.

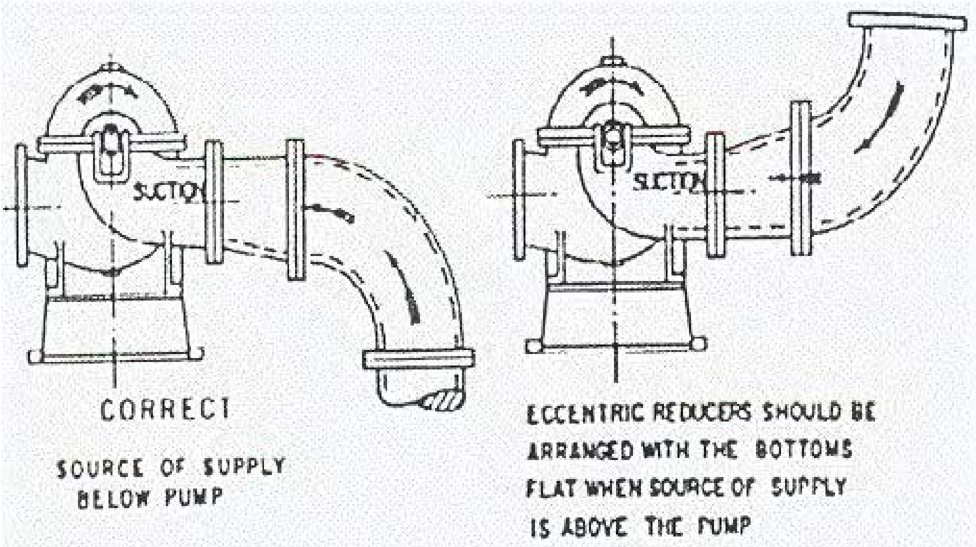


Fig. 9 - Recommended installation of reducers at pump suction

Elbows and other fittings next to the pump suction should be carefully arranged, or the flow into the pump impeller will be disturbed. Long-radius elbows are preferred for suction lines because they create less friction and provide a more uniform flow distribution than standard elbows. Pumps should not be connected near any fitting. There should be a straight length of pipe minimum 10 x pipe diameter before the pump inlet.

If a common suction head for two or more pumps is used, branches should be designed so that flow disturbance before the pump inlets is not caused. T-pieces should not be used - a Y-piece is recommended.

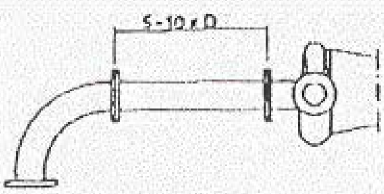


Fig. 10 - Do not connect bends directly to the pump suction

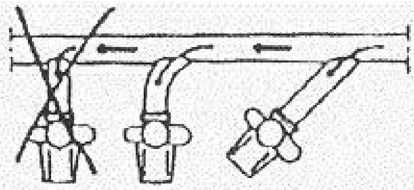


Fig. 11 - Connection of pumps to a common suction header

Discharge Piping

Generally, both a check valve and a gate valve are installed in the discharge line. The check valve is placed between the pump and the gate valve and protects the pump from reverse flow in the event of unexpected driver failure, or from reverse flow from another operating pump.

The gate valve is used when priming the pump or when shutting it down for inspection and repairs. Manually operated valves that are difficult to reach should be fitted with a sprocket rim wheel and chain. In some cases, discharge gate valves are motorised and can be operated by remote control.

Piping Strains

Cast iron pumps are never provided with raised face flanges. If steel suction or discharge piping is used, the pipe flanges should be of the flat-face and not the raised-face type. Full-face gaskets must be used with cast iron pumps.

Piping should not impose excessive forces and movements on the pump to which it is connected, since these might spring the pump or pull it out of position. Piping flanges must be brought squarely together before the bolts are tightened. The suction and discharge piping and all associated valves, strainers, etc should be supported and anchored near to, but independent of, the pump so that strain will be transmitted to the pump casing.

There are four factors to be considered in determining the effect of nozzle loads; material stress in pump nozzles resulting from forces and bending movements, distortion of internal moving parts affecting critical clearances, stresses in pump hold-down bolts, and distortion in pump supports and baseplates resulting in driver coupling misalignment.

With large pumps, or when major temperature changes are expected, the pump manufacturer generally indicates to the user the maximum movements and forces that can be imposed on the pump by the piping.

Expansion Joints

Expansion joints are sometimes used in the discharge and suction piping to avoid transmitting any piping strains caused by misalignment, or by expansion when hot liquids are handled. On occasion, expansion joints are formed by looping the pipe. More often, they are of the slip-joint or corrugateddiaphragm-type. However, they transmit to the pump a force equal to the area of the expansion joint, times the pressure in the pipe. These forces can be of very significant magnitude, and it is impractical to design the pump casings, baseplates, etc to withstand them. Consequently, when expansion joints are used, a suitable pipe anchor must be installed between them and the pump proper. Alternately, tie rods can be used to prevent the forces from being transmitted to the pump.

Suction Strainers

Except for certain special designs, pumps are not intended to handle liquid containing foreign matter. If the particles are sufficiently large, such foreign matter can clog the pump, reduce its capacity, or even render it altogether incapable of pumping. Small particles of foreign matter may cause damage by lodging between close-running clearances. Therefore, proper suction strainers may be required in the suction lines of pumps not specially designed to handle foreign matter.

In such an installation, the piping must first be thoroughly cleaned and flushed. The recommended practice is to flush all piping to waste before connecting it to the pump. Then a temporary strainer of appropriate size should be installed in the suction line as close to the pump as possible. This temporary strainer may have a finer mesh than the permanent strainer installed after the piping has been thoroughly cleaned of all possible mill scale or other foreign matter. The size of the mesh is generally recommended by the pump manufacturer.

Venting and Draining

Vent valves are generally installed at one or more high points of the pump casing waterways to provide a means of escape for air or vapour trapped in the casing. These valves are used during the priming of the pump or during operation if the pump should become air or vapour-bound. In most cases, these valves need not be piped up away from the pump because their use is infrequent and the vented air or vapours can be allowed to escape into the surrounding atmosphere.

On the other hand, vents from pumps handling flammable, toxic or corrosive fluids must be connected in such a way that they endanger neither the operating personnel, nor the installation. The suction vents of pumps taking liquids from closed vessels under vacuum must be piped to the source of the pump suction above the liquid level. All drain and drip connections should be piped to a point where the leakage can be disposed of or collected for re-use if worth reclaiming.

Warm-Up Piping

When it is necessary for a pump to come up to operating temperature before it is started, or to keep it ready to start at rated temperature, provision should be made for a warm-up flow to pass through the pump. There are a number of arrangements used to accomplish this. If the pump is operated under positive pressure on the suction, the pumped liquid can be permitted to drain out through the pump casing drain connection to some point at a pressure lower than the suction pressure.

Alternately, some liquid can be made to flow back from the discharge header through a jumper line around the check valve, into the pump and out into the suction header. An orifice is provided in this jumper line to regulate the amount of the warm-up flow. Care must be exercised in such an installation to maintain the suction valve open (unless the warm-up line valve is closed, as when the pump is to be dismantled), lest the entire pump, suction valve, and suction piping be subjected to full discharge pressure.

The manufacturer's recommendations should be sought in all cases as to the best means of providing an adequate warm-up procedure.

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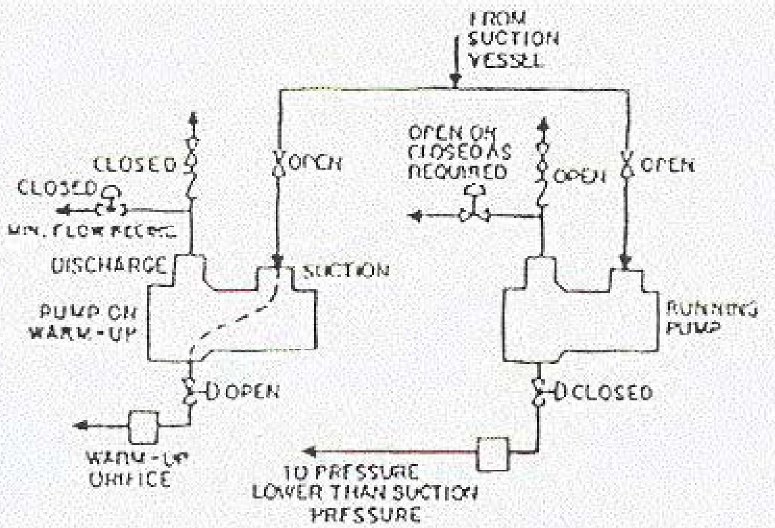

Arrangement for warm-up through pump casing drain connection.

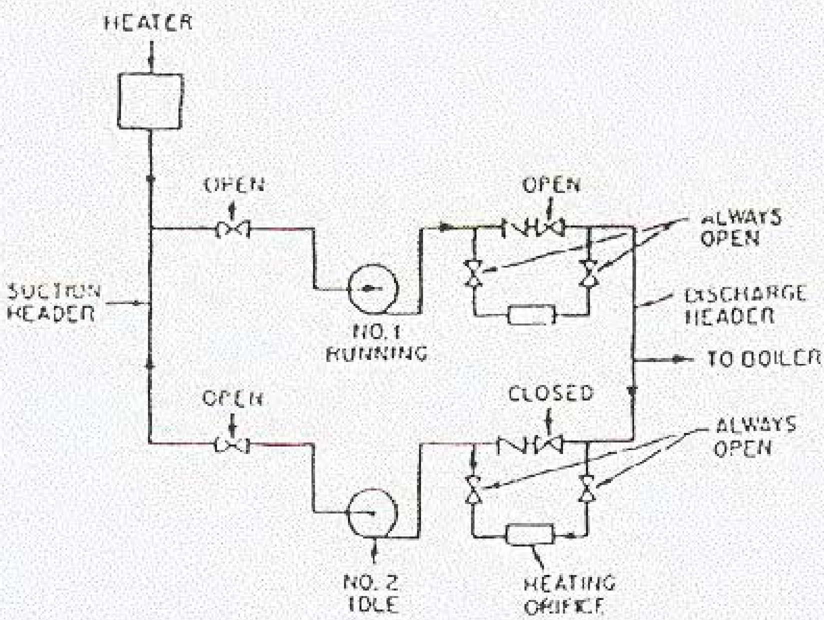

Fig. 12 - Arrangement for warm-up through jumper line around discharge check valve

Relief Valves

Positive displacement pumps, such as rotary and reciprocating pumps can develop discharge pressures much in excess of their maximum design pressures. To protect these pumps against excessive pressures when the discharge is throttled or shut off, a pressure relief valve must be used.

Some pumps are provided with internal integral relief valves, but unless operation against a closed discharge is both infrequent and of very short duration, a relief valve with an external return connection must be used and the liquid from the relief valve must be piped back to the source of supply.

Surge Chambers

Generally, centrifugal pumps do not require surge chambers in their suction or discharge piping. Reciprocating pumps may have a suction and discharge piping layout that does not require compensation for variations in the flow velocity in the piping system.

In many cases however, reciprocating pump installations require surge chambers when the suction or discharge lines are of considerable length, when there is an appreciable static head on the discharge, when the liquid pumped is hot, or when it is desirable to smooth out variations in the discharge flow. The type, size and arrangement of the surge chamber should be chosen on the basis of the manufacturer's recommendations.

Instrumentation

There are a number of instruments which are essential to maintaining a close check on the performance and condition of a pump. A compound pressure gauge should be connected to the suction of the pump and a pressure gauge should be connected to its discharge at the pressure taps which may be provided in the suction and discharge flanges. The gauges should be mounted in a convenient location so that they can be easily observed.

In addition, it is advisable to provide a flow-metering device. Depending upon the importance of the installation, indicating meters may be supplemented by recording attachments.

Whenever pumps incorporate various leak-off arrangements, such as a balancing device or pressure-reducing labyrinths, a check should be maintained on the quantity of these leak-offs by measuring orifices and differential gauges installed in the leak-off lines.

Pumps operating in important or complex services, or operating completely unattended by remote control, may have additional instrumentation such as speed indicators, vibration monitors, and bearing or casing temperature indicators.