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When it comes to the reliability of its pumps, no industry or operation can afford to ignore the basics. Check out this down & dirty refresher by one of the most noted experts in the field.

Correct and complete installation practices can mean the difference between a pump that gives many years of trouble-free service and one that requires constant and repetitive maintenance. While the space available to us in this article denies us the opportunity to provide a detailed instruction on how to install all types of pumps, most of the information herein refers to the single-stage, end-suction design.
Three particular areas must be satisfied to ensure that a pump will provide long and reliable operation within a system.

- Foundation
- Piping arrangement
- Alignment

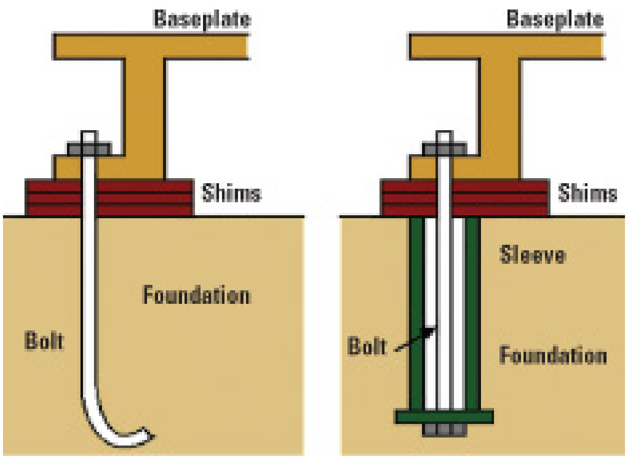

Fig. 1. Sleeve and "J" type anchor bolts

Foundation

In general, a pump should be mounted on a strong baseplate supported by a strong concrete foundation. It is also necessary to properly connect the pump to the system by accurately aligning it to the piping system, as well as the driving motor.

A strong foundation and grouting can result in a unit that gives reliable, uninterrupted service versus one that requires constant realignment. It should be everyone's concern that only the best materials—*together with proper design*—be used when installing the pump.

The concrete foundation must be substantial enough to absorb any vibration and form a permanent rigid support for the baseplate. A frequently used rule of thumb is that the foundation should be about five times the weight of the pump/motor assembly and approximately 6" longer and wider than the baseplate. The anchor bolts are usually of the sleeve type—*or the "J" type*—shown in Fig. 1 and must be located in accordance with the certified outline drawing of the baseplate.

Prior to mounting the baseplate, the entire surface of the foundation should be leveled by chipping away any defective concrete, leaving it rough, but level. The surface must then be freed of all oil, grease and loose particles. While individual practices vary throughout industry, there is a tendency in most leading companies to remove the pump and driver from the baseplate prior to installation. This facilitates leveling of the base and in removing any distortion.

The baseplate should be supported on leveling screws, shims or metal wedges with a small taper located close to the foundation bolts. All leveling screws and other areas that require protection from grout spatter should then be covered with a wax to prevent the grout from adhering to them. Check the machined mounting surfaces on the baseplate by adjusting the leveling devices and using a precision level. Ensure that the baseplate's machined mounting surfaces are horizontal, flat and parallel. To prevent stress and distortion of the equipment, all surfaces in the same plane must be within 0.002" overall.

When the baseplate is level, check that all support wedges or shims are in full contact with the foundation and baseplate. Tighten the foundation anchor bolts evenly and double-check the level.

The temperature of the baseplate, grout and foundation should be kept between 40 and 90 F during grouting—*and for a period of at least 24 hours afterwards*. When using cement-based grouting, follow the grout supplier's instructions in detail and ensure that the grout placement is done quickly and continuously to prevent cold joints and voids under the baseplate. The grout should be allowed to harden in accordance with the manufacturer's instructions.

The use of epoxy grout is becoming increasingly common in a number of industries. The increased bond strength helps to maintain the alignment between the pump and driver, thereby reducing misalignment failures and maintenance costs. Its use also facilitates cleanup in the event of an accidental spill as the surface of epoxy grout is nonporous.

In recent years, considerable success has been achieved by using pre-grouted baseplates to eliminate many of the traditional problems identified with onsite baseplate leveling and grouting. Baseplates are grouted in an upside-down position in the factory, thus reducing epoxy grout volumetric shrinkage that can otherwise cause baseplate distortion. These pre-grouted units have proven to travel well and arrive at the site flat and aligned—*just as they were when they left the factory*. They also are capable of being installed on-site with the pumps and motors in place.

Piping arrangement

Without any doubt, this is the single most abused area of pump installation. In fact, it can be stated unequivocally that most pumps are piped up incorrectly.

Even today, many installations resemble a "plumber's nightmare." In these situations, the pumps look as though they've been squeezed into a corner, out of the way, and the pipes threaded in and out, without consideration for fluid flow patterns or access for future maintenance activities. The blame for this must be laid squarely at the feet of the pump supplier! After all, if you were installing a new pump in a new system, where would you go for information on how the pump piping should be arranged?

Most of us would refer to the pump manufacturer's Installation, Operation and Maintenance (IOM) Manual. Unfortunately, that won't provide a lot of information, as most pump companies once subscribed to an attitude of limiting their responsibility within the confines of the suction and discharge nozzles of the pump. Although this attitude is fast disappearing, the change has not yet reached most of the IOM Manuals—*which means accurate and complete information from this source is still severely limited*.
Consequently, a high proportion of the pumps in most industries are installed with inappropriate

piping arrangements that result in premature pump failure.

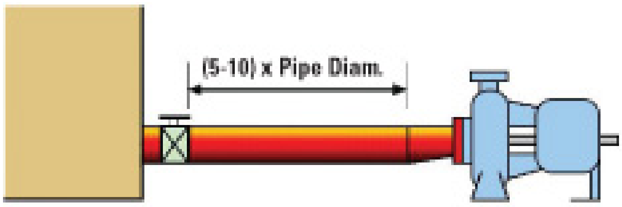

Fig. 2. Recommended pump suction piping

Sadly, the trouble is rarely traced to incorrect piping, as there are many other reasons why seals and bearings fail. The main difficulty is that inadequate piping locates the root cause of many pump failures outside the physical confines of the pump itself, thus making it difficult to detect for the unwary and inexperienced.

The location of the pump relative to its suction source is critical to its ultimate reliability. Every pump needs to be located as close to its suction source as possible to reduce the effect of friction losses on the NPSH available. However, it must also be far enough away from the suction source to ensure that correct piping practices can be followed (Fig. 2).

These piping practices involve a number of simple rules which, if followed, will eliminate a significant percentage of all potential pump problems.

The 5 Rules of Pump Piping are as follows:

1. Provide the suction side with a straight run of pipe, in a length equivalent to 5 to 10 times the diameter of that pipe, between the suction reducer and the first obstruction in the line. Failure to do so can create problems such as hydraulic instabilities in the impeller that translate into additional shaft loading, higher vibration levels and premature failure of the seal and bearings.
2. The pipe diameter on both the inlet and the outlet sides of the pump should be at least one size larger than the nozzle itself. The pipe diameter on the horizontal inlet to the pump suction must be reduced to the nozzle diameter by means of an eccentric reducer positioned in such a way as to have the flat side on top. The increaser on the discharge side can be a standard concentric design.
3. Eliminate elbows mounted on the inlet nozzle of the pump. Failure to do so can cause the hydraulic instabilities referred to in rule #1 above.
4. Eliminate the potential for vortices or air entrainment in the suction source. These conditions can cause problems that are frequently confused with cavitation.
5. Arrange the piping in such a way that there is no strain imposed on the pump casing, as

discussed in the following section on alignment.

Alignment

Industry has progressed well beyond any discussion of the statement that good alignment is essential to safe and trouble-free operation of rotating equipment. When we discuss "alignment" in the pump industry, we are usually discussing either "piping alignment" or "shaft alignment." It must be noted that the term "coupling alignment" is a misnomer.

Shaft alignment…

We are not concerned about bringing the coupling halves into alignment. The only criterion is to ensure that the shafts of the pump and its driver will rotate on a common axis. If the shafts are not coaxial, the resulting moments will increase the forces on the pump shaft and bearings, causing accelerated wear and premature failure.

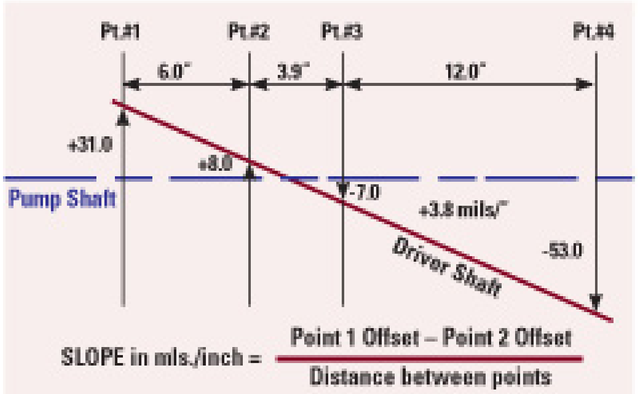

Fig. 3. Shaft offset and angular misalignment

Alignment is achieved when two lines that are superimposed on each other form a single line. Misalignment is a measure of how far apart the two lines are from forming that single line. The two lines we are concerned with here are the centerlines of the pump shaft and the driver shaft.

In one misaligned condition, the two lines can be parallel with each other, but at a constant distance apart. This is referred to as *offset* or *parallel misalignment* (Fig. 3). In the other, one line will be at an angle to the other, and is referred to as *angular misalignment*
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Parallel misalignment can be considered as the distance between the driver shaft centerline and the pump shaft centerline at any given point along the length— *and this misalignment can happen in any plane*. So, it is worthwhile to take the necessary measurements on the top and on the bottom for vertical offset and also on each side for the horizontal offset.

Angular misalignment refers to the difference in slope of the two shafts. If the pump, base and foundation have been properly installed, the shaft centerline of the pump can be considered as level and, therefore, as the reference or datum line. The slope of the driver shaft can be calculated by determining the offset measurement at two different points, subtracting one from the other, then dividing the result by the axial distance between the two points. This misalignment needs to be measured and calculated in both the vertical and horizontal planes.

Shaft couplings…

It is important to mention that flexible shaft couplings are not necessarily the answer to a shaft misalignment problem. All couplings resist being operated when misaligned, and the restoring forces and moments resulting in this resistance can damage bearings, seals and the shaft itself. These restoring forces are proportional to misalignment. In other words, the larger the misalignment of the shafts, the greater the forces on the bearings, etc. Thus, the shafts of the pump and the driver should be aligned as closely as possible to provide optimum reliability of the pump.

Piping misalignment…

Piping flanges must be accurately aligned before the bolts are tightened, and all piping, valves and associated fittings should be independently supported without any strain being imposed on the pump. Any stresses imposed on the pump casing by the piping reduce the probability of satisfactory reliability and performance—*and can result in high maintenance costs*.

Laser pipe alignment tools provide significant benefits to the pump user. Mounted on the pump or the piping, these tools are an effective way to prevent pipe strain during initial installation, which is exactly the right time to stop it.

The effects of pipe strain in a conventional process pump also can be transmitted to the shaft coupling. With the accuracy of laser alignment technology, pipe strain can be measured much in the same way as soft foot and should be integrated into the shaft alignment program. By loosening the pipe connection after a correct shaft alignment has been performed, any movement at the coupling will indicate the existence of pipe strain and can therefore be corrected.

As there is an exception to almost every rule, the API 610 Pump Specification used in the petroleum industry identifies a maximum level of forces and moments that may be imposed on the pump flanges. These must be acceptable to any pump being sold into any industry using that specification. As a consequence, all API pumps are of a much more robust and heavier design than their ANSI size equivalents.

In high-temperature applications, some piping misalignment is inevitable owing to thermal growth during the operating cycle. Under these conditions, thermal expansion joints are often introduced to avoid transmitting any piping strains to the pump. However, if the end of the expansion joint closest to the pump is not anchored securely, the pipe strain is passed through to the pump, thus defeating the objective of the expansion joint.

Conclusion

Improper pump installation can lead to premature failure and increased maintenance costs. Conversely, when they are correctly installed and given reasonable care and maintenance, your pumps will be capable of operating satisfactorily—*and delivering for you-*—for a long time. **MT**

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