GRUNDFOS

WHITE PAPER

BASEPLATES

by Greg Towsley

Pump baseplates come in as many configurations, designs and styles as there are pumps. No matter the design, the main purpose of the baseplate, as described by the Hydraulic Institute (HI)[1], is to mount the pump and driver together, while maintaining shaft alignment between the two pieces of equipment.

When designing and fabricating a baseplate, it is the hope that the complete unit is robust enough to survive the travel to the site and be simple to install. It should allow for final alignment of the pump and driver, and allow for removal and reinstallation of the equipment if necessary.

The purpose of this article is to provide an overview of the different types of baseplates and design considerations. The requirements of the user and the pump should be reviewed with the pump supplier to determine the design of the baseplate.

To minimize the equipments Life Cycle Costs, the proper baseplate for the equipment and the application must be chosen, as well as proper installation on its foundation and alignment.

TYPES

The type of baseplate used in an application varies within each industry, company, application, and pump design. The following types of baseplates provide an understanding of the many variations available.

SOLEPLATES

Soleplates are the simplest and most basic of pump baseplates. A soleplate is a single steel plate mounted under the feet of the rotating equipment. Although it is simple, it is suitable for grouting. In the case of a coupled unit, a steel plate is mounted under each of the feet of the pump and driver.

For large pumps and drivers, soleplates are less expensive than baseplates, which would be difficult to fabricate and constructed from heavy steel. A soleplate is used for very large pumps, such as double suction or split case pumps, and their separate driver.

It is also common for vertical turbine pumps, with the driver mounted on top, to use a soleplate. The use of a soleplate allows for ease of removal of the vertical turbine pump. The soleplate for the vertical turbine pump in *Figure 1* can be seen grouted into the foundation.

CAST IRON

Baseplates of cast iron material are commonly used for small pump units, including ANSI process pumps, due to their low cost. Many pump manufacturers provide this baseplate as standard because of the minimal labor involved in its production.

Figure 1. *Vertical Turbine Pump Mounted on Soleplate*

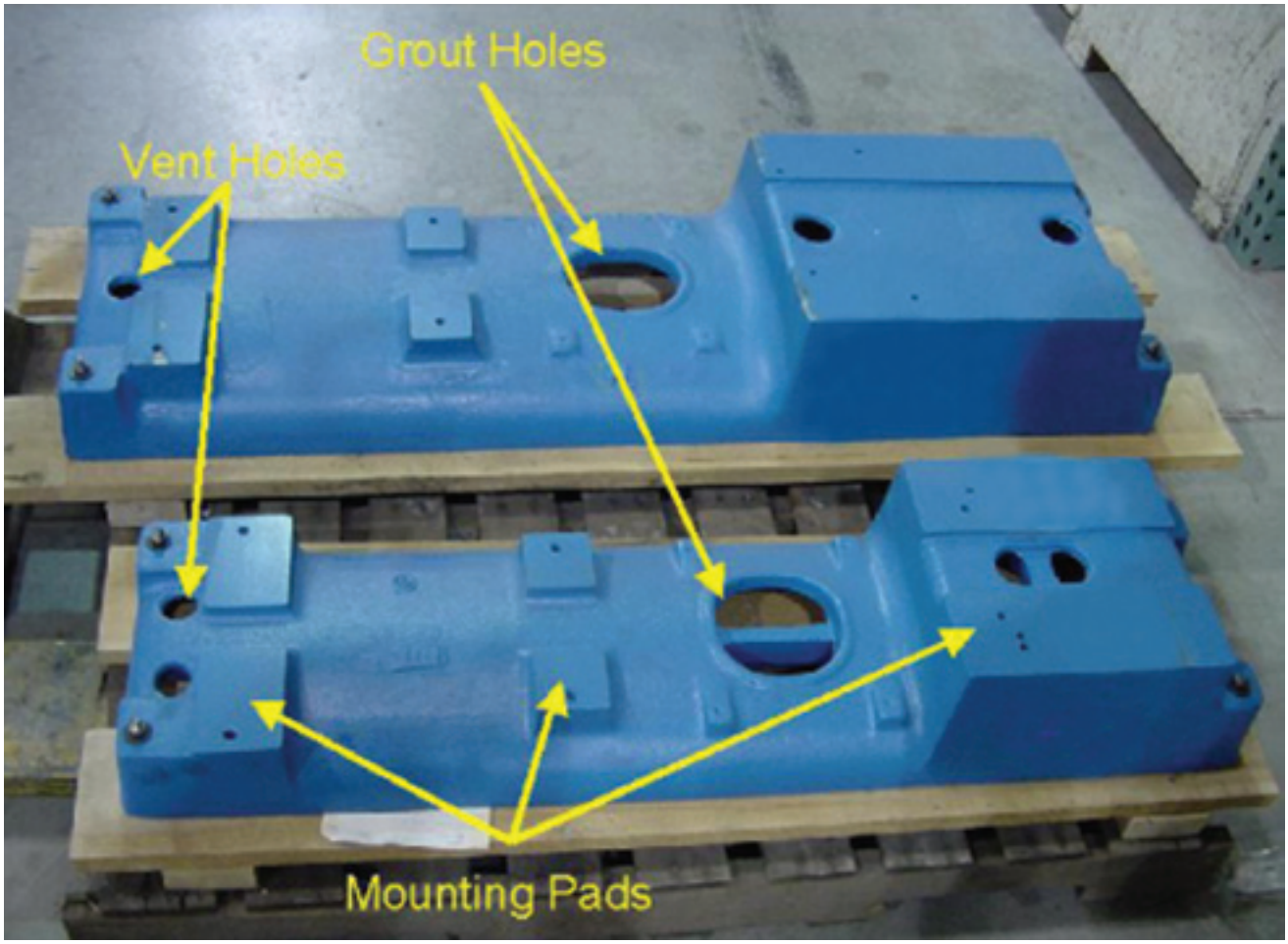


Figure 2. *Cast Iron Baseplates with Camber Tops*

For small pumps, the cast iron base has a camber top with a motor pad cast in place. The mounting pads for the pump and driver are machined flat. Standard NEMA frame motors are used, and the baseplate has grout and vent holes.

The smaller cast iron baseplates do not have any feature for drainage collection. The baseplates shown in *Figure 2* are cast iron with grout holes, vent holes, and mounting pads. Use of these baseplates would require the cleaning of the mounting pads to remove paint and other material.

Cast iron baseplates for large horizontal pumps also provide mounting provisions for NEMA motors and have an integral drainage collection feature. For those large pumps that use non-NEMA motors or special drivers, cast iron baseplates are typically flat on top and have a continuous drip lip around the top of the base.

Where the pump may be driven by v-belts or drivers supplied by a supplier other than that of the pump, a cast iron baseplate might be available. This design may incorporate a drip lip.

When the pump and driver are extremely large, cast iron baseplates may not be the most economical. The use of a fabricated steel baseplate may be required when the dimensions of the

baseplate are greater than 32 inches (81.3 cm) wide or 114 inches (289.6 cm) long, or both.

Fabricated steel is more rigid, has greater strength, and, at these larger sizes, is lighter in weight than cast iron. In addition, the costs involved with baseplates at this size prove to be less expensive for fabricated steel.

FABRICATED STEEL

Fabricated steel baseplates are manufactured using different materials. They can be made more rigid than cast iron bases. However, they are typically more expensive due to the materials required and the additional labor required for welding.

Rolled or bent steel, which have been formed in a large brake, are the least expensive. The driver mounting pads are welded on the baseplate. As shown in *Figure 3*, the motor mounting pad is fabricated as necessary to meet the motor size, and then welded to the pump baseplate.

The ends are open to assist in moving the assembled pump unit. In addition, rolled steel baseplates do not have grout holes, which assist in keeping the cost low. *Figure 4* provides a view of a rolled steel baseplate ready for mounting the direct drive electric motor.

Standard industrial c-shape channel steel is used for baseplates in sizes up to 18 inches (45 cm) wide. As with the rolled steel baseplates, the driver mounting pad, also constructed of channel steel, is welded on the baseplate. In addition, the ends are open to assist in moving the assembled pump unit and this design does not have grout holes.

The unique baseplate in *Figure 5* is customized to mount two sets of pumps and drivers. Small c-shape channel is used for the support structure. The entire baseplate has a drip rim around the outer edge, which has been welded with a continuous bead.

Because of the size of the material and the intent to minimize the costs, the fabricated steel baseplate is typically constructed to have no overhang of the pump, driver, valves, or other

Figure 3. *Rolled Steel Baseplate with Motor Mounting Pad*

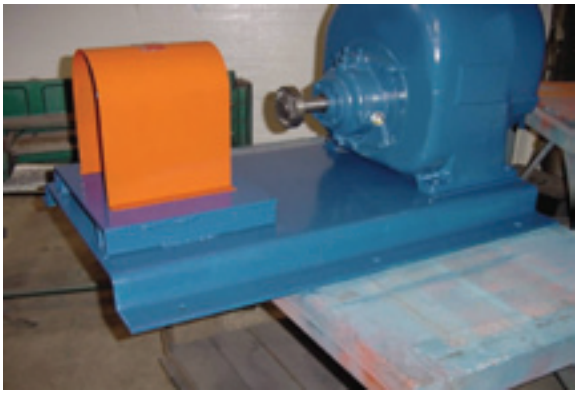


Figure 4. *Rolled Steel Baseplate with Motor Mounting Pad*

Figure 5. *Fabricated Steel Baseplate with Drip Rim and Channel Steel*

accessories, except for the conduit box (for wiring ease). However, a fabricated steel baseplate has more flexibility with other features that may be required, such as special dimensions, a drip lip with drain, and grout holes.

The fabricated steel base shown in *Figure 6* provides a view of an electric motor that is mounted above the pump and a baseplate sized only for the pump.

FIBERGLASS REINFORCED POLYESTER (FRP)

Baseplates manufactured with fiberglass-reinforced polyester (FRP) are commonly provided with ANSI pumps in services that require severe corrosion resistance.

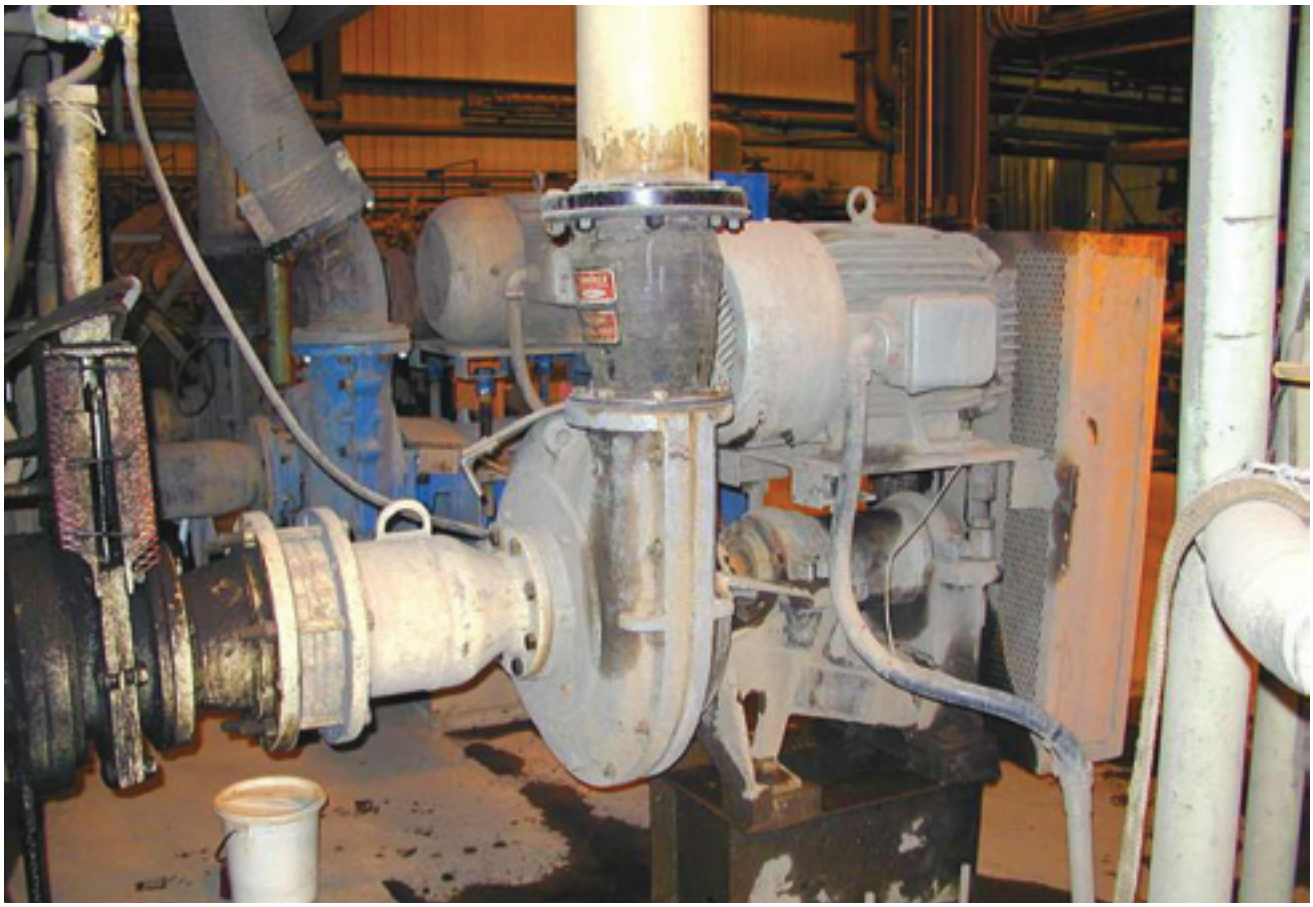


Figure 6. *Overhead-Mounted Driver*

To provide rigidity to the baseplate, stainless steel support plates are inserted within the FRP baseplate to provide rigidity and mounting pads for the equipment. The baseplate can be grouted into place or mounted in some other type of flexible configuration.

SPRING-LOADED

In applications where thermal expansion of suction and discharge piping is present, pump flanges may experience excessive loads. Typically, expansion loops or joints may be used, but large piping systems may cause this option to be cost prohibitive.

An option that can allow some movement in the horizontal and vertical planes due to high temperatures or high pressures is the use of spring-loaded baseplates.

Although the use of spring-loaded baseplates can compensate for these movements, they should NOT be used to compensate for poor design of the piping system. The maximum allowable movement in either the horizontal or the vertical plane should be no more than one (1) inch (2.54 cm).

To compensate for movement in the vertical plane, a double set of coil springs is located at the four corners of the baseplate and at additional points as necessary.

One of the coil springs limits the downward motion, and the other limits the upward motion. The spring size is selected based on calculations for acceptable flange loads on the pump and to accommodate thermal expansions.

Compensation in the horizontal plane is done with a set of bearing plates, mounted on the feet that use a graphite-type substance with low coefficient of friction. These allow the unit to move horizontally on stainless steel pads on the foundation or the floor.

Because of the complexity of the unit, spring-loaded baseplates are assembled in the field at the location of the service. For proper installation of the unit, the suction and discharge piping must be properly supported. An advantage of this style is that the vibration frequency may become many times greater than natural frequency of assembled unit.

DESIGN CONSIDERATIONS

Although manufacturers have designs and features that are standard with their baseplates, many additional design considerations can enhance the baseplate and assist in extending the life of the equipment.

When mounting a driver on a common baseplate, alignment must be done prior to operation of the equipment. Alignment extends the life of the equipment and can reduce energy consumption.

To assist in ease of alignment, the driver mounting pad(s) is designed and fabricated to allow a minimum of 0.125 inch (3.175 mm) of shims under the driver feet. After shipment and final installation, the amount of shim can be adjusted as required.

The mounting pads for the pump and the driver should extend a minimum of one (1) inch (2.54 cm) beyond equipment feet in each direction.

In addition, with respect to the mounting pads of the pump and driver, they may be machined to the same plane to 0.002 inch (0.05 mm) coplaner flatness. This would be done after all of the fabrication is done to the steel baseplate.

This feature assists in the alignment and equipment reliability. The enhanced baseplate shown in *Figures 7* and *8* provide a view of the pump and motor mounting pads.

As described above, some manufacturers can provide a drip containment feature with their baseplate for an additional cost. The drip rim with a threaded drain can be viewed in *Figure 8*.

An inexpensive alternative to capture leakage is a stainless steel drip pan. This can be mounted under the pump and sized to extend under flanges and mechanical seal chambers.

For fabricated steel baseplates that may be excessively long or wide, stiffeners may be provided under the baseplate. *Figure 9* provides a view of a stiffener welded to the underside of a fabricated stainless steel baseplate.

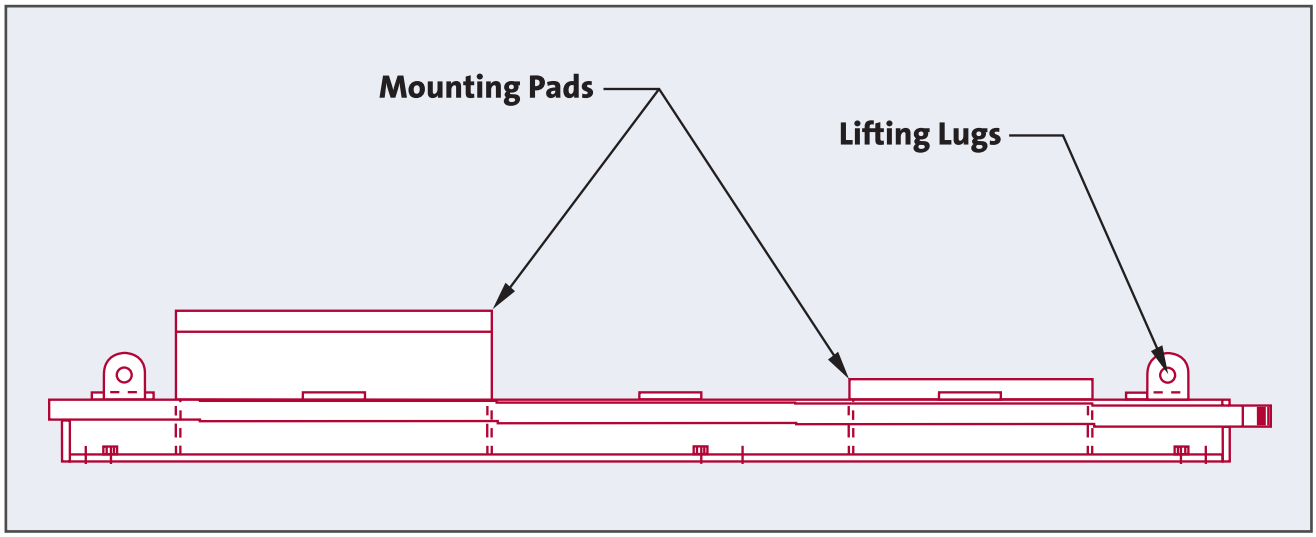


Figure 7. *Enhanced Baseplate – Elevation View*

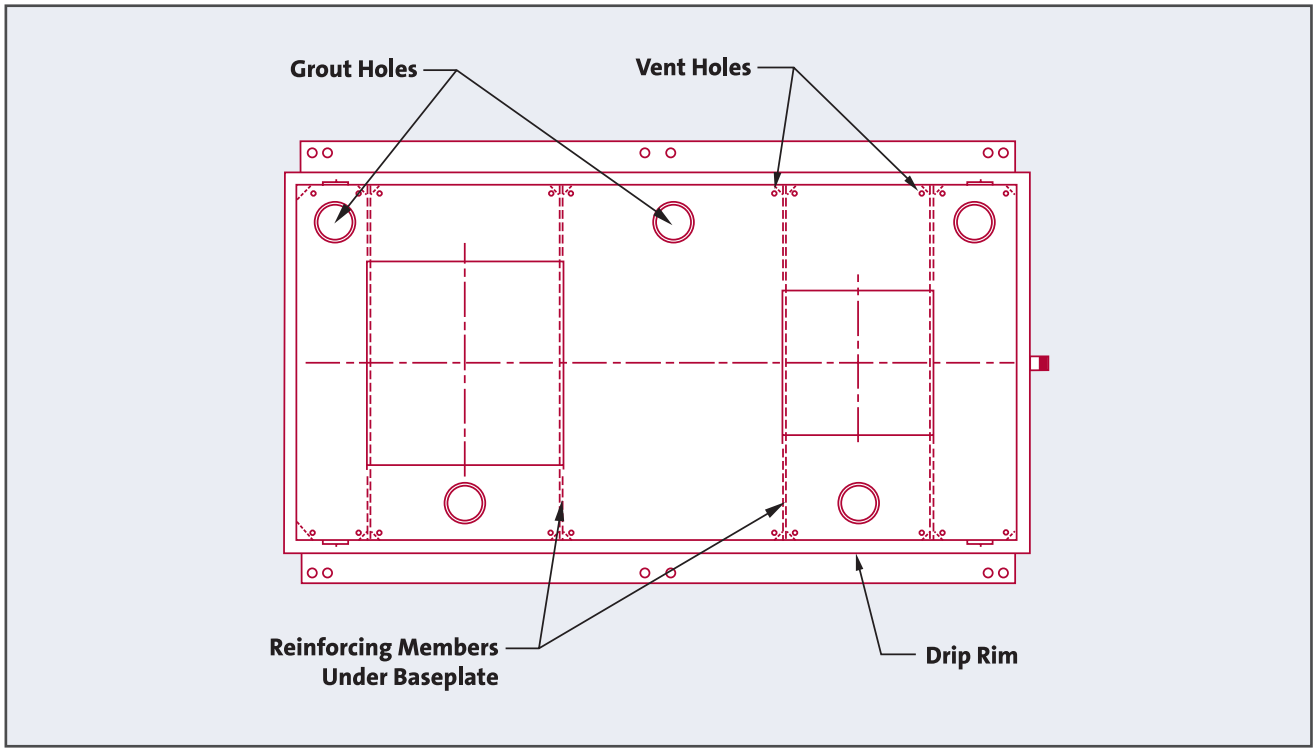
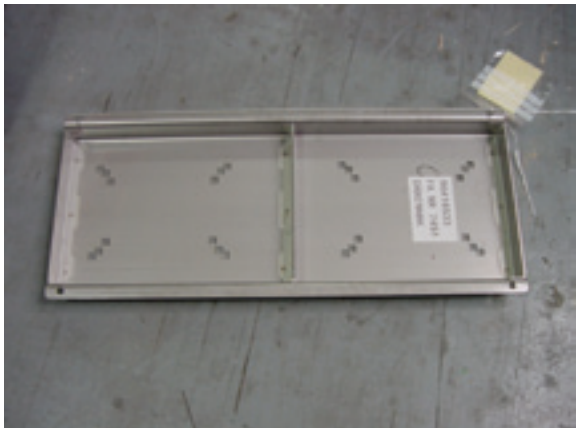


Figure 8. *Enhanced Baseplate – Plan View*



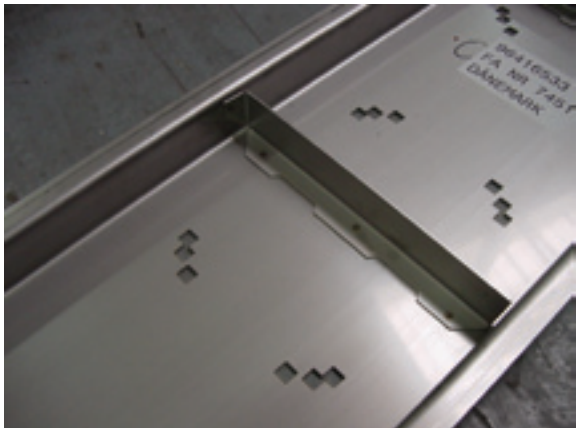


Figure 9. *Fabricated Stainless Steel Baseplate with Stiffener*

For high temperature applications, the pump and baseplate is designed to support the pump casing at its centerline. This design prevents excess strains from temperature fluctuations of the product being pumped.

This is a standard feature on pumps in the petroleum industry, and can also seen on boiler feed pumps. Depending upon the material of construction and the manufacturer's pump design, it may also be required in temperatures as low as 250° to 350°F (121° to 177° C).

For personnel safety and to prevent damage of equipment in a heavy-traffic area, baseplates can be designed to not allow any overhang, outside the baseplate envelope, of the pump, driver, valves or accessories. It may be acceptable to allow the conduit box to overhang for ease of wiring.

For very large pumps and drivers, positioning lugs with jackscrews may be welded onto baseplates help move the heavy equipment axially and laterally during alignment. If this feature is chosen, it must be originally included during fabrication. If this were done in the field, the welding could cause warping or damage of the baseplate.

BASEPLATE SPECIFICATIONS

Many large pump users develop baseplate specifications to provide consistency to the products they purchase, as well as controlling the quality and rigidity of their design. Specifications for the manufacture of baseplates also exist from a number of technical professional societies.

ANSI B73.1M-2001

The intent of ANSI B73.1M-2001[2] is to provide dimensional interchangeability requirements and design features for installation and maintenance. The Standard details requirements for pump manufacturers to provide pump and related equipment to be dimensionally interchangeable.

These dimensional requirements are in respect to the mounting dimensions of the pump, the size and location of suction and discharge nozzles, the location of the input shafts, the baseplate, and the foundation bolt holes.

The design also provides for a more heavy-duty baseplate than a cast iron or channel steel baseplate. The design provides increased rigidity and reliability of the mounted equipment.

ANSI/HI 1.3.5-2000

A standard developed by the Hydraulic Institute[1] is specifically for fabrication criteria of baseplates for horizontal pumps. This Standard is applicable for all types of horizontal pumps. It is a criterion for the dimensioning, toleranceing, working stresses and stiffness of the baseplate.

Design features are not covered by the specification, such as the style of base, drip collection features, and continuous vs. intermittent welding during fabrication. This Standard may not be applicable for certain types of pumps, such as close-coupled or high-energy pumps. The manufacturer or other standards should be utilized to discuss these other needs.

The Standard discusses the use of unmachined, light duty baseplates, such as channel steel, for pump units under 10 hp (7.5 kw). As the driver size increases to 200 hp (150 kw), the baseplate requires additional consideration for greater rigidity. For those units over 200 hp (150 kw), the manufacturing tolerances of the baseplates must be greater, so these units are typically machined.

With larger pumps and drivers, the stress levels of the baseplates need to be considered. Improper design and fabrication of the baseplate may cause improper installation in the field and difficulty during alignment. This, in turn, may make the equipment less reliable and cause increased power consumption.

When reviewing the stress levels of the baseplate, the materials of construction and the type of welding used need to be considered. After fabrication, the stress that may be caused during skidding, transportation or lifting must also be included in the review.

The rigidity of the baseplate affects many areas of the pump unit after the final installation. Inadequate rigidity may cause distortion of the baseplate after installation, grouting and piping, and difficulty in the final alignment. Piping loads or motor torque may also affect the pump unit if the baseplate is not rigid enough. The Standard[1] recommends that the motor torque and piping loads combined should not cause more than 0.010 inch (0.254 mm) parallel and 0.005 inch/inch (0.127 mm/mm) angular distortions.

The Standard recommends that the pump and driver mounting holes and bolts be sized to allow maximum movement of the equipment for alignment purposes. The fasteners that are used for mounting the pump and driver should be threaded directly into the baseplate material to a depth equal to the thread diameter.

Nuts can also be used on the underside of the baseplate for holding the pump and driver in place. Shims should only be used under the driver, not the pump, during final alignment.

Provisions should be made for lifting and moving the assembled baseplate unit during transportation and installation. As grout adds stiffness to the assembled unit, recommendations are made for the size and spacing of grout holes in the baseplate. To prevent grout stress under the baseplate, all corners should be fabricated with a radius.

The enhanced ANSI baseplate shown in *Figure 10* shows many of the features discussed: machined mounting pads, grout holes, vent holes, leak containment, lifting lugs, leveling nuts (less screws), and standard dimensions.

API-610

Although a separate specification has not been developed for baseplates, the American Petroleum Institute (API) addresses baseplates for centrifugal pumps in API-610[3]. Other API specifications for reciprocating, controlled volume, rotary pumps address baseplate specifications in a similar manner to API-610.

API-610 requires some of the features discussed in the Design Considerations section above, such as machining of the mounting pads, minimum shim requirements, drain collection rim, piping

accessories clearance, and standard dimensions and centerline heights based on the size of the pump.

As previously mentioned, a rigid baseplate is important to the reliability of the equipment. API-610 provides specific requirements for welded stiffeners under base and continuous welds. Figure 8 identifies stiffeners under a baseplate. It is can be required by the purchaser that the structural stiffness of the baseplate be tested.

To provide a more robust unit, API-610 requires many features on the baseplate that are used when grouting to the foundation. Lifting lugs, as identified in *Figure 7*, are required to aid in the installation of the assembled unit.

Besides defining the size and location of grout holes and vent holes, locking hooks under the baseplate are specified to adhere better to the grout. Also to improve the bond between the baseplate and the grout, it is required that the underside of the base be sandblasted and epoxy coated, and have outside radii that are a minimum of 2 inches (5 cm).

To assist in alignment, API-610 requires jackscrews that move the drive components that weigh more than 450 pounds (205 kg) to ease alignment in the horizontal plane, jackscrews that move the drive components that weigh more than 900 pounds (410 kg) to ease alignment axially, and vertical leveling screws. The jackscrews identified in *Figure 11* provide assistance in horizontal movement of the motor during alignment.

Figure 10. *Enhanced ANSI Baseplate*

Figure 11. *Baseplate with Motor Jackscrews*

INSTALLATION

The installation of baseplates should follow the recommendations of the pump manufacturer. Some suggested installation items to check, with regards to the baseplate, are to make sure that the underside clean and free of oil, scale, and dirt prior to epoxy coating or grouting.

Any welds, especially those that are continuous, are free of cracks. Vent holes should be unobstructed prior to grouting.

REFERENCES

1. ANSI/HI 1.3.5-2000, Centrifugal Pumps for Design and Application, Hydraulic Institute, 9 Sylvan Way, Parsippany, NJ, http://www.pumps.org.
2. ASME B73.1M-2001, Specification for Horizontal End Suction Pumps for Chemical Process, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, http://www.asme.org.
3. API Standard 610, Centrifugal Pumps for Petroleum, Heavy Duty Chemical, and Gas Industry Services, Eighth Edition, American Petroleum Institute, 1220 L Street Northwest, Washington, DC 20005, http://www.api.org.

ACKNOWLEDGEMENTS

Figures 1, 3, 6, and 11:
Diagnostic Solutions, LLC.

USA
GRUNDFOS Pumps Corporation
17100 West 118th Terrace
Olathe, KS 66061
Phone: (913) 227-3400
Telefax: (913) 227-3500

USA
PACO Pumps – National Headquarters
Grundfos CBS Inc.
902 Koomey Road
Brookshire, TX 77423
Phone: (800) 955-5847
Telefax: (800) 945-4777

CANADA
GRUNDFOS Canada Inc.
2941 Brighton Road
Oakville, Ontario
L6H 6C9
Phone: (905) 829-9533
Telefax: (905) 829-9512

MEXICO
Bombas GRUNDFOS de Mexico S.A. de C.V.
Boulevard TLC No. 15
Parque Industrial Stiva Aeropuerto
C.P. 66600 Apodaca, N.L. Mexico
Phone: 011-52-81-8144 4000
Telefax: 011-52-81-8144-4010

L-CBS-WP-02 • Rev. 04/09 (US)