GRUNDFOS

WHITE PAPER

FOUNDATIONS

by Greg Towsley

Although a baseplate is designed to be a rigid support for a pump and its driver, it will deflect. For this reason a foundation may be provided for additional support. One of the most significant factors for a reliable and trouble-free pump installation is a good foundation.

Other factors of a good installation are the baseplate, its installation, and the alignment of the equipment. Other White Papers by Grundfos discuss these topics. This White Paper focuses on good industrial practices for pump foundations, but the installer should refer to the requirements of the manufacturer or owner.

A good foundation will be stout enough to provide stability and give rigid support. It will be able to absorb the normal strains and shocks that may be transferred to it while operating in service.

The foundation must also minimize vibration that the pump and driver create, or external sources, such as piping, building structures or other operating equipment.

Figure 1 shows a multistage boiler feed pump with electric motor, mounted on a common baseplate. This entire unit has been grouted to a foundation for a durable installation.

Figure 1. *Boiler Feed Pump Unit*

Another key purpose of a good foundation is to help maintain alignment between the pump and driver. Alignment is also critical to the reliability of the equipment.

Without a good foundation, distortion of the baseplate may occur due to the ground settling, thermal distortion of the baseplate, excessive piping forces, and pressure or vacuum forces that occur because of expansion joints.

This may cause the pump and driver to become misaligned, and reduce the reliability of the rotating equipment.

DESIGN RECOMMENDATIONS

The foundation should begin with a firm footing. Fabricating a concrete foundation from the solid ground is the most acceptable. Concrete is the best material for construction of foundations because it is low in cost.

The mass of the concrete foundation is great enough that it absorbs any of the dynamic and static forces previously described. The Hydraulic Institute recommends in its Standards[1] that the mass of the concrete foundation should be on the order of five (5) times that of the equipment it is supporting.

If the pump unit is mounted on other than concrete foundation, such as a steel structure, the base should be supported on rigid steel beams along its length. It should also be mounted as near as possible to main structural members, other beams and the surrounding walls.

Calculations should be made on the steel structure to insure that it has adequate rigidity to minimize baseplate distortion and vibration

during operation. The Hydraulic Institute also recommends in its Standards[2] that "light-weight pump units may be fastened directly to an existing concrete floor if the floor meets the criteria of a foundation". If this is done, installation of threaded bolts into the foundation can be done as shown in *Figure 2*. This provides a rigid installation.

The depth of the foundation should reach through the concrete flooring or elevation to solid ground or footings. The height of the foundation above the elevation is as required by the piping layout, but at least 20 times the diameter of the foundation bolts.

General industry practice provides a foundation that is 3 to 6 inches (7.6 cm to 15.2 cm) longer and wider that the baseplate that will be installed. A practice of the petrochemical industry provides a design that insures the foundation is wide enough to provide a rigid support.

This practice draws imaginary lines downward 30° on either side of the vertical of the pump, through the shaft centerline. These imaginary lines, as seen in *Figure 3*, should pass through the bottom of the foundation, not the sides.

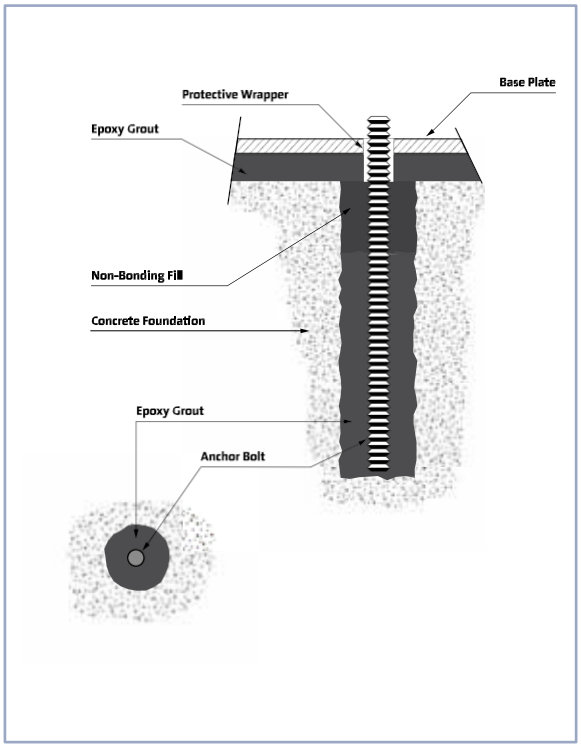

Figure 2. *Threaded Anchor Bolt in Foundation*

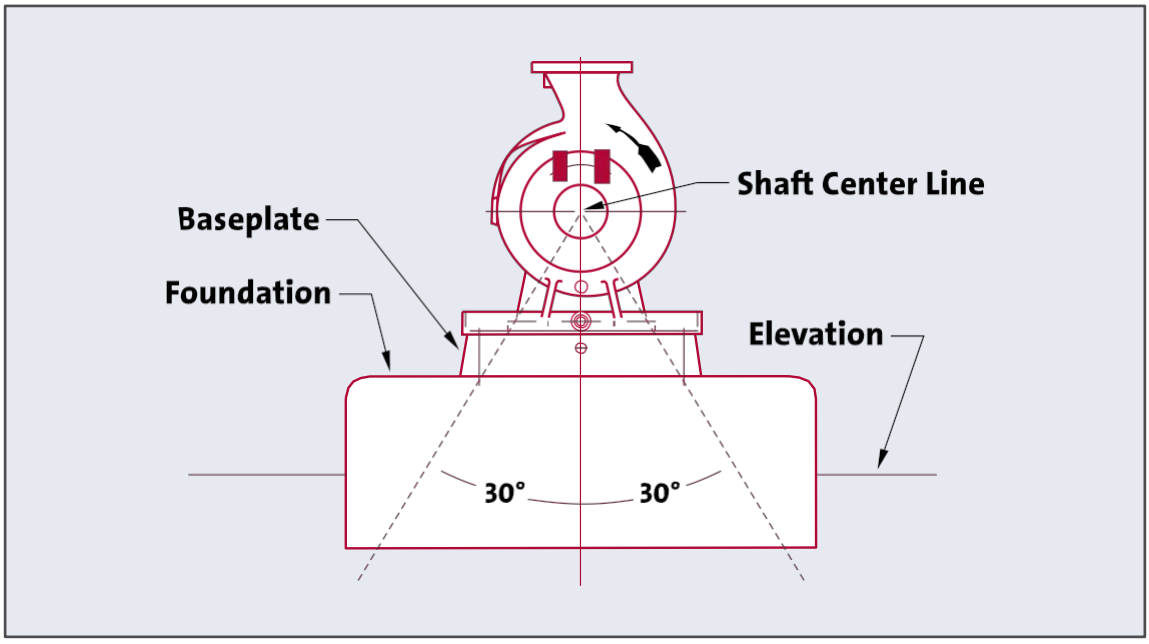

Figure 3. *Foundation Design*

For elevated pump installations, similar to that shown in *Figure 4*, the overall size and mass of the foundation must be maximized to insure the best possible rigidity.

If a new pump unit is being installed in place of an existing unit, the existing foundation should be removed in its entirety. The removal should be total and allow the new foundation to reach to the solid ground or footing.

To properly hold the baseplate to the foundation, proper foundation bolts are required. The supplier of the pump unit normally recommends the diameter of the bolts.

For proper holding of the base through the foundation, the bolt length should extend from in the foundation, through 0.75 inches to 1.5 inches (2 cm to 3.8 cm) of grout, the base height, and 0.25 inches to 0.50 (0.6 cm to 1.3 cm) inches above the nut.

These foundation bolts are embedded in the concrete floor or foundation, and are located according to a drawing provided by the pump supplier. To assist in the proper location of the bolts and to maintain their position when pouring the foundation, a template can be formed.

Pipe sleeves are used to allow final positioning of the bolt. These sleeves are a minimum of 3 times larger than the bolt, and have a length of at least 10 times the diameter. *Figure 5* provides a view of the anchor bolt and pipe sleeve in which it is installed.

It must be noted that pre-cast foundations, baseplates, and combination units are available. These pre-cast units are constructed of a polymer material that is inert to many chemicals. They may also reduce installation time for a new or replacement foundation.

Some of the following installation and grouting recommendations still apply to the pre-cast system. The ANSI chemical pump shown in *Figure 6* is installed on a flexibly mounted cast iron baseplate. This installation design does not provide much rigidity for a pump unit.

Figure 4. *Elevated Pump Unit*

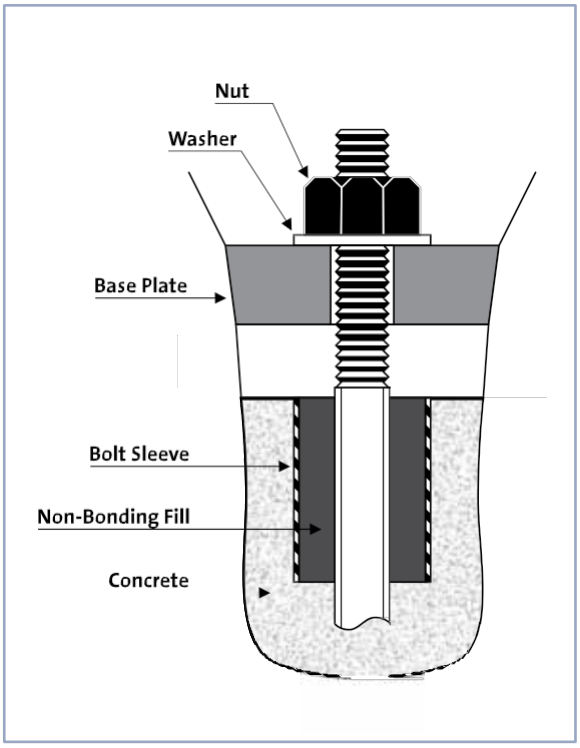

Figure 5. *Anchor Bolt and Pipe Sleeve Detail*

Figure 6. *ANSI Chemical Pump on Flexible Base*

Figure 7. *ANSI Chemical Pump on New Pre-Cast Baseplate/Foundation*

The lack of rigidity will affect alignment and mechanical seal reliability. This installation was replace with a pre-cast polymer baseplate/foundation shown in *Figure 7*.

INSTALLATION RECOMMENDATIONS

Installation of the foundation is critical to the life of the pump unit. Best practice recommends that all equipment be removed from the baseplate. This practice will vary from company to company, and will mostly be done with large equipment. The bolt locations should be double-checked with drawings and base.

Once the foundation is ready to pour, the exposed threads of the anchor bolts should be covered with grease or wax and then the exposed threads should be wrapped.

The foundation bolt sleeves may be packed with some type of non-binding material, such as rags or grease, to prevent concrete from entering the sleeve and prevent and final adjustment of the foundation bolts.

Insure that enough concrete is available to complete the job all at once. The poured concrete foundation should then be allowed to cure for a minimum of 14 days. Hydraulic Institute[2] prefers 28 days. Waxed forms assist in the removal after the concrete has cured.

Before installing the baseplate, the underside should be cleaned and coated with an epoxy primer. The foundation should have been poured with a rough surface or should be roughed after pouring, to provide a good surface to allow the grout to bond.

In addition, the foundation should be inspected for dust, dirt, oil, or water, and all contaminants should be removed. Oil-free, high-pressure air can be used to blow the foundation clear.

The baseplate should be leveled in accordance with the manufacturer's instructions, but there may be some additional considerations. When utilizing leveling wedges or shim sets, they should assemble together with minimal voids. This will assist in providing a homogenous mass.

Figure 8 provides a view of a typical baseplate that is grouted to a foundation. Note that the anchor bolts are not shown. It is also important that no sharp edges come in immediate contact with the grout. Sharp corners or edges may cause the grout to crack. Corners should be made round, such as those on the leveling wedges.

In lieu of leveling wedges, the baseplate may be provided with 0.75 inches to 1.5 inches (1.9 cm to 3.8 cm) jackscrews. These should be coated with an anti-seize compound to assist in the removal after grouting.

Final leveling should bring the pump and driver mounting pads back to the plane in which they were machined to co-planer flatness.

GROUTING RECOMMENDATIONS

Before any piping is installed on the pump, the entire pump unit needs to be grouted. Grouting of the baseplate to the foundation is done to provide a good, sturdy union between them. Grout is a concrete-type material that is used to fill between the baseplate and the foundation.

The grout increases the mass of the baseplate to help in reducing vibration. In addition, the grout will fill any voids or imperfections in the foundation surface. When the grout solidifies, the baseplate and the foundation become one solid entity.

Similar to pouring the concrete foundation, some site preparation must be completed. If any equipment was removed from the baseplate before installation, it should now be replaced. Preliminary alignment should be done on the equipment. The equipment should be tightened evenly, but not fully, as they will be final aligned later.

Forms are then used to prepare the unit for grouting. The forms shall be of ample strength for the expansion of the grout, and secured to

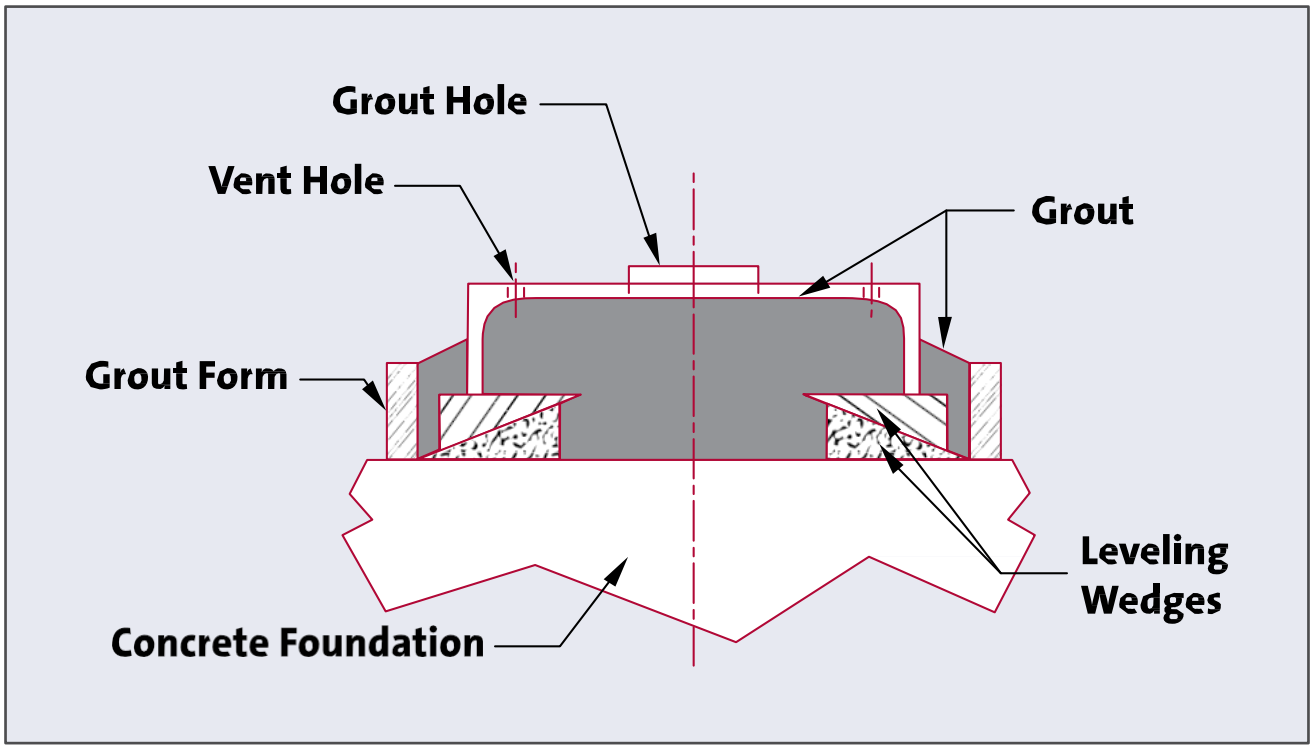

Figure 8. *Typical Baseplate with Grouting*

Figure 9. *Vertical Turbine Pumps – Proper Installation*

Figure 10. *Vertical Turbine Pumps – Improper Installation*

prevent movement. The forms shall be taller than the lowest edge of the leveled baseplate.

To assist with removal after the grout has cured, the forms should be coated with a paste wax. After the forms are in place, the joints should be sealed with a "liquid-tight" material to prevent the grout from seeping out of the forms. *Figure 8* provides a view of the grout forms in place around a baseplate.

In the case of vertical pumps, the discharge head, a curb ring, or a soleplate is grouted into position. As with a horizontal pump, a foundation is first fabricated for the unit.

Figure 9 shows properly installed vertical turbine pump discharge heads and soleplates that are mounted on a foundation and grouted into place.

Figure 10 provides a view of a damaged foundation of a vertical turbine pump. As it was not mounted properly to the foundation and grouted into place, the operation of the pump has caused damage to the foundation. In addition, the end user has attempted to minimize the vibration and stiffen the installation by adding shim under the soleplate.

Proper grouting of an equipment baseplate requires many recommended practices, however, one should always follow the instructions and recommendations of the grout manufacturer. The instructions may differ between an expanding grout and a non-shrink grout.

Typically, the grout should be poured when the ambient temperature is between 50° to 90° F (10° to 32° C). This will provide a good consistency in the grout. It should be mixed to a water-like consistency to allow it to flow evenly within the baseplate and for all air to be expelled from the vent holes in the baseplate compartments.

If only one grout hole or other opening exists (see *Figure 11*), it should only be poured from this location. *Figure 12* shows an ANSI pump mounted on a channel steel baseplate. For this installation, the grout was filled from an end, as detailed with the arrow.

Figure 11. *Grout Hole*

Figure 12. *ANSI Pump – Channel Baseplate*

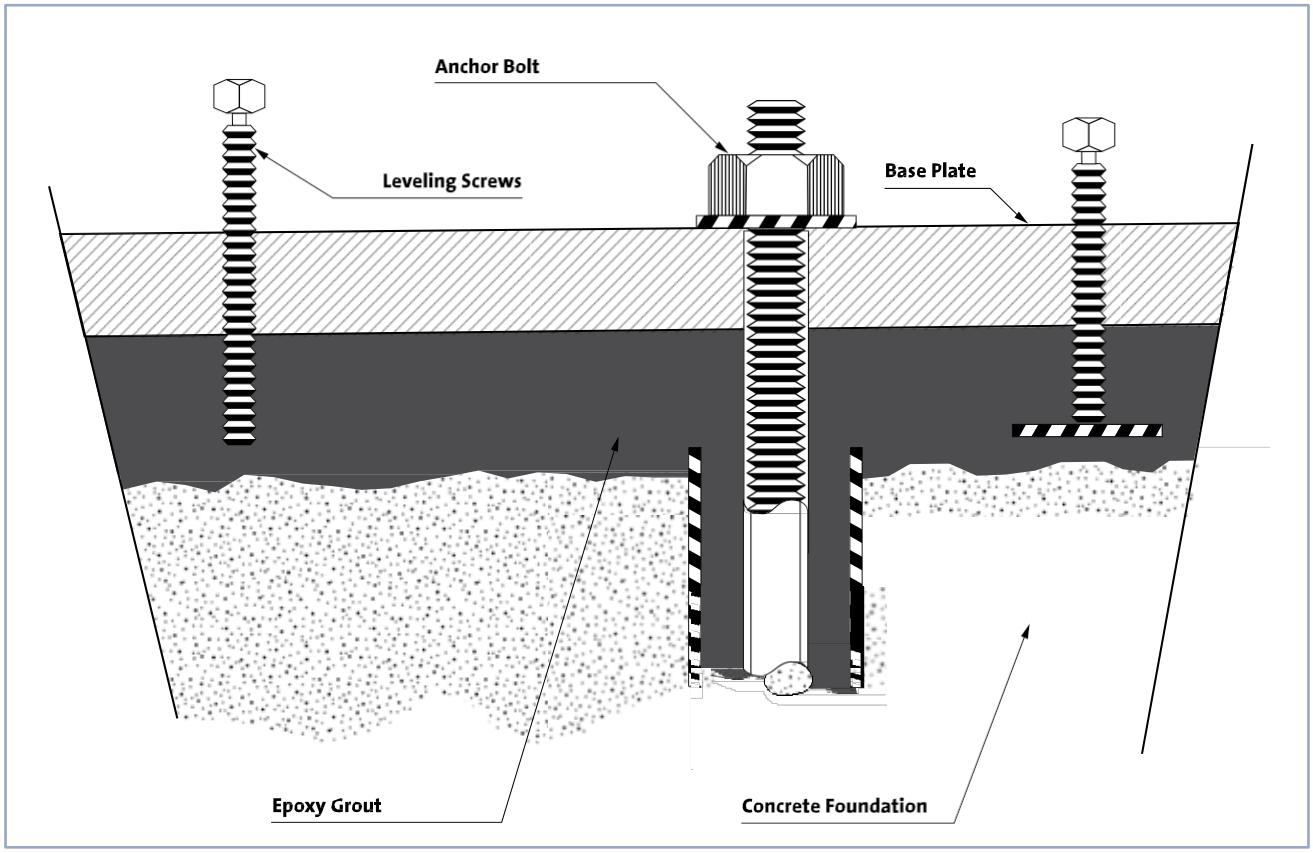

Figure 13. *Baseplate with Leveling Screws*

For baseplates with multiple grout holes, each of these should be used to ensure the underside compartments are completely filled and void of air pockets. The baseplate leveling pieces described previously are grouted into place.

These will become part of the baseplate foundation. *Figure 13* provides another view of baseplate leveling. Baseplates can be fabricated with leveling screws that provide ease of alignment. Baseplates manufactured to industry specifications, such as HI 1.4[1] or API-610[3], provide recommended specifications for this value-added feature.

The grout should be filled until it starts to come up through all of the vent holes. To check for voids or air pockets, a hammer can be used on the baseplate to help in locating and eliminating the voids. During this process, prevent the grout from dropping below the level of the bottom edge of the baseplate.

Figure 14 provides a view of a grouted baseplate with a void. Epoxy grout manufacturers provide instructions on how to fill these voids to provide for a solid installation.

The grout should be allowed to cure for 48 hours, or as recommended by the manufacturer. The baseplate and grout should be protected from wet weather and temperatures outside of the limits recommended by the manufacturer. The foundation bolts can then be fully tightened after the grout is cured.

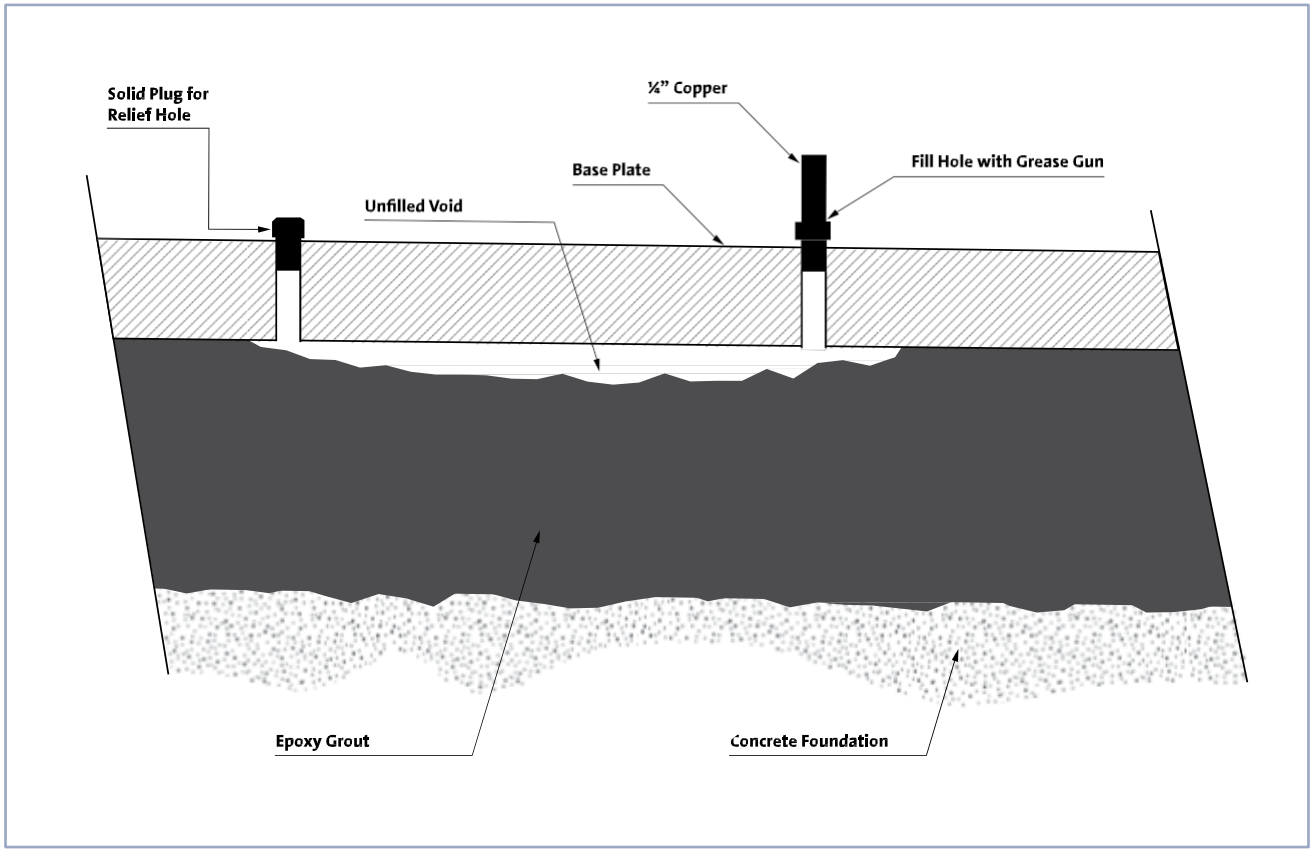

Figure 14. *Baseplate with Void*

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3. American Petroleum Institute (2004). *API Standard 610, 10th Edition, Centrifugal Pumps for Petroleum, Petro Chemical, and Natural Gas Industries*. American Petroleum Institute, 1220 L Street NW, Washington, DC, 2005. http://www.api.org.

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Figures 1, 4, 9, 11, and 12:
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