Technical Bulletin 419

Steel Baseplate Considerations

Key Steel Baseplate Considerations:

- *If bond to the steel baseplate is expected/required, this decision is made at the design stage by the structural engineer.*
- *Most steel baseplate preparation steps need to be done prior to setting the equipment.*
- *When using **cementitious grouts**, the steel baseplate bonding surface should be clean, and free of oil, grease, dirt, scale, rust, and other bond inhibiting contaminants.*
- *When using **epoxy grouts**, the steel baseplate bonding surface should be dry, clean, and free of oil, grease, dirt, scale, rust, and other bond inhibiting contaminants. A non-petroleum based solvent can be used to clean the bonding surface before grouting. An SSPC-SP6 commercial finish on all metal surfaces will optimize the bond.*

The metal baseplate or structural frame member (usually steel) is a critical component in the support, load transfer, and anchoring of a piece of equipment or structural column. The way a grout interfaces with this component depends on its condition at the time the grout is placed, and the design of that component can affect the way in which the grout needs to be installed.

To address these considerations, this technical bulletin is divided up into three sections:

I. Contractor Considerations When Installing Grout

II. Engineering Considerations for Grout Placement

III. Engineering Considerations for Baseplate Design

Note: Since most metal baseplates and structural frame components are steel, this technical bulletin is written assuming they are steel. If the metal baseplate or structural member is made from a different material, (aluminum, titanium, etc.) it is likely that the same principles apply but the reader should contact Five Star Products to verify how the grout will interact with the material. The terms baseplate and structural frame member should be considered the same component when using this document. They both refer to the metal object that is in contact with the grout.

Industry Standards and References

The requirements and recommendations on the product's Five Star® Technical Data Sheet represent the minimum required surface preparation of steel baseplates. This document provides additional details on metal baseplate design and surface preparation.

The American Petroleum Industry Recommended Practice for Machinery Installation and Installation Design (API RP 686) is the most referenced and adopted standard for epoxy grouting. It provides the most baseplate design detail and has very prescriptive and specific requirements for steel baseplate preparation and maximizing the bond of epoxy grout to the steel baseplate.

A list of the most commonly referenced documents and standards related to grouting is provided below:

- American Petroleum Institute Recommended Practice 686. Recommended Practice for Machinery Installation and Installation Design; Chapter 5
- American Concrete Institute ACI 351.1R-12 Report on Grouting between Foundations and Bases for Support of Equipment and Machinery
- Process Industry Practices Structural PIP STS03601 Epoxy Grout Specification (Section 4.7.10.1), December 2010

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I. Contractor Considerations When Installing Grout

In most applications, grout is expected to bond to the concrete foundation if the foundation is prepared properly. Refer to Technical Bulletin (TB) 103 Cementitious Grouts- Concrete Surface Preparation and TB 213 Epoxy Grout - Concrete Surface Preparation for details.

If bond to the steel baseplate is expected/required, this decision is normally made at the design stage by the structural engineer who is responsible for installing the equipment or structural steel member. The structural engineer decides the type of grout to be used and if a bonding agent should be used for the application. If the strength of the bond to the steel baseplate is critical, the structural engineer should also specify how the steel baseplate is to be prepared prior to grouting.

Most steel baseplate preparation steps need to be done prior to setting the equipment. Unless the grout installation contractor is involved in all phases of installing the equipment or structural member, it is often not practical for the grout installation contractor to do any more than "clean" the steel baseplate prior to the installation of grout. In most instances even cleaning the steel baseplate prior to grouting may present challenges.

A. Cementitious Grouts

- Every attempt should be made to ensure that the steel baseplate bonding surface is clean, and free of oil, grease, dirt, scale, rust, and other bond inhibiting contaminants. Possible cleaning methods include blowing the surface clean with oil free compressed air or pressure wash.

B. Epoxy Grouts

- Every attempt should be made to ensure that the steel baseplate bonding surface is dry, clean, and free of oil, grease, dirt, scale, rust, and other bond inhibiting contaminants. If it is possible, clean the bonding surface with a non-petroleum based solvent prior to grouting and allow the solvent to dry prior to grouting. This will not only remove any grease or waxes but will "open up" the coating (if the surface happens to be primed or painted) and enhance the bonding capability of the epoxy grout. The decision about what type of non-petroleum solvent to use and/or how to clean the baseplate must be made by the project engineer or project manager.
- Metal surfaces in contact with the grout will optimize the bond development to steel. An SSPC-SP6 surface finish is considered the minimum sandblast specification if sandblasting is required. Sandblasting is often not practical at the time of grout installation. The decision to require a surface preparation other than a thorough cleaning (including a solvent cleaning) must be made by the project engineer or project manager.

There are often project specifications and other referenced industry guidelines which detail additional steel baseplate surface preparation requirements. The installation contractor must follow the applicable project and design specifications that apply to steel baseplate surface preparation. Any questions or concerns should be brought to the attention of the project engineer or manager for resolution.

II. Engineering Considerations for Grout Placement

A. Function of Grout

When using grout as part of the foundation system for equipment or structural members, the function of the grout is to completely fill the space between the equipment or structural member and the concrete foundation, maintain a precise elevation, and completely transfer all the load to the foundation.

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II. Engineering Considerations for Grout Placement cont'd

B. Types of Steel Baseplates

The foundation is usually a concrete floor or slab and the equipment or structural member normally has a metal plate or wide surface structural steel element that is in contact with the foundation. The most common metal for a steel baseplate is carbon steel but there are other metal surfaces that may be encountered such as galvanized steel, stainless steel, aluminum, etc. This technical bulletin assumes the baseplate is steel, but regardless of the type of metal used for the baseplate the discussion points apply to all metal types. Contact Five Star Products if there are any concerns with materials other than steel.

C. Equipment Design Stage Decisions

The structural engineer responsible for installing the equipment/structural steel member must make the following decisions during the design stage:

- The type of grout to be used
- Whether a bond to the steel baseplate is expected/required. If the strength of the bond to the steel baseplate is critical, specify how the steel baseplate is to be prepared prior to setting the equipment and grouting.
- Is it necessary to enhance the bond between a grout and a steel baseplate? If yes, a decision must be made whether this is accomplished via a bonding agent, sandblasting, or working with a coating on the steel baseplate.

Most steel baseplate preparation steps need to be done prior to setting the equipment. Because the steel baseplate bonding surface is on the underside of what is being grouted, it is often extremely difficult or too late to "prepare and enhance" the steel baseplate bond surface in the field immediately prior to installing the grout. Once the equipment is set, the best the grout installation contractor can do is clean the steel baseplate prior to installing the grout and in most instances even cleaning the steel baseplate prior to grouting may present challenges.

D. Cementitious Grout Considerations

The bond between a cementitious grout and a steel baseplate is not considered significant, so if a bond at this interface is desired an epoxy bonding agent will typically be required as part of the installation. A bond of any kind between a cementitious grout and a steel baseplate will be maximized if the surface has profile, and is clean and free of any "bond inhibiting materials" like oils, greases, waxes, etc. Any significant cleaning and surface preparation must be done prior to the equipment being installed.

1. Epoxy Bonding Agent

If an epoxy bonding agent is specified and used, the strength of the bonding agent is what controls the strength of the bond of the grout to the steel baseplate. The installing contractor must follow the bonding agent's instructions. The specifying engineer must

- Verify with the bonding agent manufacturer that the bonding agent will be compatible with the specified grouts.
- Understand that applying a bonding agent to a steel baseplate prior to grout installation may present challenges.
- Select a bonding agent that will be ready to bond to the grout when it is installed. Refer to the open time discussion under Section E2 Epoxy Grouts - Coatings. The epoxy bonding agent must be open at the time the cementitious grout is applied in order to achieve a bond at the cementitious grout/bonding agent/steel baseplate interface.

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E. Epoxy Grout Considerations

The bond between an epoxy grout and a steel baseplate can be significant and desirable. This is one of the primary reasons for selecting an epoxy grout over a cementitious grout. If the epoxy grout is bonded to the concrete and the steel baseplate, the grout along with the anchor bolts "locks" the equipment to the foundation. This "locked" foundation system will dampen and transfer load and vibration better than an unbonded foundation system.

Like cementitious grouts, the bond of an epoxy grout to a steel baseplate will be maximized if the surface has profile, and is clean and free of any "bond inhibiting materials" like oils, greases, waxes, etc. Five Star's internal data indicates that epoxy grouts can have a bond greater than 2,500 psi (17.2 MPa) when the grout is applied to a cleaned, smooth steel surface and post cured at laboratory conditions. When the epoxy grout bond to smooth, clean steel is tested using the methodology of ASTM C882 Slant Shear Bond Strength, and similar cure conditions, the bond strength exceeds 3,000 psi (20.7 MPa). Epoxy grout bond strengths are similar for steel or stainless steel, however for galvanized steel, the bond is approximately one-third of what it is for steel or stainless steel. Five Star does not test the bond of its epoxy grouts to the myriads of coatings that are available.

Once the equipment is set, requiring the grout installation contractor, in the field, to ensure the steel baseplate surface is clean and free of bond inhibiting contaminants is usually accomplished by pressure washing followed by blowing the surface clean with oil free compressed air. Cleaning the surface more vigorously prior to installation of the grout often presents challenges.

1. Sandblasting

If the contact surface of a carbon steel baseplate is sandblasted and left for any length of time before the grout is installed, the surface will likely rust. There is also the challenge of sandblasting large equipment frames and steel baseplates during or after they are constructed. If the surface is sandblasted and the steel rusts, as long as the rust is not scaly and disintegrating the steel (i.e. there is only a rust bloom), the epoxy grout will bond to the steel and the bond will not be compromised. The rust will also be encapsulated in the grout and the surface of the steel baseplate and should not continue to rust.

A SSPC-SP6 surface finish is considered the minimum sandblast specification if sandblasting is required. The engineer should consider whether a sandblasting requirement and the added expense is necessary for the application. A stainless steel baseplate would not be subject to rusting.

2. Coatings

It is much more common for the grout contact surface of a steel baseplate to be coated with a paint or primer during fabrication/manufacturing. As with the sandblasting requirement above, the engineer should carefully consider how to properly prepare a coated surface for epoxy grouting and whether addressing the coating is necessary for the application.

If there is an opportunity to influence the decision of applying a coating at the time of fabrication or just prior to installation, there are commercially available coatings and primers that will bond to epoxy. The bond of epoxy grout to a coating is enhanced if the coating is still considered "open" when it meets the epoxy grout. Coatings are available with long and short open times. The goal is to select a coating that will remain open during the transportation, installation, and grout preparation stages. In most instances even the longest open times usually require the coating to be "re-opened" (softening the hardened surface) just prior to grouting.

Re-opening a coating usually involves some mechanical roughening and cleaning the existing coating with a non-petroleum based solvent to remove the hardened surface. A petroleum based solvent will act as a bond breaker. The coating manufacturer should be contacted to determine the best way to prepare the coating so that it will maximize the bond to epoxy grout. Much the same as sandblasting, this can be a costly and labor intensive activity so careful consideration should be given as to whether it is required.

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2. Coatings cont'd

In most instances, the practical decision is to leave the factory coating in place and accept the bond that will develop.

Here are several points to consider when deciding how to address a steel baseplate that has a coating on it:

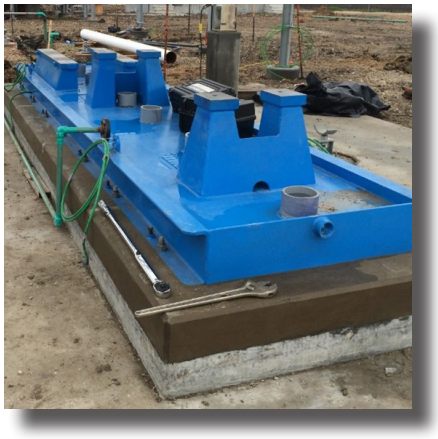
- Five Star® epoxy grouts will develop some type of bond to an existing coating if the bond surface is clean and free of dirt.
- While the strength of that bond is unknown (because Five Star does not test its grouts with all available coatings), the expansive agents in the grout will be sufficient to keep the grout in contact with the bottom of the baseplate until the grout cures.
- The anchor bolts (if properly designed and torqued) along with the weight of the equipment, in conjunction with any grout bond will hold the equipment in place and transfer the load and the vibration to the foundation.

For additional metal baseplate surface preparation considerations and discussion see the Industry Standards and References information on page 1 of this document.

III. Engineering – Steel Baseplate Design

When field installed grout is used to set and hold precision alignment as well as minimize vibration, specific enhancements and features can be incorporated into the design of the equipment which will allow the grout to be installed easily.

A. Baseplate Grout Holes



When a baseplate has a covered top, grout holes must be provided to aid the grout in "filling" the base. Grout holes are often used to install grout under the structural members of large equipment, often minimizing the distance the grout must flow. Grout holes are typically a minimum of 4 inches (100 mm) in diameter and usually have a ½ inch (12 mm) raised lip around the edge.

Best practices dictate that

- Each bulkhead section must have at least one grout hole.
- The grout hole should be accessible from the top of the equipment in an area that has sufficient clearance for installing the grout.

Grout is installed through a grout hole using a funnel or cone. Traffic cones are often used because they are readily available on most job sites and work well for the application.

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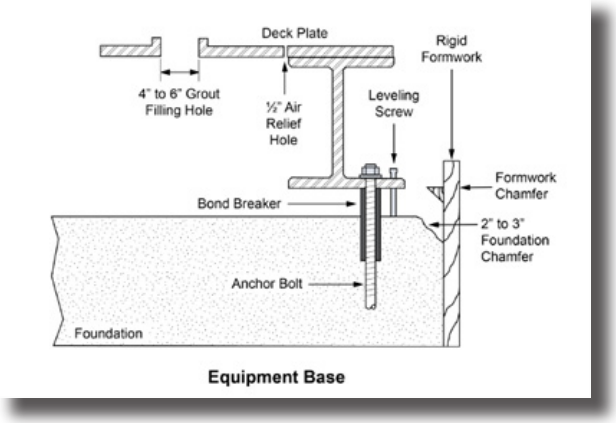
B. Baseplate Vent Holes

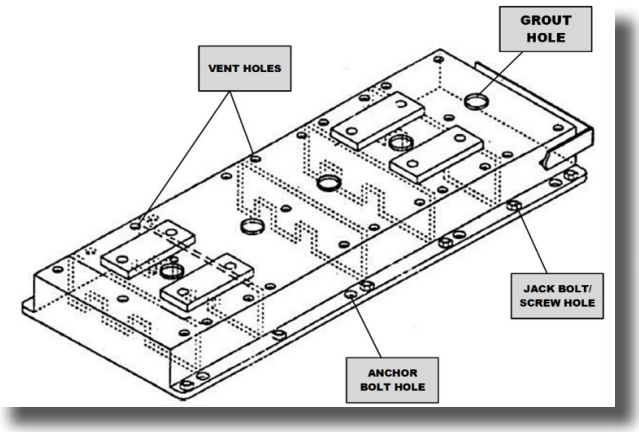


Equipment Base

Whenever there exists the possibility of air being tapped which will impede or slow the travel of grout as it is being installed, it is recommended that a vent hole be installed. Like grout holes, vent/air relief holes are often found on large, complicated baseplates.

Vent holes are placed at the high point of each bulkhead section and at each 90 degree corner. The vent holes bleed air as the grout is filling preventing "vapor lock" and allow the installer to verify that the grout has filled an entire bulkhead section. When the grout flows out the vent hole, the section is filled. Vent holes are typically ½ inch (12 mm) in diameter or larger.

C. Jack Screws/Bolts and Bearing Pads



Jack screws/bolts are used to set the elevation of the equipment being grouted. Once the grout has been placed and cured, the jack bolts are backed off to transfer the full load of the equipment to the grout. The ideal jack screw/bolt is one that is not encapsulated in the grout. If the jack screws/bolts are encapsulated in the grout, to remain fully functional, they should be generously coated with a bond break material such as wax or "never-seize" to prevent epoxy grout from bonding to them.

It is common to have a bearing pad at the base of a screw/bolt so that the concrete foundation does not see a point load from the weight of the equipment on the end of the screw/bolt.

Bearing pads are

- Typically, ½ inch thick (12 mm) steel with generously rounded edges. The ideal bearing pad is round like a washer.
- Often epoxy bonded to the concrete.

If bearing pads are left encapsulated in the grout, they should be 2 inches (50 mm) or more from the edge of the grout, and ideally 2 inches (50 mm) inside the edge of the baseplate.

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D. Shims

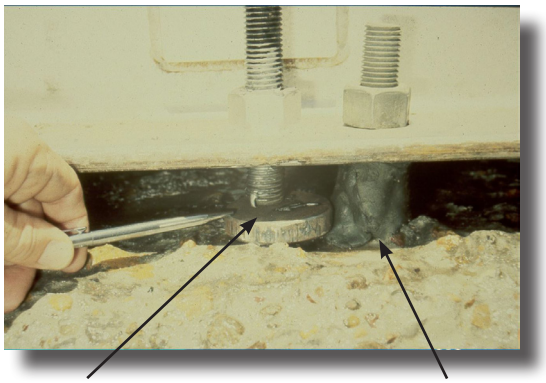
The most common method for leveling and setting the elevation of a piece of equipment is to use shims or wedges even though it is not the preferred method. The preferred method is to use jack screws/bolts or to remove the shims prior to fully torquing the anchor bolts which ensures that the grout is fully loaded. Shims, unlike jack screws/bolts, cannot be "backed off" and cannot be removed once the grout has cured. Shims and wedges, if left in place after grouting, may cause "hard" spots that interfere with the grout's ability to provide uniform base support.

Five Star recognizes that, although not the preferred method for setting and maintaining level, square/rectangular shims are commonly and widely used in industry and are, invariably, left encapsulated in the grout. Every effort should be made prior to installing the grout to ensure that stress concentrations caused by non-radiused shims are reduced.

If shims are used, Five Star recommends the following:

- Shims should have generously radiused corners to reduce the risk of cracks which could arise from potential stress concentrations created by sharp corners.
- Shims should be located 2 inches (50 mm) away from the edge of the equipment baseplate and be aligned and parallel to the edge of the plate.
- If shims have not been properly prepared with radiused corners prior to installation, the shims should be wrapped in duct tape or plumbers' putty which can be effective at minimizing the stress concentrations in the grout.

E. Anchor Bolt Protection



ANTI SEIZE ON BOLT

ANCHOR BOLT WRAPPED WITH DUCT TAPE

An engineer sizes anchor bolts to have a specific hold down capacity. As part of that calculation each anchor bolt has a specific "stretch length" when fully tightened or torqued. If epoxy grout is allowed to bond to the anchor bolt, it can effectively change the stretch length of the bolt thereby changing its capacity.

Anchor bolts may be cast in place, mechanically installed, grouted in place, or installed in an anchor bolt sleeve. Regardless of how the anchor bolt is installed, the portion of the anchor bolt that protrudes above the foundation (and is encapsulated in the grout) needs to be protected from grout bonding to it. Protection methods include covering the bolt with foam pipe insulation, duct tape, putty, or coating the bolt with a "bond break" material/coatings. Bond break materials/coatings include waxes, greases and "never-seize".

For additional information, contact your Five Star® Technical Sales Representative.

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