

PREFILLED EQUIPMENT BASEPLATES— HOW TO GET A SUPERIOR EQUIPMENT INSTALLATION FOR LESS MONEY

by

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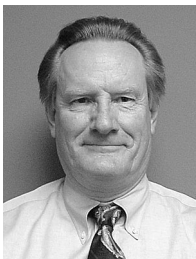
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percent. He also developed the concept for C.R. Gregg & Associates' Stay-Tru™ process for pregrouting of machinery baseplates.

Mr. Palmer received a B.A. degree (Marketing, 1965) from Texas University.

ABSTRACT

This paper outlines a new void-free baseplate installation method that saves over 30 percent of the installation costs, when compared to traditional two-pour grouting methods. Common field installation problems are discussed, and new insights are presented to show the causes and corrections.

For installations utilizing cement based grouting systems, the paper shows how to greatly improve the bond between the grout and the baseplate, when using the prefilled method.

A new installation technique is also introduced that utilizes a thin-pour epoxy grout system. When coupled with a prefilled baseplate, this new technique will greatly reduce the total installed cost for machinery baseplates. A complete breakdown of the installation costs is provided to justify the cost savings.

INTRODUCTION

Proper field installation of rotating equipment has a tremendous impact on the life-cycle cost of machinery. According to statistical reliability analysis, as much as 65 percent of the life-cycle costs are determined during the design, procurement, and installation phases of new machinery applications (Barringer and Monroe, 1999). While design and procurement are important aspects for any application, the installation of the equipment plays a very significant role. A superb design, poorly installed, will give poor results. A moderate design, properly installed, will give good results (Barringer and Monroe, 1999).

A proper installation involves many facets; good foundation design, no pipe strain, proper alignment, just to name a few. All these issues revolve around the idea of reducing dynamic vibration in the machinery system. Great design effort and cost are expensed in the construction of a machinery foundation, as can be seen in Figure 1. The machinery foundation, and the relationship of $F = ma$, is extremely important to the reliability of rotating equipment. Forces and mass have a direct correlation to the magnitude of vibration in rotating equipment systems. The forces acting on the system, such as off-design operating conditions, unbalance, misalignment, or looseness, can be transient and hard to quantify. An easier and more conservative way to minimize motion in the system is to utilize a large foundational mass. Through years of empirical evidence, the rule of thumb has been developed that the foundation mass should be three to five times the mass of the centrifugal equipment system.

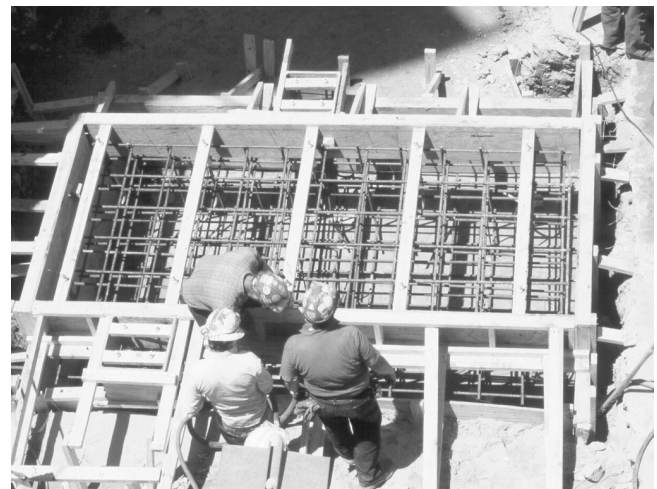


Figure 1. Construction of Machinery Foundation.

The cornerstone to a proper installation, and reduced vibration, is determined by how well the machinery system is joined to the foundation system. The baseplate, or skid, of the machinery system must become a monolithic member of the foundation system. Machinery vibration should ideally be transmitted through the baseplate to the foundation and down through the subsoil. "Mother Earth" can provide very effective damping (frequency attenuation) to reduce equipment shaft vibration. Failure to do so will result in the machinery resonating on the baseplate, as shown in Figure 2. Proper machinery installation will result in significant increase in mean time between failures (MTBF), longer life for mechanical seal and bearings, and a reduction in life-cycle cost (Myers, 1998).

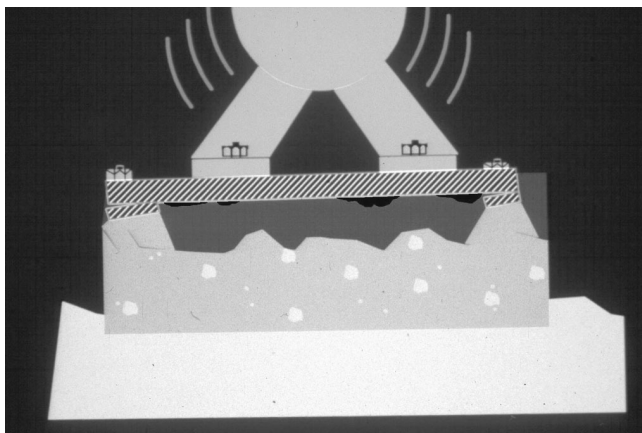


Figure 2. Machinery Vibration.

The issue is to determine the most cost effective method for joining the equipment baseplate to the foundation. Various grouting materials and methods have been developed over the years, but the issue always boils down to cost: life-cycle costs versus first cost. It is the classic battle between the "gold platers" (machinery engineers) and the "penny-pinchers" (project engineers). The machinery engineer wants to use an expensive baseplate design with epoxy grout. The project engineer wants to use a less expensive baseplate design with cementitious grout.

This paper outlines a new grouting method, the Stay-Tru™ Pregouted Base Plate System, and a new installation technique, the Stay-Tru™ Field Installation System. Utilizing these two systems will satisfy the requirements of both the machinery engineer and the project engineer. The discussion and techniques described with this process are based on the flow and pour characteristics of Escoweld® 7560.

CONVENTIONAL GROUTING METHODS

The traditional approach to joining the baseplate to the foundation has been to build a liquid tight wooden form around the perimeter of the foundation, and fill the void between the baseplate and the foundation with either a cementitious or epoxy grout. There are two methods used with this approach, the two-pour method, shown in Figure 3, or the one-pour method, shown in Figure 4.

The two-pour method is the most widely used, and can utilize either a cementitious or epoxy grout. The wooden grout forms for the two-pour method are easier to build because of the open top. The void between the foundation and the bottom flange of the baseplate is filled with grout on the first pour, and allowed to set. A second grout pour is performed to fill the cavity of the baseplate, by using grout holes and vent holes provided in the top of the baseplate.

The one-pour grouting method requires a more elaborate form building technique, but does reduce labor cost. The wooden grout form now requires a top plate that forms a liquid tight seal against the bottom flange of the baseplate. The form must be vented along

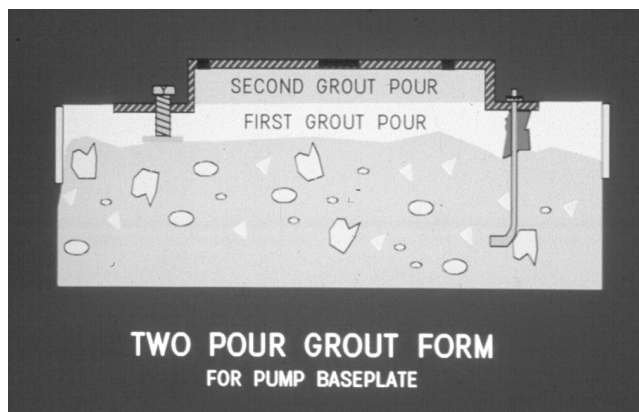


Figure 3. Two-Pour Grout Method.

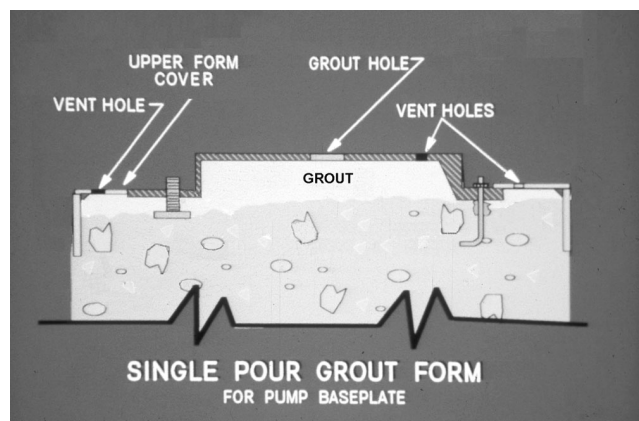


Figure 4. One-Pour Grout Method.

the top seal plate, and be sturdy enough to withstand the hydraulic head produced by the grout. All the grout material is poured through the grout holes in the top of the baseplate. This pour technique requires good flow characteristics from the grout material, and is typically used for only epoxy grout applications.

FIELD INSTALLATION PROBLEMS

Grouting a baseplate or skid to a foundation requires careful attention to many details. A successful grout job will provide a mounting surface for the equipment that is flat, level, very rigid, and completely bonded to the foundation system. Many times these attributes are not obtained during the first attempt at grouting, and expensive field correction techniques have to be employed. The most prominent installation problems involve voids and distortion of the mounting surfaces.

Voids and Bonding Issues

As shown in Figure 5, the presence of voids at the interface between the grout material and the bottom of the baseplate negate the very purpose of grouting. Whether the void is one inch deep, or one-thousandth of an inch deep the desired monolithic support system has not been achieved. Voids inhibit the foundation system from dampening resonance and shaft generated vibration. There are several causes attributed to the creation of voids:

- Insufficient vent holes in baseplate
- Insufficient static head during grout pour
- Grout material properties
- Improper surface preparation to baseplate underside
- Improper surface primer

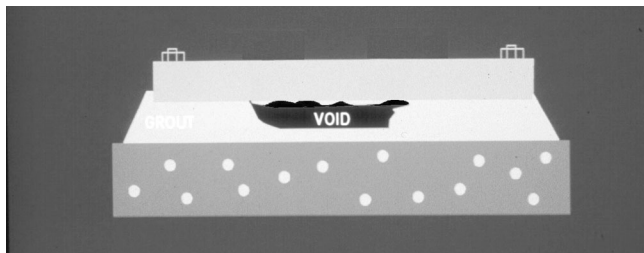


Figure 5. Grout Void Under Baseplate.

Insufficient vent holes or static head are execution issues that can be addressed through proper installation techniques, and usually leave large voids. The most overlooked causes of voids are related to bonding issues. These types of voids are difficult to repair because of the small crevices to be filled.

The first issue of bonding has to do with the material properties of the grout. Cementitious grout systems have little or no bonding capabilities. Epoxy grout systems have very good bonding properties, typically an average of 2000 psi tensile to steel, but surface preparation and primer selection greatly affect the bond strength. The underside of the baseplate must be cleaned, and the surface must be free of oils, grease, moisture, and other contaminants. All these contaminants greatly reduce the tensile bond strength of the epoxy grout system.

The type of primer used on the underside of the baseplate also affects the bond between the epoxy grout and the baseplate. Ideally, the best bonding surface would be a sandblasted surface with no primer. This is not feasible for conventional grouting methods, so a primer must be used, and the selection of the primer must be based on the tensile bond strength to steel. The epoxy grout system will bond to the primer, but the primer must bond to the steel baseplate to eliminate the formation of voids. The best primers will be epoxy based, and have minimum tensile bond strength of 1000 psi. Other types of primers, such as inorganic zinc, have been used, but the results vary greatly with how well the inorganic zinc has been applied.

Figure 6 shows the underside of a baseplate sprayed with inorganic zinc primer. The primer has little or no strength, and can be easily removed with the tip of a trowel. The inorganic zinc was applied too thick, and the top layer of the primer is little more than a powdery matrix. The ideal dry film thickness for inorganic zinc is three mils, and is very hard to achieve in practice. The dry film thickness for this example is 9 to 13 mils, as shown in Figure 7.

The consequence of applying epoxy grout to such a primer is shown in Figure 8. This is a core sample taken from a baseplate that was free of voids for the first few days. As time progressed, a void appeared, and over the course of a week the epoxy grout became completely disbonded from the baseplate. The core sample shows that the inorganic zinc primer bonded to the steel baseplate, and the epoxy grout bonded to the inorganic zinc primer, but the primer delaminated. It sheared apart because it was applied too thick, and created a void across the entire top of the baseplate.

Distortion of Mounting Surfaces

Another field installation problem with costly implications is distortion to the baseplate machine surfaces. This can either be induced prior to grouting due to poor field leveling techniques, or the distortion can be generated by the grout itself.

Baseplate designs have become less rigid over time. Attention has been focused on the pump end of the baseplate to provide enough structural support to contend with nozzle load requirements. The motor end of the baseplate is generally not as rigid, as shown in Figure 9. The process of shipping, lifting, storing, and setting the baseplate can have a negative impact on the motor mounting surfaces. While these surfaces may have initially been flat, when the baseplate reaches the field, there is work to be done.

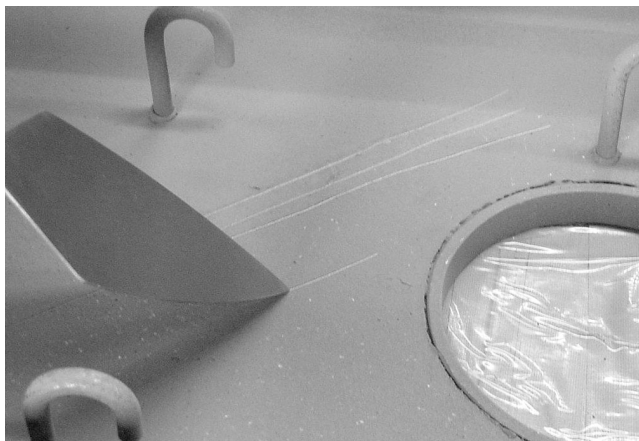


Figure 6. Soft Inorganic Zinc Primer.

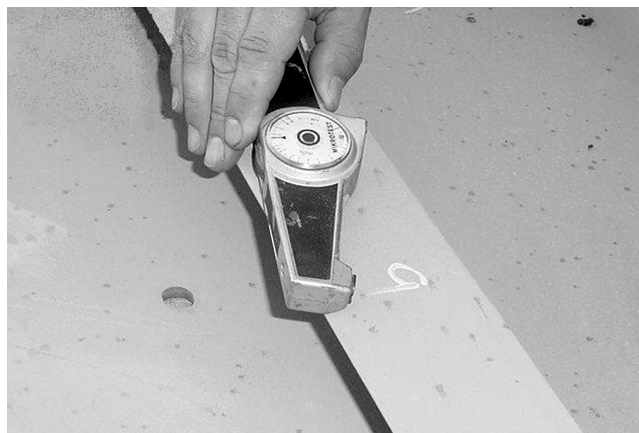


Figure 7. Dry Film Thickness Indicator.



Figure 8. Baseplate Core Sample with Zinc Primer.

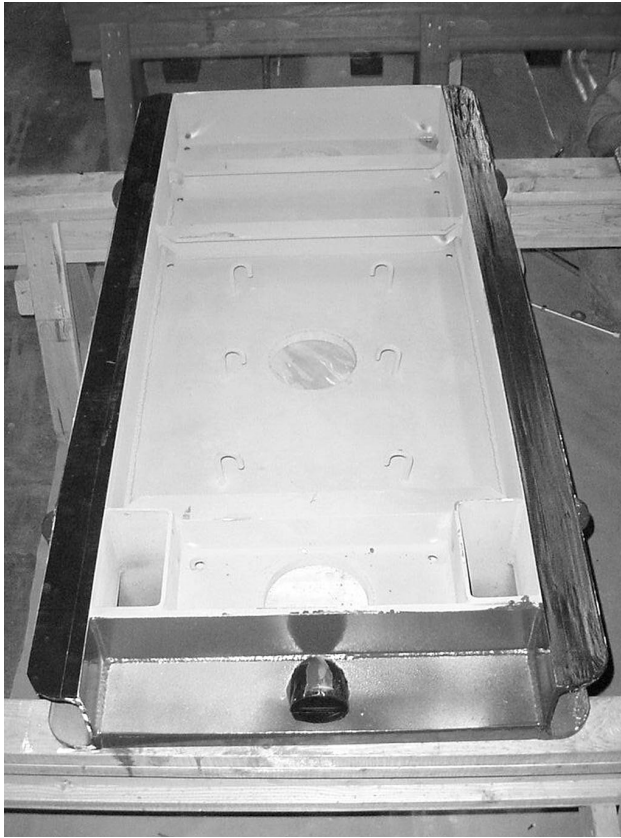


Figure 9. Underside of API Baseplate.

Using the system of jack bolts and anchor bolts (Figure 10), the mounting surfaces can be reshaped during the leveling process, but the concept of flatness and level have become confused. Flatness cannot be measured with a precision level, and unfortunately this has become the practice of the day. A precision level measures slope in inches per foot, and flatness is not a slope, it is a displacement. In the field, flatness should be measured with a ground bar and a feeler gauge, as shown in Figure 11, not with a level. Once the mounting surfaces are determined to be flat, then the baseplate can be properly leveled. This confusion has caused many baseplates to be installed with the mounting surfaces out of tolerances for both flatness and level.



Figure 10. Anchor Bolt and Jack Bolt System.

The other issue of mounting surface distortion comes from the grout itself. All epoxy grout systems have a slight shrinkage factor.



Figure 11. Flatness and Coplanar Check.

While this shrinkage is very small, typically 0.0002 in/in, the tolerances for flatness and level of the mounting surfaces are also very small. The chemical reaction that occurs when an epoxy grout is mixed together results in a volume change that is referred to as shrinkage. Chemical cross-linking and volume change occur as the material cools after the exothermic reaction. Epoxy grout systems cure from the inside out, as shown in Figure 12. The areas closest to the baseplate/grout interface experience the highest volume change.

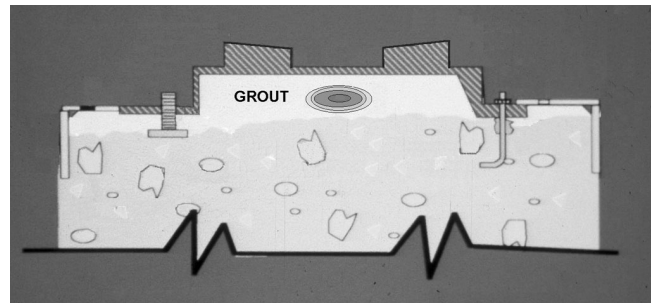


Figure 12. Grout Cure and Mounting Surface Distortion.

Baseplates with sturdy cross braces are not affected by the slight volume change of the grout. For less rigid designs, the bond strength of the epoxy grout can be stronger than the baseplate itself. Referring back to Figure 12, after the grout has cured, the motor mounting surfaces become distorted, and are no longer coplanar. Tolerances for alignment and motor soft foot become very difficult to achieve in this scenario. This “pull down” phenomenon has been proven by finite element analysis (FEA) modeling and empirical lab tests jointly performed by the authors’ company, a major grout manufacturer, and a major petrochemical company.

Hidden Budget Busters

Correcting the problems of voids and mounting surface distortion in the field is a very costly venture. Repairing voids takes a lot of time, patience, and skill to avoid further damage to the baseplate system. Field machining the mounting surfaces of a baseplate also involves commodities that are in short supply: time and money.

The real problem with correcting baseplate field installation problems is that the issues of “repair” are not accounted for in the construction budget. Every field correction is a step backward, in both time and money. For a fixed-cost project, the contractor eats

the costs. For a cost-plus project, the client eats the cost. Either way, you can be assured that there will be a “meeting,” which is just another debit from the time and money column.

PREGROUTED BASEPLATES

The best way to solve a problem is to concentrate on the cause, rather than develop a solution for the effect. The answer for resolving field installation problems is not to develop better void repair procedures or field machining techniques, it is to eliminate the causes for voids and mounting surface distortion.

A new baseplate grouting system has been developed to address the causes for field installation problems. The term “pregROUTED baseplate” sounds simple enough, but addressing the causes of installation problems involves far more than flipping a baseplate over and filling it up with grout. In that scenario, the issues of surface preparation, bonding, and mounting surface distortion still have not been addressed. A proper pregROUTED baseplate will provide complete bonding to the baseplate underside, contain zero voids, and provide mounting surfaces that are flat, coplanar, and colinear within the required tolerances. To assure that these requirements are met, a good pregROUT system will include the following:

Proper Surface Preparation

Baseplates that have been specified with an epoxy primer on the underside should be solvent washed, lightly sanded to remove the gross finish, and solvent washed again. For inorganic zinc and other primer systems, the bond strength to the metal should be determined. There are several methods for determining this, but as a rule of thumb, if the primer can be removed with a putty knife, the primer should be removed. Sandblasting to an SP-6 finish is the preferred method for primer removal. After sandblasting, the surface should be solvent washed, and grouted within eight hours.

Void-Free Grout Installation

By its very nature, pregROUTING a baseplate will greatly reduce the problems of entrained air creating voids. However, because grout materials are highly viscous, proper placement of the grout is still important to prevent developing air pockets. The baseplate must also be well supported to prevent severe distortion of the mounting surfaces due to the weight of the grout.

A side benefit to using a pregROUTED baseplate system is the ability to successfully use cementitious grouts as the fill material. With conventional installation methods, cementitious grout is very difficult to place and has no bond strength to the metal baseplate. With the pregROUT system, an epoxy based concrete adhesive can be applied to the metal prior to the placement of the grout (Figure 13). This technique will provide bond strength equal to the tensile strength of the cementitious grout, which is around 700 psi.

For epoxy grout systems, flow ability is no longer an issue, and highly loaded systems can now be employed. Adding pea gravel to the epoxy grout system will increase the yield, increase the strength, and reduce the shrinkage factor. Figure 14 shows an application using a high-filled epoxy grout system.

Post Curing of the Grout

As mentioned earlier, epoxy grout systems undergo a slight volume change during the curing process. For conventional installation methods, this physical property creates distortion. While the effects are greatly reduced with the pregROUTED system, it is still necessary to allow the epoxy grout to fully cure before any inspection or correction to the mounting surfaces is performed. Figure 15 shows a time versus cure chart that can be used for epoxy grout systems.

For cementitious grout systems, the material should be kept wet and covered for at least three days to help facilitate the curing process. While cementitious grout systems are nonshrink and do not induce distortion to the mounting surfaces, the post curing



Figure 13. Epoxy Bond Adhesive for Cementitious Grout.



Figure 14. High Fill Epoxy Grout System.

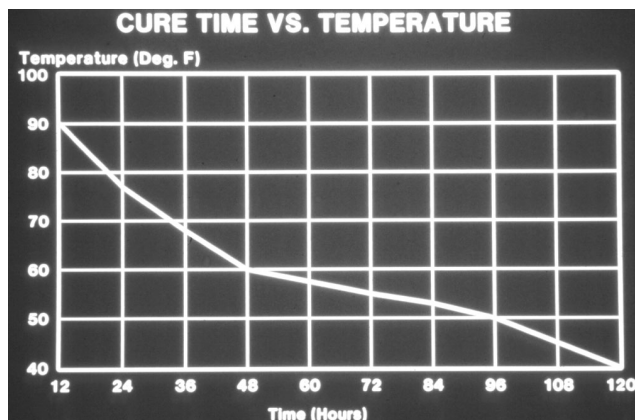


Figure 15. Epoxy Grout Cure Time Versus Temperature.

process helps to achieve full compressive strength. To further enhance the curing process, after 24 hours the grout surface can be sealed with an epoxy resin to prevent contamination and water evaporation (Figure 16).



Figure 16. Epoxy Sealer for Cementitious Grout.

Mounting Surfaces

Once the pregrout baseplate has been fully cured, a complete inspection of the mounting surfaces should be performed. If surface grinding of the mounting surfaces is necessary, then a postmachining inspection must also be performed. Careful inspection for flatness, coplanar, and relative level (colinear) surfaces should be well documented for the construction or equipment files. The methods and tolerances for inspection should conform to the following:

Flatness

A precision ground parallel bar is placed on each mounting surface. The gap between the precision ground bar and the mounting surface is measured with a feeler gauge. The critical areas for flatness are within a 2 inch to 3 inch radius of the equipment hold down bolts. Inside this area, the measured gap must be less than 0.001 inch. Outside the critical area, the measured gap must be less than 0.002 inch. If the baseplate flatness falls outside these tolerances, the baseplate needs to be surface ground.

Coplanar

A precision ground parallel bar is used to span across the pump and motor mounting pads in five different positions; three lateral and two diagonal. At each location, the gap between the precision ground bar and the mounting surfaces is measured with a feeler gauge. If the gap at any location along the ground bar is found to be more than 0.002 inch, the mounting pads will be deemed noncoplanar, and the baseplate will need to be surface ground.

Relative Level (Colinear)

It is important to understand the difference between relative level and absolute level. Absolute level is the relationship of the machined surfaces to the earth. The procedure for absolute level is done in the field, and is not a part of this inspection. Relative level is an evaluation of the ability to achieve absolute level before the baseplate gets to the field.

The procedure for this evaluation is based on a rough level condition. A precision level is placed on each machine surface and

the rough level measurement, and direction, for each machine surface is recorded. The rough level measurement of each surface is then compared to each other to determine the relative level. The difference between the rough level measurements is the relative level. The tolerance for relative level is 0.010 in/ft.

FIELD INSTALLATION METHODS FOR PREGROUTED BASEPLATES

The use of a proper pregrouted baseplate system will eliminate the problem areas associated with field installations. The baseplate has been filled with grout that has properly bonded and is void-free. All the mounting surfaces have been inspected, corrected, and documented to provide flat, coplanar, and colinear surfaces. The next step is to join the prefilled baseplate to the foundation system. This can be done using conventional grouting methods, or a new grouting method that will be discussed later.

Field Leveling

Knowing that the mounting surfaces already meet flatness and coplanar tolerances makes field leveling of the baseplate very easy. Because the prefilled baseplate is very rigid, it moves as a system during the leveling process. The best method is to use a precision level for each mounting surface. This will give a clear picture of the position of the baseplate to absolute level. The level must also fit completely inside the footprint of the mounting surface to read properly. If the level is larger than the mounting surface, use a smaller level or a ground parallel bar to assure that the ends of the level are in contact with the surface.

With the levels in position, adjust the jack bolt and anchor bolt system to the desired height for the final grout pour, typically 1½ to 2 inches for conventional grout. With the grout height established, the final adjustments for level can be made. The baseplate should be leveled in the longitudinal or axial direction first, as shown in Figure 17, then in the transverse direction, as shown in Figure 18.

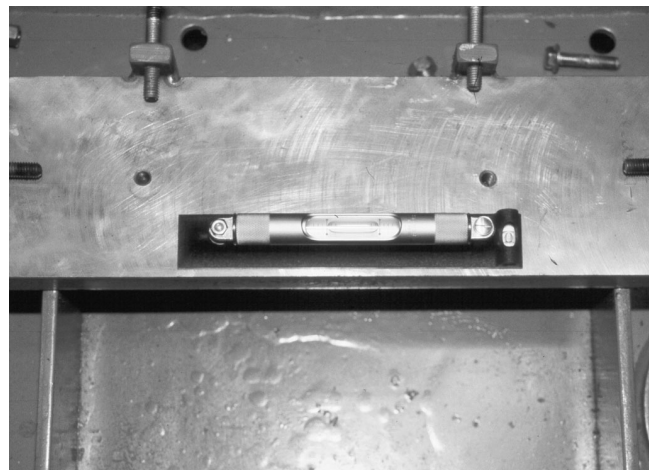


Figure 17. Field Leveling in Axial Direction.

Conventional Grouting Method

Using the conventional method for installing a pregrouted baseplate is no different from the first pour of a two-pour grout procedure. After the concrete foundation has been chipped and cleaned, and the baseplate has been leveled, grout forms must be constructed to hold the grout (Figure 19). To prevent trapping air under the prefilled baseplate, all the grout material must be poured from one side. As the grout moves under the baseplate, it pushes the air out. Because of this, the grout material must have good flow characteristics. To assist the flow, a head box should be constructed and kept full during the grouting process.

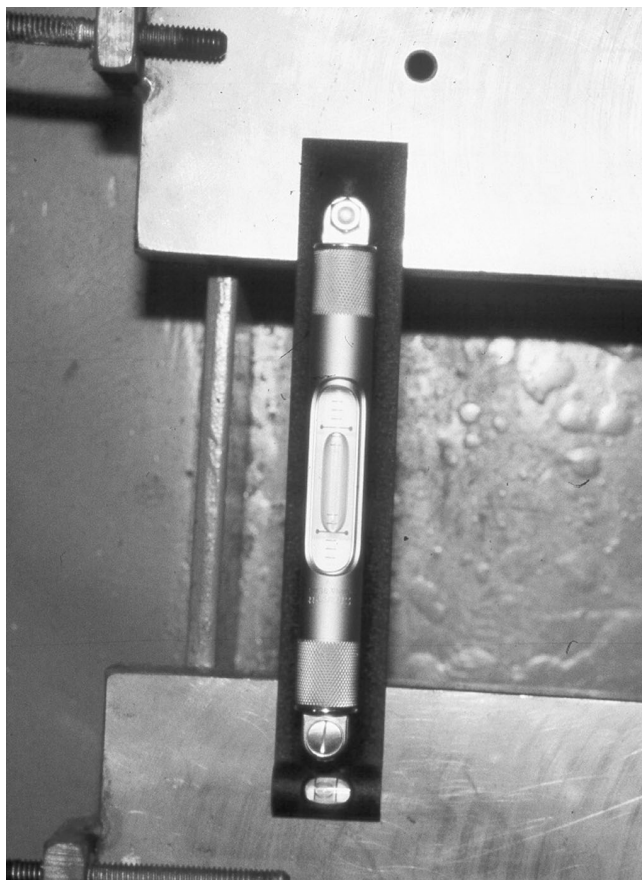


Figure 18. Field Leveling in Transverse Direction.



Figure 19. Pregrout Installation Using Conventional Method.

Hydraulic Lift of a Pregouted Baseplate

It is important when using a head box that the pregouted baseplate is well secured in place. The jack bolt and anchor bolt system must be tight, and the anchor bolt nut should be locked down to the equivalent of 30 to 45 ft-lb.

The bottom of a pregouted baseplate provides lots of flat surface area. The specific gravity of most epoxy grout systems is in the range of 1.9 to 2.1. Large surface areas and very dense fluids create an ideal environment for buoyancy. Table 1 shows the inches

of grout head necessary to begin lifting a pregouted ANSI baseplate. During the course of a conventional grouting procedure, it is very common to exceed the inches of head necessary to lift a prefilled baseplate. For this reason, it is very important to assure that the baseplate is locked down. As a point of interest, the whole range of API baseplates listed in Appendix M of API 610 (1995) can be lifted with 9 inches of grout head.

Table 1. Hydraulic Lifting Forces for ANSI Baseplates.

Grout Head Pressure Required to Lift a Pre-Grouted Baseplate								
ANSI Type Baseplates								
Base Size	Length (in)	Width (in)	Height (in)	Volume (in ³)	Base Weight (lbs)	Epoxy Grout Weight (lbs)	Equalizing Pressure (psi)	Grout Head (in)
139	39	15	4.00	2340	93	169	0.45	6.22
148	48	18	4.00	3456	138	250	0.45	6.22
153	53	21	4.00	4452	178	322	0.45	6.22
245	45	15	4.00	2700	108	195	0.45	6.22
252	52	18	4.00	3744	150	271	0.45	6.22
258	58	21	4.00	4872	195	352	0.45	6.22
264	64	22	4.00	5632	225	407	0.45	6.22
268	68	26	4.25	7514	283	544	0.47	6.47
280	80	26	4.25	8840	332	639	0.47	6.47
368	68	26	4.25	7514	283	544	0.47	6.47
380	80	26	4.25	8840	332	639	0.47	6.47
398	98	26	4.25	10829	407	783	0.47	6.47

Density of Grout 125 lbs/ft³
Specific Gravity 2.00

Baseplate Stress Versus Anchor Bolt Torque

With the necessity of using the jack bolt and anchor bolt system to lock the pregouted baseplate in position, it is important to determine if this practice introduces stresses to the baseplate. It is also important to remember that any induced stresses are not permanent stresses, provided they remain below the yield strength of the baseplate. The anchor bolts will be loosened, and the jack bolts removed, after the grout has cured.

An FEA analysis was performed on a pregouted ANSI baseplate and a pregouted API baseplate. The baseplates that were analyzed had six anchor bolt and jack bolt locations, used 3/4 inch bolts, and were based on 45 ft-lb and 100 ft-lb of torque to the anchor bolts. The 100 ft-lb of torque was considered to be extremely excessive for leveling and locking down a baseplate, but was analyzed as a worst case scenario.

The peak local stress loads for 45 ft-lb were 14,000 psi, and 28,000 psi for 100 ft-lb. Most baseplates are fabricated from ASTM A36 steel, which has a yield stress of 36,000 psi. As Figure 20 shows, the stresses are very localized and decay very rapidly. The result of the FEA analysis shows that the effect of locking down the pregouted baseplate does not induce any detrimental stresses.

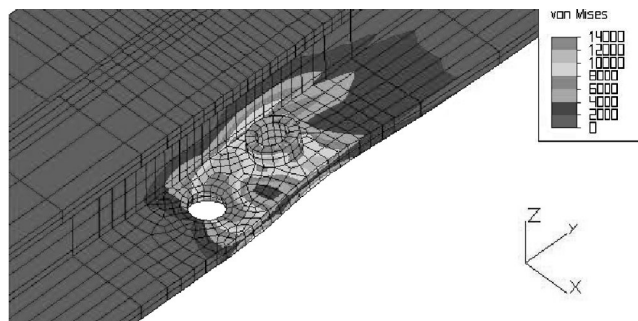


Figure 20. Stresses Due to 45 ft-lb Anchor Bolt Preload.

NEW FIELD GROUTING METHOD FOR PREGROUTED BASEPLATES

Conventional grouting methods for nonfilled baseplates, by their very nature, are labor and time intensive. Utilizing a pregouted

baseplate with conventional grouting methods helps to minimize some of the cost, but the last pour still requires a full grout crew, skilled carpentry work, and good logistics. To further minimize the costs associated with baseplate installations, a new field grouting method has been developed for pregrouted baseplates. This new method utilizes a low viscosity high strength epoxy grout system that greatly reduces foundation preparation, grout form construction, crew size, and the amount of epoxy grout used for the final pour.

While there may be other low viscosity high strength epoxy grout systems available on the market, the discussion and techniques that follow are based on the flow and pour characteristics of the grout system mentioned in the INTRODUCTION. This type of low viscosity grout system can be poured from 1/2 inch to 2 inch depths, has the viscosity of thin pancake batter, and is packaged and mixed in a liquid container. As shown in Figure 21, this material can be mixed and poured with a two-man crew.



Figure 21. Mixing of Low Viscosity Epoxy Grout.

Concrete Foundation Preparation

One of the leading conflicts on epoxy grout installations is the issue of surface preparation of the concrete foundation. Removing the cement lattice on the surface of the concrete is very important for proper bonding, but this issue can be carried too far (Figure 22). Traditional grouting methods require plenty of room to properly place the grout, and this requires chipping all the way to the shoulder of the foundation. Utilizing a low viscosity epoxy grout system will greatly reduce the amount of concrete chipping required to achieve a proper installation.



Figure 22. Chipping of Concrete Foundation.

Referencing Figure 23, the new installation method allows for the chipped area to be limited to the footprint of the baseplate. A bushing hammer can be used to remove the concrete lattice, and the required depth of the final grout pour is reduced to 3/4 inch to 1 inch.

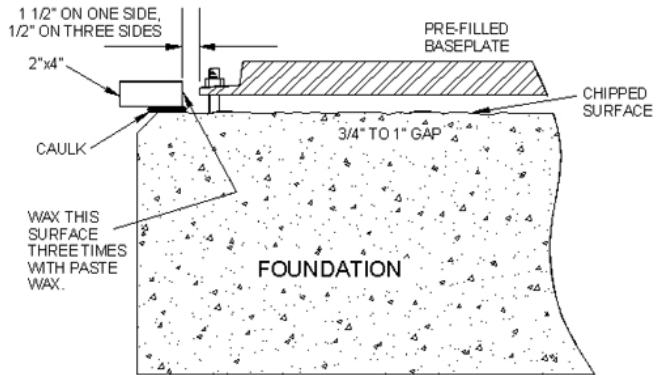


Figure 23. New Grout Installation Technique.

New Grout Forming Technique

With the smooth concrete shoulder of the foundation still intact, a very simple "2 x 4" grout form can be used (Figure 24). One side of the simple grout form is waxed, and the entire grout form is sealed and held in place with caulk (refer back to Figure 23). While the caulk is setting up, a simple head box can be constructed out of dux seal. Due to the flow characteristics of the low viscosity epoxy grout, this head box does not need to be very large or very tall.

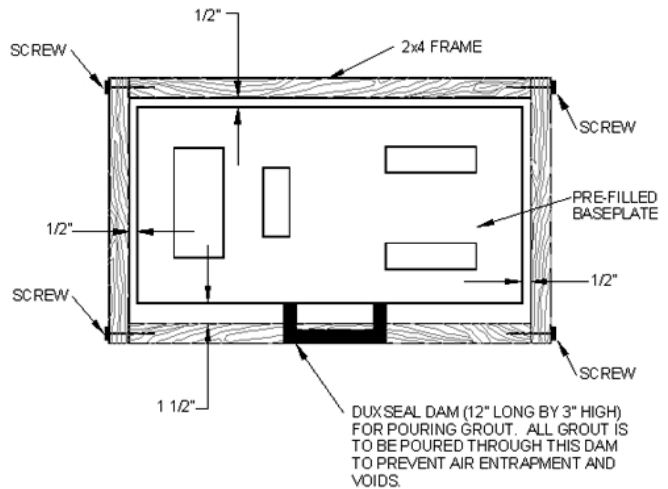


Figure 24. New Grout Forming Technique.

The low viscosity epoxy grout is mixed with a hand drill, and all the grout is poured through the head box to prevent trapping an air pocket under the baseplate.

This new installation method has been used for both ANSI and API style baseplates with great success. With this technique, field experience has shown that a pregrouted baseplate can be routinely leveled, formed, and poured with a two-man crew in three to four hours.

FIELD INSTALLATION COST COMPARISON

The benefits of using a pregrouted baseplate with the new installation method can be clearly seen when field installation costs are compared. This comparison looks at realistic labor costs, and does not take any credit for the elimination of repair costs associated with field installation problems, such as void repair and field machining.

After participating in numerous conventional grout pours over the last 25 years, it can be safely stated that the average size grout crew for conventional installations is eight men. An actual man-hour labor cost of \$45/hr can be easily defended when benefits and overhead are included.

A cost comparison can be developed, based on the installation of a typical API baseplate using epoxy grout, for the conventional two-pour procedure and a pregrouted baseplate using the new installation method. The following conditions apply:

- Baseplate dimensions: 72 in × 36 in × 6 in
- Foundation dimensions: 76 in × 40 in × 2 in (grout depth)
- Labor cost: \$45/hr
- Epoxy grout cost: \$111/cu ft

A baseplate with the listed dimensions can be pregrouted for \$2969.00. This would include surface preparation, epoxy grout, surface grinding, and a guaranteed inspection.

Table 2 shows a realistic accounting of time and labor for the installation of a typical API baseplate. The total installed cost for a conventional two-pour installation is \$6259. The total installed cost for a pregrouted baseplate, installed with the new installation method, is \$4194. That is a cost savings of almost 50 percent, and the installation is void-free and the mounting surfaces are in tolerance.

Table 2. Cost Comparison for Two-Pour Versus New Method.

Installation Labor Cost for Two Pour Procedure		Installation Labor Cost for Stay-Tru System	
Leveling of Base Plate		Leveling of Base Plate	
Millwright: 2 men X 4 hrs X \$65/hr	520	Millwright: 2 men X 1 hr X \$65/hr	130
Forming of Base Plate		Forming of Base Plate	
4 MEN X 4 hrs X \$HR=	720	2 MEN X 2 hours X \$HR=	180
First Pour		Grout Set-Up Time	
Grout Set-Up Time		2 MEN X 1.0 HR. X \$HR=	90
8 MEN X 1.0 HR. X \$HR=	360	Grout Placement	
Grout Placement		2 MEN X 2.0 HR. X \$HR=	180
8 MEN X 2.0 HR. X \$HR=	720	Grout Clean-up	
Grout Clean-up		2 MEN X 1.0 HR. X \$HR=	90
8 MEN X 1.0 HR. X \$HR=	360	Additional Cost:	
Additional Cost:		Wood Forming Materials=	
Fork Lift & driver; 1HR x \$45=	45		50
Supervisor; 4.0 hr X \$HR=	180		
Mortar Mixer=	100		
Wood Forming Materials=	100		
Second Pour			
Grout Set-Up Time			
8 MEN X 1.0 HR. X \$HR=	360		
Grout Placement			
8 MEN X 2.0 HR. X \$HR=	720		
Grout Clean-up			
8 MEN X 1.0 HR. X \$HR=	360		
Additional Cost:			
Fork Lift & driver; 1HR x \$45=	45		
Supervisor; 4.0 hr X \$HR=	180		
Mortar Mixer=	100		
LABOR COST	4570	LABOR COST	670
ADDITIONAL COST	300	ADDITIONAL COST	50
GROUT COST	1389.56	STAY-TRU COST	2969
		GROUT COST (7560)	505.3
TOTAL PER BASE	\$6,259.56	TOTAL PER BASE	\$4,194.30

CONCLUSIONS

It is possible to satisfy the concerns of both the project engineer and the machinery engineer regarding rotating equipment installation. The issues of first costs versus life-cycle costs can both be met with this new approach to machinery field installations. And as an added bonus, the term “repair” can be eliminated from the grouting experience.

REFERENCES

API Standard 610, 1995, “Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services,” Eighth Edition, American Petroleum Institute, Washington, D.C.

Barringer, H. P. and Monroe, T. R., 1999, “How to Justify Machinery Improvements Using Reliability Engineering Principles,” *Proceedings of the Sixteenth International Pump Users Symposium*, Turbomachinery Laboratory, Texas A&M University, College Station, Texas, pp.171-184.

Myers, R., 1998, “Repair Grouting to Combat Pump Vibration,” *Chemical Engineering*.

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