



FIVE STAR PRODUCTS, INC.

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DESIGN-A-SPEC™ GUIDELINES FIVE STAR® DP EPOXY GROUT HIGH FLOW

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PART A - GENERAL CONDITIONS - EPOXY GROUTING

1.01 SCOPE

The work covered by this document consists of furnishing all equipment, materials, labor and performing all operations required for the installation of precision non-shrink grouts as directed by the engineer or owner.

1.02 QUALITY ASSURANCE

- A. The manufacturer shall have been in the business of manufacturing similar products for over ten years, maintain a strict quality assurance program, offer technical services and provide a representative at the jobsite for product training, prior to product installation, upon written request.
- B. The contractor shall submit to the engineer or owner at least three job references where the contractor has successfully completed similar applications.

1.03 DELIVERY, STORAGE AND HANDLING

- A. All materials shall be delivered to the jobsite in their original, unopened packages, clearly labeled with the manufacturer's identification, printed instructions and batch code.
- B. Store and condition the specified product in accordance with Section 3.07 Environmental Conditions.
- C. For handling instructions, refer to the Safety Data Sheet.

1.04 PROJECT/SITE CONDITIONS

Refer to PART C - PREPARATION, ENVIRONMENTAL CONDITIONS, or contact the manufacturer directly for any physical or environmental limitations required by the product.

PART B - MATERIAL SPECIFICATIONS - EPOXY GROUTING

2.01 MATERIALS

- A. Non-shrink epoxy grout shall be 100% solids, low exotherm, pre-packaged system containing thermosetting epoxy resins, expansive additives and inert fillers. The manufacturer shall be ISO 9001 certified and have at least 15 years' experience in the manufacture of non-shrink epoxy grouts. The manufacturer shall offer technical services and provide a representative at the jobsite for product training prior to product installation upon five days advance notice.

- B. The grout material shall meet all the following typical performance criteria when cured at 73°F (23°C), unless otherwise specified:
1. **Compressive Strength, EN 12190:1999**
 - a. Requirement: ≥ 45 MPa @ 28 Days (Class R4)
 - b. Five Star Products' results: 80 MPa @ 1 Day
90 MPa @ 7 Days
 2. **Bond Strength, EN 1542:1999**
 - a. Requirement: ≥ 2 MPa (Class R4)
 - b. Five Star Products' result: ≥ 2 MPa
 3. **Chloride Ion Content, EN 1015-17:2000**
 - a. Requirement: $\leq 0.05\%$
 - b. Five Star Products' result: $\leq 0.05\%$
 4. **Modulus of Elasticity, EN 13412:2002**
 - a. Requirement: ≥ 20 GPa
 - b. Five Star Products' result: ≥ 22 GPa
 5. **Freeze Thaw Cycling, EN 13687-1:2022**
 - a. Requirement: ≥ 2 MPa
 - b. Five Star Products' result: ≥ 2 MPa
 6. **Tensile Strength, BS 6319 Part 7 per ASTM C 307**
 - a. Requirement: Not Required
 - b. Five Star Products' result: 14 MPa @ 7 Days
 7. **Flexural Strength, EN 12190:1999**
 - a. Requirement: Not Required
 - b. Five Star Products' results: 25 MPa @ 7 Days
30 MPa @ 28 Days
 8. **Fire Classification:, EN 1504-3 Section 5.5**
 - a. Requirement: Declared
 - b. Five Star Products' result: Euroclass B
 9. **Dangerous Substances, EN 1504-3 Section 5.4**
 - a. Requirement: Declared
 - b. Five Star Products' result: Complies
 10. **Working Time² @ 21°C, ASTM D 2471 Modified**
 - a. Requirement: Declared per FPC³
 - b. Five Star Products' result: 60 minutes
 11. **Height Change, ASTM C 827, at 32°C**
 - a. Requirement: Not Required
 - b. Five Star Products' result: Positive Expansion

¹ NR = Not Required

² May be affected by colder & warmer temperatures. Refer to Five Star® Technical Bulletins: *Epoxy Grouting in Cold Weather*, *Epoxy Grouting in Hot Weather*

³ FPC= Factory Production Control

The data shown above reflects typical results based on laboratory testing under controlled conditions. Reasonable variations from the data shown above may result. Test methods are modified where applicable.

The data shown above reflect typical results based on laboratory testing under controlled conditions. Reasonable variations from the data shown above may result in the field. Test methods are modified where applicable.

- C. An acceptable product which meets these criteria is:

Five Star® DP Epoxy Grout High Flow

As manufactured by Five Star Products, Inc., Shelton, CT 06484, (203) 336-7900.

- D. Subject to meeting the performance criteria stated above, other products may be formally submitted to the engineer for approval up to three days prior to the bid date. All requests for approval shall contain certified test data verifying conformance with the specification. Three references of successfully completed projects of similar nature and scope of the work detailed in this specification shall be provided as well as a minimum ten year history of use in the industry. The testing laboratory shall certify to any modifications made to the test performed and provide details of modifications.

2.02 AGGREGATE REDUCTION OR ADDITION

- A. Aggregate content of the epoxy grout shall not be reduced beyond manufacturer's recommendations.
- B. Manufacturer shall submit physical test data for their epoxy grout at reduced aggregate content for engineer's approval.
- C. Where aggregate sources other than those from grout manufacturer are allowed, grout manufacturer must specify type of aggregate allowed and amount per mix.

2.03 CLEARANCES

- A. The grout shall be placed from 25 mm to 160 mm in depth. For baseplate clearances less than 25 mm or greater than 160 mm or greater than 1.7 cubic meters, contact the manufacturer.

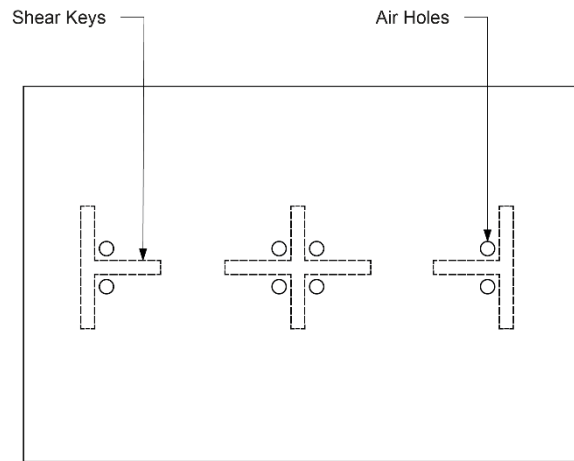
PART C – PREPARATION - EPOXY GROUTING

3.01 CONCRETE SURFACES

- A. Concrete surfaces shall be a minimum 28 days old, dimensionally stable, free of oil, grease, laitance and other contaminants. Mechanically roughen surfaces to obtain clean, sound and rough concrete by acceptable mechanical means. Use of surface retarders and/or high-pressure water blast are also acceptable. Do not use jack hammers to prepare concrete surfaces. Expose coarse aggregate to ensure optimal bond development.
- B. Prior to placement, concrete surfaces shall be visibly dry and blown free of dust and debris using oil free compressed air.

3.02 METAL SURFACES

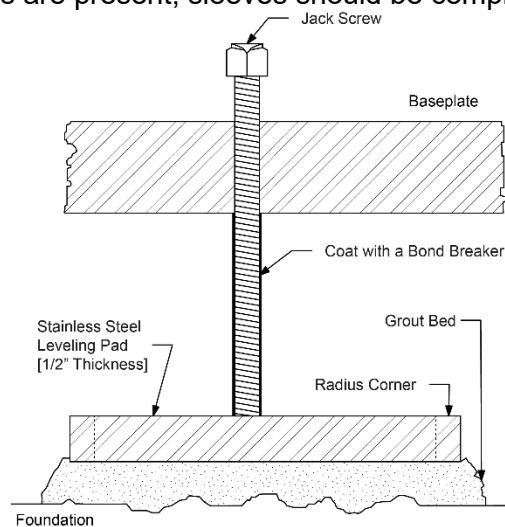
- A. Where bond to metal surfaces is not required, coat with a bond breaker such as paste wax or duct tape.
- B. Where bond to metal or primed surfaces is required, the surface shall be clean, free of oil, grease, rust and other contaminants. Sandblasting to a SSPC-SP6* commercial finish will optimize bond development of epoxy to steel surfaces.
- C. To prevent oxidation steel surfaces should be coated with an acceptable epoxy primer when grout is not placed within 12 hours of sandblasting. Steel primer must be epoxy based and approved by the grout manufacturer.
- D. Equipment and baseplates should be grouted within the open time of the steel primer as recommended by primer manufacturer. If open time is exceeded, primer surfaces should be sanded or abraded prior to grouting and wiped with a solvent coated rag.



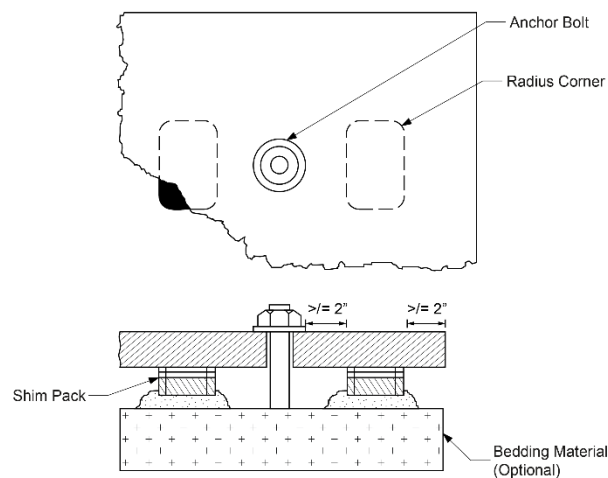
Baseplate with Shear Keys

3.03 SKID MOUNTED EQUIPMENT / ANCHOR BOLTS

- A. Jack screws or similar device should be used to level baseplates. Jack screws should have steel bearing plate and should not bear directly on concrete surfaces. Bearing plates should have rounded edges to reduce stress concentrations in grout.
- B. Jack screw bearing pads should be 12.7 mm thick minimum. Jack screws must be coated with a suitable bond breaker to allow removal after grout has cured. Jack screws should remain in place for 72 hours prior to removal.
- C. When shims are used to level baseplates, they must have rounded corners to reduce stress concentrations and cracking in epoxy grout. Shims may be left in place or isolated for future removal.
- D. Anchor bolts and sleeves should be wrapped and sealed using Dux-Seal or similar material to prevent grout from bonding to anchor bolt and filling anchor bolt sleeve. Where sleeves are present, sleeves should be completely dry and free of water.



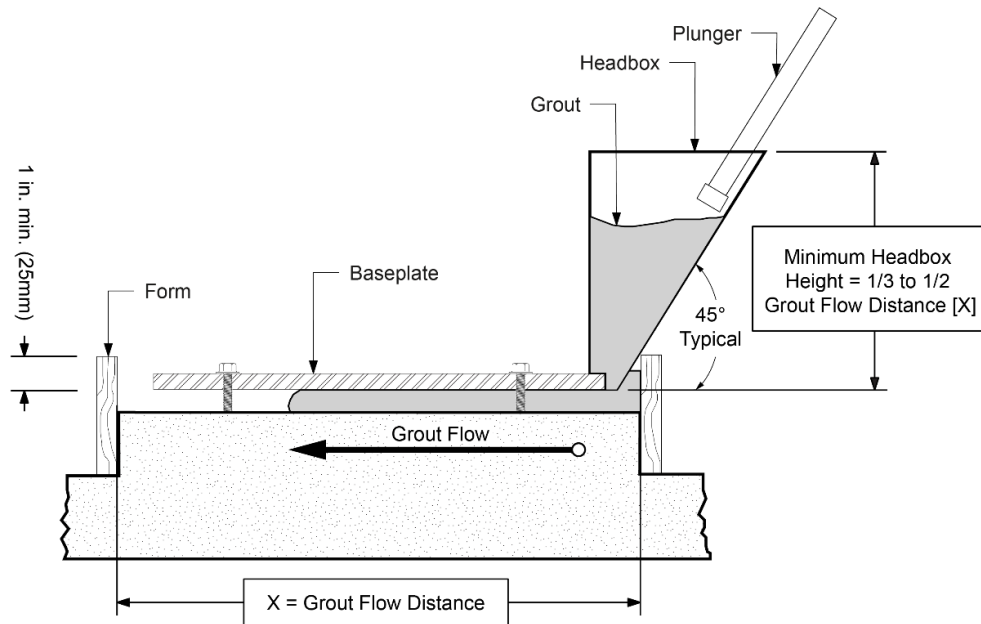
Typical Jack Screw Detail



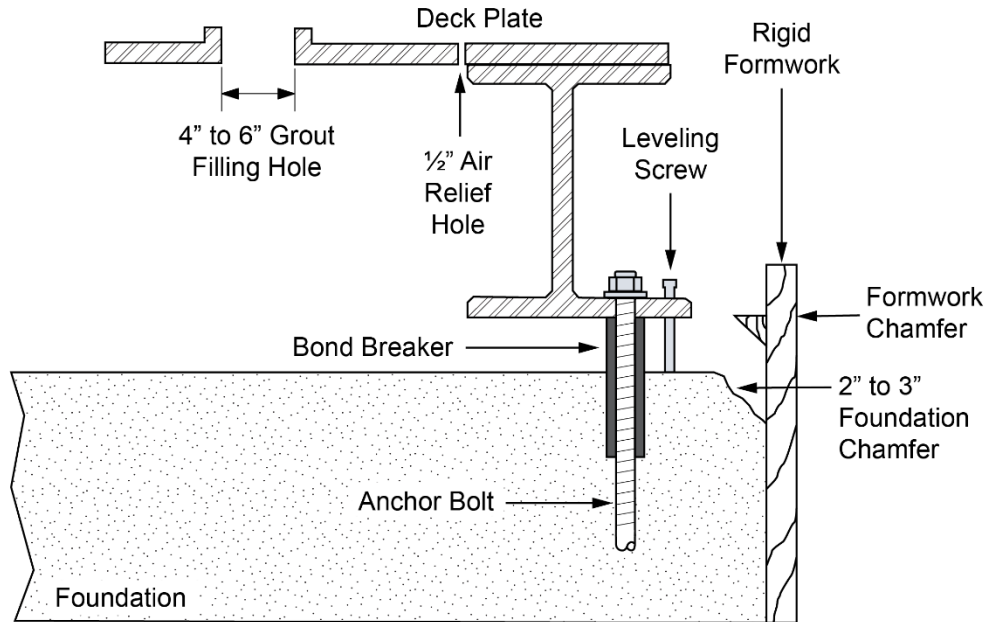
Shim Pack At Anchor Bolt

3.04 FORMWORK

- A. Formwork shall be constructed of rigid nonabsorbent materials, securely anchored, caulked liquid tight and strong enough to resist forces developed during grout placement. Chamfer edges shall be built into forms before grout placement.
- B. Formwork shall be constructed so that grout is placed across the shortest distance whenever possible. The clearance between formwork and baseplate shall be sufficient to allow for headbox. The clearance for remaining sides shall be 25 to 75 mm. **Epoxy grout shoulders should not exceed 75 mm without additional mechanical anchoring.**



- C. Height of formwork shall extend a minimum of 25 mm above bottom edge of the baseplate. Grout forms shall have 25 mm chamfer strips at all vertical corners and top edges of grout shoulders.

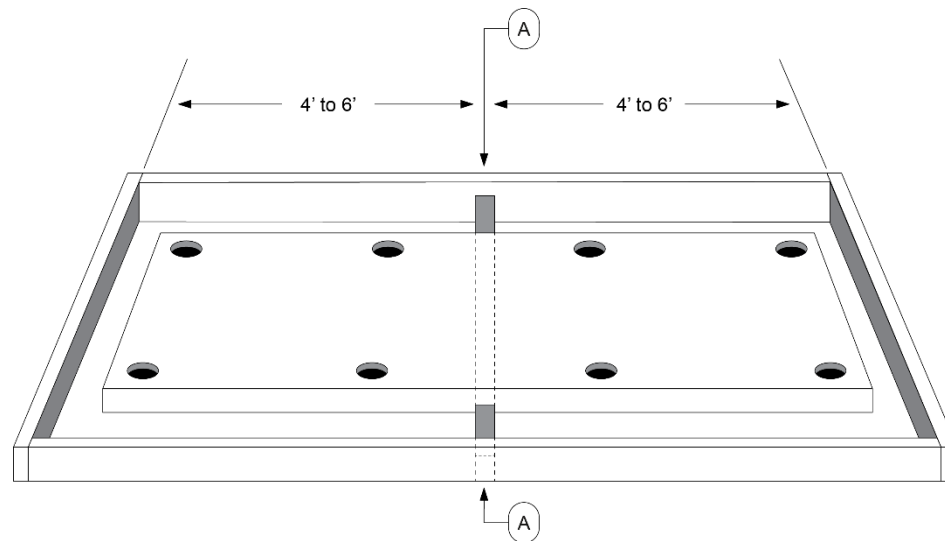


Equipment Base

- D. All formwork shall be coated with a bond breaker such as two to three heavy coats of paste wax or polyethylene. Form release oil is not acceptable. Caution: Care should be taken not to contaminate grouting surfaces where bond is required.

3.05 EXPANSION JOINTS

- A. Expansion joints shall be incorporated into large epoxy grout pours to reduce the possibility of cracking, especially when machinery-to-grout temperature differentials of 30 °C (50 °F) are encountered. Expansion joints should be placed at approximately 1.4 m to 2.8 m (4 ft to 6 ft) intervals in the grout foundation.
- B. Expansion joints should be made from 12 mm to 25 mm (1/2 in. to 1 in.) thick closed-cell neoprene foam rubber. Polystyrene may also be used. Ensure that the expansion joint material is compatible with the grout.
- C. Expansion joints require sealing after the grout has cured with elastic epoxy seam sealant (liquid rubber) or silicone rubber room temperature vulcanizable (RTV).



3.06 SHOULDERS

- A. Unconfined epoxy grout shoulders can result in tensile stresses, edgelifting and cracking in epoxy grout and concrete foundation. To minimize this, unconfined grout shoulders should be kept to 76.2 mm maximum wherever possible.
- B. Pinning of epoxy grout shoulders is recommended. Pins should be placed on approximately 203 mm to 254 mm centers and typically are #6 or #8 rebar grouted in place using Five Star RS Anchor Gel or similar adhesive. Pins should extend out of concrete a maximum of 2/3 depth of the grout.
- C. Larger shoulders may be overlaid with Five Star Structural Concrete. Area between epoxy grout and Structural Concrete may be treated as a joint and filled accordingly.

3.07 ENVIRONMENTAL CONDITIONS

- A. Condition and maintain materials to between 21°C and 32°C and all surfaces that contact grout to between 15°C and 32°C. Shade from direct sunlight as necessary. *[For detailed conditioning procedures for Cold Weather or Hot Weather Grouting, refer to PART F – EXTREME WEATHER CONDITIONS.]*

3.08 CLEARANCES

- A. Epoxy grout shall be placed from 25 mm to 160 mm in depth depending upon application. Volume of grout placed shall not exceed manufacturer's recommendations.

3.09 EQUIPMENT AND MATERIALS

- A. All necessary tools, equipment and materials shall be as close as possible to the area being grouted, such as mixers, trowels and grout. Provide an adequate number of mixers, in good operating condition, for uninterrupted placement. Equipment shall be clean and dry.
- B. Appropriate clothing and safety equipment shall be worn to avoid breathing dust and prevent eye and skin contact with components and mixed grout.
- C. Wheelbarrows and buckets shall be clean and available for transporting mixed grout.
- D. Provide headbox and plunger when pouring grout.
- E. An appropriate material shall be available for clean up. Refer to data sheet of the grout specified.

3.10 MIXING

Mortar Mixer (Stationary Barrel with Moving Paddles)

- A. Do not exceed one-half capacity of mixer when mixing grout.
- B. Combine Component A (resin) and Component B (hardener) by pouring Component B (hardener) into pail containing Component A (resin). Mix thoroughly by hand with a paddle or preferably by slow speed industrial drill and paddle attachment until a uniform color is obtained with no streaks. **Avoid air entrapment.** Immediately pour all mixed liquids into mortar mixer. While mixing at a slow speed (approximately 20RPM), slowly add Component C (aggregate) without delay and mix only until aggregate is completely wet.
- C. Do not mix more material than can be placed within the working time of the grout.

PART D – APPLICATION - EPOXY GROUTING

4.01 PLACEMENT PROCEDURES

POURING

- A. Grout must be placed without interruption. Should a delay occur beyond the working time of the material, all equipment used in mixing and placing the epoxy grout, shall be cleaned.
- B. A headbox or similar device is required for a continuous pour to avoid air pockets under the baseplate. All grouting shall be placed from one side to the other, maintaining contact with the bottom of the baseplate at all times, maximizing effective bearing area (EBA).
- C. When installing grout under long baseplates, start pouring from one end across the short dimension and work down the longer side as the material fills under the baseplate.
- D. When pouring through grout holes, placement shall proceed continuously with a headbox until the grout has risen in the next hole. Maintain head pressure at initial hole so that grout stays in contact with the bottom of the baseplate at all times. Commence grouting at the next hole with an additional headbox. Continue process, alternating headboxes until grouting is complete.
- E. When pouring, the headbox shall be kept at least half full and filled in a manner to avoid air entrapment. To assist flow, a plunger may be used if necessary. This procedure shall continue until the grout rises above the bottom edge of the baseplate on the opposite side.
- F. Throughout the pour, forms shall be constantly checked for leaks. All leaks shall be sealed immediately.
- G. If two or more layers are necessary, rake or scarify the surface of the initial pour. The surface temperature of the initial pour shall have cooled to 32°C maximum prior to placing additional layers. Additional layers shall be placed within 24 hours.

PART E – FINISHING AND CURING - EPOXY GROUTING

5.01 FINISHING

- A. Prior to hardening, epoxy grout can be finished with a solvent wiped steel trowel. Maintaining a sufficient solvent coat is important as epoxy grout will adhere to dry trowel.
- B. Joint materials may be removed (if required) after the grout has cured and filled with a flexible compound.
- C. Epoxy grouts cannot be trimmed after set except by mechanical means. Final level in the forms should be brought to the finished elevation before hardening.

5.02 CURING

- A. Protect grout from temperature extremes, rain and water after placement. Do not wet cure epoxy grout.
- B. The grout should be protected from temperatures below 10°C until required minimum compressive strength is achieved.
- C. In-service operation may begin immediately after minimum required grout strength and modulus have been achieved.

REFERENCES

ACI 351.1-R93
"Grouting for Support of Equipment and Machinery"

PIP/API RP-686
Machinery Installation Mounting Plate Grouting

API 610
Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services

PART F – EXTREME WEATHER CONDITIONS - EPOXY GROUTING**6.01 COLD WEATHER GROUTING**

[Low temperatures decrease flow, delay set and strength development of epoxy products. The procedures below may compensate for these conditions.]

- A. All epoxy grout components (resin, hardener and aggregate) should be pre-conditioned so that placed grout is between 21°C and 32°C. Due to the mass of palletized material (aggregate component), up to 72 hours of pre-conditioning may be required. Store epoxy grout components in an enclosed, warm or heated area where necessary.
- B. Indirect heating of surfaces (steel, concrete) will also help compensate for cold temperatures. During mixing, the barrel of the mortar mixer may be heated using an appropriate heater to keep the grout mix temperature within an acceptable range.
- C. When necessary, heating should be accomplished by indirect exposure. Heated enclosures must be windproof and weatherproof. Heaters should not be permitted to unevenly heat concrete. *Caution: Exhaust gases of unvented heaters may contaminate or cause carbonation of concrete within the enclosed environment.*
- D. Grout temperature should be maintained above 16°C until grout reaches required strength.
[Specify minimum required strength.]
- E. Gradually allow grout temperature to cool to ambient to avoid thermal shock.

REFERENCES

ACI 351.1 - R93

"Grouting for Support of Equipment and Machinery"

PIP/API RP-686

Machinery Installation Mounting Plate Grouting

API 610

Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services

PART G – EXTREME WEATHER CONDITIONS - EPOXY GROUTING

6.02 HOT WEATHER GROUTING

[High temperatures accelerate set, decrease working time, and accelerate strength gain of epoxy products. The procedures below may compensate for these conditions.]

- A. All epoxy grout components (resin, hardener and aggregate) should be pre-conditioned so that the mixed material is between 21°C and 32°C. Due to the mass of palletized material (aggregate) up to 72 hours of pre-conditioning may be required. Store all epoxy grout components in a cool, shaded area out of direct sunlight.
- B. All surfaces, equipment and tools in contact with epoxy grout should be shaded and kept at temperatures between 15°C and 32°C. **Do not** use water to cool surfaces or equipment in contact with epoxy grout.
- C. Shade application area from direct sunlight and where feasible, place epoxy grout when temperatures are decreasing, at night or during early morning.
- D. Place epoxy grout immediately after mixing, do not allow epoxy grout to sit for extended periods of time in buckets or wheelbarrows.
- E. Maintain shading of application area for 24 hours after placement.

REFERENCES

ACI 351.1 - R93

"Grouting for Support of Equipment and Machinery"

PIP/API RP-686

Machinery Installation Mounting Plate Grouting

API 610

Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services

PART H – LAYERED PRECISION GROUT PLACEMENT

7.01 LAYERED COMBINATION

- A. A layered combination of precision non-shrink cement and epoxy grouts, both meeting ASTM C-827, may be used for precision grouting machinery with large baseplates that contain structural steel webs deeper than 228 mm (9 in).
- B. The layered placement does not necessarily require a combination of precision non-shrink cementitious and epoxy grouts. It can be accomplished using a multilayer pour of epoxy grout, in accordance with the grouting manufacturer's instructions or as specified by the user's designated representative.

7.02 LAYERED PLACEMENT – FIRST POUR

- A. The first layer for this type of grout installation shall be a precision non-shrink epoxy grout poured to a level that is flush with the bottom of the baseplate.
- B. A primary perimeter pour is required to lock the baseplate into its level position and to seal the outer perimeter in preparation for the secondary layer. The secondary layer is important to encapsulate the internal stiffeners used to support machinery mounting surfaces.
- C. Confirm with the epoxy grout manufacturer as to what the greatest recommended monolithic placement thickness is. A monolithic initial pour is always preferred, but an all epoxy filled baseplate may require several pours so as to not exceed the grout manufacturer's maximum pour thickness.
- D. If the depths require a secondary initial pour, this should be accomplished within 24 hours to provide a greater bond between the two epoxy grouts. Before pouring a secondary layer, the surface temperature of the initial pour shall have cooled to 32°C maximum, prior to placing an additional layer.

7.03 LAYERED PLACEMENT – SECOND POUR

- A. The second pour, intended to fill the majority of the remaining cavity space, shall be a precision non-shrink cementitious grout conforming to ASTM-C-827. Pour to a level that is approximately 50-77 mm (2-3 inches) from the top of the baseplate decking.
- B. Non-shrink cementitious grout shall be high strength, pre-packaged, cement-based grout requiring only the addition of potable water.
- C. The manufacturer shall be ISO 9001 certified and have at least 10 years experience in the manufacture of precision cement-based grouts.
- D. The precision non-shrink cementitious grout material shall meet all the following typical performance criteria when cured at 20°C:

1. Compressive Strength, EN 12190:1999

- | | |
|---------------------------------|-----------------------------------|
| a. Requirement: | ≥ 45 MPa @ 28 Days |
| b. Five Star Products' results: | 36 MPa @ 1 Day
65 MPa @ 7 Days |

2. Chloride Ion Content, EN 1015-17:2000

- | | |
|--------------------------------|---------|
| a. Requirement: | ≤ 0.05% |
| b. Five Star Products' result: | ≤ 0.05% |

3. Bond Strength, EN 1542:1999

- | | |
|--------------------------------|--------------------|
| a. Requirement: | ≥ 2 MPa (Class R4) |
| b. Five Star Products' result: | ≥ 2.3 MPa |

4. Modulus of Elasticity, EN 13412:2002	
a. Requirement:	≥ 20 GPa
b. Five Star Products' result:	≥ 26 GPa
5. Freeze Thaw Cycling, EN 13687-1:2022	
a. Requirement:	≥ 2 MPa
b. Five Star Products' result:	≥ 2 MPa
6. Pull Out Strength, EN 1881:2006	
a. Requirement:	Displacement ≤ 0.6 mm
b. Five Star Products' result:	Displacement ≤ 0.6 mm @ 75 kN
7. Creep Under Tensile Load, EN 1544:2007	
a. Requirement:	Displacement ≤ 0.6 mm @ 3 months
b. Five Star Products' results:	≤ 0.6 mm @ 3 months
8. Carbonation Resistance, EN 13295:2005	
a. Requirement:	$d_k \leq \text{concrete (Class R4)}$
b. Five Star Products' result:	$d_k \leq \text{concrete control}$
9. Fire Classification, EN 1504-3 Section 5.5	
a. Requirement:	Declared
b. Five Star Products' result:	Euroclass A1
10. Flow Between Glass Plates @ 5°C & 20°C	
a. Requirement:	Per MCHW 2601, Part 4 (iii): Material should flow under the glass plate and rise ≥ 10 mm above the underside of the top plate at all positions, without signs of segregation, bleeding, effervescence or air inclusion
b. Five Star Products' result:	PASS/PASS
11. Working Time @ 20°C, EN 13395-1 Modified	
a. Requirement:	Declared per FPC
b. Five Star Products' result:	60 minutes
12. Early Height Change, ASTM C 827	
a. Requirement:	Positive Expansion
b. Five Star Products' result:	0.0 to 4.0%

The data shown above reflects typical results based on laboratory testing under controlled conditions. Reasonable variations from the data shown may result. Test methods are modified where applicable.

E. An acceptable product which meets these criteria is:

Five Star® High Strength 130 Grout

As manufactured by Five Star Products, Inc., Shelton, CT 06484, (203) 336-7900.

7.04 LAYERED PLACEMENT – THIRD POUR

A. The third pour shall be a precision non-shrink epoxy grout, completely filling the remaining void and can commence after the Five Star® High Strength 130 Grout has cured for 72 hours.

NOTE: The next layer in sequence for this type of installation shall not be poured until the previous layer is properly cured.

REFERENCES: PIP/API RP-686 Machinery Installation Mounting Plate Grouting