3M

Custom Coating Guide

For Application of
Scotchkote™ Fusion Bonded Epoxy Coatings

Table of Contents

Introduction . . . 1

Methods of Application . . . 1

- Fluid Bed . . . 1
- Electrostatic Spray/Flock Spray . . . 1
- Surface Preparation . . . 1
- Masking . . . 2

Material Selection . . . 2

- Preheating . . . 3
- Coating. . . . 3
- Fluid Bed . . . 3
- Electrostatic Spray Flocking . . . 4

Coating Thickness . . . 4

- Cure . . . 4
- Continuity Testing . . . 5
- Patching and Repair . . . 5
- Removal of Cured Coating . . . 5
- Powder Quality Control and Storage . . . 5
- Handling Precautions . . . 5

Appendix I: Fluid Bed Construction and Operating Requirements . . . I-1

Appendix II: Electrostatic Spray Operation and Maintenance and Equipment . . . II-1

Appendix III: Steel Pipe Cool Down Rate . . . III-1

- Steel Plate Cool Down Rate . . . III-2

Introduction

Fusion Bonded Epoxy Coating (FBEC) has been used used for a variety of corrosion mitigation applications for over 40 years. This booklet is a guide for the manual application of 3M™ Scotchkote™ Fusion Bonded Epoxy Powder Coatings onto preheated parts in coating thicknesses of 10 mils – 40 mils (250 µm – 1000 µm).

Methods of Application

Fluid Bed

The fluidized bed consists of two chambers, one on top of the other, separated by a specially designed porous membrane. The upper chamber is filled with powder coating. Air introduced into the lower chamber is evenly diffused by the porous membrane throughout the powder creating a dense, fluid like powder/air suspension. In proper operation, the powder volume expands from 20% to 50% depending on the specific powder used. When preheated parts are immersed in the powder/air suspension, all exposed surfaces are instantly coated. For details on fluid bed construction, see Appendix I.

Every powder coating exhibits unique fluidization and application characteristics. Properties such as composition, particle shape and particle size distribution are major determinants of powder fluidization and appearance of the applied coating. When fluidized beds are used with Scotchkote FBEC, maximum uniformity can be obtained without sags, runs or pinholes.

Electrostatic Spray/Flock Spray

An electrostatic spray unit consists of a powder feed mechanism (usually a fluid bed), a spray gun equipped with a charging device and a power supply. During application, the powder is electrostatically charged as it is sprayed onto a grounded part.

Electrostatic coating reduces overspray waste and aids in achieving a uniform thickness. Electrostatically applied coatings have greater continuity, especially on edges and welds. However, electrostatic application to inside corners and recesses is difficult because charged powder tends to be repelled from these areas due to a phenomenon known as the Faraday Cage Effect. Increasing coating thickness insulates against the charge and reduces electrostatic efficiency.

Flock spray units use a gun equipped with a simple pressure pot screwed into the body or a siphon system connected to a fluid bed. Flock spray is the application of uncharged powder onto a part.

Flocking guns have a cost advantage over their electrostatic counterparts. Since they have fewer operating parts, they are less likely to break down and repairs are simple and inexpensive. Gun output can be several times that of an electrostatic unit, a benefit when coating large parts. Application to inside corners and recesses is not as difficult as with electrostatic spray. However, flocking produces more overspray waste than electrostatic spray. Depending on the complexity of the part and desired coating thickness, flocking overspray can be as much as 40 percent.

For information on flocking and electrostatic equipment manufacturers, see Appendix II.

Surface Preparation

For the best performance results, blast metal surfaces to near-white or white metal. The near-white surface finish allows very light shadows or slight discoloration of the metal. These surface finishes can be achieved by using sand, steel grit, aluminum oxide, garnet, etc.

Prior to application of all Scotchkote Fusion Bonded Epoxy Coatings, blast cleaning is recommended to clean the surface and establish an anchor pattern. Anchor pattern refers to the etched surface or "tooth" in the substrate metal produced by abrasive impacts.

To clean metal surfaces:

1. Grind down welds and sharp edges to approximately 1/8 in. (3 mm) radius and remove weld splatter with grinding wheels or chipping hammers.
2. Remove oil and grease from surfaces with an inorganic solvent such as MEK (Methyl Ethyl Ketone) or toluene. Do not use paraffin solvents such as gasoline or kerosene.

   In extreme cases, remove grease and other organic contaminants by heating the part at 700˚F/370˚C for at least 10 hours. This burnout step can be used on new steel to remove hydrocarbons or other forming oil deposited during the manufacturing process. It is also an effective method for removing organic contaminants that have been absorbed by parts such as porous castings while in service.
3. Blast clean metal surfaces to near white metal. Use a cleaning media that will produce a 2 mil/50 µm anchor pattern.
4. After blasting, remove residual traces of grit and dust with a vacuum cleaner or dry air blast.

Standard references for surface preparation are:

• National Association of Corrosion Engineers (NACE)
1440 S. Creek Drive
Houston, TX 77084-4906
Ph: 1-281-492-0535
Fx: 1-281-492-7254
www.NACE.org

a. NACE No. 1 white metal blast cleaned surface finish.
b. NACE No. 2 near-white metal blast cleaned surface finish.

• Society for Protective Coatings (SSPC),
40 24th Street 6th Floor
Pittsburgh, PA 15222-4565
Ph: 1-412-281-2331
Fx: 1-412-281-9992
www.SSPC.org

a. SSPC-SP 1 removal of oil and grease.
b. SSPC-SP 5 white metal blast cleaning.
c. SSPC-SP 10 near-white metal blast cleaning.
ISO 8501-sa2.5

Note: SSPC-SP 10 and NACE #2 and SSPC5/NAQ 2 have been combined – see attached.

Coat parts as soon as possible after cleaning to prevent the formation of rust bloom. If rust bloom forms, parts must be reblasted.

Masking

High temperature masking tapes, release agents and plugs can be used to protect certain areas of a part from coating. The most widely used are tapes, for example, 3M™ Masking Tape 2364. When coating preheated parts, remove masking tape immediately after powder application while the coating is slightly soft. Removal at this time is easy, so the coating will break away in a clean, even line. If the part is allowed to to cool, the masking tape becomes fused to the work, making removal difficult. When masking with tape, always leave a folded tab along one edge so it can be grasped with protective gloves or pliers for easy removal.

Liquid release agents are often used to prevent coating adhesion on large surface areas and reduce masking labor costs. These liquids usually have a fluorochemical or silicone base. Do not use high temperature grease.

A manufacturer of release agents is:

• Silicone Lubricant
3M Adhesives Division
Building 220-7E-03
St. Paul, MN 55144-1000
1-800-362-3550
www.3M.com/adhesives

To protect threaded holes, use silicone plugs or consider tapping holes after coating. All Scotchkote™ FBEC can be machined. Holes and pipe ends can be threaded after coating Seating grooves and flange holes can be reamed out to specific tolerances.

Material Selection

Select a Scotchkote FBEC which suits the required performance and application method.

Suggested manual application methods for Scotchkote coatings are:

Fluid Bed Application	Electrostatic Spray/Flock Spray
206N	134

Gel and cure times are important factors in the material selection decision. They determine application method and influence application technique and economy of production. Gel time is the period of time the coating is in a liquid or molten state before hardening. Cure time is the period of time required at temperature to complete the heat activated cross-linking reaction. Increases in preheat temperature shorten gel and cure time. Decreases in preheat temperature lengthen gel and cure time.

Spray application must occur within the gel time of the coating to prevent a mottled or “sandpaper” surface finish.

To maximize spray time:

- Select materials with long gel times from the products suggested for spray in the section.
- Reduce part preheat temperature. Coatings that have a long gel time must be post baked to achieve cure.

Fluid bed applications are suggested for coatings with short gel and cure times. These coatings are usually applied at high preheat temperatures to eliminate a post-bake step. Parts do not require a post bake if they retain enough heat to cure for the time and at the temperature listed in the applicable Scotchkote data sheet. Small parts may be sprayed with fast gel/cure coating provided application can be accomplished within the product’s gel time.

Preheating

The oven is one of the most important components of a powder coating system. Indirect, circulating, gas fired or electric ovens are preferred. Ovens should be able to raise the temperature of heavy metal parts to the coating temperature in 45 minutes. Even oven temperature is also important. Heat should not vary more than 10˚F/5˚C in any part of the oven. See Appendix II for oven manufacturers.

Part temperature can be monitored by optical pyrometers, digital thermometers, 3M™ Infrared Heat Tracers or Tempilstiks™ which are special thermoplastic crayons that melt at specific temperatures.

• For information on Tempilstiks contact:
Big Three Industries, Inc.
Tempil Division
Hamilton Blvd.
South Plainfield, NJ 07080
Ph: 1-908-757-8300
Fx: 1-908-757-9273
www.tempil.com

• For information on the 3M Heat Tracer contact:
3M Company
Electrical Products Division
6801 River Place Blvd.
Austin, TX 78726-9000
Ph: 1-800-245-3573
Fx: 1-800-245-0329

Coating

During the application process, powder coatings deposit at a slower rate as thickness increases. The rate of powder deposition and coating thickness is dependent upon the temperature of the part and the time of exposure to the powder source (fluid bed or spray).

Fluid Bed

- When designing a fluid bed, consider the type of powder coating used, part size and shape. Allow adequate space between part and bed side walls. See Appendix I for fluid bed construction details.
- The fluid bed coating area needs an efficient evacuation or exhaust system to remove powder blow off after parts are dipped. The design of the system is dictated by the size of the bed and the parts being coated. Careful consideration must be given to the air movement capacity of the system and the size and location of exhaust port openings. Improper placement of openings and excess capacity may remove fine particles and fluidizing agents directly from the bed, causing surface irregularities in the applied coating.
- Usually, parts are dipped vertically to allow maximum flow of powder around and through the part and to prevent air bubbles.
- Parts must be agitated slightly while immersed in the powder. The part may be twisted or moved up and down.
- Sometimes it is difficult to control thickness using fluid beds, especially when coating heavy, cumbersome parts. Coating on a 10 ft/3 m pipe segment dipped vertically may vary as much as 20 mils/500 µm from one end to the other because the end that goes in first, comes out last and gets more coating. Coating thickness can be controlled by reducing part temperature or increasing dipping speed.
- Monitor material usage and air pressure during bed operation to prevent powder compaction on the bottom. Reduce voids in the powder suspension and keep particle size distribution as close as possible to that of virgin material. Particle stratification occurs in all beds as heavier particles sink to the bottom. Eventually, coating thickness and quality to the finish can be affected. Deep fluid beds may require a periodic purge with virgin powder.
- Make frequent, low quantity additions to the bed to replace powder consumed on parts. Less frequent large volume replenishment changes bed density in relation to the air pressure, and this will have an affect on coating uniformity and appearance.

  Do not arbitrarily increase air pressure to raise powder level. Increased air pressure changes bed density and releases fine powder particles and fluidizing agents which are needed for proper fluidization.
- When dipping parts in a fluid bed, blow off excess powder brought up on horizontal surfaces such as flanges and holes. Use a high pressure 80 psi/5,5 bar air dusting gun with diffuser nozzle. Remove as much excess powder as possible during blow off without disturbing the still molten coating. Material waste due to blow off varies with part complexity and size from 5% to 30%.

Electrostatic Spray–Flocking

- Before spraying, make sure equipment is functioning properly. See Appendix II for electrostatic gun operation and maintenance.
- Powder coatings are repelled from recesses and inside corners when electrostatic spray is used. Minimize repulsion by reducing charging voltage or spray parallel with inside corners rather than directly into them.
- To ensure proper coverage and thickness, do not inundate the part with powder coating all at once. Spray part surfaces systematically.
- Because of the limited output of electrostatic guns, it may be necessary to use more than one gun to coat very large parts. Powder must be applied within the gel time of the product to prevent a granular surface finish. Coatings must also be completed before the part cools below the melt point of the powder.

Consider coating some items in separate stages. For example, a tubular item may be coated on the inside and the outside in two separate operations, rather than all at once.

To calculate gun output required, first find out the part cool-down rate. This determines how quickly the coating application must be completed. Approximate cool-down rates of various thicknesses of steel pipe and plate are shown in Appendix III. If a more exact cool-down rate is required, preheat the part and measure cool-down rate with Tempilstiks, pyrometers or thermocouples. Next, calculate the surface area to be coated and determine the amount of powder coating needed from the Scotchkote data sheet. Add an approximate waste factor. Determine gun output by timing spray into a vacuum cleaner or plastic bag and weigh results; 1 lb/0,45 kg per minute is typical.

- Apply Scotchkote until the finish coat begins to “frost” or appear sandy, this occurs at about 270˚F/132˚C. Reheat part and continue spraying.
- If coating is too thin, double coat before the initial coat has been fully cured. Application of a second coat can result in a satisfactory bond with no additional surface preparation. A light surface blast improves inter-coat adhesion if the first coat has been fully cured.

Note: Overcoating is not recommended. Check inter-coating adhesion thoroughly by knife cutting, scraping or other means to ensure a satisfactory bond.

- On complex parts such as pumps and valves, consider using both electrostatic spray and flocking.

Coating Thickness

Many corrosion protection applications require coatings in excess of 10 mils/254 µm. Use magnetic flux and eddy current gauges to check coating thickness on ferrous and nonferrous metals. Magnetic thickness can be used to determine coating thickness on ferrous metals. See Appendix II for sources of coating thickness devices.

Cure

Scotchkote FBEC must be cured according to the product data sheets. “Cure temperature” means substrate or part temperature. The best way to ensure cure is to monitor part preheat and post-bake temperature history, install automatic recording charts on ovens and check the precoat temperature of parts.

Two tests to determine cure are:

- Solvent Test – After coating has cooled to room temperature, place a cloth saturated with acetone or MEK on the coating for approximately 30 seconds. If the coating becomes tacky and transfers onto the cloth, it is not cured. This test in only good for determining drastic under cure. A nearly cured coating may pass this test, Also, some coatings have pigments soluble in MEK or acetone. These pigments will leave traces of color on a cloth even though the coating is fully cured.

OR

- Impact Test – Because an uncured film of fusion bonded epoxy coating is more brittle than a cured film, impact resistance can be used as a cure indicator. Uncured coatings fracture readily when impacted. This test is destructive and should be used with care. Substrate thickness, substrate curvature, substrate cleanliness and shape of the impact device all affect results.
- Parts with uncured coating can be post baked to full cure even after the parts have cooled completely and considerable time has passed.
- To save time and effort, parts can be coated in one application, allowed to cool and post baked later. While this is not difficult, thermal shrinkage of some parts may cause hairline cracks to appear in the hard but uncured coating. This occurs because the uncured coating has little elasticity. If this occurs, the parts must be post cured before allowing to cool.

Continuity Testing

After cure, use holiday detectors to check the coating for pinholes, voids, contamination, cracks and damaged areas. Use a 67,5 volt wet sponge jeeper or, for dry inspection, a continuous D.C. voltage detector. Set dry detector voltage at 125 times the mil thickness of the coating. Example: A 12 mil/305 µm coating should be checked at 1500 volts (12 x 125). See Appendix II for manufacturers of coating holiday test equipment. For more detailed information, including voltage calculations, please refer to NACE Standard RP0490-95.

Patching and Repair

Repair Scotchkote™ FBEC with two-component liquid epoxy resins, patch compounds or hot melt patch sticks color matched to the product used.

Use the following repair procedure:

1. Remove all oil, grease, oxidation and other contaminants from the damaged area using inorganic solvents such as toluene. Do not use gasoline or kerosene.
2. Remove rust from the damaged area by wire brushing, grinding or sandblasting. Abrade or lightly blast approximately 1 in/2,5 cm around the damaged area to provide an anchoring surface for the patch material.
3. Apply Scotchkote liquid patch compound or patch stick to the specified film thickness. For additional application information, see product data sheets and application specifications.

Removal of Cured Coating

It is extremely difficult to remove cured fusion bonded epoxy coating by sandblasting alone.

To make removal easier:

- Bake above 600˚F/316˚C for several hours or above 800˚F/427˚C for one hour prior to sandblasting.

OR

- Heat coated part to 250˚F/121˚C or above and scrape coating off.

Other removal methods include the use of epoxy strippers and hot sand baths.

A manufacturer of epoxy strippers is:

• Oakite Products, Inc.
  50 Valley Road
  Berkeley Heights, NJ 07922
  Ph: 1-908-464-6900
  Fx: 1-908-464-4658
  www.oakite.com

• Acklands-Grainger
  Alberta, Canada
  Ph: 1-780-955-2221
  Fx: 1-780-955-2535
  www.acklandsgrainger.com

Powder Quality Control and Storage

Store powder in a cool, dry place below 80˚F/27˚C. Double tie partially used bags of powder to protect against moisture and dust contamination.

Heat and humidity have the most detrimental effects on fusion bonded powder coating materials in storage. Extended storage above 80˚F/27˚C can affect the gel time of the powder, which in turn affects application and appearance of the final coating. The shorter the gel and cure time of the product, the more critical storage conditions become.

A gel check is one of the simplest ways to determine the condition of a fusion bonded epoxy coating. All that is required for this test is a stable hot plate, spatula and a surface thermometer. Set the hot plate at 400˚F/204˚C and spread a small amount of powdered resin onto the plate. Good coating melts out well, stirs easily and glosses. Advanced material turns gummy and will not flow.

Check all incoming boxes of coating for lumps. This indicates moisture in the powder. Check powder which has been sitting in fluid beds, reclaim systems or gun delivery systems for extended periods of time. Do not squeeze powder by hand to determine moisture content. Moisture on the skin is enough to make the powder lump.

Handling Precautions

Read all Health Hazard, Precautionary, and First Aid statements found in the Material Safety Data Sheet (MSDS) and/or product label of chemicals prior to handling or use.

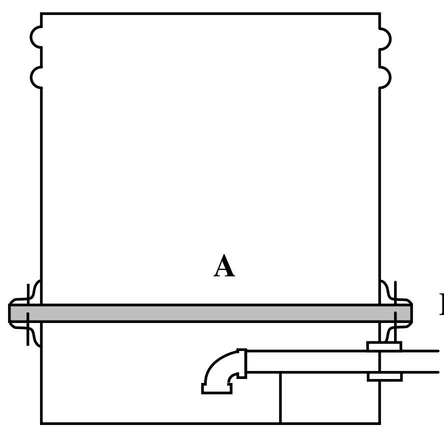
Appendix I

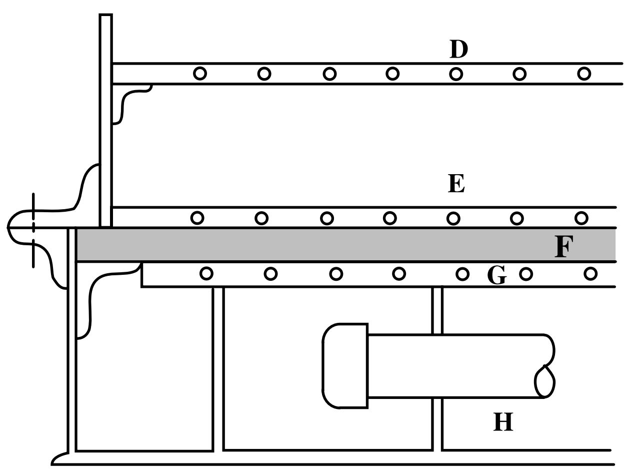
Appendix I

Fluid Bed Construction and Operating Requirements

Fluid Bed Construction

Fluid beds can be assembled easily from sheet metal, steel, plywood or even discarded drums. The illustrations below are cross sections of a small drum fluidized bed and a large fluid bed requiring membrane support.





A. Porous membrane - see list of membrane materials in this appendix.

B. Flange bolt and seal to outside. Do not seal to inside. Inside seals are difficult to make and frequently leak. Seal with gasket sealer.

C. Direct air downward in center of bottom chamber. Use 1/2 in/13 mm or or 3/4 in/19 mm pipe with elbow.

D. To air source. Use moisture traps and desiccant air dryers.

E. Removable open flooring. Protects membrane from dropped parts.

F. Permanent open flooring for additional membrane protection. Also prevents membrane bowing.

G. Supported open flooring. Provides membrane and powdered resin support.

H. Air manifold. Direct air downward and distribute evenly in bottom chamber. Use oil free, dry air. Seal outer flange mating surfaces with rubber gasket and sealer.

Note: On larger beds, build a port into the side of the powder chamber to facilitate resin removal.

Compressor Size and Air Pressure

Air compressors are recommended for bed fluidization. It takes very little air pressure to aerate even a large bed containing thousands of pounds of powder. This is because air is being mixed with powder, not lifting it. The compressor should be regulated in two stages to prevent erratic rising and falling of the bed level due to compressor surges. Place a 160 psi/11,0 bar regulator at the compressor and a 30 psi/2,1 bar regulator at the bed. The air volume required for fluidization of 3M Scotchkote FBEC is approximately 2.5 Cfm per ft^2/ (0.7 m^3/min per m^2) of membrane surface area. Compressors produce about 4 cfm/(0.11 m^3/min) per horsepower.

Use only oil-free, dry air for fluid beds. Compressors should be equipped with adequate oil filtration devices. A dew point of -20˚F/-29˚C or lower is suggested.

Vibrators

Vibrators can be very useful in maintaining optimum powder fluidization. Attach air or electric vibrators to opposing sides of the bed, just below powder level. Air vibrators should be oversized and operated at low air pressure. Air Vibrolators® are available from:

Martin Engineering Company
One Martin Place
Neponset, IL 61345-9766
Ph: 1-309-594-2384 or 1-800-544-2947
http://www.martin-eng.com

Porous Membranes

A porous membrane is a material through which air can pass but powder cannot. Some beds use uncoated 1/2 in/12,7 mm thick sound deadening board. Sound deadening board is inexpensive and available at most lumber yards in a standard 4 ft/1.2 m x 8ft/2,4 m construction sheet.

More durable materials are available from:

•Fluidizing Grade Porous Polyethylene Sheets
Atlas Minerals & Chemicals, Inc.
1227 Valley Road
Mertztown, PA 19539
Ph: 1-800-523-8269
Fx: 1-610-682-9200
www.atlasmin.com

•Glass Bead Plates
Maryland Ceramics
3100 Dublin Road
Street, MD 21154
Ph: 1-410-838-4114
Fx: 1-410-457-4333

Calculating Powder Required for Fluidization

Fluid bed density of Scotchkote powder coatings are in the range of 25-35 lb/ft^3/380-530 kg/m^3. This information can be found in the “Properties” section of the Scotchkote data sheet.

Dipping by Hoist

When dipping heavy parts, use a variable speed mechanical hoist capable of operating at 50 ft/15 m per minute. Load capacity is dictated by part weight. Use slow speed to position part, fast speed for part immersion.

Appendix II

Appendix II

Electrostatic Spray Operation and Maintenance and Equipment

- Read gun manufacturer's operation manual thoroughly before using.
- Air supply to gun should be dry, oil-free and capable of continuously supplying at least 20 ft^3/min at 80 psi (0,57 m^3/min.) at 5,5 bar. A dew point at -20˚F/-29˚C is recommended. If there is moisture in the powder, sieve it through a coarse screen to break up lumps and dry by fluidizing for several hours. Replace powder if necessary.
- Make sure all gun connections are tight and secure.
- Make sure all parts, equipment and operator are grounded. Shoes must be non-insulating. Do not wear metallic articles or have metallic items in pockets.
- Straighten all air and powder feed lines, make sure there are no kinks.
- Powder is abrasive. Check all powder feed lines and gun venturis at least once a week or more often if in continual use. A worn venturi causes surging and makes powder output difficult to control.
- Sometimes powder cakes or "cold welds" on gun parts, nozzles and feed lines. Never scrape parts to remove caked powder or damage to equipment can occur. Soak parts in a solvent such as naphtha or wash in warm water and detergent. Do not use soap.
- Purge guns when spraying operation is finished.
- Keep spray area clean.
- Never attempt to use powder that has been swept up from the floor.
- Turn power supply off before performing maintenance.

Electrostatic Spray Guns

Nordson Corporation
300 Nordson Drive
Amherst, OH 44001
Ph: 1-440-985-4000
Fx: 1-888-229-4580
www.nordson.com

Flock Spray Equipment

Binks Sames Corporation
ITW Company
195 International Blvd.
Glendale Heights, IL 60139
Ph: 1-630-237-5000
Fx: 1-630-237-5003
www.binks.com

Holiday Detection Equipment

Pipeline Inspection Co., Ltd.
1919 Antoine
P.O. Box 55648
Houston, TX 77255-5648
Ph: 1-713-681-5837
Fx: 1-713-681-4838
www.picltd.com

Tinker & Rasor
P.O. Box 281
San Gabriel, CA 91778-0281
Ph: 1-626-287-7942
Fx: 1-626-287-0132
www.tinker-rasor.com

Ovens

Despatch Industries, Inc.
P.O. Box 1320
Minneapolis, MN 55418
Ph: 1-800-726-0110
Fx: 1-612-781-5353
www.mbbnet.umn.edu/company-folder/di.html

Thickness Gauges

KTA-TATOR, Inc.
115 Technology Drive
Pittsburgh, PA 15275
Ph: 1-412-788-1300
www.KTA.com

Appendix III

Appendix III

Steel Pipe Cool Down Rate

Time (min.)	Temperature °F/°C/Plate Thickness (in/mm)						
	0.10in/2.54mm °F/°C	0.15in/3.81mm °F/°C	0.20in/5.08mm °F/°C	0.30in/7.62mm °F/°C	0.40in/10.16mm °F/°C	0.50in/12.7mm °F/°C	0.60in/15.24mm °F/°C
0.000	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1
0.500	444.7/229.2	454.2/234.6	459.0/237.2	464.2/240.1	466.9/241.6	468.5/242.5	469.5/243.1
1.000	419.3/215.1	435.8/224.3	444.7/229.3	454.2/234.6	459.2/237.3	462.1/238.9	464.2/240.1
1.500	397.3/203.0	419.4/215.4	431.5/221.9	444.6/229.2	451.9/233.3	456.2/235.7	459.2/237.3
2.000	377.9/192.2	404.3/206.8	419.3/215.2	435.9/224.4	444.8/229.3	450.4/234.4	454.2/234.6
2.500	360.4/182.4	390.6/199.2	408.0/208.9	427.4/219.7	438.1/225.6	444.8/229.3	449.5/231.9
3.000	344.6/173.6	377.9/192.2	397.3/202.9	419.4/215.4	431.6/222.0	439.4/226.3	444.8/229.3
3.500	330.0/165.6	366.1/185.6	387.3/197.4	411.7/210.9	425.4/218.6	434.1/223.3	440.3/226.8
4.000	316.6/158.1	355.0/179.4	377.9/192.2	404.4/206.9	419.4/215.2	429.8/221.0	435.9/224.4
4.500	304.0/151.1	344.6/173.7	369.0/187.2	397.3/202.9	413.6/212.0	424.1/217.8	431.6/222.0
5.000	292.1/144.5	334.8/168.2	360.5/182.5	390.6/199.2	408.0/208.9	419.3/215.2	427.4/219.7
5.500	281.0/138.3	325.5/163.1	352.4/178.0	384.1/195.6	402.6/205.8	414.7/212.6	423.3/217.4
6.000	270.4/132.4	316.6/158.1	344.6/173.7	377.9/192.2	397.4/203.0	410.2/210.1	419.4/215.2
7.000	–	300.9/149.4	330.1/165.6	366.1/185.6	387.4/197.4	401.5/205.3	411.7/210.9
8.000	–	284.7/140.4	316.6/158.1	355.0/179.4	377.9/192.2	393.3/200.7	404.4/206.9
9.000	–	–	304.0/151.1	344.6/173.7	369.0/187.2	385.4/196.3	397.3/202.9
10.000	–	–	292.2/144.6	334.8/168.2	360.5/182.5	377.9/192.2	390.6/199.2
11.000	–	–	281.0/138.3	325.5/163.1	352.4/178.0	370.7/188.2	384.1/195.6
12.000	–	–	–	–	344.6/173.7	363.8/184.3	377.9/192.2
14.000	–	–	–	–	–	350.8/177.1	366.1/185.6
16.000	–	–	–	–	–	338.7/170.4	355.0/179.4
18.000	–	–	–	–	–	327.3/164.1	344.6/173.7
20.000	–	–	–	–	–	316.6/158.1	334.8/168.2
22.000	–	–	–	–	–	–	325.5/163.1
24.000	–	–	–	–	–	–	316.6/158.1

Steel Plate Cool Down Rate

Time (min.)	Temperature˚F/Plate Thickness 0.10in/2.54mm °F/°C	0.20in/5.08mm °F/°C	0.30in/7.62mm °F/°C	0.40in/10.16mm °F/°C	0.50in/12.7mm °F/°C	0.60in/15.24mm °F/°C	0.80in/20.32mm °F/°C	1.00in/25.4mm °F/°C
0.000	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1	475.0/246.1
1.000	375.5/190.8	417.4/214.1	434.0/223.3	442.9/228.2	448.5/231.3	452.3/233.5	457.2/236.2	460.2/237.9
2.000	313.9/156.6	375.2/190.7	401.1/205.1	416.2/213.4	425.7/218.7	432.4/222.4	441.2/227.3	446.6/230.3
3.000	267.6/130.9	341.4/171.9	374.2/190.1	393.2/200.6	405.8/207.7	414.7/212.6	426.6/219.2	434.1/223.4
4.000	–	312.9/156.1	350.7/177.1	373.0/189.4	387.9/197.7	398.7/203.7	413.2/211.8	422.5/216.9
5.000	–	288.2/142.3	330.0/165.5	355.0/179.4	371.9/188.8	384.1/195.6	400.8/204.9	411.6/210.9
6.000	–	266.1/130.1	311.3/155.2	338.6/170.3	357.1/180.6	370.7/188.2	389.3/198.5	401.5/205.3
8.000	–	–	278.7/137.1	309.6/154.2	331.0/166.1	346.6/174.8	368.4/186.9	382.8/194.9
10.000	–	–	–	284.6/140.3	308.0/153.3	325.4/163.0	349.8/176.6	366.0/185.6
12.000	–	–	–	–	287.6/142.0	306.4/152.4	332.9/167.2	350.7/177.1
14.000	–	–	–	–	269.0/131.7	289.1/142.8	317.5/158.6	336.6/169.2

Handling and Safety Precautions

Read all Health Hazard, Precautionary, and First Aid statements found in the Material Safety Data Sheet, and/or product label prior to handling or use.

Ordering Information/Customer Service

For ordering information, technical information, product information or to request a copy of the Material Safety Data Sheet:

Phone: 800/722-6721 or 512/984-9385
Fax: 877/601-1305 or 512/984-6296

Important Notice

All statements, technical information, and recommendations related to 3M's products are based on information believed to be reliable, but the accuracy or completeness is not guaranteed. Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use. Any statements related to the product which are not contained in 3M's current publications, or any contrary statements contained on your purchase order shall have no force or effect unless expressly agreed upon, in writing, by an authorized officer of 3M.

Warranty; Limited Remedy; Limited Liability.

This product will be free from defects in material and manufacture for a period of [add warranty time period] from the time of purchase. **3M MAKES NO OTHER WARRANTIES INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.** If this product is defective within the warranty period stated above, your exclusive remedy shall be, at 3M's option, to replace or repair the 3M product or refund the purchase price of the 3M product. **Except where prohibited by law, 3M will not be liable for any indirect, special, incidental or consequential loss or damage arising from this 3M product, regardless of the legal theory asserted.**

3M

Corrosion Protection Products

6801 River Place Blvd.
Austin, TX 78726-9000
www.3M.com/corrosion

Please Recycle.

Litho in USA