## LINING OF VESSELS FOR IMMERSION SERVICE

PURPOSE
The purpose of this document is to amplify the standard information in Carboline's product data sheets and to provide more detailed information for proper specifications and inspection in order to secure the best coating and lining quality.

### TABLE OF CONTENTS


| SECTION | | PAGE |
|---|---|---|
| - | Reference Sources | 1 |
| 1 | Coating Evaluation and Selection | 2 |
| 2 | Specifications | 2 |
| 3 | Inspection Requirements | 4 |
| 4 | Surface Preparation | 9 |
| 5 | Coating Applications | 11 |
| 6 | Safety | 13 |
| 7 | Ventilation | 14 |
| 8 | Accelerated Curing and High Heat Baking | 15 |

| CHART | | PAGE |
|---|---|---|
| Chart I | Tank Construction Guide for Lined Tanks (Figures 1-11) | 19 |
| Chart II | Accelerated Curing Chart | 22 |
| Chart III | Carboline Coatings Solvent Factors | 23 |
| Chart IV | Carboline Thinners Flash Points | 24 |
| Chart V A | Distribution Requirements for Force Curing | 25 |
| Chart V B | Ventilation<br>(A) Horizontal<br>(B) Vertical | 26 |
| Chart VI | Coverage Estimation Chart | 27 |


### REFERENCE SOURCES

**NACE** - National Association of Corrosion Engineers
P.O. Box 218340
Houston, TX 77218

**EPA** - United States Environmental Protection Agency
Assessment Division/MC 4503F
401 M Street, SW
Washington, DC 20460

**ACGIH** - American Conference of Governmental Industrial Hygienists
1330 Kemper Meadow Drive
Cincinnati, OH 45240

**OSHA** - Occupational Safety & Health Administration
Office of Occupational Health Compliance Programming
200 Constitution Ave., NW
Washington, DC 20210

**ASTM** - American Society of Testing & Materials
1916 Race Street
Philadelphia, PA 19103

**SSPC** - Steel Structures Painting Council
40-24th Street, 6th Floor
Pittsburgh, PA 15222

**AIHA** - American Industrial Hygiene Association
2700 Prosperity Ave., Suite 250
Fairfax, VA 22031

## SECTION 1: COATING EVALUATION AND SELECTON

### 1.1 General

In the selection of an applicable coating and lining, it is important to have an accurate evaluation of laboratory test data. For guidelines on test evaluations, refer to these references:

1.1.1 Determine the problem and exposure.

1.1.1.1 Plasite Protective Coatings', "Recommendation and Test Questionnaire."

1.1.2 Select generic type or types that may be applicable.

1.1.2.1 Plasite Protective Coatings, W.T. Singleton, "Coating Selection Guidelines Based on Generic Types and Film Thickness," Feb. 1992.

1.1.2.2 NACE Publication TPC-2, "Coatings and Linings for Immersion Service."

1.1.2.3 NACE Standards on Test Methods – "TM;" Material Requirements – "MR" and Recommended Practices – "RP" that are applicable as established by the Technical Practices Committee. Publications may be obtained by ordering from NACE.

1.1.3 Chemical resistance.

1.1.3.1 Plasite chemical resistance data.

1.1.3.2 NACE Publication TPC-2, "Coatings and Linings for Immersion Service."

1.1.4 Methods of evaluation and testing.

1.1.4.1 NACE Standard TM-01-74, "Laboratory Methods for the Evaluation of Protective Coatings Used as Lining Materials in Immersion Service."

### 1.2 Conditions to Consider in Coating and Lining Material Selection

1.2.1 Chemical resistance based on laboratory and field history.

1.2.2 Surface preparation and accessibility.

1.2.3 Film thickness-continuity and quality depends on skilled application.

1.2.4 Design of tankage and equipment.

1.2.5 Physical conditions during application including temperature, humidity, size of enclosure, ventilation and other variables.

1.2.6 Physical abuse, abrasion, impingement, liquid velocities, impact.

1.2.7 Electrochemical, cathodic protection.

1.2.8 Thermal shock, cyclical heating and cooling.

1.2.9 Temperature limits and operating characteristics.

1.2.10 Impurities, combinations and concentrations of reagents, pH range and trace elements, if any.

1.2.11 Chemicals proposed for vessel clean-out.

## SECTION 2: SPECIFICATIONS

### 2.1 General

Writing specifications is an art that requires detailed knowledge of the exposure, the coating material, the applicator's skill and the conditions under which the coating is to be applied.

**References:**

NACE Publication 6J-162, "Guide to the Preparation of Contracts and Specifications for the Application of Protective Coatings."

NACE Standard RP-01-78, "Design, Fabrication and Surface Finish of Metal Tanks and Vessels to be Lined for Chemical Immersion Service."

NACE Publication 6D-161, "Specification Format for Surface Preparation and Material Application for Industrial Maintenance Painting."

NACE Publication 6D-160, "Industrial Maintenance Painting Program."

NACE Publication 6B-157, “Protective Coatings for Atmospheric Use: Their Surface Preparation and Application, Physical Characteristics and Resistances.”

NACE Publication 6D-163, “A Manual for Painter Safety.”

OSHA Standards – Subpart D – “Walking-Working Surfaces;” Subpart E – “Means of Egress;” Subpart F – “Powered Platforms, Manlifts and Vehicles – Mounted Work Platforms;” Subpart G – “Occupational Health & Environment Control;” Subpart H – “Hazardous Materials;” Subpart I – “Personal Protective Equipment;” Subpart K – “Medical and First Aid, Portable Fire Suppression Equipment, Other Fire Protection Systems;” Subpart Z – “Toxic and Hazardous Substances.”

2.2 **Specification Outline**

2.2.1 General Conditions – A brief description of location site, work to be done, procedure of work, starting date, etc.

2.2.2 Special Conditions – This may include special contingencies such as available work schedule, working conditions, inspection of site, weather conditions, contract details, etc.

2.2.3 Scope of Work – A brief concise schedule of work to be performed as to quantity, drawing references, coating systems, etc.

2.2.4 Types of Construction Recommendation.

**References:**

NACE Standard RP-01-78, “Design, Fabrication and Surface Finish of Metal Tanks and Vessels to be Lined for Chemical Immersion Service.”

Chart I (Figures 1-11), “Tank Construction Guide for Lined Tanks.”

2.2.4.1 Use round or curved structural members, reinforced whenever possible and require that all sharp edges be ground to a 1/8” minimum radius.

2.2.4.2 Weld beads shall be continuous and free of porosities and undercutting.

2.2.4.3 Weld splatter shall be removed.

2.2.4.4 Skip welding shall not be permitted. Lap construction shall be welded continuously on both sides.

2.2.4.5 Nozzles, drains and crevices shall be smooth and self-draining.

2.2.4.6 Where impossible to fill voids, laps and fillets with continuous welds, a 100% solids non-shrinking compound shall be used that is compatible and similar in resistance to the lining specified.

2.2.4.7 The coating of old or new riveted tanks generally is considered unsatisfactory where service is severe and complete continuity of coating film is required.

2.2.5 Inspection Requirements – Shall consist of primary inspection of the work to be completed as well as the equipment and supplies. Intermediate inspection includes the scrutiny of surface preparation and actual coating work. The final inspection to include acceptance of appearance, film thickness, continuity and final cure.

2.2.6 Surface Preparation – Shall include a full description of appearance and anchor pattern required for the job as well as other requirements such as the abrasive, nozzle pressure, nozzle size, blasting procedure, etc.

2.2.7 Coating Application – Reference can be made to manufacturer’s current product data sheet with information extracted and amplified as required to meet special conditions or requirements. Thinners shall be specified in accordance with coating manufacturer’s recommendations.

2.2.8 Accelerated Curing.

**Reference:**

Chart II, “Accelerated Curing Chart.”

This may be a specification addendum or part of the application section when force curing is required.

2.2.9 Safety Requirements – Shall include the safety code of owner and/or applicable state, local and national (OSHA) safety codes covering working conditions, scaffolding, clothing, fire and explosion hazards, safety equipment, solvent lighting, ventilation and grounding of vessels.

## SECTION 3: INSPECTION REQUIREMENTS

**References:**

SSPC, "Surface Preparation Specifications."

SSPC, "Pictorial Surface Preparation Standards."

SSPC, "Profile Comparative Panels."

NACE Publication RP0288-94, "Recommended Practices for Inspection of Linings on Steel and Concrete."

NACE Publication 6F-166, "Recommended Practices for Inspection of Linings on Steel and Concrete."

D.M. Berger and S.E. Mrox, "Instruments for Inspection of Coatings," ASTM, Journal of Testing & Evaluation, Vol. 4, No. 1, 1969.

### 3.1 Primary Inspection

3.1.1 Inspect equipment and supplies to verify that they are of the approved type and capacity required for the job and are in good operating condition. This includes a clean, dry, properly trapped and filtered air supply of sufficient volume and pressure. The abrasive is to be inspected to assure that it is of the size that will obtain the proper anchor pattern, or profile, non-contaminating and as specified. The surface shall be inspected to determine if pre-baking or pre-cleaning is required before blasting to remove contaminants on the surface or in the pores of the substrate.

3.1.2 Spray equipment shall be clean and new hoses are preferred.

3.1.3 Preliminary safety checks shall be made (see SECTION 6: SAFETY) to determine if explosive or toxic gases are present.

### 3.2 Intermediate Inspection

3.2.1 Inspect the surface preparation during the blasting and make a final check to verify that the surface meets the requirements of "white metal blast" and the anchor pattern, or profile, specified.

3.2.2 Use a surface profile measuring device or comparator as called for in the specifications to verify the depth of the profile and the number of peaks per square inch. A visual comparison is provided with Clemtex or KTA-Tator, Inc. anchor pattern panels. Measurements with the Testex Press-O-Film may also be used. They can be obtained at the following addresses:

| Supplier Name | Supplier Address | Product or Service |
|---|---|---|
| **Clemtex** | P.O. Box 15214<br>Houston, TX 77220 | Anchor Pattern Panels |
| **KTA-Tator, Inc.** | 115 Technology Dr.<br>Pittsburgh, PA 15275 | Anchor Pattern Panels |
| **Testex, Inc.** | P.O. Box 867<br>Newark, DE 19715 | Anchor Pattern Panels |

3.2.3 The freshly blasted surface shall be coated the same day surface was blasted or prior to the formation of rust bloom.

3.2.4 The applicator shall check the coating material to determine there is no jelling or settling that cannot be remixed using mechanical mixing equipment.

3.2.5 Manufacturer's recommended thinner shall be used to adjust for variances in temperature and humidity so as to obtain a good wet appearing film. By spraying a sample, it can be determined if it is in the proper viscosity range. Coatings of this type will spray with a wide variance in viscosity and this is the main check in the field. Various types of viscosity measurements are made with the most common being the Ford Cup #4 and the No. G2 Zahn Cup. Another unit sometimes used is the standard Poise.

3.2.5.1 Thinning is required to adjust coating viscosity. The following table cross-references the three viscosity measurement types listed in Paragraph 3.2.5.

| Poise | #4 Ford Cup | #G2 Zahn Cup |
|---|---|---|
| | 12 | 14 |
| | 15 | 18 |
| | 18 | 21 |
| **.50** | 21 | 25 |
| | 24 | 29 |
| **.65** | 27 | 32 |
| | 30 | 36 |
| **.85** | 33 | 39 |
| | 36 | 43 |
| **1.00** | 40 | 47 |

3.2.5.2 The type of thinner and the amount required will vary depending on the following conditions:

(a) Temperature
(b) Ventilation
(c) Humidity
(d) Type of Spray Equipment
(e) Viscosity of Coating
(f) Type of Coating
(g) Desired Film Thickness

3.2.6 Application technique and coverage rate shall be checked during the coating application. A rough estimate of coverage shall be made with a wet film gauge used immediately after application of the coating. Insert into the wet film **immediately** after making a spray pass with the gun.

Checking the wet film in this manner indicates to the applicator the amount of coating he is applying per coat. For example, a 10 mil wet film reading with a 40% solids by volume coating (without thinning) should dry to a dry film of 4 mils. Using a wet film gauge the painter can add or subtract passes until the necessary wet film thickness is obtained which will result in the dry film thickness specified.

## 3.3 Final Inspection

3.3.1 The general appearance of the film shall be free of runs and sags, orange peel, pinholing, fisheyes, dry spray (overspray), trash in the film and voids.

3.3.2 Runs and sags trap solvents and generally indicate poor workmanship. Small to moderate runs and sags may be brushed out. Heavy runs and sags may require sanding and dress coating or reblasting followed by reapplication of the coating.

3.3.3 Film thickness is specified for the service required, indicating minimum and maximum. The gauges that measure film thickness generally are the magnetic type and there are many factors that affect their calibration and reading. Margins of error may run as high as ± 40% for thin films of 1 to 4 mils and ± 10% for films from 10 to 20 mils. Therefore, they should be frequently calibrated. Gauges used must have adequate range in order that the anticipated dry film thickness will be read mid-range on the gauge scale.

3.3.4 Destructive test methods are employed where repairs can be made and, at times, to resolve controversy over the accuracy of dry film thickness measurements. The Tooke Coating Inspection Gauge 102/TG, which is an accepted destructive gauge, cuts a V-shaped notch in the coating with a precision ground cutter blade. The thickness of the coating at the V-cut is then measured geometrically by viewing through an illuminated microscope that is built in the gauge.

3.3.5 Electrical testing to determine the presence and number of discontinuities in a coating film is performed on a nonconductive coating applied to a conductive surface. The allowable number of discontinuities should be determined prior to conducting this test since the acceptable number of discontinuities will vary depending on coating film thickness, design and environment.

Two types of test equipment are used to determine discontinuities: a low voltage wet sponge and a high voltage spark tester. The low voltage wet sponge tester is used to determine discontinuities in coating films having a total film thickness of 20 mils or less. The high voltage spark tester may be used for all film thicknesses, but MUST be used when film thickness is greater than 20 mils. The high voltage tester can be destructive, particularly if proper output voltage and type of equipment is not selected. Consult coating manufacturer for the recommended test voltage and equipment. Refer to NACE Standard "Discontinuity (Holiday) Testing of Protective Coatings."

3.3.5.1 Inspection of Coating Continuity.

**Reference:**

NACE Publication 6F-166, "Recommended Practices for Inspection of Linings on Steel and Concrete," Paragraph 17-26, Page 78.

3.3.5.1.1 Descriptive Terminology.

The degrees of continuity are termed as conditions "A," "B" and "C."

Condition "A" – Pinhole Free. The applied coating film shall be continuous.

Condition "B" – Relatively Pinhole Free. The applied film should contain only a negligible number of points of minor discontinuity. No more than two points of discontinuity should occur within an area having a radius of six inches as measured from a point of discontinuity (pinhole). No gross discontinuity (larger than pinpoint size) should be allowed.

Condition "C" – Commercially Continuous. The applied film should contain only a minor number of points of discontinuity. No more than two points of discontinuity should occur within an area having a radius of six inches as measured from a point of discontinuity (pinhole). No more than 40% of the total number of allowable points of discontinuity should occur within any one area equal to 25% of the total area being coated.

Total allowable number of discontinuity points for all specified thicknesses of coatings in all three conditions defined above are given in the table below.

| Surface Area Being Coated (Sq. Ft.) | "A" Pinhole Free | "B" Relatively Pinhole Free | "C" Commercial Continuous |
|---|---|---|---|
| **10** | 0 | 1 | 5 |
| **10-50** | 0 | 2 | 10 |
| **50-100** | 0 | 5 | 20 |
| **100-500** | 0 | 10 | 30 |
| **500-1000** | 0 | 15 | 50 |
| **1000-5000** | 0 | 25 | 75 |

3.3.5.1.2 Discontinuity Definitions.

"A void, crack, thin spot, foreign inclusion or contamination in the coating film that significantly lowers the dielectric strength of the coating. May also be identified as a holiday or pinhole.

Holidays, skips and misses are gross discontinuities caused by faulty workmanship. By common usage in the industrial coatings field, the term “holidays” has become synonymous with discontinuities.

Pores, voids, fisheyes, pits and pinholes are names of various types of small cavities or holes in a coating film, all of which may be discontinuities. These are commonly acknowledged to be caused by: (a) application short-comings; (b) imperfections of the substrate surface; (c) a contaminant in the coating film; (d) a contaminant on the substrate; (e) too rapid release of solvents or products of reaction, such as, water or (f) a short-coming of the film forming properties of the coating material.

Blisters are faults of the coating film caused by too rapid release of solvents, products of reaction or entrapped air. Blisters often will occur after the applied coating has been exposed to high temperatures. Blisters may or may not become discontinuities, as defined above.

All discontinuities or latent discontinuities (those which may develop later during service) are to be avoided or corrected. Even when the tests indicate that the applied coating film contains no discontinuities, experience has proved that discontinuities can exist or may develop later during service. This is true for thin film coatings. Thin film coatings normally should not be used in an environment corrosive enough to cause catastrophic attack on the substrate.”

3.3.6 Final Cure – There are several ways of checking the final cure. One method is the test where a specified solvent recommended by the coating manufacturer is placed on the film for a period of five to ten minutes. The coating in presumed to be approaching its final cure if there is no sign of dissolving or only a slight softening that hardens after the solvent is removed. The hardness may be checked against a cured sample. If the condition is severe, force curing is generally recommended to assure that the final cure is reached before exposure. Some baked coatings change color when cured and color panels may be provided by the manufacturer showing the minimum acceptable color change.

3.4 **Inspection Test Equipment**

3.4.1 Film thickness measurements are usually measured in mils (1 mil = .001”).

3.4.2 The following are non-destructive film thickness gauges suitable for determining dry film thickness of protective coatings. Before using, ensure that they have been properly calibrated.

3.4.2.1 Elcometer Inspector Thickness Gauge: Permits measurement of non-magnetic protective coatings applied to a magnetic surface with an accuracy of ± 10%.

3.4.2.2 Positector: Measures non-magnetic coating thickness over ferrous substrates with an accuracy of ± 3%. Digital reading remains until next measurement taken.

3.4.2.3 MikroTest Thickness Gauge: A highly accurate hand gauge which operates on the attraction power of a permanent magnet through a non-magnetic coating to the base steel with an accuracy of ± 5%.

3.4.3 A holiday detector is usually an electronic device (by means of a meter or audible alarm) that indicates a void or discontinuity.

3.4.3.1 Tinker & Rasor Model M-1: A low voltage, wet sponge type detector considered to be non-destructive. It operates on a 67-1/2 volt battery and is equipped with a cellulose sponge probe. When the sponge is moistened with water and passed over a discontinuity, a small current flows and actuates an audible alarm. This is a portable device based on the electrical principle of an electromagnetic sensitive relay or solid-state electronic relay circuit.

3.4.3.2 Tinker & Rasor Model AP-W: A high voltage holiday detector operating at voltages adjustable between 900 to 35,000 volts. This device, when used in the voltage range of 3,000 to 4,500 volts, is used in testing for holidays in thicker films, such as, the 40 mil sprayable vinyl ester coatings.

3.4.3.3 K-D Bird Dog Detector: A fully electronic resistance comparator of great sensitivity. The transistor circuit responds instantly to changes in coating resistance by an audible change in frequency. Good contact to the coating is provided by the wet sponge electrodes which also furnish moisture for wetting the surface. The instrument operates on low DC voltage and is non-destructive. This is a portable device based on the principle of an electronic relaxation oscillator circuit.

3.4.3.4 D.E. Stearns Holiday Detector: A high voltage holiday detector used to locate voids in heavy coatings. The instrument has an adjustable voltage range of 1,000 to 14,000 volts.

3.4.4 Hardness tests may be read in Pendulum, Sward or Pencil hardness numbers.

3.4.4.1 Sward Hardness Rocker: An instrument used for testing hardness by recording the number of oscillations as compared to a standard plate glass panel. It is essentially a pendulum supported by the material being tested and records the resistance ratio. Results are given in number of rock oscillations compared to the plate glass standard of 50 oscillations.

3.4.4.2 Castell Pencils: Recognized standards and, in the hands of an experienced operator, can provide more information on the actual film hardness characteristics than the Sward Rocker. The pencils are applied according to TT-P-14 lb. Federal Standards method.

3.4.4.3 Konig Pendulum Hardness Tester: This hardness tester operates with a pendulum whose fulcrum rides on a horizontal coating panel. The swing of the pendulum is started at the same length for all coatings. The instrument measures the time taken for a set decrease in swing length. The softer the coating, the quicker the decrease in length of swing of the pendulum. Glass is measured at 250 ± 3 seconds.

3.4.5 Inspection Test Equipment Suppliers:

| Supplier Name | Supplier Address |
|---|---|
| **BYK-Gardner** | 2435 Linden Lane<br>Silver Spring, MD 20910 |
| **De Felsko Corporation** | 802 Proctor Avenue<br>Ogdensburg, NY 13669 |
| **KTA-Tator, Inc.** | 115 Technology Drive<br>Pittsburgh, PA 15275 |
| **Nordson Corporation** | 555 Jackson Street<br>Amherst, OH 44001 |
| **S.G. Pinney & Associates, Inc.** | P.O. Box 9220<br>Port St. Lucie, FL 34985 |
| **Technical Inspection Services, Inc.** | 5202 South Shaver Street<br>Houston, TX 77034 |
| **Tinker & Rasor** | P.O. Box 281<br>417 Agostono Road<br>San Gabriel, CA 91778 |

## SECTION 4: SURFACE PREPARATION

### 4.1 Steel

**References:**

NACE Publication 6F-163, "Surface Preparation of Steel or Concrete Tank Interiors."

NACE Publication TM-01-70, "Visual Standard for Surfaces of New Steel Airblast Cleaned with Sand Abrasive."

SSPC-SP-5 and SSPC-SP-10.

NACE Publication 6G-164, "Surface Preparation Abrasives for Industrial Maintenance Painting."

NACE Publication 6G-174, "Centrifugal Wheel Blast Cleaning of Steel Plate, Shapes and Fabrications."

NACE Publication 6G-176, "Cleanliness and Anchor Patterns Available Through Centrifugal Blast Cleaning of Steel."

4.1.1 The compressed air supply shall be of ample volume and pressure and free of oil and moisture.

4.1.2 Preliminary surface preparation prior to blasting such as degreasing, steaming, sealing or preheating may be necessary to remove grease and oil and other contaminants residing in the "pores" of the metal.

4.1.3 Steel which has been in previous service, such as hydrochloric acid or other acid service, usually will require extensive cleaning such as steam (or pre-bake), blast, steam (or pre-bake) and blast to thoroughly remove all of the contaminants out of the pores of the metal.

4.1.4 The degree of blast and anchor pattern shall be as specified with proper reference as described in "intermediate inspection."

4.1.5 A 1-1/2" diameter hose is recommended with 95 to 100 psi at the nozzle for best impact and production efficiency.

4.1.6 Allow no condensation on a freshly blasted surface prior to the application of the first coat. If the steel temperature approaches the air dew point by 5°F, it will be necessary to raise the temperature or use dehumidification equipment to avoid reaching a dew point.

4.1.7 Use only clean, non-contaminating, properly separated and graded, sharp abrasive for all blasting.

4.1.8 The air supply shall be properly trapped and filtered to prevent contamination of the substrate by oil and water.

4.1.9 The surface shall be cleaned free of all dust and abrasive with a heavy-duty industrial type vacuum cleaner.

### 4.2 Concrete

**References:**

NACE Publication 6F-163, "Surface Preparation of Steel or Concrete Tank Interiors."

NACE Publication 6G-166, "Surface Preparation of Concrete for Coating."

NACE Publication 6H-175, "Surface Preparation and Surfacing Materials for Cementitious Surfaces."

4.2.1 Inspect for structural failures – cracks, protrusions and fins. Grind surface flush and grind cracks to "V" configuration. Chip out all loose concrete to width of ¼" minimum.

4.2.2 Repair larger holes, cracks, voids and other imperfections with manufacturer's recommended materials.

4.2.3 Concrete surface must have at least 30 days minimum cure, be clean, hard, dense, neutral and free of laitance, form oil and release agents. Blow holes, pits and cavities shall be opened in order that they be properly filled and sealed. To prepare the surface use one of the following methods listed in order of preference:

4.2.3.1 Whip blast with fine grade of abrasive with low nozzle pressure. Pressure and distance of nozzle from surface depends on characteristics of concrete. Do not overblast as it will result in high consumption of material and labor.

4.2.3.2 Water blasting at pressure of approximately 4000 psi may be used to produce similar results.

### 4.3 Abrasive Blasting Equipment

4.3.1 For better efficiency and a proper blast pattern, a Venturi nozzle is preferred. A remote dead man control shall be used.

4.3.2 Blasting Machines – Any commercially available machine is satisfactory. Those that contain a recovery system are preferred because they allow for recovery of the more expensive abrasives.

4.3.3 The blasting operator shall be equipped with a filtered air-fed blasting helmet.

4.3.4 Abrasive Suppliers:

| Supplier Name | Supplier Address |
|---|---|
| **Clemco Industries** | 1 Cable Car Drive<br>Washington, MO 63090 |
| **Ervin Industries** | P.O. Box 1168<br>Ann Arbor, MI 48106 |
| **Pangborn Corporation** | P.O. Box 380, Dept. 20<br>Hagerstown, MD 21741 |
| **Reed Minerals Division of Harsco** | 8149 Kennedy Avenue<br>Highland, IN 46322 |
| **The Wheelabrator Corporation** | 1606 Executive Drive<br>LaGrange, GA 30240 |

4.3.5 Blasting Abrasives.

4.3.5.1 Natural silica sand has been used for outside work where recovery is impossible. It has several disadvantages; it may lack angularity, it may contain friable constituents of an alkaline nature which break up and cling to the surface and it has a high fracture rate. IT ALSO CONTAINS FREE SILICA WHICH AFTER PROLONGED EXPOSURE WILL LIKELY CAUSE SILICOSIS. Therefore, an air-fed hood is a requirement and must be worn by the sandblaster.

4.3.5.2 Crushed flint or “Chat” is used extensively prior to application of metalizing and some thick film coatings. It owes its angularity to the conchoidal type of fracture characteristic of flint. Those of very high purity leave a considerable amount of material imbedded in the surface. MAY CONTAIN FREE SILICA WHICH AFTER PROLONGED EXPOSURE WILL LIKELY CAUSE SILICOSIS.

4.3.5.3 Crushed slag is extremely angular with a low break-down rate but leaves some material imbedded in the surface. Tests show this material may or may not completely be inert from a corrosion standpoint. Check with coating manufacturer on acceptable type of slag.

4.3.5.4 Angular steel grit is widely used where recovery is possible. It leaves minimum particles imbedded in the surface.

4.3.5.5 Abrasive particles shall not be reused unless they are cleaned, dried and screened to the original sizing.

4.3.5.6 Small surfaces, such as repair work, may be blasted with a portable blast gun or mechanical cleaning, such as, the Von Arx Air Needle Gun or 3M Roto Peen.

4.3.5.7 Approximate Rate of Abrasive Flow, Lbs./Hr.

| Blast Nozzle Orifice Size In. | Sharp Angular Sand | Crushed Steel Grit | Aluminum Oxide | Flint | Garnet | Crushed Slag |
|---|---|---|---|---|---|---|
| **3/16** | 500 | 1250 | 750 | 450 | 700 | 500 |
| **1/4** | 900 | 2250 | 1350 | 800 | 1250 | 950 |
| **5/16** | 1200 | 3250 | 1950 | 1150 | 1800 | 1400 |
| **3/8** | 1700 | 4250 | 2550 | 1500 | 2350 | 1800 |
| **7/16** | 2200 | 5500 | 3300 | 1950 | 3050 | 2350 |
| **1/2** | 3000 | 7500 | 4500 | 2650 | 4100 | 3200 |

4.3.6 Surface Preparation Equipment Suppliers:

| Supplier Name | Supplier Address | Product or Service |
|---|---|---|
| **Clemco Industries** | 1 Cable Car Drive<br>Washington, MO 63090 | Automatic & Portable Shop Equipment (wet & dry blast) |
| **Clements National Company** | 6650 S. Narragansett Avenue<br>Chicago, IL 60638 | Portable Shop Equipment |
| **Dynabrade** | 8989 Sheridan Drive<br>Clarence, NY 14031 | 3M Company Roto Peen |
| **Henkel Surface Technologies** | 32100 Stephenson Hwy.<br>Madison Heights, MI 48071 | Alodine® 1200S |
| **MacDermid, Inc.** | 245 Freight Street<br>Waterbury, CT 06702 | Iritite® 14-2 |
| **Oakite Products** | 50 Valley Road<br>Berkeley Heights, NJ 07922 | Oakite Cryscoat 747LTS®; Oakite Cryscoat Ultraseal® |
| **Pangborn Corporation** | P.O. Box 380, Dept. 20<br>Hagerstown, MD 21741 | Automatic & Portable Shop Equipment (wet & dry blast) |
| **Ruemelin Manufacturing Co.** | 3860 North Palmer Street<br>Milwaukee, WI 53212 | Automatic & Portable Shop Equipment (wet & dry blast) |
| **Spencer Turbine Company** | 600 Day Hill Road<br>Windsor, CT 06095 | Industrial Vacuum Cleaning Equipment |
| **The Wheelabrator Corporation** | 1606 Executive Drive<br>LaGrange, GA 30240 | Automatic & Portable Shop Equipment (wet & dry blast) |

## SECTION 5: COATING AND LINING APPLICATION

**References:**

NACE Publication 6B-157, “Protective Coatings for Atmospheric Use: Their Surface Preparation and Application, Physical Characteristics and Resistances.”

Plasite Protective Coatings, A.L. Hendricks, “Application Problems; Causes, Prevention and Remedies,” February 1992.

5.1 A first coat shall be brush applied to all welds, seams, corners and rough surfaces and surfaces pitted from previous exposure. Coating shall be thinned 50% by volume with the appropriate thinner. The technique for brushing shall be to “brush out” the coating rather than “flow on” the coating.

5.2 A minimum surface temperature is required to obtain polymerization of the coating system. Refer to appropriate Plasite product data sheet for surface temperature requirements. Succeeding coats cannot be applied without damaging the system until the surface temperature rises sufficiently to obtain polymerization. Additional thinning will be required when surface temperatures are above 80°F. For surface temperatures above 110°F, consult the Plasite Technical Service Department.

5.3 Thinners, as specified, shall be used to adjust coating for various application conditions. A ratio of 5-25% shall be used depending on ambient conditions and metal temperatures. At 75°F, a suggested thinning ratio is 5-10%; the amount of thinner may be increased at a ratio of approximately 5% per 5°. At higher temperatures, a slower evaporating solvent must be utilized. Thinner should be added if surface temperatures are lower than ambient. A faster evaporating solvent must be utilized in this case.

5.4 High humidity conditions may cause "fisheyeing, crawling or blushing." Coating application shall not be conducted when the surface temperature is within 5°F of the wet bulb temperature. Environmental control equipment shall be used when weather conditions do not meet this requirement if coating application is to continue.

5.5 An experienced spray applicator can tell when addition of thinner is required in order to have the proper sprayability and flow out of the coating as it is applied to the substrate.

5.6 MEK can be used for cleanup of equipment.

5.7 A "multi-pass" method of spray application, as described in the current Plasite product data sheets, shall be employed.

5.8 Extreme cleanliness is required. Clean clothing shall be worn, disposable booties shall be used over work shoes and care shall be taken to avoid contaminating the blasted surface with handprints and through other negligent acts.

5.9 Previously used hoses must be completely cleaned. New hoses are preferred. When using catalyzed materials, it is necessary to clean the equipment thoroughly after each use as most catalyst cured materials cannot be dissolved by their own solvent after partial cure.

5.10 Compatible caulking compounds shall be used in voids, fillets or extremely rough and pitted areas as a last resort where welding cannot be accomplished. Caulking compounds shall be similar in chemical resistance and in physical properties to the finished coating material. Apply in "sandwich" form. That is, coating-caulking-coating for a two-coat system.

5.11 Remove all overspray by dry brushing or scraping.

5.12 Coating Application Equipment:

5.12.1 CONVENTIONAL AIR SPRAY GUNS: The following chart indicates the standard types of conventional air spray guns, nozzles and air caps recommended for best atomization, material break-up and high production rates. Use of a pot with an agitator is preferred.

| GUN | FLUID | AIR |
|---|---|---|
| Binks #2001 | 66-SS | 63-PB |
| DeVilbiss JGA-510 | E | 797 |
| Graco P-800 | 04 | 02 |

Note: The same guns may be used with a stainless needle and tip.

| GUN | FLUID | AIR |
|---|---|---|
| Binks #2001 | 59ASS | 251 with a 559SS needle |

5.12.2 AIRLESS SPRAY EQUIPMENT: The airless pump shall be of sufficient size to properly atomize the coating with the spray tip selected. The orifice size required will range between .013" to .035" varying with the viscosity of the coating. In selecting a spray tip, a suitable fan width for the configuration of the substrate shall be of major consideration. The amount of thinner required will vary up to approximately 30% depending on temperature, substrate size and individual technique.

| GUN | TIP |
|---|---|
| Graco Bulldog (or equivalent) | .013" - .035" |

5.12.2.1 The high build vinyl ester coatings require a large capacity pump with a capability of 3 gpm, a minimum tip size of .025" with a 12" spray width recommended. The liquid pressure shall be in the range of 1800 to 2200 psi. Airless spray is not recommended for abrasion resistant formulations because of the extreme wear on the tips and lower units of the pump unless the airless unit is designed for abrasive type materials.

5.12.2.2 Airless Spray Advantages and Disadvantages:

Advantages: No problem with contaminated air. Overspray is kept to a minimum and the production rate is high. Thick films may be obtained without runs or sags under some conditions.

Disadvantages: The large output of the gun makes it difficult to handle in small tanks where working conditions are crowded or cramped causing runs or sags. Due to the large amount of liquid handled and the easy build properties of this equipment, it is possible, with improper thinning and improper technique, to apply the coating material at too high a rate per pass. The end result usually being solvent entrapment and porous film, runs and sags.

5.13 **Equipment Manufacturers:**

| Supplier Name | Supplier Address | Product or Service |
|---|---|---|
| **Binks Manufacturing Co.** | 9201 W. Belmont Avenue<br>Franklin Park, IL 60131 | Air Atomizing & Airless Spray Equipment |
| **DeVilbiss Ransburg** | 1724 Indian Wood Circle, Ste. F<br>Maumee, OH 43537 | Air Atomizing & Airless Spray Equipment |
| **Graco, Inc.** | P.O. Drawer 1441<br>Minneapolis, MN 55440 | Airless Spray Equipment |
| **Nordson Corporation** | 555 Jackson Street<br>Amherst, OH 44001 | Airless Spray Equipment |

## SECTION 6: SAFETY

### 6.1 General

The basic concept of safety in surface preparation, coating application and inspection is being knowledgeable in safety procedure, proper use of safety equipment and being aware of the hazards involved. Before starting coating application, it is recommended that the applicator read all available safety data including, but not limited to, OSHA approved material safety data sheet and product data sheet.

**References:**

NACE Publication 6D-163, "A Manual for Painter Safety."

NACE Publication TPC-2, "Coatings and Linings for Immersion Service."

Occupational Safety and Health Administration, Office of Occupational Health Compliance Programming, 200 Constitution Ave., Washington, DC 20210.

"General Industry Standards," United States Department of Labor, Occupational Safety and Health, Washington, DC 20210.

OSHA Regulations 29 CFR 1910 (in its entirety) Pertaining to Work in Confined Areas: OSHA Subparts B, D, E and F as may apply. Subpart Z – "Toxic and Hazardous Substance," 1910.1000 "Air Contaminants," 1910.1001 through 1910.1017 "Dealing with Specific Contaminants," Subpart G – 1910.94 "Ventilation," Subpart H – 1910.106 "Flammable and Combustible Liquids," 1910.107 "Spray Finishing Using Flammable and Combustible Liquids," Subpart I – 1910.133 "Eye and Face Protection," 1910.134 "Respiratory Protection" and 1910.135, 1910.136 and 1910.137 as may apply. Subpart L – "Fire Protection," 1910.156 through 1910.163 as may apply.

United States Environmental Protection Agency, Assessment Division, 401 M. Street, S.W., Washington, DC 20460.

"Handbook of Organic Industrial Solvents," National Association of Mutual Casualty Company, 20 North Wacker Drive, Chicago, IL 60606 (1972).

Purging Principles and Practices," American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209, Second Edition (1975). SSPC "Good Painting Practice," Volume 1, Chapter 5.3.

6.2 Scaffolding shall be of the approved type similar to those requirements as suggested by the National Safety Council and/or the Occupational Safety and Health Administration.

6.3 All electrical equipment shall be explosion proof. All equipment including ladders, tools, etc. must be spark proof. Workmen's shoes shall have rubber soles and heels.

6.4 All matches, smoking, flames or sparks resulting from any source including welding must be removed from the hazardous area.

6.5 All equipment shall be properly grounded per OSHA regulations.

6.6 When working in tanks and other totally enclosed areas, workmen shall be supplied with fresh air fed masks.

6.7 When working in tanks and other totally enclosed areas, the workmen shall employ the "buddy system" where at least one person is on constant standby to assist the other in case of emergency.

6.8 **Safety Equipment Suppliers:**

| Supplier Name | Supplier Address | Product or Service |
|---|---|---|
| **Clemco Industries** | 1 Cable Car Drive<br>Washington, MO 63090 | Airline Filters |
| **Kaydon Corporation** | P.O. Box 250<br>515 Bohannon Avenue<br>Greenville, TN 37745 | Airline Filters; Air Purifiers; Air Drying Equipment |
| **Mine Safety Appliance Co.** | RIDC Industrial Park<br>121 Gamma Drive<br>Pittsburgh, PA 15238 | Fresh Air Masks; Hoods; Gloves; Explosive Gas Detection Devices; Airline Filters |
| **Pall Trinity Micro Corp.** | 3643 Route 281<br>Cortland, NY 13045 | Airline Filters; Air Purifiers |
| **Safety Lamp of Houston, Inc.** | 15550 West Hardy Road<br>Houston, TX 77060 | Vapor Proof Lighting |

## SECTION 7: VENTILATION

**References:**

See references under SECTION 6: SAFETY.

Chart III, "Plasite Coating Solvent Factors."

7.1 **Ventilation Requirements**

7.1.1 Sufficient air changes must be provided to keep the solvent concentration below the lower explosive limits and to keep the solvent concentration below the allowable threshold limits in ppm for toxicity.

7.1.2 Solvent vapors shall be removed from the bottom of the tank as most solvents are heavier than air. A suction intake that is distributed so as to completely remove these fumes and not short circuit between the fresh air intake and the contaminated air intake is desirable. Ductwork for accelerated curing may be used for dilution, dispersing and removal as well. Refer to Charts V A and V B.

7.1.3 Constant monitoring, by use of an approved explosive and toxic gas detection device, such as available from the firms listed in Paragraph 6.8, is required to assure adequate ventilation to prevent both explosion and toxicity hazard conditions.

7.1.4 It is the user's responsibility to compute and supply adequate ventilation in order to prevent explosion and toxicity hazard conditions as prescribed by standards of good safety practices, local and state regulations, OSHA and other federal regulations.

FACTORS INVOLVED IN COMPUTING CFM REQUIRED ARE BASED ON:

1. PERSONNEL – (NUMBER) & HOURS EXPOSURE
2. VOLUMETRIC SPACE
3. SOLVENTS USED & TOTAL VAPOR VOLUME
4. COATING APPLICATION RATE
5. EVOLUTION RATE
6. TLV (THRESHOLD LIMIT VALUE)
7. LEL (LOWER EXPLOSIVE LIMIT)
8. FLASHPOINT
9. SAFETY DATA SHEETS

Suggested Formula Sources:

1. "Industrial Ventilation Manual of Accepted Practice," published by American Conference of Governmental Industrial Hygienists, Section 2 – Dilution Ventilation: Page 2-1, Paragraph 10; Page 2-2, Paragraph 2; Page 2-4, Paragraph 10; Page 2-5, Paragraph 6; Page 2-6, Paragraph 5, 1330 Kemper Meadow Drive, Cincinnati, OH 45240.

2. "Handbook of Organic Industrial Solvents," Pages 11-13, Alliance of American Insurers, Loss Control Dept., 1501 Woodfield Road, Suite 400 West, Shaumburg, IL 60173.

The American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031; Managing Director: John Meagher publishes a list of Industrial Hygiene Consultants familiar with the problems of toxicity and ventilation.

IN GENERAL, THE TLV VENTILATION REQUIREMENTS EXCEED THE REQUIREMENTS FOR LEL.

Note: Regardless if adequate ventilation is supplied, good safety practices dictate that workmen be supplied with fresh air fed masks when working in tanks or other totally enclosed areas.

7.2 **Definition of Flash Point**

The flash point of a volatile liquid is the minimum or lowest temperature at which the liquid gives off vapor within a vessel in sufficient concentration to form an ignitable mixture with air. Flash points are determined using the Closed Cup Method following ASTM standard methods.

7.2.1 For specific information on flash point and percent volume solvent per gallon, refer to OSHA approved material safety data sheet for each Plasite coating. These material safety data sheets are available from manufacturer on request.

## SECTION 8: ACCELERATED CURING AND HIGH HEAT BAKING

**References:**

NACE Publication 6D-168, "Contract and Plant Force Painting: Advantages and Disadvantages."

Chart V A and V B, "Distribution Requirements for Force Curing and Ventilation."

8.1 **When to Specify Accelerated Curing** (Surface Temperature 120 - 300°F), insulation is recommended but may not be required.

8.1.1 When the application temperature is below 65°F and when relatively small field jobs are involved. Application crews normally complete the job in a shorter period of time at less cost with assurance that the coating is cured.

8.1.2 When high humidity and condensation conditions prevail. Using the proper air heating unit can lower the relative humidity in the space.

8.1.3 When severe in-service conditions are involved, or previous test evaluations have been conducted on accelerated cured coating coupons.

8.1.4 When the finished tank is to be closed and all minute traces of solvent odor must be removed.

8.1.5 When recommended by the coating manufacturer for the service employed.

8.1.6 The chemical resistance of many coating materials is increased by elevating the temperature. This procedure is recommended for many severe services.

8.1.7 For food related service.

8.2 **Preparation for Baking Tanks in the Field** (Surface Temperatures 300 - 400°F)

8.2.1 Tanks that are lined and cured in the field require proper insulation so as to achieve a uniform cure. Tank shells and roofs, clips, nozzles, ladders and stairs, etc. shall be temporarily insulated.

8.2.2 Tank bottom supports that have little insulating effect may act as a heat sink and cause difficulty in obtaining a proper cure. This problem can be solved by heating the bottom portion of the tank first with proper distribution which may require erecting a false ceiling approximately 6' above the tank bottom. This confined space may be cured first and the ceiling raised to cure upper levels of the tank walls and top.

8.2.3 Curing is impossible, regardless of the type and amount of insulation, if any water or sizable air pockets exist between the tank pad and tank bottom. Temporary insulation that becomes wet shall be removed and replaced with dry insulation.

8.3 **Air Distribution**

8.3.1 Air has some of the physical properties of plastic, in that it is flexible, compressible and does not mix readily with itself where different temperatures are involved. Mechanical handling of air under constant conditions is similar to that of water in its friction problems, flow and horsepower requirements.

8.3.2 It is important that the blower for air heating equipment be of adequate size with surplus horsepower. Whenever possible, variable speed drive or adjustable sheave should be employed for volume control. Selection of equipment of 25-50% excess capacity in relation to anticipated needs is standard practice.

8.3.3 A common error made in designing air distribution systems is failure to supply enough air or air velocity at the coating surface to provide good heat transfer.

8.3.4 To provide adequate heat exchange it is necessary to have a high turbulent velocity directly on the surface to be heated. Otherwise, the air tends to stratify and the higher temperature air tends to seek a higher level causing problems in heating the bottom of tanks and vessels. All discharge outlets should have an approximate velocity of 3500 fpm (standard air).

8.3.5 Poor air distribution is generally caused by poor design including low capacity blower and continuous ductwork of the same size which drops the velocity at the outlets. This problem can be overcome by maintaining a constant velocity in each section of the distribution duct, using numerous small high velocity outlets that maintain a turbulent velocity.

8.4 **Accelerated Curing Schedule**

Refer to Chart II, "Accelerated Curing Chart."

This chart shall be referred to for estimating the time-temperature functions and for overcoming the possibility of solvent blistering that may occur when the coating films containing solvent are heated too rapidly. This chart was not constructed to indicate a final guaranteed cure. It is to be used with care and good judgment as many factors affect the force cure such as air distribution, size and shape of vessel, thickness of steel and exterior surface temperatures. The air dry period is the normal time required, at ambient temperature, to allow a large percentage of the solvents to leave and start the initial polymerization of the coating before excessive heat is applied.

8.5 **Temperature Controls for Baking**

Temperature readings can be obtained in several ways. The direct metal surface reading using a surface pyrometer is the most accurate and recommended method. A quick indicator method is the temperature crayon, such as tempil sticks. If used, they should only be used for low temperature force curing. They are not accurate enough for high temperature baking.

8.5.2 Visual inspection is always recommended during the force cure and should follow the coating manufacturer's recommendations. High bake coatings are cured after a specific minimum time-temperature baking schedule. A set of coated coupons that show the various degrees of cure for baking phenolic coatings may be obtained from the manufacturer.

## 8.6 Principle Mistakes in Accelerated Curing and High Heat Baking

The principle mistakes made in accelerated curing and baking are insufficient air dry time of the coating prior to the start of the heating cycle, raising the temperature of ambient too rapidly (raise the temperature not more than 30°F every 30 minutes), insufficient air volume and poor air distribution, as well as, not allowing additional time for curing in corners and heavy metal areas of rapid heat loss. Good judgement, experience and trained supervisory personnel can prevent these costly mistakes.

## 8.7 Types of Air Heater Units

8.7.1 **Ovens** of many types are used and it is required they have even distribution of heat with proper venting. These use electricity and gas and, in a few cases, oil as a source of heat. Direct oil fired is not acceptable as this will leave oily deposits on the coating film. Ovens are particularly adaptable because of close temperature control capability and good heat distribution for the handling of small parts and for production and semi-production work.

8.7.2 **Gas or oil fired indirect air heaters** (combustion products are discharged separately) will generally produce air temperatures as high as 150°F above ambient and, in some cases, ultimate temperatures as high at 280°F. These units are most popular for both shop and field work. The advantages of these types of units are: units do not form condensation on cold surfaces; automatic operation; hot air at various temperatures may be used for removing moisture from tanks or enclosures or preventing condensation overnight on freshly blasted surfaces; units can be portable and have many other uses where space heating problems exist and they may be used to supply tempered air and ventilation while workmen are enclosed.

8.7.3 **Steam coils and blowers** can provide temperature rises of predetermined requirements up to 300°F at 100 psi steam pressure. Many of these types of units are already used as heating and

ventilating units in many plants. In general, however, they are not portable unless they are provided with their own vehicle and a portable boiler.

The advantages are essentially the same as the advantages for the gas or oil fired indirect units with the exception that, in general, they are safer because there is no open flame.

8.7.4 **Electric strip heater blowers** are similar to the steam coil and blower system.

8.7.5 **Gas fired direct air heaters**, for their size, generate more BTU's than other type heating units. The advantages of gas fired air heaters are: less initial cost based on BTU capacity; higher temperature ranges available, approximately 20% less fuel required for an equivalent BTU output and uses only clean burning fuels such as natural gas, butane and propane. Do not use fuel oil.

Some of the disadvantages, when compared to the indirect fired units follow: Units cannot be used for dehumidifying. Combustion products may condense on cold surface causing rust bloom on the freshly blasted surface or blushing on freshly applied film of coating. Some units of this type are designed for oven heating and have insufficient blower capacity. This will cause an uneven distribution of air and heat booster blowers may be necessary in some areas.

If personnel are within enclosure, direct fired units must be approved by the manufacturer for comfort heating and be given a CO check to ensure unit is operating within allowable safety limits.

8.7.6 Other sources of equipment that may be used as a field or shop expediency when required are **heat lamps or infrared heating**.

## 8.8 **Accelerated and Baking Equipment Suppliers:**

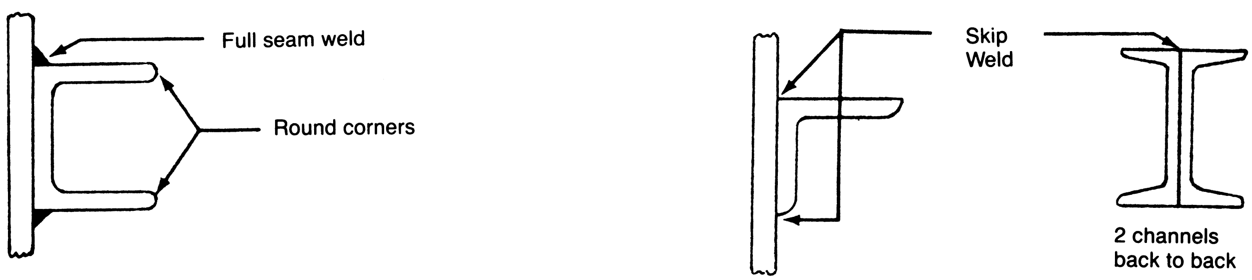
| Supplier Name | Supplier Address | Product or Service |
|---|---|---|
| **Aerovent, Inc.** | 5959 Trenton Lane<br>Plymouth, MN 55442 | Steam Coil & Fan Units; Direct Fired Gas Units |
| **Air Liquide America Corp.** | P.O. Box 3047<br>Houston, TX 77253 | Tempil Sticks |
| **Clements National Company** | 6650 S. Narragansett Avenue<br>Chicago, IL 60638 | Electrical Heat Guns (Cadillac Brand-Flameless-Operates at 350 - 1000°F – Nozzle Velocity at 350°F is 38.5 CFM – at 1000°F nozzle velocity is 8.5 CFM) |
| **Global Heat, Inc.** | 1210 East 223rd St., Ste. 321<br>Carson, CA 90745 | A sub-contractor providing on-site service to coating contractors and applicators requiring gas or electric force curing and baking |
| **Harden Fan Company** | 490 Broadway<br>Buffalo, NY 14204 | Blowers & Fans |
| **Industrial Combustion Engineers, Inc.** | P.O. Box 6038<br>7000 W. 21st Avenue<br>Gary, IN 46406 | Direct Fired Gas Units; Ovens; Indirect Fired Gas-Oil Units |
| **International Industrial Services** | 1021 Centennial Avenue<br>Piscataway, NJ 08854 | A sub-contractor providing on-site services to coating contractors and applicators requiring gas or electrical force curing and baking |
| **Master Appliance Corporation** | 2420 18th Street<br>Racine, WI 53403 | Electrical Heat Guns (Flameless) |
| **Maxon Corporation** | 201 East 18th Street<br>Muncie, IN 47302 | Direct Fired Gas Heaters |
| **Modine Manufacturing Co.** | 1500 DeKoven Avenue<br>Racine, WI 53403 | Steam Coil & Fan Units |
| **New York Blower Company** | 7660 Quincy Street<br>Willowbrook, IL 60521 | Steam Coil & Fan Units; Direct Fired Gas Units |
| **George M. Philpott Co., Inc.** | 8700 Fruitridge Road<br>Sacramento, CA 95826 | Distributors of American Air Filter District Fired Gas Units |
| **Smith-Victor Corporation** | 301 North Colfax Street<br>Griffith, IN 46319 | Distributors of S-V Model TL2 Torchlamp |

## CHART I

## TANK CONSTRUCTION GUIDE FOR LINED TANKS
## (Figures 1-11)

### How to Design and Prepare Tanks for Lining

Appendix to NACE Standard RP-01-78
"Design, Fabrication and Surface Finish of Metal Tanks & Vessels
to be Lined for Chemical Immersion Service"




**DO** **Figure 1** **DON'T**

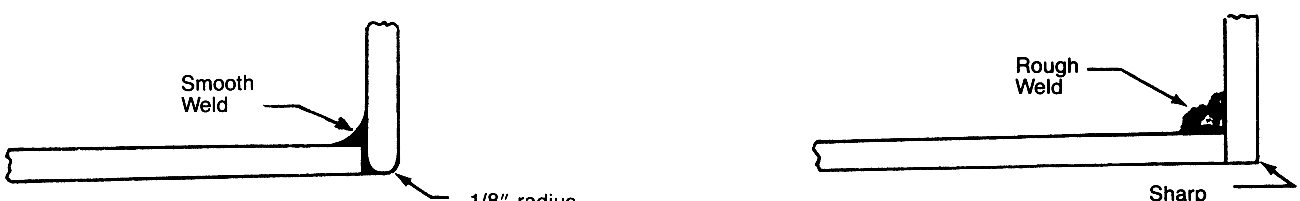
All construction involving pockets or crevices that will not drain or that cannot be properly abrasive blasted and lined must be avoided.


**DO** **Figure 2** **DON'T**

All joints **must** be continuous solid welded. All welds must be smooth with no porosity, holes, high spots, lumps or pockets. Grinding is required to eliminate porosity, sharp edges and high spots.


**DO** **Figure 3** **DON'T**

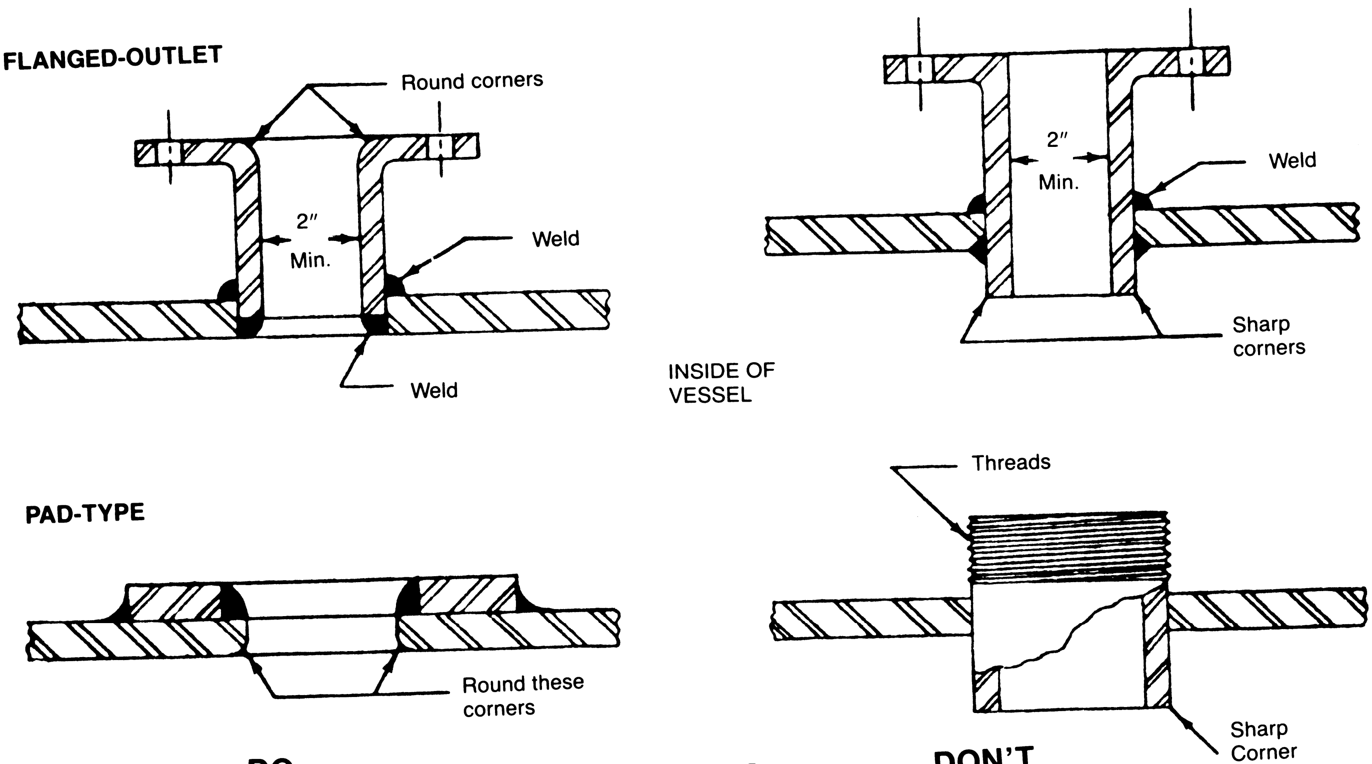
All weld spatter **must** be removed




**DO** **DON'T**

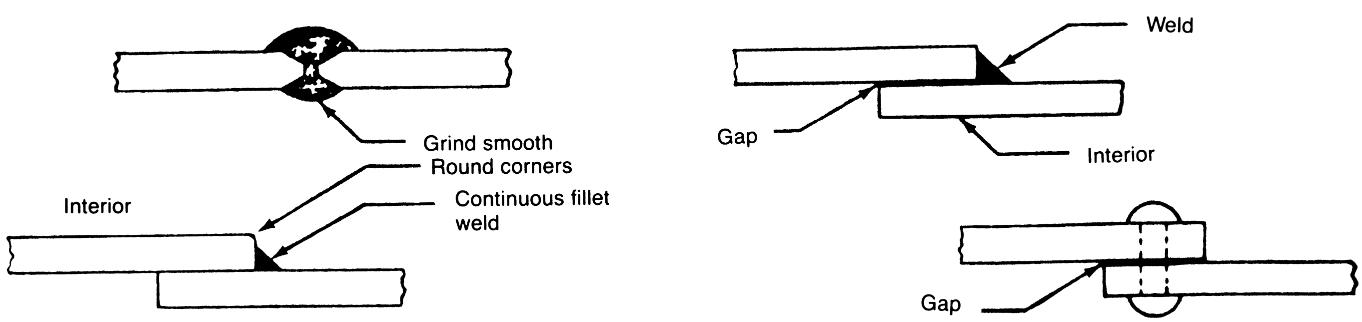
**Figure 4**

All sharp edges **must** be ground to a minimum 1/8″ radius.




**DO** **Figure 5** **DON'T**

1. The outlets **must** be flanged or pad-type rather than threaded.
2. Within pressure limitations **slip-on flanges** are preferred as the I.D. of the attaching weld is readily available for radiusing and grinding. If pressure dictates the use of **weld neck** flanges the I.D. of the attaching weld is in the throat of the nozzle. It is therefore more difficult to repair surface irregularities such as weld undercutting by grinding.




**DO** **Figure 6** **DON'T**

Butt-welding should be utilized rather than lap welding or riveted construction.


**DO** **Figure 7** **DON'T**

Stiffening members should be on the **outside** of the vessel or tank.

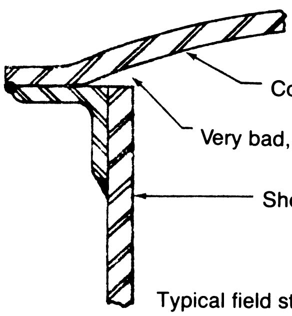



**Figure 8**

Dissimilar metal (galvanic) corrosion will occur where an alloy is used to replace the steel bottom of a tank. If a lining is then applied to the steel and for several inches (usually 6″-24″) onto the alloy, any discontinuity in the coating will become anodic. Once corrosion starts it progresses rapidly because of the large exposed alloy cathodic area. Without the coating, galvanic corrosion would cause the steel to corrode at the weld area, but at a much slower rate. The recommended practice is to line **completely** the alloy as well as the steel thereby eliminating the possible occurrence of a large cathode to small anode surface.

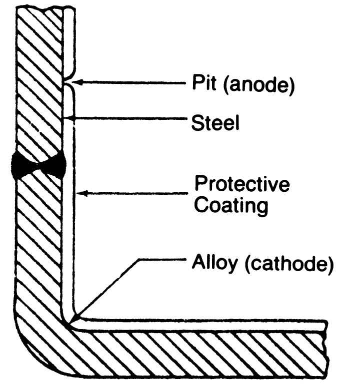



**Figure 9**

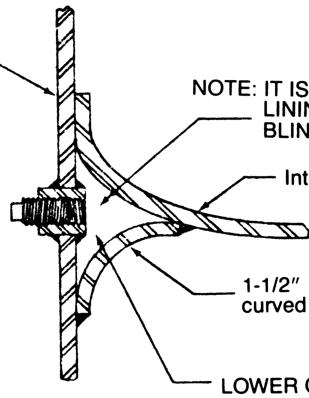



**Figure 10**

A technique (detail of fabrication) to allow for good continuity of lining application for inaccessible areas for such as multi-compartment tanks.

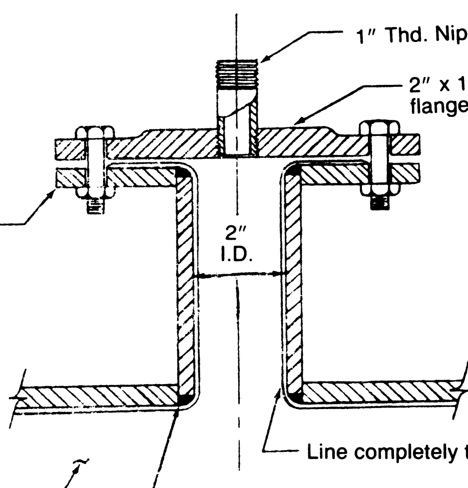



**Figure 11**

## CHART II

## ACCELERATED CURING TIME – TEMPERATURE OPTIONS

### CURING TIME IN HOURS REQUIRED AT METAL TEMPERATURES AS INDICATED

| COATING | 130°F | 140°F | 150°F | 160°F | 170°F | 175°F | 180°F | 190°F | 200°F | 225°F |
|---|---|---|---|---|---|---|---|---|---|---|
| **729** | 15 | 9 | 6 | 4 ½ | 3 ½ | | 2 ½ | 2 | 1 ¾ | |
| **826** | 15 | 9 | 6 | 4 ½ | 3 ½ | | 2 ½ | 2 | 1 ¾ | |
| **4100** | 18 | 10 | 6 | 4 ½ | 3 ½ | | 2 ½ | 2 | 1 ¾ | |
| **4300** | 18 | 10 | 6 | 4 ½ | 3 ½ | | 2 ½ | 2 | 1 ¾ | |
| **7122** | 18 | 10 | 6 | 4 ½ | 3 ½ | | 2 ½ | 2 | 1 ¾ | |
| **7133HS** | | | 8 | | | 6 | | | 5 | 4 |
| **7156** | 18 | 10 | 6 | 4 ½ | 3 ½ | | 2 ½ | 2 | 1 ¾ | |
| **9052** | 18 | 10 | 6 | 4 ½ | 3 ½ | | 2 ½ | 2 | 1 ¾ | |
| **9060** | | | 12 | | | 10 | | | 6 | 4 |
| **9133** | | | 12 | | | 10 | | | 6 | 4 |

**Note:** Prior to raising the metal to the force curing temperature, it is necessary that an air dry time of 2 to 5 hours at temperatures from 70 to 100°F, with adequate ventilation, be allowed.

The time-temperature accelerated cure options listed are based on good ventilation (see SECTION 7: VENTILATION REQUIREMENTS and CHARTS V A and V B – DISTRIBUTION REQUIREMENTS FOR FORCE CURING). While these force cure options are designed to provide adequate cure for routine immersion environments, certain exposures (such as taste sensitive food and water applications) may require, based on the user's own tests or experience, force curing for longer periods than listed.

## CHART III

## PLASITE COATINGS SOLVENT FACTORS

This chart is provided as an aid in determining proper ventilation for prevention of explosion and toxicity hazards. User is responsible for supplying adequate ventilation in order to prevent explosion and toxicity hazard conditions as prescribed by standards of good safety practices, local and state regulations, OSHA and other federal regulations.

The following is a definition of terms used in the chart listed below:

**THEORETICAL PERCENT BY VOLUME SOLVENT PER GALLON =** The total amount in percent volatile material, by volume, present in a one gallon unit of coating. It should be understood that the total volatile material may be a combination of solvents with each having a different TLV and LEL rating.

**THRESHOLD LIMIT =** A set of standards established by the American Conference of Governmental Industrial Hygienists for concentrations of airborne substances in workroom air: they refer to time-weighted concentrations for a 7 or 8-hour workday and 40-hour workweek.

**LOWER EXPLOSIVE LIMIT =** The range of concentration of a flammable gas or liquid in which explosion can occur upon ignition in a confined area. The lowest percentage at which this occurs is the lower limit, and the highest percentage is the upper limit.

**FLASH POINT =** The temperature at which a liquid or volatile solid gives off a vapor sufficient to form an ignitable mixture with the air near the surface of the liquid or within the test vessel. Values listed below are based on Tag Closed Cup ASTM methods. Flash point is explained in more detail in Paragraph 7.2.

Note: For additional information a U.S. Department of Labor approved material safety data sheet for each Plasite coating is available upon request.

| Plasite Coating | Theoretical % Volume Solvent per Gallon * | Flash Point Closed Cup |
|---|---|---|
| **729 Epoxy** | 15 ± 2 | 24°F |
| **726 Epoxy** | 40 ± 2 | 24°F |
| **850 Epoxy** | 19 ± 2 | 24°F |
| **1246 Epoxy Phenolic** | 64 ± 2 | 81°F |
| **2087 Aliphatic Polyurethane** | 38 ± 2 | 81°F |
| **2900 Acrylic Polyurethane** | 36 ± 2 | 102°F |
| **3066 Phenolic** | 65 ± 2 | 41°F |
| **3070 Phenolic** | 39 ± 2 | 56°F |
| **7111 Epoxy Phenolic (Pigmented)** | 55 ± 2 | 24°F |
| **7122 Epoxy Phenolic (Pigmented)** | 44 ± 2 | 24°F |
| **7122HS Epoxy Phenolic** | 46 ± 2 | 24°F |
| **7122HAR Epoxy Phenolic** | 50 ± 2 | 24°F |
| **7133 Epoxy Polyamide (Pigmented)** | 50 ± 2 | 24°F |
| **7133HS Polyamide Epoxy** | 38 ± 2 | 24°F |
| **7140 Organic Zinc** | 41 ± 2 | 24°F |
| **7159 Epoxy** | 32 ± 2 | 41°F |
| **7156 Epoxy Phenolic** | 47 ± 2 | 24°F |
| **9029 Polyamide Epoxy** | N/A | 100°F |
| **9052 Epoxy** | 23 ± 2 | 24°F |
| **9060 Epoxy** | 18 ± 2 | 24°F |
| **9133 Epoxy** | 14 ± 2 | 24°F |
| **9500 Epoxy** | 20 ± 2 | 81°F |
| **9570 Epoxy** | 18 ± 2 | 24°F |
| **9571 Epoxy** | 18 ± 2 | 24°F |
| **9573 Epoxy** | 18 ± 2 | 24°F |

*Note: Percent volume of solvent may vary depending on color.

## CHART IV

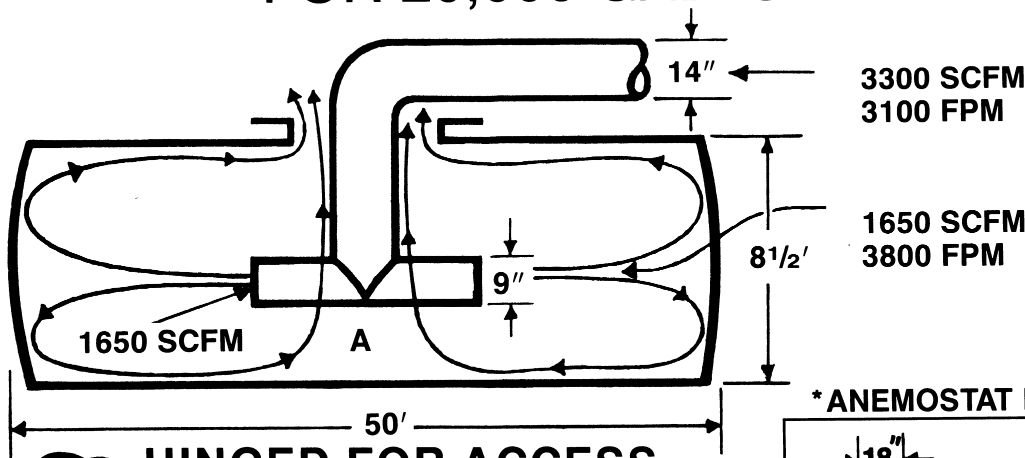
## PLASITE THINNERS FLASH POINTS

| PLASITE THINNER | FLASH POINT (CLOSED CUP) |
| --- | --- |
| **4** | 53°F |
| **8** | 24°F |
| **15** | 81°F |
| **20** | 24°F |
| **30** | 41°F |
| **69** | 24°F |
| **70** | 56°F |
| **71** | 24°F |
| **72** | 60°F |
| **86** | 102°F |
| **87** | 81°F |
| **95** | 41°F |
| **201** | 45°F |

CHART V A

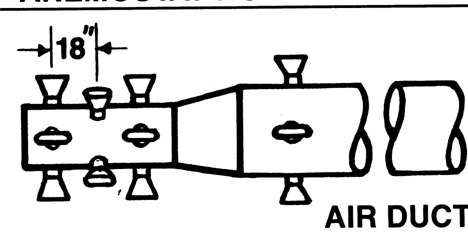
# DISTRIBUTION REQUIREMENTS FOR FORCE CURING

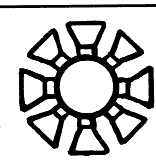
## TYPICAL PIPE SIZES AND VELOCITIES RECOMMENDED FOR 20,000 GALLON TANKS





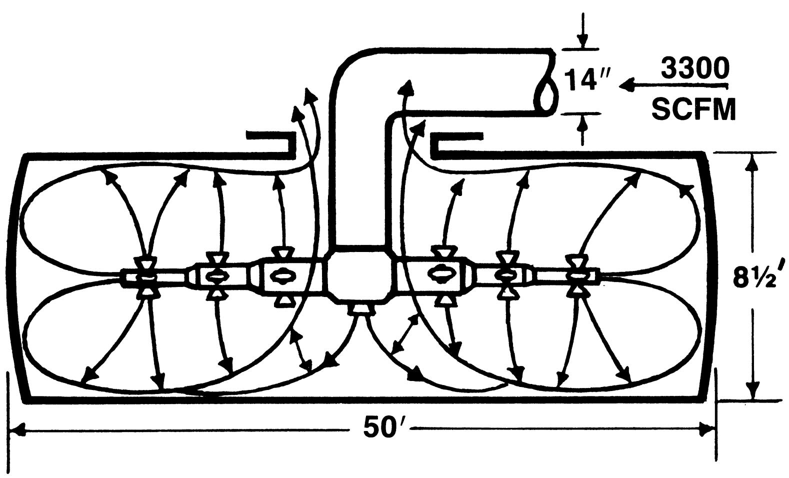
*ANEMOSTAT NOZZLES



CROSS SECTION

REDUCE PIPE SIZE TO MAINTAIN OUTLET VELOCITIES OF APPROXIMATELY 3600 FPM (STANDARD AIR)



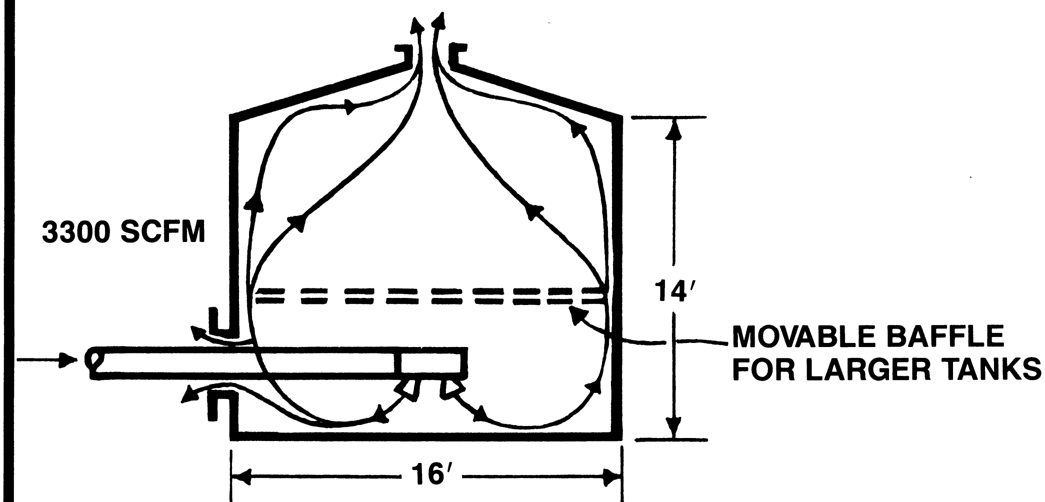

*ANEMOSTAT NOZZLE #10 NV, PART 80149; ACQUIRED FROM ANEMOSTAT PRODUCTS DIV., P.O. 1083, SCRANTON, PA 18501

**NOTE:** THE SAME DUCTS MAY BE USED FOR VENTILATION. REVERSE FLOW IS NOT NECESSARY. FOR LARGE TANKS IT IS RECOMMENDED THAT ADDITIONAL SUCTION PIPING BE PLACED AT BOTTOM Examples above are based on a standard portable natural or propane gas air heater with temperature range of 150°F to 750°F and air capacity of 3300 SCFM at 2″ W.C. Larger or smaller tanks will require properly sized and rated air heater equipment, or adjusted input.

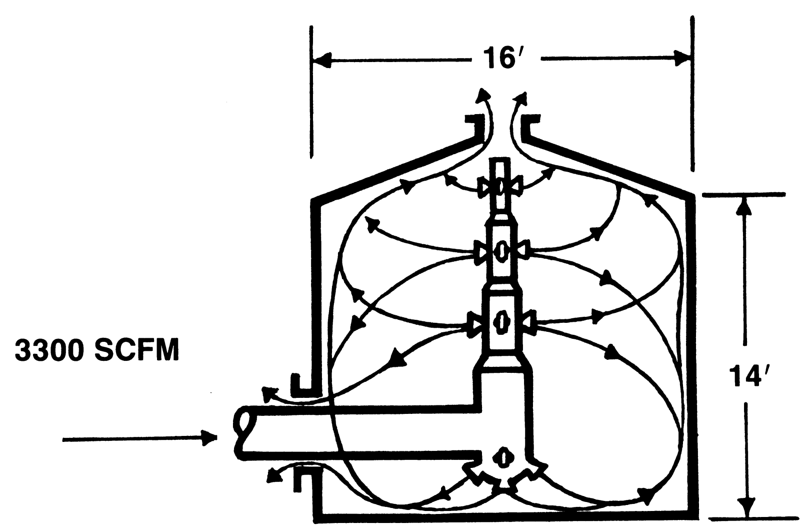
Chart V B

# DISTRIBUTION REQUIREMENTS FOR FORCE CURING

## TYPICAL PIPE SIZES AND VELOCITIES RECOMMENDED FOR 20,000 GALLON TANKS




**REDUCE PIPE SIZE TO MAINTAIN OUTLET VELOCITIES OF APPROXIMATELY 3600 FPM (STANDARD AIR)**




**NOTE: THE SAME DUCTS MAY BE USED FOR VENTILATION. REVERSE FLOW IS NOT NECESSARY. FOR LARGE TANKS IT IS RECOMMENDED THAT ADDITIONAL SUCTION PIPING BE PLACED AT BOTTOM** Examples above are based on a standard portable natural or propane gas air heater with temperature range of 150°F to 750°F and air capacity of 3300 SCFM at 2″ W.C. Larger or smaller tanks will require properly sized and rated air heater equipment, or adjusted input.

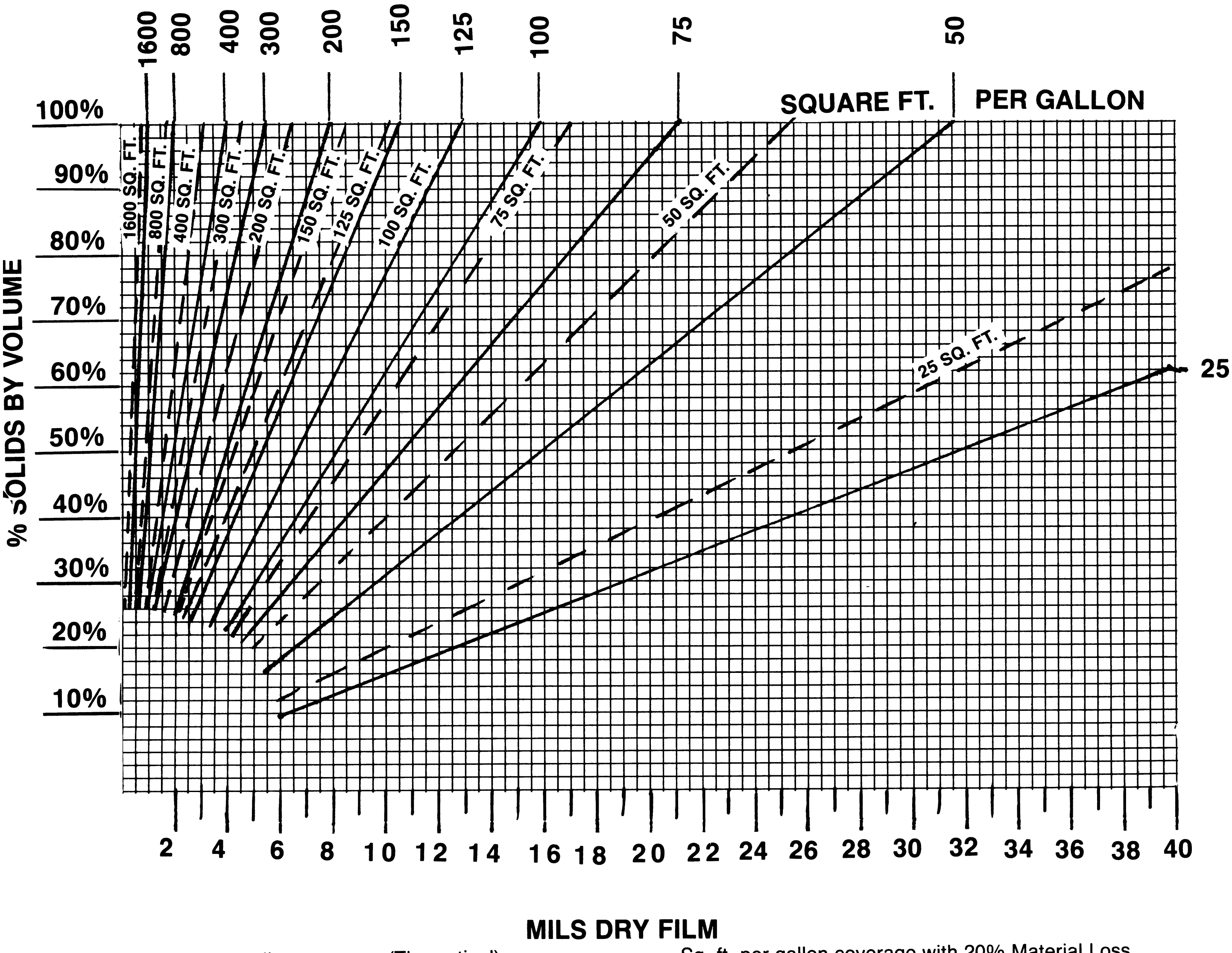
# CHART VI
# COVERAGE ESTIMATION CHART

The formula for calculating practical coverage per U. S. gallon at required film thickness with loss factor included is:

$$Cp = \frac{V \times P \times L}{M}$$

**Where:** Cp = coverage in mil sq. ft. per gallon practical.
V = mil sq. ft. per gallon of 100% solids by volume liquid (always 1604).
P = percentage of solids by volume of coating involved.
L = loss factor in percent.
M = mils of coating thickness required.

**Note:** Theoretical coverage in mil sq. ft. per U. S. gallon is V x P.




_____ Sq. ft. per gallon coverage (Theoretical) ----- Sq. ft. per gallon coverage with 20% Material Loss

**TO DETERMINE COVERAGE FROM CHART** Follow solids by volume line to where it intersects with the mil thickness desired, intersection of these lines is material coverage per gallon.

**METRIC CONVERSION CHART** **COVERAGE SHOWN IS BASED ON A 100% SOLIDS (THEORETICAL). APPLY MATERIAL LOSS AND % SOLIDS FACTORS.**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| INCHES | .002 | .003 | .004 | .006 | .008 | .010 | .012 | .020 | .040 |
| MILS | 2 | 3 | 4 | 6 | 8 | 10 | 12 | 20 | 40 |
| MICRONS | 51 | 76 | 102 | 153 | 204 | 254 | 305 | 509 | 1018 |
| SQ. FT./GAL. | 802 | 534.6 | 401 | 267.3 | 200.5 | 160.4 | 133.7 | 80.2 | 40.1 |
| SQ. M/GAL. | 74.3 | 49.6 | 37.0 | 24.8 | 18.6 | 14.9 | 12.4 | 7.4 | 3.7 |
| SQ. FT./L | 211.7 | 141.2 | 105.9 | 70.6 | 52.9 | 42.3 | 35.3 | 21.2 | 10.5 |
| SQ. M/L | 19.6 | 13.1 | 9.8 | 6.5 | 4.9 | 3.9 | 3.3 | 1.9 | .982 |

350 Hanley Industrial Court, St. Louis, MO 63144-1599
314/644-1000 314/644-4617 (fax) www.carboline.com

An RPM Company

May 2003