



SURFACE PREPARATION AND APPLICATION GUIDE

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1.0 INTRODUCTION

Most surface preparation and application operations require the use of appropriate personal protection equipment and engineering and administrative controls. The most obvious examples of this are abrasive blast cleaning and spray painting operations. It is incumbent upon the coatings and abrasive blast cleaning contractors to ensure that all personnel are properly protected from all hazards.

Numerous OSHA regulations specify when, where and how workers are to be protected. These regulations, the coatings and equipment manufacturers, and/or local OSHA officials should be consulted as necessary to ensure proper protection, compliance with the law, and to avoid liability issues. Product labels and Safety Data Sheets should always be consulted prior to coatings operations.

Safety and health details should be addressed prior to implementing these operations.

Each year millions of dollars are wasted on good coating systems that will fail prematurely due to inadequate surface preparation or improper application. Much of this waste is needless and can be prevented through proper evaluation, specification and control of these two vital factors. The intent of this portfolio is to offer basic guidelines enabling you to maximize your coating expenditure. The information presented has been accumulated from outside technical reports and publications, as well as Tnemec's own research and experience in this field.

1.1 SURFACE PREPARATION AND COATING PERFORMANCE

Coating performance is dependent on adequate surface preparation and application. Properly written painting specifications incorporate surface preparation and application procedures as an integral part of the coating system in recognition of this fact. This guide is designed not only as a basic reference to surface preparation and application methods and procedures, but as an aid in selecting the proper type of surface preparation and application for a particular design requirement or service condition.

1.2 COST OF SURFACE PREPARATION

The major cost of a coating system is not the coating material itself, but the cost of labor for surface preparation and application of the coating system. The cost breakdown of a typical coating operation will normally fall within percentage ranges listed in Table I:

TABLE I – COATING SYSTEM

Application Labor	30–60%
Surface Preparation	15–40%
Coating Material	15–20%
Clean-up Labor	5–10%
Tools and Equipment	2–5%

In recent years, both application and surface preparation costs have escalated much more rapidly than the cost of coating materials. It is estimated that labor costs will continue to increase faster than materials and the difference between the two will, therefore, become even greater. These cost factors further underscore the advisability of evaluating, specifying and controlling the surface preparation

and application on every coating project where high performance and long-term protection are expected.



2.0 SURFACE PREPARATION OF CARBON STEEL

The surface preparation required for different types of coating systems to be applied over carbon steel will vary considerably depending on the type of coating as well as the service environment. The Society for Protective Coatings (SSPC), NACE International (NACE), American Water Works Association (AWWA) and the American Society for Testing and Materials (ASTM) all make reference to various standards that define degrees and methods of surface preparation. The most widely used surface preparation specifications are those published in Steel Structures Painting Manual, Vol. 2, Systems and Specifications. Given below is a brief description of the various SSPC and NACE surface preparation standards. It is recommended that you refer to the SSPC or NACE standards for the complete text of the specifications.

2.1 SSPC-SPI SOLVENT CLEANING

The removal of all visible oil, grease, soil, drawing and cutting compounds and other soluble contaminants from surfaces with solvents or commercial cleaners using various methods of cleaning such as wiping, dipping, steam cleaning or vapor degreasing.

It is generally conceded that wiping with solvents will not positively remove all oil, grease and other soluble contaminants from the surface. Therefore, a more efficient cleaning method such as vapor degreasing or steam cleaning should be employed where coatings will not tolerate any oil, grease and other soluble contaminants residue.

It should be noted that organic solvents may not remove water soluble contaminants such as acid and alkali salts. Such contaminants should be removed using water and/or water-based cleansing agents. Reference SSPC-SP COM, Surface Preparation Commentary for Steel and Concrete Substrates.

2.2 SSPC-SP2 HAND TOOL CLEANING

The removal of all loose mill scale, loose rust, loose paint and other loose detrimental foreign matter by the use of non-power hand tools. Hand tool cleaning will not remove adherent mill scale, rust and paint. Mill scale, rust and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

2.3 SSPC-SP3 POWER TOOL CLEANING

The removal of all loose mill scale, loose rust, loose paint and other loose detrimental foreign matter by the use of power-assisted hand tools. Power tool cleaning will not remove adherent mill scale, rust and paint. Mill scale, rust and paint are considered adherent if they cannot be removed by lifting with a dull putty knife. Power tool cleaning usually provides a slightly higher degree of cleanliness than hand tool cleaning, but is not regarded as adequate surface preparation for long-term exterior exposure of most high-performance coating systems.

2.4 SSPC-SP5/NACE 1 WHITE METAL BLAST CLEANING

The complete removal of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products and other foreign matter by compressed air nozzle blasting, centrifugal wheels or other specified method.

2.5 SSPC-SP6/NACE 3 COMMERCIAL BLAST CLEANING

The removal of all visible oil, grease, dirt, dust, mill scale, rust, paint oxides, corrosion products and other foreign matter by compressed air nozzle blasting, centrifugal wheels or other specified method. Discoloration caused by certain stains shall be limited to no more than 33 percent of each unit area. Unit area is approximately 9 sq. in. (5776 sq. mm).

2.6 SSPC-SP7/NACE 4 BRUSH-OFF BLAST CLEANING

A brush-off, blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust and loose coating. Tightly adherent mill scale, rust and coating may remain on the surface. Mill scale, rust and coating are considered tightly adherent if they cannot be removed by lifting with a dull putty knife. The entire surface shall be subjected to the abrasive blast. The remaining mill scale, rust or coating shall be tight. When coating is specified, the surface shall be roughened to a degree suitable for the specified coating system. Prior to coating application, the surface shall comply with the degree of cleaning as specified herein. Visual standards of comparators may be specified to supplement the written definition. In any dispute, the written standards shall take precedence over visual standards and comparators.

2.7 SSPC-SP10/NACE 2 NEAR-WHITE METAL BLAST CLEANING

The removal of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products and other foreign matter by compressed air nozzle blasting, centrifugal wheels or other specified method. Discoloration caused by certain stains shall be limited to no more than 5 percent of each unit area. Unit area is approximately 9 sq. in. (5776 sq. mm).

2.8 SSPC-SP11 POWER TOOL CLEANING TO BARE METAL

The removal of all visible oil, grease, dirt, mill scale, rust, paint, oxide, corrosion products, and other foreign matter. Slight residues of rust and paint may be left in the lower portion of pits if the original surface is pitted. Differs from SSPC-SP3 in that it requires more thorough cleaning and a surface profile not less than 1 mil (25 microns).

2.9 SURFACE PREPARATION BY WATER JETTING

Surface preparation and cleaning of steel and other hard materials by high- and ultra-high pressure water jetting to achieve various degrees of surface cleanliness prior to recoating. This standard is limited in scope to the use of water only without the addition of solid particles in the stream. Depending upon the specified level of cleanliness, the user should refer to the Joint Surface Preparation Standard Waterjet Cleaning of Metals issued by NACE and SSPC under the designation of NACE WJ-X(1-4)/SSPC SP WJ-X(1-4). Refer to the full standard for all details regarding this preparation method.

2.10 DEGREE OF CLEANLINESS VS. COATING PERFORMANCE

Abrasive blast cleaning as defined in SSPC specifications SSPC-SP5/NACE 1 (White Metal Blast Cleaning), SSPC-SP6/NACE 3 (Commercial Blast Cleaning) and SSPC-SP10/NACE 2 (Near White Blast Cleaning) is often regarded as the preferred method of surface preparation for carbon steel.

Experience has proven that a coating system applied over a properly blast-cleaned surface will cost less per square foot per year than the same system applied over a hand or power tool cleaned surface.

This can be attributed to the two main purposes of surface preparation: to increase coating adhesion and to decrease surface contamination. Having strong adhesion will increase the service life of a coating; removing contamination will decrease the risk of future coating failure. While some coatings are designed to be tolerant to marginally prepared surfaces, the rule of thumb is that for a given coating system, a lower degree of surface preparation will result in poorer adhesion and an increased risk of failure.

When performed properly, abrasive blasting provides the best foundation for a coating system, which translates to longer service life and ultimately lower cost per square foot over the life of the system.

2.11 METHOD OF ABRASIVE BLAST CLEANING

The SSPC specification for abrasive blast cleaning lists a number of alternative blast cleaning methods. The two most widely used are compressed air nozzle blast cleaning and centrifugal wheel blast cleaning. Since either method is capable of producing the same quality of surface preparation, both are equally acceptable for coating applications. A large quantity of shop-fabricated structural, plate and miscellaneous steel is now prepared by centrifugal wheel blast cleaning equipment because of the speed, production capacity and cost advantage of this method. Also, portable centrifugal wheel blast cleaning units can be transported to the jobsite and set up to process fabricated structural steel and plate assemblies as they are scheduled for erection.

Vacuum blasting is used in areas where the amount of abrasive dust created by compressed air nozzle blasting cannot be tolerated. However, it is recommended that motors, bearings and moving parts close to the work be protected.

Other methods of abrasive blast cleaning are not discussed here because of their more limited or specialized applications. Each has its own advantages and limitations which would merit its consideration for certain specialized types of work.

2.12 DETERMINING SURFACE CLEANLINESS

The cleanliness of abrasive blast-cleaned steel may be determined by comparison with SSPC-Vis-1 pictorial standards, Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning. To avoid interpretations resulting from color and profile variations due to different types of steel and abrasive media, small steel panels can be abrasive blast-cleaned and used as representative samples of the work. These panels should be securely wrapped in clear plastic to protect them from deterioration.

2.13 MEASURING SURFACE PROFILE

It is generally agreed that the surface profile contributes to the adhesion and performance of most zinc-rich coatings, tank linings and other high performance systems. Surface profile can be closely predetermined by the selection of the type and size of abrasive from the tables contained in SSPC and NACE Surface Preparation Specifications or from the abrasive supplier's data.

A number of devices are available for measuring surface profile. However, it should be noted that different types of test equipment will not necessarily give comparable readings and cannot be used for comparative purposes. Therefore, it is necessary to determine what test equipment is to be used if duplicate readings will be taken for verification or approval.

ASTM D4417, Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel, outlines four methods by which profile measurements can be taken. SSPC-PA 17, Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements, outlines suggested procedures on the number of measurements that may be taken to qualify an area.

2.14 SELECTION OF ABRASIVE MEDIA

Where a sharp angular profile is desired, a sharp, hard abrasive must be used such as garnet or a synthetic abrasive of equivalent hardness. A recyclable mix that is often accepted consists of not more than three parts chilled iron shot and one part of chilled iron grit. Recycled cast iron and malleable iron shot and grit, or 100 percent chilled shot are regarded as unsatisfactory for producing a sharp angular profile, but may be used where this type of profile is not required. Reference SSPC-AB 1, Mineral and Slag Abrasives, SSPC-AB 2, Cleanliness of Recycled Ferrous Metallic Abrasive, and SSPC-AB 3, Ferrous Metallic Abrasive.

2.15 REMOVAL OF DUST FROM ABRASIVE BLAST-CLEANED SURFACES

Dust and blast products should be removed from the surface of abrasive blasted steel by high-pressure air, vacuum cleaning or brushing.

2.16 ORGANIC CONTAMINATION OF ABRASIVE BLAST-CLEANED SURFACES

The greatest danger of organic contamination during abrasive blast cleaning is from oil and moisture. Compressed air used for nozzle blasting should be periodically checked to verify that it is clean, dry and oil-free (Reference ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air). Oil and water separators, traps or other equipment may be necessary to achieve clean, dry air. Fabricated steel is sometimes not solvent-cleaned prior to abrasive blast cleaning on the assumption that oil and grease will be removed by the blast cleaning process. Experience has shown that this is not always the case. Also, if proper quality control procedures are not employed during centrifugal wheel blast cleaning, the recycled abrasive may pick up oil, so that in time the abrasive itself will contaminate the steel being cleaned.

Oil contamination of a blast-cleaned surface is very difficult to detect visually or by ultra-violet light examination. The best protection against oil contamination is taking remedial measures to prevent its occurrence. If the blast-cleaned surface becomes contaminated by oil, grease, hand prints or other foreign matter, it should be solvent-cleaned and then reblasted according to the original specifications to ensure the same degree of surface cleanliness.

2.17 ENVIRONMENTAL CONDITIONS

Abrasive blast-cleaned surfaces should be coated before any visible rust forms on the surface. For this reason, it is recommended that abrasive blast cleaning be performed only when the relative humidity is no higher than 85% and the surface temperature of the steel at its coldest point is at least 5°F (3°C) above the temperature of the dew point. Some specifiers may include a time/humidity table in their specifications to ensure that the abrasive blast-cleaned surface is coated before flash rusting occurs. The general practice is that no more surface be prepared for painting than can be coated in a single shift.

2.18 PREPARATION OF WELDS

Preparation of welds should be scheduled ahead of surface preparation. This work can be best handled by the metal trades connected with fabrication or erection, especially when code inspection and certification are involved. Weld spatter and slag can be removed by chipping or grinding. If the surface will be exposed to severe environmental conditions, it is suggested that sharp edges and corners be rounded to a smooth contour by grinding. Undercuts and recesses should be smoothed by grinding and porous welds ground down to pinhole-free metal. Remove weld flux from the surface by washing with water (Reference NACE SP0178, Surface Finishing of Welds Prior to Coating).

2.19 STEEL AND FABRICATION DEFECTS

Steel and fabrication defects revealed by surface preparation such as weld imperfections, laminations, scabs and slivers should be corrected before proceeding further with surface preparations.

2.20 INACCESSIBLE AREAS

It is not possible to properly prepare and apply a protective coating behind rafters or skip-welded lap joints, or in between back-to-back angle iron bracing. When allowable, these inaccessible

areas should be coated before assembly or they will continue to erode away in a corrosive environment, leaving rust stains on the exposed coated surface below. In an aggressively corrosive environment, coated surfaces adjacent to these areas will actually be undercut and fail due to the corrosive action taking place in these inaccessible areas. Therefore, if total protection of the surface is mandatory, all surface voids should be seal-welded and back-to-back bracing and tank rafters either coated before assembly or eliminated from the design and construction. Sharp corners and edges should be ground to a smooth contour and welds prepared as suggested in NACE SP0178. (See Weld Preparation.)

3.0 SURFACE PREPARATION OF DUCTILE AND CAST IRON

Depending on the process used to manufacture cast iron, anchor profile after casting is often higher than what would be achieved by abrasive blast cleaning carbon steel. Abrasive blast cleaning is, therefore, not always necessary to achieve optimum adhesion to cast iron substrates. Better, more efficient surface preparation methods can often be recommended.

The National Association of Pipe Fabricators has published surface preparation standards for ductile iron pipe and cast ductile iron fittings. These standards (NAPF 500-03) can be referenced along with Tnemec Technical Bulletin No. 98-15 Surface Prep for Cast Iron.

The Society for Protective Coatings and NACE International abrasive blast cleaning surface preparation specifications (SP5/NACE 1, SP6/NACE 3, etc.) were developed for carbon steel substrates. Based on information provided by the Ductile Iron Pipe Research Association (DIPRA) and Tnemec laboratory testing, it has been learned that the manufacturing and processing differences between carbon steel and cast iron preclude using SSPC and NACE surface preparation specifications for steel when preparing cast iron. Indeed, it is possible to “overblast” the exterior surface of certain types of cast iron (ductile iron, white iron, gray iron, etc.) which could result in reduced long-term system performance.

4.0 SURFACE PREPARATION OF STAINLESS STEEL

If stainless steel requires solvent cleaning prior to coating, only solvents and cleaning solutions appropriate for stainless steel should be used to prevent stress corrosion cracking. If the substrate requires abrasive blasting to increase mechanical adhesion of the coating system, the height of the profile and the texture required should be defined for the operator and as a standard for the acceptance of the work. **NOTE:** The use of ferrous metallic abrasives is not recommended.

Pictorial standards for the surface cleanliness of carbon steel are not applicable to stainless steel since there are no corrosion products or mill scale to remove from the surface.

5.0 SURFACE PREPARATION OF GALVANIZED STEEL AND OTHER NON-FERROUS METALS

Surfaces should be clean and dry. Remove dust and dirt by blowing off the surface with high pressure air or wiping clean with dry rags. Oil, grease, protective mill coatings and other soluble contaminants should be removed by solvent cleaning. White rust should be removed from galvanized steel by hand or power brushing. Care should be taken not to damage or remove the galvanizing. Rust should be removed from old galvanized steel by hand or power tool cleaning.

Hot-dipped galvanized and galvanized steel is often treated with passivation agents or coatings by the galvanizers. Although these treatments are used to prohibit the premature oxidation of the galvanized surface, they can prevent proper adhesion of the coating system and lead to delamination of the coating film. Great care should be taken to ensure proper surface preparation of passivated surfaces. Abrasive blast cleaning to increase mechanical adhesion is the preferred method of surface preparation (Reference ASTM D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting).

For specific recommendations, contact your Tnemec representative or Tnemec Technical Services at 1-800-TNEMEC1 (Reference Technical Bulletin No. 10-78, Surface Prep and Coating of Hot-Dipped Galvanized and Galvanized Steel).

6.0 SURFACE PREPARATION OF CONCRETE AND MASONRY

The type of surface preparation required for concrete and masonry is dependent upon the type of coating system to be applied and the intended service of the vessel or structure. NACE International, the Society for Protective Coatings, the International Concrete Repair Institute and the American Society for Testing and Materials all reference various methods of surface preparation. Following are surface preparation suggestions and brief descriptions of some of the practices recommended by NACE, SSPC, ICRI and ASTM.

SSPC-SP13/NACE 6 Surface Preparation of Concrete: This standard gives requirements for surface preparation of concrete by mechanical, chemical or thermal methods prior to the application of protective coating and lining systems.

ICRI Guideline No. 310.2: This guide provides designers, specifiers, contractors and manufacturers with the tools to select and specify the methods for preparing concrete surfaces prior to the application of sealers, coatings and polymer overlay systems.

6.1 TESTING FOR MOISTURE CONTENT

New concrete and masonry typically should not be coated for at least 28 days to permit the concrete or mortar to cure and dry out unless otherwise directed by the manufacturer. Free water and soluble alkaline salts remaining in the concrete may contaminate coatings or eventually cause delamination, blistering, peeling and/or efflorescence staining. For this reason, concrete should be visually

inspected and tested for moisture content before painting.

Damp spots, efflorescence or white salts appearing on the surface are obvious indicators of moisture. Moisture presence can be tested by performing tests such as ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method, ASTM F1869, Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride, or ASTM F2170, Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes. See the appropriate Product Data Sheet for moisture content limitations.

6.2 REPAIR OF SURFACE DEFECTS AND REMOVAL OF CONTAMINANTS

The surface to be coated should be examined for defects such as fins, protrusions, bulges and mortar spatter. These defects should be corrected by grinding or scraping. Repair of surface defects includes patching voids and cracks that will cause discontinuities or unsightly appearance in the coating, and using a patching compound that is compatible with the coating system. Remove non-degraded release agents, fats, oil and wax and grease by scraping off heavy deposits followed by cleaning with an appropriate solvent or steam cleaning with an appropriate solution. Repeat the cleaning operation until the contamination is removed and flush the area with clean water to remove residual cleaning solution. Consult a supplier to provide assistance in choosing an adequate cleaning chemical. Always ensure that the cleaning solution is maintained at a constant temperature level to keep the contaminants soluble until they are removed. Allow to dry thoroughly before coating.

6.3 REMOVAL OF LAITANCE

High-build, high film strength coatings will not develop optimum adhesion to concrete unless laitance and other loosely bound material are first removed from the surface. Common methods of removal are acid etching and abrasive blasting. Abrasive blasting is preferred where practical, although dust and abrasive removal may present a problem on some projects. Acid etching is an economical way to prepare concrete floors, however, it is hazardous in its application and is not recommended for vertical or overhead surfaces.

6.4 ABRASIVE BLASTING

Abrasive blasting should be sufficiently performed so as to remove weak laitance and solid contaminants. This procedure will open up surface voids, bugholes, air pockets, etc. Concrete substrates are abrasive blasted to provide a clean, sound substrate with a uniform anchor profile, but not to erode the surface beyond that which is necessary. Recommended blasting methods include dry abrasive with air-blast, hydroblasting with an abrasive and airless centrifugal wheel blast, and vacuum blasting.

Abrasive blasting using compressed air is the more common method of abrasive blasting. The blasting is often performed dry, but can incorporate water to control dusts. The water can be mixed with the abrasive and used as a slurry or the water can be injected into the abrasive at the end of the blast nozzle. Before wet blasting, one should consider the schedule constraints of the project. Time may not allow for ample drying of the surfaces before coatings are to be applied. The selected abrasive must be clean and dry with a maximum particle size that can pass through a 16-mesh screen.

The preferred method of abrasive blasting floors is with a portable unit incorporating centrifugal wheel blast using steel shot abrasive. These units reclaim much of the shot and subsequent dusts, minimizing the final clean-up before coating. The size of the steel shot, coupled with the travel speed of the unit, determines the aggressiveness of the blast cleaning.

After blast cleaning, residual abrasive, dust and other loose particles must be removed from the surface by vacuuming or blowing off with clean, dry compressed high-pressure air. Reference ASTM D4259, Standard Practice for Abrading Concrete, SSPC-SP13 and ICRI Guide 310.2, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays and Concrete Repair, for the complete procedures and guidance regarding abrasive blast cleaning.

6.5 ACID ETCHING

Acid etching is often used on horizontal surfaces because it provides results at a low cost. It is impractical and dangerous to use for vertical and overhead surfaces as it will not etch the surface uniformly and does not have any effect on opening voids and holes near the surface.

Acid etching may not be suitable in some situations where the concrete surface has been power troweled and/or a thick film coating system has been specified. For specific recommendations, contact your Tnemec representative or Tnemec Technical Services.

Residual dust and dirt should be removed from the surface of the concrete by thoroughly sweeping or vacuuming.

Etched concrete should be examined for uniformity and texture, and should achieve ICRI CSP1 (minimal roughness). The surface should be free of surface glaze, laitance, salts and loosely adhering material. In many cases, more than one acid etching operation may be required to obtain a satisfactory profile. Reference ASTM D4260, Standard Practice for Liquid and Gelled Acid Etching of Concrete, ASTM D4262, Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces, ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method, SSPC-SP13, Surface Preparation of Concrete or ICRI Guideline No. 310.2 for complete procedures before moving forward.

6.6 REINFORCING STEEL REPAIR

Where corrosion of the reinforcement of steel (rebar) exists, continue concrete removal along the corroded steel and any adjacent areas which show evidence of corrosion-induced damage that would inhibit bonding of repair material. When the exposed reinforcing steel has loose rust, corrosion products or is not well bonded to the surrounding concrete, removal should include undercutting the corroded reinforcing steel by approximately 3/4 in (19 mm) in accordance with ICRI Guideline No. 310.1R, Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion.

Every precaution should be made to avoid cutting underlying reinforcement. All exposed reinforcement surfaces shall be thoroughly cleaned of all loose concrete, rust and other contaminants. A protective coating can be applied to the reinforcement after surface preparation. Avoid spillage or application onto the parent concrete.

7.0 SURFACE PREPARATION OF PLASTER

Plaster should be permitted to cure and dry out for at least 28 days before painting. Coating over plaster that contains free water, lime and other soluble alkaline salts may cause delamination, blistering, peeling, discoloration, efflorescence or staining. If there is a question about the moisture content of the plaster, it should be checked and verified following the procedure outlined for concrete or with a moisture meter. Give attention to areas that are likely to slow the drying out process.

Remove plaster nibs and other protrusions by scraping. Grease and oil may be removed by a hot cleaning solution. The cleaning solution may be applied by sponge or brush, working from the bottom to the top of the soiled area. The cleaning operation should be repeated if the contaminants are not completely removed. Flush the cleaned surface with fresh water and allow drying. Patch voids and cracks with a suitable compound that is compatible with the substrate and coating. Sand flush with the surface when cured or dry.

8.0 SURFACE PREPARATION OF GYPSUM DRYWALL CONSTRUCTION

Sand joint compound with fine grit, open-coated sandpaper to provide a smooth flat surface. Avoid heavy sanding of the adjacent wallboard surfaces, which will raise the nap of the paper covering. Remove dust from the surface by wiping with clean rags or other means. If additional joint finishing is required to provide a smooth surface, the same joint compound or a ready-mixed spackling compound should be used. Putty, patching pencils, caulking or masking tape should not be applied to drywall surfaces to be painted.

Lightly abrade tape joints after priming to remove raised paper nap. Take care not to sand through the prime coat. Remove dust by wiping with clean rags.

9.0 SURFACE PREPARATION OF WOOD

Wood should be clean and dry. Remove surface deposits, sap or pitch by scraping and wiping clean with rags dampened with mineral spirits or VM&P Naptha. Seal knots and pitch pockets with shellac reduced with equal parts of shellac thinner (denatured alcohol) before priming. Sand rough spots with the grain, starting with medium grit sandpaper and finishing with fine grit. Remove sanding dust. After the prime coat is dry, fill cracks and holes with a suitable compound that is compatible with the substrate and coating. When filler is hard, sand flush with the surface using the fine grit sand paper. Sand lightly between coats with fine grit, open-coat sandpaper.

10.0 SURFACE PREPARATION OF PREVIOUSLY PAINTED SURFACES

Whether or not overcoating is a feasible alternative to complete removal and repainting depends a great deal on the condition of the existing coating system. The amount of corrosion present, number of coats, adhesion between coats and exposure conditions are some of the factors that need to be considered before a specifier can make an overcoat or complete removal decision. The latest version of Tnemec Technical Bulletin No. 98-10 can be used as a guide to assist in making complete removal versus overcoat decisions.

Surface preparation of an existing coating system will vary depending on generic type, exposure conditions and other variables. For specific recommendations, contact your Tnemec representative or Tnemec Technical Services.



11.0 APPLICATION GUIDE

While surface preparation is usually defined and controlled by the specification, application is frequently specified to be performed “in accordance with the manufacturer’s instruction.” These instructions usually include ranges or limits governing the use of the product such as air and surface temperature, recoat time, spreading rate, film thickness, etc. They also include recommendations for various methods of application such as brush, roller, or spray as well as mixing and thinning instructions. For most types of coatings, the manufacturer’s recommendations contain more than one method of application, and the applicator has the option of choosing the method of application that is most economical or best suited for a particular job.

The term “application” is no longer limited to just application methods, but has been expanded to include a number of related factors such as environmental conditions, material preparation, equipment, film characteristics, curing and recoating. Each of these factors has a bearing on the proper application of the coating system.

11.1 STORAGE AND HANDLING

Facilities should be available at the shop or jobsite for handling and storage of coatings in accordance with the manufacturer's recommendations. In most instances, coatings should be stored in a protected or enclosed area where temperature conditions are controlled. Excessively high or low temperatures may affect application properties of a coating sufficiently so that it cannot be properly applied until it is brought within the recommended storage temperature range again. Furthermore, the physical and chemical properties of coatings may be adversely affected by storage at temperature extremes. All materials should be stored in sealed containers prior to use. Any material held in storage beyond the manufacturer's shelf life limits should be withdrawn from stock and disposed of in accordance with the appropriate regulations.

11.2 TEMPERATURE AND HUMIDITY

Manufacturer's data on air and surface temperature limits and relative humidity should be adhered to during the application and through the cure of the coatings. While some coatings will tolerate much broader temperature and humidity ranges than others, the application and performance of any coating can be adversely affected if prescribed limits are not followed. (See Film Characteristics Section.) Even temperature variations within these limits may change the application properties of some coatings, requiring solvent and equipment adjustments as recommended by the manufacturer for proper application.

Continuous recording of environmental conditions with data loggers is often employed to monitor temperature and humidity conditions during the application and curing of coatings where these factors are essential to film formation and cure. If this type of equipment is not available, periodic readings can be taken with air and surface temperature thermometers and a sling psychrometer and then recorded to verify temperature and humidity conditions which were maintained during the coating and curing phase.

This is not to imply that all coatings applications must be monitored in this manner. However, it may be helpful to have such instrumentation available to settle questions where there is doubt as to whether the temperature and humidity conditions are suitable for the application of a coating.

11.3 WIND VELOCITY

Excessive wind velocity can seriously impair spray application, resulting in significant material loss, low film build, excessive dry spray or overspray, plus the possibility of depositing airborne spray mist on unprotected surfaces downwind from the work. Some of these adverse effects can be compensated for by material and equipment adjustments if winds are not too high. Generally speaking, wind velocity above 15 m.p.h. can cause sufficient spray application problems, in which case suspending work until conditions improve should be considered.

11.4 VENTILATION

Most coatings contain some type of solvent which must evaporate from the film as part of the drying or curing process. While temperature plays an important role in solvent evaporation, ventilation is even more essential to the process. Supplementary ventilation, such as fans and blowers, should be employed in confined or enclosed areas to carry off solvents during the evaporation stage. **NOTE:** A

professional engineer should be consulted for sufficient ventilation.

11.5 DUST AND CONTAMINATION

Airborne dust and contaminants settling on freshly applied coatings not only produce an unsatisfactory "sandy" appearance, but also provide a critical path for penetration of the film, shortening the service life of the coating. Chemical contaminants may actually attack the film and lay the groundwork for early failure of the coating system. Coating work should be scheduled to avoid excessive dust and airborne contaminants, or work areas should be protected from these adverse conditions during the application and curing phase. Surface accumulation of dust and contaminants on previously coated work should be removed before applying succeeding coats to prevent intercoat contamination and loss of adhesion.



11.6 MIXING AND THINNING

Most coatings will stay in suspension for several hours after mixing without further stirring or agitation. However, some are prone to rapid settling and must be stirred frequently or kept under constant agitation during application. The manufacturer's instructions should be followed in these instances.

Nearly all coating materials are subject to some degree of settling or standing in the container, and require stirring or mechanical agitation before application. Some products require the addition of solvents to adjust the viscosity for different methods of application and variations in temperature. Only the type of solvent recommended for the coating should be used, and the material should not be overthinned. Do not thin coatings before initial stirring, since some materials develop a false thixotropic body on standing, which breaks down to normal viscosity with stirring or agitation.

11.7 MULTI-COMPONENT

Multi-component products are either packaged in double compartment containers or separate containers marked "Part A" and "Part B", or some other designation, and contain the precaution not to use without mixing all components. Multi-component materials are premeasured in the container so the proper mixing ratio can be

achieved by mixing the entire contents of each container.

The manufacturer's instructions usually recommend that the mixing be done under agitation. With some materials, it is important that the components be added in a prescribed sequence and the procedure should not be reversed. Thorough blending of the components is essential for proper performance of the coating and power agitation is generally recommended. Thorough blending of two liquid components can take 1-3 minutes with the proper size mixing blades. If a dry powder component is added to a liquid component, the two should be thoroughly blended until they are free of lumps. Usually straining is recommended before application to remove any undispersed material that could clog spray equipment.

It is advisable to have someone familiar with the product supervise the mixing of multi-component materials. A mixing error such as leaving out one of the components, using the wrong mixing ratio, insufficient mixing or adding the wrong component, will result in an unsatisfactory product. The material should be discarded, unless it is definitely known what the error was and the mix can be corrected to conform with the manufacturer's mixing instructions. If improperly mixed material is applied to the surface, it is generally necessary to completely remove the coating and recoat the surface with properly mixed material. Consult the manufacturer for their recommendation.

11.8 POT LIFE

Nearly all recommended usable multi-component materials have a pot life, or time limit, during which the mixed material can be used. The pot life will generally vary with temperature and is usually much shorter at higher temperature ranges. Pot life limits must be strictly observed. Care should be taken not to mix more material than can be applied during the pot life. If the pot life has been exceeded, the material should be discarded even though it may still look like it is satisfactory to use.

11.9 APPLICATION EQUIPMENT AND TECHNIQUES

Application equipment and techniques recommended by the coating manufacturer are usually based on test reports from the equipment manufacturers, test applications and field experience gained under a variety of job conditions. The type of equipment, pressure settings and application techniques recommended by the manufacturer will usually permit satisfactory application of the coating under most job conditions. Variations in equipment, pressure settings and technique can be made by the applicator as long as proper atomization and application characteristics are not affected. For unusual or specialized applications, it is recommended that the coating manufacturer be consulted.

It is important that tools and equipment be clean and in good operating condition. Dirty tools and equipment can be a source of coating contamination, and broken or worn-out equipment may not be capable of satisfactory application. Frequently, the material is blamed for application problems when the real problem is the use of wrong or defective equipment.

11.10 FILM THICKNESS AND SPREADING RATE

Adequate film build is essential to the satisfactory performance of protective coatings. The coating manufacturer will specify the spreading rate (sq. ft. per gallon) that is required to achieve the specified dry film

thickness. The calculations are based on the fact that each standard U.S. gallon (128 fluid ounces) contains 1,604 mil sq. ft. of liquid. If it is determined that a dry film thickness of 3.0 mils (0.003 inches) is required, and it is known that the product contains 54 percent solids by volume, the theoretical spreading rate would be calculated at 289 sq. ft. per gallon ($1604 \div 3 \times .54 = 288.7$), and the wet film thickness would be calculated at 5.6 mils ($1604 \div 288.7 = 5.55$). Calculations are usually rounded off to the closest 5 sq. ft. and closest 0.5 mil for convenience. Theoretical spreading rates do not include material losses due to the method of application or surface irregularities. Deductions for material losses should be made to arrive at a practical spreading rate.

Film thicknesses and theoretical spreading rate can be quickly determined from Table IV if the solids by volume are known.

TABLE IV

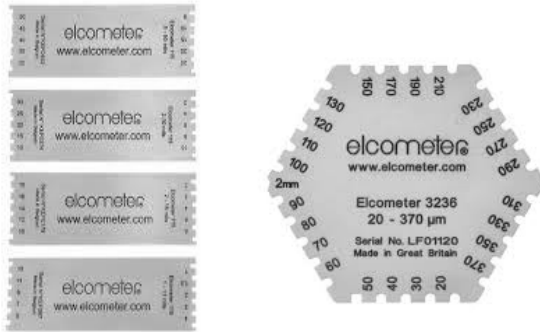
Theoretical Spreading Rates (ft ² /gal) at Several Dry Film Thicknesses and Volume Solids								
% Vol. Solids	Dry Film Thickness (DFT)							
	1 mil	2 mils	3 mils	4 mils	5 mils	6 mils	8 mils	10 mils
30	481	241	160	120	96	80	60	48
35	561	281	187	140	112	94	70	56
40	642	321	214	160	128	107	80	64
45	722	361	241	180	144	120	90	72
50	802	401	267	201	160	134	100	80
55	882	441	294	221	176	147	110	88
60	962	481	321	241	192	160	120	96
65	1,043	521	348	261	209	174	130	104
70	1,123	561	374	281	225	187	140	112
72	1,155	577	385	289	231	192	144	115
74	1,187	593	396	297	237	198	148	119
76	1,219	610	406	305	244	203	152	122
78	1,251	626	417	313	250	209	156	125
80	1,283	642	428	321	257	214	160	128
82	1,315	658	438	329	263	219	164	132
84	1,347	674	449	337	269	225	168	135
86	1,379	690	460	345	276	230	172	138
88	1,412	706	471	353	282	235	176	141
90	1,444	722	481	361	289	241	180	144
92	1,476	738	492	369	295	246	184	148
94	1,508	754	503	377	302	251	188	151
96	1,540	770	513	385	308	257	192	154
98	1,572	786	524	393	314	262	196	157
100	1,604	802	535	401	321	267	201	160

Theoretical spreading rates may be used as a rough guide for determining film thickness. However, in order to assure sufficient material is being applied, wet film thickness readings are often taken at random locations immediately after application. A Nordson Wet Film Gauge or similar instrument may be used for this purpose. The dry film can be calculated by multiplying the average wet film thickness by the percent solids by volume. For example, if the wet film averages 8.0 mils, and if the solids by volume are 54 percent, the dry film thickness would be calculated at 4.3 mils (8.0×0.54

= 4.3). Consideration should also be given to variables that could have an effect on the calculated dry film thickness, such as loss of wet film due to absorption into a porous substrate, surface profile, thinning, etc.

Dry film thickness may be measured on ferrous metals using a magnetic gauge following the procedure outlined in SSPC-PA2, Section IV, Paint Thickness Measurement. Readings should be taken in accordance with the specification or applicable standards such as those mentioned above.

While primary concern should be given to applying sufficient film thickness for adequate protection, it is sometimes equally important to guard against applying too heavy a coat. Excessively heavy coats may result in runs and sags, producing an unsightly appearance as well as leaving weak spots in the film. Heavy coats may also upset the drying properties, causing wrinkling or cracking, affect intercoat adhesion or leave excessive solvents trapped within the film.



Above: Elcometer Wet Film Gauges



Above: Elcometer Type II Dry Film Thickness Gauge

11.12 FILM CHARACTERISTICS

The object of application is to deposit a coating on the surface that will provide the decorative and protective properties that are inherent with the coating. This requires that the coating be uniformly applied at the prescribed thickness, and be free of film defects that would adversely affect the appearance or performance.

Due to advancements in coating technology, quality applications are easier to achieve than ever before. However, the state-of-the-art has not reached the point where shop and field applicators can apply coating systems that are completely free of defects. Furthermore, not all film defects will adversely affect performance and/or appearance and many types of minor defects would not be a basis for rejection of the work or even necessitate touch-up or repair. Also, there are differences in the acceptance criteria for a decorative coating, where appearance is the primary factor, and a protective coating, where performance is the most important consideration. Therefore, it is important that the inspection and acceptance criteria be defined in advance for the applicator. If dry film thickness measurements and/or holiday testing work is to be performed, questions of what type of test equipment is to be used, where and how many readings are to be taken, who will perform the inspection and what kind of inspection records should be addressed.

Defining the acceptance standards for the appearance of a coating is more difficult. Often the specification language emphasizes what coating characteristics are not acceptable rather than what is acceptable. For example: "Finish coats shall be free of runs, sags, skipped and missed areas, etc." This is often backed up with the requirement that a small area of a room be coated and approved before proceeding with the rest of the job.

This procedure points out the need for a common language to describe film characteristics in order to avoid costly misunderstandings and delays in dealing with shop or field applications. Table VI lists a number of common film characteristics and gives their probable causes as well as various methods of correction. The term "Film Characteristics" rather than "Defects" was chosen intentionally and no implication is made that any of the conditions listed would necessarily constitute defective work or form a basis for rejection.

11.13 HOLIDAY TESTING

If required by the project specifications, holiday testing should be performed in accordance with NACE SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates. For coating thicknesses less than 20.0 mils DFT, a Tinker & Razor Low Voltage Model M/1 Holiday Detector is typically used. For coating thicknesses greater than 20.0 mils DFT, high voltage discontinuity (spark) testing shall be performed using a Tinker & Razor AP/W High Voltage Holiday Tester or equivalent. As a general rule, voltages are set between 100-125 volts per dry mil of coating. Contact Tnemec Technical Service for voltage recommendations and curing parameters prior to testing.

11.14 CURING AND RECOATING

Coatings achieve film formation by various curing mechanisms including coalescence, hydrolysis and chemical conversion. The term "curing" refers to the process by which a liquid becomes a hard film. Table V lists the four phases of curing that are typically referenced.

TABLE V

TO TOUCH	The point at which the film will no longer pick up on the finger when lightly touched.
TO HANDLE (OR DRY-THROUGH TIME)	The point at which a coating will not loosen, wrinkle, detach or distort when maximum downward thumb pressure is exerted and the thumb is turned.
TO RECOAT	The point at which the film is sufficiently cured to receive the next coat without adverse effects.
FULL CURE	The point at which the film initially reaches its full physical and chemical properties and is ready to be placed in service.

12.0 FILM CHARACTERISTICS

The time it normally takes to reach these various phases in the curing cycle at ambient temperature will be provided by the coating manufacturer. Variations in film thickness, temperature, humidity and air movement during the curing cycle will affect the actual length of time of each of these phases. Therefore, the time factor alone cannot be relied upon completely for determining when a coating is sufficiently cured to handle, to touch, to recoat or when it reaches full cure and is ready to place in service.

Some coatings have a maximum recoat time and must be topcoated within this time limit for proper intercoat adhesion and performance properties. If, for some reason, the maximum recoat time is exceeded, the manufacturer should be consulted before proceeding to prevent possible problems or costly failures.

TABLE VI

CHARACTERISTIC/ DESCRIPTION	PROBABLE CAUSE	CORRECTION
Alligatoring Cross-hatch pattern of surface cracking.	1. Incompatibility of topcoat and underfilm, or coating over a soft underfilm.	1. Remove failed coating and recoat with compatible system suitable for exposure conditions. Do not topcoat until underfilm is dry enough to recoat.
Bubbling Bubbles on the surface of the dried film. May be microscopic in size.	1. Rapid volatilization of solvents within the film. 2. Air displacement resulting from absorption of wet film into porous substrate. 3. Urethanes in contact with moisture.	1. Level surface defects by sanding and reapply coating at lower air or surface temperature, or add slower solvent to increase open time of wet film. 2. Bridge or fill voids by applying a mist coat, a filler or sealer. 3. Remove bubbles by sanding and reapply coating at a lower relative humidity. Allow coating to cure before contacting moisture.
Cracking Visible cracks through the surface of the film.	1. Stress or compression cracking of rigid substrate. 2. Bending or flexing of non-rigid substrates. 3. Physical damage: impact, heat, cold, exposure, etc. 4. Surface freezing of fresh latex coatings.	1. Patch cracks and recoat. 2. Replace with coating having sufficient flexural strength to tolerate condition. 3. Replace with coating that will tolerate physical conditions. 4. Recoat when air and surface temperatures are above minimum recommendations.
Cratering Round V- or U- shaped thin spots or voids.	1. Caused when bubbles break.	1. See "Bubbling."
Crazing Fine line cracking forming a network or overall pattern.	See "Cracking."	See "Cracking."

Delamination Loss of adhesion to substrate or between coats (inter-coat adhesion).	<ol style="list-style-type: none"> 1. Dust, dirt, contamination, dry spray. 2. Water migration through porous substrates. 3. Underfilm allowed to cure beyond maximum recoat time. 4. Topcoat incompatible with underfilm. 	<ol style="list-style-type: none"> 1. Remove coating not tightly bonded, clean surface and recoat. 2. Correct cause of water migration, remove coating not tightly bonded and recoat. 3. Remove coating not tightly bonded, abrade surface and recoat. (See manufacturer's instruction.) 4. Completely remove coating and recoat with compatible system.
Dry Spray Rough, sandy surface texture on spray-applied coating.	<ol style="list-style-type: none"> 1. Spray particles partially dry before reaching surface. 	<ol style="list-style-type: none"> 1. Sand smooth and adjust material, equipment and techniques for prevailing temperature and humidity conditions.
Flattening Loss of gloss.	<ol style="list-style-type: none"> 1. Rain, fog, high humidity, or damp surfaces. 2. Overthinning or use of wrong solvent. 	<ol style="list-style-type: none"> 1. Recoat when surface is dry and weather conditions are satisfactory. 2. Remove coating if film properties or adhesion are affected and recoat with properly thinned material.
Framing Color, texture or hiding variations when roller-applied surfaces join work cut in with a brush.	<ol style="list-style-type: none"> 1. Uneven film build between roller- and brush-applied work. 	<ol style="list-style-type: none"> 1. Recoat deficient work, apply heavier wet film or an additional coat on new work.
(Poor) Hiding Uneven color or shadowy appearance of topcoat.	<ol style="list-style-type: none"> 1. Insufficient number of coats or low film build. 	<ol style="list-style-type: none"> 1. See "Framing." (Note: Some colors have weak hiding properties and require an additional coat for satisfactory hiding.)
Holidays Skipped or missed areas.		<ol style="list-style-type: none"> 1. Touch-up or recoat.
Lapping (Lap Marks) Color, sheen or texture variations where one freshly painted area overlaps another.	<ol style="list-style-type: none"> 1. First area painted has set up before overlap was made. 	<ol style="list-style-type: none"> 1a. Adjust material, equipment and technique for weather conditions. 1b. Work smaller areas to reduce lap time.

Mud Cracking Cross-hatched pattern of surface cracking.	<ol style="list-style-type: none"> 1. Excessive film build or hot, dry weather. 	<ol style="list-style-type: none"> 1. Remove failed coating and recoat at recommended film thickness. Add additional solvent or slower solvent to retard drying during hot, dry weather.
Orange Peel Fine pebbled surface texture on spray-applied coating.	<ol style="list-style-type: none"> 1. Insufficient atomization. 	<ol style="list-style-type: none"> 1. Sand smooth and recoat after adjusting material, equipment and technique to obtain better flow and leveling.
Overspray Rough sandy areas on spray-applied work.	<ol style="list-style-type: none"> 1. Deflected spray mist that settles on dry or partially dry coated surfaces. 	<ol style="list-style-type: none"> 1. Sand smooth and recoat using proper application technique and lap time. Protect dry film from overspray.
Peeling See "Delamination."		
Pinholing Small holes or discontinuities in the film. May be microscopic.	<ol style="list-style-type: none"> 1. Solvent migration through the film after the film has begun to set. (Also see "Bubbling" and "Cratering".) 	<ol style="list-style-type: none"> 1a. If occasional pinholes are detected, touch-up or recoat. 1b. If pinholing is a general surface condition, it indicates that coating was applied and cured under adverse environmental conditions. Apply a thin or mist coat to fill surface voids, followed by a full wet coat when environmental conditions are suitable for recoating.
Roller Tracks (a.) V-shaped texture pattern on roller-applied surfaces or (b.) Lines at edge of roller passes.	<ol style="list-style-type: none"> 1. Use of long nap roller cover on smooth surfaces. 2. Material not properly thinned. 3. Material not rolled out properly. 	<ol style="list-style-type: none"> 1. Change to shorter nap roller cover. 2. Make solvent adjustment to improve flow and leveling. 3. Use proper applicator technique.
Runs Heavy V-shaped or pencil shaped vertical build-ups on surface of coating.	<ol style="list-style-type: none"> 1. Excessive film build. 	
Sags Heavy U-shaped build-ups or horizontal lips on the surface of coatings. (Long sags may also be referred to as curtains.)	<ol style="list-style-type: none"> 1. See "Runs." 	<ol style="list-style-type: none"> 1. See "Runs."

Sandy (Appearance) Dull, rough appearance of film.	1. Dust and dirt contamination of the wet film.	1. Sand smooth and recoat. Protect freshly painted areas against dust and dirt contamination or suspend painting operations until environmental conditions are satisfactory.
Shadowing See "Hiding."	1. See "Hiding."	1. See "Hiding."
Solvent Trap Residual solvents remaining within film.	1. Excessive film build. 2. Low temperature curing.	1. Try to drive solvents out of film by force-drying, (see manufacturer's data), test for hardness and adhesion. If film will not adhere or cure properly, remove and recoat. 2. Same as "1."
Streaking Areas having a rough texture on spray surface.	1. Equipment malfunction or use of wrong equipment. 2. Spray passes not properly lapped.	1. Sand smooth and recoat after correcting equipment malfunction or change to recommended equipment if wrong equipment was being used. 2. Sand smooth and recoat using proper applicator technique.
Water Spotting See "Flatting."		
Wrinkling Formation of wrinkle pattern on top of film.	1. Excessive film build. 2. Slow drying conditions.	1. Sand smooth and recoat at proper film thickness. 2. Sand smooth and recoat when drying conditions are satisfactory.

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- American National Standards Institute
- American Society of Testing and Materials
- American Water Works Association
- Construction Specification Institute
- International Concrete Repair Institute
- NACE International
- Society for Protective Coatings
- Water and Waste Equipment Manufacturers Association, Inc.
- Water Environmental Federation

Tnemec believes in working hand-in-hand with professionals in these various fields and maintains active membership and technical representation in all of the above organizations.