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Standard Guide for Painting Inspectors (Concrete and Masonry Substrates)[1]

This standard is issued under the fixed designation D 6237; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is intended as an information aid to painting inspectors in carrying out the task efficiently. It includes the key elements of surface preparation, coatings application, and final approval for both field and shop work. The items should be selected that are pertinent to a particular job.

NOTE 1—For additional helpful information, refer to the following documents:

Manual of Concrete Practice ACI 515R American Concrete Institute[2]

Manual of Coating Work for Light Water Nuclear Power Plant Primary Containment and Other Safety Related Facilities[3]

C 811 Practice for Surface Preparation of Concrete for Application of Chemical-Resistant Resin Monolithic Surfacings[4]

SSPC-PA Guide 3 - A Guide to Safety in Paint Application[5]

Steel Structures Painting Manual Vol. 1- Good Painting Practices[5]

Steel Structures Painting Manual Vol. 2 - Systems and Specifications[5]

Manufacturers Specifications and Instructions (made available to the inspector for reference to special requirements for proper application)

Material Safety Data Sheets (needed to insure that personnel take necessary precautions in handling hazardous materials) Available from Materials manufacturer.

1.2 The values stand in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of whomever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 This guide is arranged in the following order:

[1] This guide is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.46 on Industrial Protective Coatings.

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[2] American Concrete Institute, P.O. Box 19150, Detroit, MI 48219.

[3] ASTM, 1979.

[4] *Annual Book of ASTM Standards*, Vol 04.05.

[5] Steel Structures Painting Council, 40 24th Street, Pittsburgh, PA 15222.

2. Referenced Documents

2.1 *ASTM Standards:*

C 811 Practice for Surface Preparation of Concrete for Application of Chemical-Resistant Resin Monolithic Surfacings[4]

D 1186 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base [6]

D 1212 Test Methods for Measurement of Wet Thickness of Organic Coatings[6]

D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[6]

D 1475 Test Method for Density of Paint, Varnish, Lacquer, and Related Products[6]

D 4138 Test Method for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive Means[7]

D 4212 Test Method for Viscosity by Dip-Type Viscosity Cups[6]

D 4258 Practice for Surface Cleaning Concrete for Coating[7]

D 4259 Practice for Abrading Concrete[7]

D 4260 Practice for Acid Etching of Concrete[7]

D 4262 Test Method for Determining pH of Chemically Cleaned or Etched Concrete Surfaces[7]

D 4263 Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method[7]

D 4285 Test Method for Indicating Oil or Water Compressed Air[7]

D 4414 Practice for Measurement of Wet Film Thickness by Notch Gages[6]

D 4541 Test Method for Pull-Off strength of Coatings Using Portable Adhesion Testers[7]

D 4787 Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates[7]

D 5064 Practice for Conducting a Patch Test to Assess Coating Compatibility[7]

D 6132 Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Over Concrete Using an Ultrasonic Gage[6]

2.2 *Occupational Safety and Health Administration (OSHA) Standard:*

29 CFR 1910.1200, Hazard Communication[8]

2.3 *Steel Structures Painting Council Standards:*[5]

SSPC-SP7 Brush-off Blast Cleaning

SSPC-PA1 Paint Application Specifications

SSPC-Guide 6 (CON) Guide for Containing Debris Generated During Paint Removal Operations

SSPC-Guide 7 (DIS) Guide for the Disposal of Lead-Contaminated Surface Preparation Debris

SSPC12/NACE5 Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating

3. Significance and Use

3.1 This guide is intended as a reference for those concerned with the inspection of thin- or thick-film coating application to concrete and masonry substrates. It does not cover the application of cement-type coatings. A checklist is included as Appendix X1.1. Many of the details covered may be in a specification for a particular project. A specification for coating projects should include the coatings to be used.

4. Preparation for Inspection

4.1 The guide describes the duties of the inspector and discusses inspection methods, both visual and instrumental, that can be used to determine that the specification requirements have been met by the painting contractor.

4.2 Before the start of the job, the inspector should be provided information by the project engineer from the official plans and specifications as to surface preparation requirements, coating type, thinner to be used, mixing ratios to be used, recommended application thickness, recommended primer, tie coat, topcoat, time between coats, method of application, ambient condition restrictions, and any special precautions to be followed. These details should be recorded in an inspector's record book to eliminate any misunderstanding between the inspector and the contractor.

4.3 The inspector should obtain copies of Materials Safety Data Sheets for all products that will be used on the project, review any hazard communications program in accordance with 29 CFR 1910.1200 that will apply to the project, and review other safety information related to the work that will be performed by the contractor. The inspector should examine these materials and be supplied with appropriate protective equipment and devices.

5. Surface Preparation Methods and Requirements

5.1 *Surface Preparation*—One of the most important factors affecting the performance of coatings is surface preparation. The specifier determines the proper level according to the expected service life and type of coating specified.

5.2 *Factors Affecting Coating Performance*—There are a number of factors that must be considered to ensure a proper painting project.

5.2.1 *Surface Condition*—Concrete and masonry have unique properties associated with them due to their physical

[6] *Annual Book of ASTM Standards*, Vol 06.01.

[7] *Annual Book of ASTM Standards*, Vol 06.02.

[8] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402-9328.

nature and method of formation. New concrete may be very smooth and hard if hard trowel finished, or have cavities and holes at or just below the surface if poured. As with surface preparation of other substrates, contaminants must be removed and the surface suitably roughened. All protrusions should be removed by suitable hand or power tool technique prior to cleaning. Visible holes should be filled with a patching compound compatible with the coating to be applied.

5.2.2 *Cleanliness*—Many materials, if not removed from the surface, will affect the life of the coating. These include form release agents, surface hardeners, laitance, efflorescence, grease, soil, fungus, mold, and mildew, which make it impossible to obtain proper adhesion.

5.2.3 *Moisture*—There should be no free standing water on the surface although a damp surface may be specified for certain types of coatings. Moisture is required to cure concrete, but after the specified cure time has passed, the inspector should check for excessive moisture below the surface as determined by Test Method D 4263 or by use of a moisture meter. Many coating types will not adhere over entrapped moisture.

5.3 *Cleaning Procedures*—Safety precautions are not addressed separately for each of the following cleaning methods. Each has its own safety-related hazards, and U.S. Occupational Health and Safety Administration regulations should be followed. Materials Safety Data Sheets (MSDS) for the solvents and cleaning compounds provided by the manufacturer should also be consulted for proper worker protection.

5.3.1 *Surface Cleaning*—Broom, vacuum cleaners or a compressed air stream, or both, are used to remove surface dust and other loosely adherent solid contaminants in accordance with 6.1 to 6.3 of Practice D 4258. Compressed air should be free of water and oil. Test compressed air supply in accordance with Test Method D 4285. Visually examine the surface for the presence of dust, debris and loosely adherent concrete.

5.3.2 *Water and Steam Cleaning*—These procedures are intended to remove dust, dirt, and water-soluble surface contaminants. Clean, potable water is used with sufficient pressure to remove dust, dirt, and loose material. Hand scrubbing with a stiff-bristled brush may be necessary. Visually examine the prepared surface for debris, dirt, oil, grease, loosely adherent concrete, and other contaminants. Moisture content may be determined after the surface has dried in accordance with Test Method D 4263 or by use of a moisture meter.

5.3.2.1 Detergents or nonorganic solvent emulsifying agents are used with water and steam cleaning to remove oil and grease contaminants. Heavy oil grease deposits should be removed by scraping prior to cleaning. Residues of the cleaning agent should be removed by flushing the surface with clean potable water before the surface dries. In some cases removal of the cleaning agent may be verified by measuring the surface pH in accordance with Test Method D 4262.

5.3.2.2 Practice D 4258, 6.4 to 6.6 present the procedures and test methods for water and steam cleaning both with and without detergents or emulsifying agents.

5.3.3 *Mechanical Tool Cleaning*—Mechanical tool cleaning is used to remove fins and projections, laitance, glaze, efflorescence, and concrete curing compounds. It results in a sound concrete surface that is suitably roughened. Mechanical tool cleaning is presented in Practice D 4259, 6.1 to 6.5. Various techniques may be required by the specifier depending on the nature of the job.

5.3.3.1 *Hand Tool Cleaning* is one method used for the removal of loose or otherwise unsound concrete, by hand brushing, hand sanding, hand chipping, or scraping using wire, fiber or bristle brushes, grinding stones, sandpaper, steel wool, hand scrapers or chisels, and chipping hammers.

5.3.3.1.1 Wire brushes should be rigid enough to clean the surface thoroughly and shaped to penetrate into all corners and joints. Brushes should be kept free of all materials that may clog the wires of the brush.

5.3.3.1.2 Hand scrapers should be made of tool steel, tempered and ground to a sharp edge and should be of the proper size and shape to enable cleaning to be done as specified. Scrapers should be kept sharp at all times.

5.3.3.2 *Power Tool Cleaning* is a method used for the removal of loose or otherwise defective concrete and protrusions by power wire brushes, power impact tools, power grinders, power sanders or by a combination of these methods. All equipment should be suitable for the configuration of the work to be cleaned and maintained free of material that clogs the wire or disks making them ineffective. All impact tools should be kept sharp.

5.3.3.3 *Scarifying Machines* for concrete surfaces are available that either cut or chip away a thin layer. Aggregate loosened by mechanical impacting should be removed.

5.3.3.4 *Pre- and Post-Surface Preparation*—Mechanical tool cleaning requires that grease, oil and other penetrating contaminants be removed prior to cleaning and after surface preparation as described in 5.3.2.1.

5.3.3.5 *Finished Surface*—The surface is visually inspected for dirt, dust, grease, oil, and loose contaminants. The surface should have a roughened textured appearance and aggregate may be exposed. A roughness standard may be established by mutual agreement.

5.3.4 *Blast Cleaning* is used to remove foreign materials from concrete in accordance with Practice D 4259 to provide a roughened surface. Blast cleaning is described in Practice D 4259. Dry or wet abrasive blasting may be used or specified.

5.3.4.1 Blast cleaning requires that all oil, grease, and other contaminants be removed prior to blasting as described in 5.3.2.1. The compressed air used for blast cleaning should be free of condensed water or oil. Compressed air supply *can be tested* in accordance with Test Method D 4285.

5.3.4.2 Blast-cleaning operations should be performed so that no damage is done to the completed portion of the work. Blast cleaning is often performed from the top to bottom of the structure and should only be carried on downwind from any recently painted areas.

5.3.4.3 Blast cleaned surfaces should be examined for any traces of oil, grease or smudges; where present, the contaminants should be removed by cleaning according to 5.3.2.1. Surfaces that have been dry blasted should be brushed with clean brushes, blown with compressed air free of oil and moisture, or vacuum cleaned to eliminate any traces of blast

products, dust or dirt from the surface. This also serves to remove abrasive from pockets and corners.

5.3.4.4 The finished surface should have a roughened texture similar to 100-grit sandpaper. A roughness standard may be established by mutual agreement.

5.3.5 *Water Blast Cleaning*—A high pressure water blast, either with or without abrasive injected into the stream, is used as an alternative to open abrasive blasting since it reduces the release of dust into the atmosphere. Water blast cleaning is described in D 4259, Section 7. Low-pressure water cleaning per SSPC12/NACE5 (<5,000 psi (34MPa)) alone is usually considered a satisfactory procedure for decorative painting, but for protective barrier coatings, low-pressure water cleaning without abrasive injection may not remove enough weak surface material. High-pressure water cleaning per SSPC12/NACE5 (5,000 psi (34 MPa) to 10,000 psi (69 MPa)) is usually needed. It should be noted that water introduced into the concrete will lengthen the drying time needed. The surface should have a roughened textured appearance.

5.3.6 *Acid Etching*—This method uses acids such as muriatic (hydrochloric), citric, phosphoric or sulfamic to remove foreign materials and weak surface laitance, and to roughen the surface. Acid etching is described in Practice D 4260.

5.3.6.1 Fins and protrusions, oil, grease, concrete curing compounds, form release agents, and concrete hardeners should be removed prior to acid etching by one or more of the techniques in 5.3.1 to 5.3.5. The surface is pre-wetted prior to application of the acid and free-standing water removed.

5.3.6.2 Bubbling should be uniformly evident after the etching solution is applied. The concentration of the etching solution may have to be increased if bubbling is not evident. Curing compounds, sealers, oil, grease, and hardeners inhibit acid etching. Areas where bubbling does not occur should be mechanically cleaned to remove these contaminants and the acid reapplied.

5.3.6.3 The surfaces should be flushed with clean potable water. Repeated flushing and scrubbing with a stiff-bristled brush may be needed to remove acid residues and perhaps neutralization. Test the surface pH in accordance with Test Method D 4262 for removal of the etching solution.

5.3.6.4 The acid-etched surface should be uniformly roughened similar in appearance to a medium or coarse grade sandpaper.

5.3.6.5 It may necessary to test for moisture content in accordance with Test Method D 4263 prior to applying the coating.

5.4 *Precautions in Preparing Unpainted and Previously Painted Surfaces*—Cleaning should proceed by sections, bays, or other readily identifiable parts of the work. The cleaning of each section, bay, or part of the work should be entirely completed, inspected, and accepted before any coating is applied. The system of alternately cleaning and painting short sections by one workman is not good practice.

5.4.1 If traffic or any other source produces an objectionable amount of dust, it is customary to control the dust by using tarpaulins, etc., for a sufficient distance around the structure and take any other precaution necessary to prevent dust and dirt from coming into contact with the cleaned or freshly painted surfaces. It may be necessary at times to use some of the specified methods for cleaning surfaces of newly applied coating between the various coats.

5.4.2 Some areas to be painted or repainted may be exposed to chemical fumes and should be washed with water before painting. Washing may also be necessary between coats of paint. If there is reason to suspect the presence of chemicals, the surfaces should be tested before applying subsequent paints.

5.4.3 Current regulations require containment and collection of surface preparation debris for disposal. When the existing coating contains regulated heavy metals such as lead or chromium, or other regulated compounds such as organotin, special precautions and handling of debris may be necessary. Inspection of containment and disposal requirements, especially site storage requirements, are part of a coating inspector's activities. SSPC 6(CON) and 7(DIS) present information useful to the inspector and sections of these guides may be referenced in the specification.

5.5 *Inspection of Surfaces Prior to Field Painting*—It should be emphasized that the first coat should be applied to the cleaned surfaces before any soiling or deterioration can occur. The cleaned surface should be inspected to ensure all visible contaminants have been removed. The substrate should be suitably roughened if mechanical tool cleaning, blast cleaning, water blast cleaning, or acid etching are used. Excessive roughness and exposed aggregate is just as deleterious as too smooth a finish.

5.5.1 *New Construction*—The strength of the concrete at or near the surface may affect the adhesion of the coating system. A pull-off adhesion tester as described in Test Method D 4541 may be used to determine the tensile strength of the concrete.

5.5.2 *Maintenance Repainting*—In most cases, maintenance painting will consist of spot-cleaning and priming of small isolated areas of deterioration followed by application of one overall new finish coat to all surfaces of the structure. The inspector of maintenance painting should be alert for several conditions not encountered in the painting of new work.

5.5.2.1 Sound coating not intended to be removed should not be damaged by cleaning operations on adjacent areas. This is particularly important with spot blast cleaning.

5.5.2.2 The junctions between sound coating and spot-cleaned areas should present a smooth, feathered appeared. The application of coating to be spot-cleaned areas should overlap the old, adjacent coating by 2 in. (50.8 mm) in order to assure full coverage of the cleaned areas. Before the overall finish coat is applied, the inspector must ensure that oil, grime, dust, and other contaminants are cleaned from the old coating surfaces.

5.5.2.3 Adhesion of the newly applied coat to the old coating should be carefully checked. Practice D 5064 presents the procedure for evaluating adhesion of maintenance coatings.

5.5.2.4 Under the direction of the engineer, the inspector may explore beneath the surface of the existing or new coating film for loosening of the old film, and where he discovers such conditions, require that the surface be cleaned and repainted.

5.5.2.5 The effect of any newly applied coating on the old underlying coating should be noted. Any coating that shows

curling, lifting, or wrinkling should be reported to the engineer immediately since it may have to be removed and the area repainted. If the defects are general, rather than existing in a few isolated areas, use of a different type of coating may be necessary.

6. Cracks and Voids

6.1 *Cracks* can be present in concrete or at joints in concrete and masonry. The specification should address how cracks will be prepared. Usually, this requires caulks, sealants, or fillers to be used before the coating is applied.

6.1.1 *Cracks in Concrete* that are visible on the surface may require filling or sealing prior to coating. Either the specification or data sheet for the crack filler/sealer will indicate the maximum width of crack for which the sealer can be used. A ruler or feeler gage can be used to measure crack sizes. Larger cracks usually require other materials or treatments, including routing out the crack. Manufacturer's instructions should be obtained and followed.

6.1.2 *Joints in Concrete and Masonry* that allow moisture or other elements to penetrate may also require caulking, sealing, or filling. Joints may also require sealing to provide a continuous surface for cosmetic reasons. Caulks, putties, and fillers are used. The inspector should ensure that all joints have been properly prepared and that loose material has been removed. The caulk, putty, or filler should be applied in accordance with the manufacturer's instructions, including weather limitations. Expansion and control joints are designed to move. Coatings applied to these joints may crack when the joints move. The specifications should address the painting of expansion joints.

6.2 *Voids* or "bug holes" may be present in the surface or opened up by surface preparation. Voids should be filled prior to application of the coating. In some cases, surface fillers are applied over the entire surface to seal pores and fill in voids so a smooth surface results. Limitations may exist on how deep a void can be filled, requiring multiple applications of the filler. The data sheet for the filler should be consulted.

6.3 *Recoat Intervals* apply to crack sealers and void fillers as they do to coatings. The inspector should ensure the material cures for the minimum time before the coating is applied and the maximum recoat time, if applicable, is not exceeded.

7. Coating Storage and Handling

7.1 *Storage of Coating and Thinner*—All coatings and thinners should be stored in areas or structures that are well-ventilated and not subject to excessive heat, open flames, electrical discharge, or direct rays of the sun. Storage should be in compliance with applicable regulations and the manufacturer's written instructions. Materials susceptible to damage at low temperatures should be stored to prevent freezing, such as in heated areas. Too high a storage temperature reduces the shelf life of the coating. If a coating is stocked for a considerable length of time (several months), it is desirable to invert the containers at monthly intervals. This will prevent hard settling and thus make mixing quicker and easier when the coating is to be used.

7.1.1 Coating containers should remain unopened until needed and the oldest should be used first. The manufacturer's written instructions should be followed regarding shelf life. Coatings that have livered, gelled, or otherwise deteriorated during storage should not be used. If a particular material is in question, do not use it until it has been tested by the manufacturer or independent laboratory and found to be satisfactory.

7.1.2 Where a skin has formed in the container, the skin should be cut loose from the sides of the container, removed, and discarded. If it is felt that the skins are thick enough to have a practical effect on the composition, the remaining paint should not be used until it has been tested and found to be satisfactory.

7.2 *Mixing of Coatings*—All coatings should be thoroughly and completely mixed in clean containers before use. Where there is noticeable settling and mixing is done either by power stirrers or by hand, most of the vehicle should be poured off into a clean container. The pigment is then lifted from the bottom of the container with a clean broad, flat paddle, lumps broken up, and the pigment thoroughly mixed with the vehicle present. The poured-off vehicle should returned slowly to the original container with simultaneous stirring. It is also useful at this point to mix or pour repeatedly from one container to another (boxing) until the composition is uniform. The bottom of the original container should be inspected for the unmixed pigment. Two component paints should be mixed by stirring only, and not with boxing. After the individual components are homogenous, they are intermixed with stirring in the order stated in the manufacturer's instructions, that is, add Part B to Part A. The coating should not be mixed or kept in suspension by means of an air stream bubbling under the coating surface.

7.2.1 Some coatings may require straining after mixing to ensure homogeneity and to remove skins and foreign matter. The strainers should be of a type to remove only skins, etc., but not to remove pigment. For example, a 50-mesh (297 μm) strainer is normally satisfactory for most coatings unless some specific size is required in the specification. Containers should be covered when not in use, to reduce volatile losses and skinning.

7.2.2 Coatings should be agitated enough during application to ensure homogeneity. Some materials may even require constant agitation during use.

7.3 *Thinning*—Some specifications permit field thinning of laboratory-accepted coatings while others do not. This section describes some commonly accepted procedures when thinning is permitted.

7.3.1 *Initial Samples*—When thinning on the job site is permitted and unless other arrangements have been made (for example using manufacturer-supplied thinner from unopened containers and complying with the manufacturer's written thinning instructions), the painting inspector may need to submit to an agreed-upon testing laboratory with a 1-qt (1-L) sample from each batch to be thinned, together with a 1-qt sample of the thinner to be employed using clean sample containers in both cases. A request is submitted with these samples for advice on the proper thinning rate for the conditions prevailing and the consistency limits of the thinned coating.

7.3.2 *Thinning of Coating*—All additions of thinner should be made in the presence of the inspector and only amounts or

types of thinner permitted by the specification or manufacturer, or both, should be added. Thinning is carried out by pouring about half of the thoroughly mixed coating into an empty, clean container. The required thinner is then added and the two portions are remixed to obtain a homogenous mixture.

7.3.3 *Sampling of Thinned Coating*—During the work, additional samples need not be submitted for testing unless a deviation is noted in the coating consistency or if it is suspected that there has been a change in the thinner.

7.3.3.1 When an inspector is qualified and has the necessary equipment available at the field office, arrangements may be made for on-site inspection of thinning and of the thinned coating. This speeds acceptance of a coating and lightens the laboratory workload. The inspector should keep a record of all paint modifications, amount of thinning, weight per gallon, and viscosity. Where dry-film thickness is specified, the inspector should verify the new wet thickness necessary to obtain the desired dried thickness with the thinned coating. He should make frequent checks of wet-film thickness as work progresses, however, compliance with the specification should be based on dry-film thickness when specified.

7.3.3.2 To estimate the wet-film thickness of the thinned coating required to obtain the specified dried-film thickness, the percent volume of the nonvolatile (solids) in the original coating must be known. This figure is readily obtained from the manufacturer. With this information the calculation may be made as follows:

$$W = \frac{D(1.0 + T)}{S} \quad (1)$$

where:

W = wet-film thickness,
D = desired dry-film thickness,
S = percent by volume (expressed as a fraction) of coating solids, and
T = percent by volume (expressed as a fraction) of thinner added.

7.4 *Heating of Coating*—Coating as delivered in the manufacturer's containers and mixed thoroughly, are ready for use, unless the specification permits on-site thinning of high-viscosity material. When the temperature of the liquid coating is low (below 50°F (10°C)) the consistency (viscosity) may increase to the point that application is difficult. Where thinning is not permitted, the coating may be heated. Should the contractor wish to reduce the viscosity by heating to make application easier, the containers may be warmed in hot water, on steam radiators by storing in a warm room, or by other acceptable indirect heating processes. In-line heaters are also available for application equipment. Direct application of flame to the containers is forbidden by fire regulations. It should be noted, however, that heating of the coating alone will not compensate for ambient or surface temperatures, or both, that are below the minimum specified for that material.

8. Weather Considerations

8.1 *Drying*—It is well known that most coatings, particularly those for structures, will not dry properly at low temperatures and high relative humidities, nor will they perform well if applied over wet surfaces.

8.2 *Low Temperature*—Many specifications indicate temperature limits between which painting may be undertaken. The typical minimum temperature (air, material and surface) is usually 40°F (5°C), but may be as low as 0°F (-18°C) for" cold-curing" one or two component systems, or 50°F (10°C) for conventional two component systems. The requirements may state further that painting should not be undertaken when the temperature is dropping and within 5°F (3°C) of the lower limit. However, some authorities believe that some coatings may be applied at (or below) 32°F (0°C) without adverse effects. Within the limitations of the composition of the coating, this may be satisfactory depending upon the type of coating and providing the surface is dry. Painting over ice or frost will result in early adhesion failure of the coating.

8.3 *High Temperature*—The maximum reasonable temperature for application is 125°F (52°C) unless clearly specified otherwise. A surface that is too hot may cause the coating solvents to evaporate so fast that application is difficult, blistering takes place, or a porous film results. To keep the temperature down it may be desirable, where practical, to paint under cover at a shop or protect the surface from the sun with tarpaulins.

8.4 *Moisture*—Painting should not be performed in rain, snow, fog, or mist, or when the temperature of the surface is less than 5°F (3°C) above the dew point. This occurs more commonly in spring and fall when days are warm and nights are cool. Wet surfaces should not be painted unless the coatings are specifically designed for that condition. Relative humidity is usually an indicator of condensing conditions. High humidity can also affect the cure of some coatings. Specifications often contain an 85 % upper limit. If it is suspected that the temperature and humidity conditions are such that moisture is condensing upon the surface, measure the relative humidity and dew point as described in 11.2.1.2.

8.4.1 When coatings must be applied in damp or cold weather, the substrate should be painted under cover, or protected from the surrounding air, and the concrete or masonry heated to a satisfactory temperature. The concrete should remain under cover until the applied coating is dry or until weather conditions permit its exposure in the open.

8.4.2 Newly applied coatings improperly exposed to freezing temperatures, excessive humidity, rain, snow, or condensation should be removed, the surface again prepared and painted with the same number of coats as the undamaged area.

8.5 *Wind*—The wind direction and velocity should be considered when applying coatings in areas where airborne overspray could damage automobiles, boats, and structures nearby. Heavy winds result in considerable loss of coating and excessive drying of the droplets reaching the surface. This results in an inability of the film to flow together (dry spray). If uncorrected, dry spray may create holidays leading to poor performance and it can interfere with adhesion of the applied or subsequent coat. Thinning with slower evaporating solvents may reduce or eliminate dry spray and produce a smooth surface. These problems can be avoided by utilizing brush or roller application methods instead of spray, scheduling the work at the less windy times of day, changing materials to the fast-dry types that do not adhere or damage adjacent property,

or scheduling the work when the wind is blowing in a direction where dry spray will not cause damage.

9. Coating Application

9.1 *Residual Contaminants*—Visually inspect the surface immediately prior to painting to ensure that spent abrasive, dust, and debris have been completely removed. Dust removal should be considered satisfactory when the path left by a gloved hand wiped over the surface is barely discernable when viewed from a distance 3 ft (1 m). During the inspection, also ensure that any oil or grease contamination that may have become deposited on the surface is completely removed.

9.2 *Quality Assurance*—The inspector should consult manufacturer's product data sheet and ensure that (*1*) coatings received meet the requirements of the specification; (*2*) they are properly mixed and thinned (where allowed); (*3*) colors match a visual standard provided; (*4*) that proper precautions have been taken to prevent damage to adjacent areas from cleaning and painting operations; (*5*) working practices are so scheduled that damage to newly applied coating is minimized; (*6*) application equipment (brushes, spray) is acceptable for type, cleanliness, and usability; (*7*) weather conditions are acceptable under the requirements of the specification; (*8*) field-testing equipment on hand is in satisfactory working order ready for use; and (*9*) only the methods of application permitted under the specification are used and that their use is in accordance with 9.3-9.6. SSPC-PA1 is a specification for application of coating.

9.2.1 *Film Defects*—All coats should have nearly smooth surfaces relatively free of dry spray, overspray, orange peel, fish eyes, pinholes, craters, bubbles, or other significant defects. Bleed-through, insufficient hiding, skips and misses are not acceptable. Runs and sags should be brushed out during application or removed by sanding if the coating has cured. Abrasive, dirt, or other debris that becomes embedded in the paint film should be removed prior to the application of subsequent coats.

9.3 *Brush Application*—Painting by brush should be done in a neat, workmanlike manner to produce a smooth coat as uniform in thickness as possible. The technique is from dry to wet, with the coating applied to the surface and spread back to the wet edge of the previous strokes. Coating should be worked into all irregularities in the surface, crevices, and corners. Runs, sags, or curtains should be brushed out. Surfaces that are inaccessible for painting with brushes and on which spraying is not permitted should have coating applied by means of sheepskin daubers.

9.3.1 Brushes should be of good quality with pliable bristles that are compatible with the coating and of suitable size to match the area being coated. They should not exceed 4 in. (100 mm) in width and bristle length should be no less than 3 ½ in. (90 mm). The brushes should be kept in a clean, acceptable condition when not in use. The inspector should prohibit the use of any brush not in an acceptable condition.

9.4 *Spray Application*—Spray application may or may not be allowed. The inspector should be familiar with the different kinds of spraying, which are compressed air spray, airless spray, air-assisted airless spray, electrostatic spray, and high volume low pressure spray.

9.4.1 The equipment should be suitable for the intended purpose, capable of properly atomizing the coating to be applied, and be equipped with suitable pressure regulators and gages. The equipment should be kept in a suitably clean condition to permit proper coating application without depositing dirt, dried coating, and other foreign materials in the film. The air supply for conventional and hot spray application should be free of moisture or oil. This can be verified by performing the white blotter test in Test Method D 4285. Airless spray equipment should be properly grounded. Any solvents left in the equipment should be completely removed before applying coating to the surface being painted.

9.4.2 Coating ingredients should be kept properly mixed in spray pots or containers during coating application, either by continuous mechanical agitation or by intermittent agitation. Coating should be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern should be adjusted so that the coating is deposited uniformly. During application the gun should be held at right angles (perpendicular) to the surface (not arced or fanned) and at a distance that will ensure that a wet layer of coating is deposited on the surface. The trigger of the gun should be released at the end of each stroke. Poor spray technique resulting in excessive overspray (a sand-like finish) should not be tolerated. All runs, sags, or curtains should be brushed out immediately or sanded out if the coating has cured.

9.4.3 Brush striping of edges and other vulnerable locations may be specified. Brush or sheepskin daubers are used to coat all areas inaccessible to the spray gun and brushes are used to work coating into cracks, crevices, and blind spots, which cannot be adequately spray painted.

9.4.4 Particular care should be observed with respect to type and amount of thinner, coating temperature, and operating techniques in order to avoid depositing coating that is too viscous, too dry, or too thin when it reaches the surface.

9.5 *Roller Application*—Rollers that are clean and of a material not soluble in the coating to be applied should be used. Roller covers are available in a variety of diameters, lengths, types of fabric, and fiber lengths. The nap (length) used generally varies from ¼ to ¾ in. (6 to 19 mm). The longer fibers hold more coating but do not provide as smooth a finish. Therefore their use is generally restricted to rougher surfaces such as the substrate and faster drying coatings. Short nap rollers give a smoother finish and are generally used for applying the top coat. There are also specialized rollers available for use on pipes, fences, and even pressure rollers that continually feed the coating to the roller cover.

9.5.1 The roller cover should be dipped into the coating until it is saturated and then rolled along the tray ramp until the coating is completely wetted in. The first load of coating on the roller should be applied to scrap material to force out air bubbles trapped in the nap. Proper roller technique requires application in the form of a *V* or *W* depending on the size of the area involved. The coating should then be cross-rolled to fill in the square created by the boundaries of the initial application. Only moderate pressure should be used as heavy pressure can

cause foaming and possible cratering by entrapped air. Application should be finished with light perpendicular strokes in one direction (usually vertical) to provide the smoothest, most uniform finish.

9.6 *Miscellaneous Methods*—Methods such as pads, mitts, and squeegees or trowels are used for specialized products or in situations where the conventional methods are not suitable due to the location or configuration of the work.

9.6.1 Painter's pads generally consist of a roller-type synthetic fabric attached to a foam pad. The size is generally 4 by 7 in. (100 by 175 mm) and the fiber length is 3⁄16 in. (5 mm). Application technique with a pad on large surface areas is similar to that used with a roller.

9.6.2 Painter's mitts are lamb skin gloves that are dipped into the coating and are rubbed across the surface. They are ideal for application of coatings to small, odd-shaped surfaces.

9.6.3 Squeegee or trowel application is generally used for heavy-bodied thick-film coatings that cannot be applied by spray.

9.7 *Rate of Application*—Properly written specifications require certain minimum and maximum dry-film thicknesses for each coat. The requirements should be augmented with wet-film thickness figures calculated from the composition of the coating so that the proper dry film thickness is obtained. (Equation shown in 7.3.3.2) It is useful to check wet film thickness as the work progresses to determine reasonably well that the desired amount of coating is being applied. Later, when the films are dry, the inspector may make spot checks with a dry film measuring gage to ascertain acceptability of the coatings. If a gage[9] is used, the cut must be repaired. Film thickness measurements are more informative than visual inspection, which may show only obvious nonuniform application. Instruments for measuring film thickness and the procedures for their use are described in 11.2.5. Thickness or coverage requirements apply to the whole structure, no some specific part. It is important that the painting inspector check all areas and determine the film thickness for each coat.

10. Additional Considerations

10.1 *Ventilation*—It is essential when performing surface preparation or painting in enclosed spaces that adequate ventilation is provided for removal of dust and solvents.

10.2 *Painting Schedule*—As indicated in 5.4, painting should proceed by sections, bays or other parts of the work, and each coat on each section should be applied entirely and accepted by the inspector before a succeeding coat is applied. Any thin spots or areas missed in the application should be repainted and permitted to dry before the next coat is applied.

10.3 *Film Integrity*—Each coat should be applied as a continuous film of uniform thickness free of holidays and pores. Any thin spots or areas missed in the application should be repainted and permitted to dry before the next coat is applied.

10.4 *Recoat Time*—Each coat should be dried throughout the full thickness of the film before application of the next succeeding coat. Coating is considered dry for recoating when the next coat can be applied without the development of any detrimental film irregularities such as wrinkling, lifting, or loss of adhesion of the previous coat. For most coatings the time to dry for recoat, even under optimum conditions varies with their composition and that of the subsequent coat. Thus, an oil-based coating may take 2 to 4 days to harden sufficiently to be overcoated with a coating of the same type. However, it may take 3 or 4 months to harden to be satisfactorily overcoated with a vinyl coating or other type of coating containing strong solvents. Some coatings may have maximum recoat times. The coating manufacturer's written instructions should be consulted for recoat times.

10.5 *Coating System Failure*—Failure of completed coating work may be the result of several factors. Most obvious is noncompliance with the specifications indicating insufficient inspections of the surface preparation, coating quality, coating application, or conditions during application and dying/curing. On the other hand, failure may be due to improper specification of coatings for intended use or improperly manufactured material. Defective coatings should be removed in their entirety, the surface recleaned, and the specified coatings, or their alternatives, applied.

11. Inspection Equipment

11.1 *General*—Visual observation is the most important part of inspecting coating application. There are, however, instruments and mechanical aids that are of considerable help to the inspector. They make the painter aware that his work can be checked during progress and even after completion. The different instruments that can be used are described in this section.

11.1.1 *Adhesion of Existing Coating*—The inspector should carry a pocket knife that can be used to determine the soundness of existing paint where there might be blistering or other defect. This is a subjective test and its value depends upon the inspector's experience.

11.1.2 *Portable Pull-Off Adhesion* testers are available as described in Test Method D 4541. The testers measure the force required to remove a metal stud that has been cemented to the coated surface. Scoring around the fixture may be required, especially for thick-film coatings.

11.2 *Field Inspection Equipment* in good working order should be available to the inspector so that he may perform his function properly.

11.2.1 *Drying and Curing Times*—These are both important considerations since dry time and cure time can both be affected. Minimum temperatures are required for reactive and waterborne coatings while too high a temperature can make application difficult or cause film defects such as pinholing. Moisture-cure urethanes require certain minimum humidity conditions for proper cure. The manufacturer's recommendations should be followed.

11.2.1.1 *Thermometers*—The paint inspector may need several types of thermometers and should have at least an accurate pocket thermometer with a range from about 0°F to 150°F (-18°C to 65°C) for measuring the air temperature. The same

[9] The sole source of supply of the Tooke gage known to the committee at time is Micro Metrics, P.O. Box 13804, Atlanta, GA 30324. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

thermometer or a floating dairy thermometer may be used to determine the temperature of liquid coating, solvent, etc. Flat surface-temperature thermometers are also available for measuring substrate temperature.

11.2.1.2 *Relative Humidity and Dew Point*—A psychrometer containing a wet and dry bulb thermometer for determining relative humidity and a dew point chart are useful inspection tools. Hand-held sling or electrical types are available as well as a direct reading digital type. Atmospheric conditions, including air temperature, relative humidity, dew point and surface temperature should be measured and recorded at the location where work is being performed.

11.2.2 *Coating Consistency* is an important characteristic as to whether a film of the proper thickness can be applied since durability is related to film thickness.

11.2.2.1 *Consistency Cups*—There are occasions, such as on-site thinning, when it is necessary to check paint consistency during field application. While giving only partial information about the viscosity of a coating, the Zahn cup is a portable device for checking quickly the approximate consistency of coatings and other liquids. It consists of a bullet-shaped, stainless steel cup with an orifice at the bottom. Attached to the cup is a looped handle with a small ring at the top to align the cup in a vertical position when withdrawing it from the liquid being tested. To operate, the cup is completely immersed in the liquid to fill it and is then withdrawn rapidly and completely. The time in seconds for the liquid to escape through the orifice is an expression of viscosity, that is, Zahn Cup No.___ ( ) seconds. It should be noted that Zahn cups are not suitable for all coatings and have poor reproducibility (agreement between different cups is poor—see Test Method D 4212).

11.2.3 *Weight-per-Gallon Cup*—There are times when the inspector may wish to check the weight-per-gallon of the paint in the field. If the value is low compared to the paint specification or manufacturer's data sheets, it indicates that the material may not have been properly manufactured or that unauthorized thinning may have been done, while differing values from the same container show that the coating has not been thoroughly mixed for application. The weight-per-gallon cup holds a given volume when filled at 77°F (25°C) or other specified temperature. It has a closely fitted lid with a small hole in it. In use, the cup is filled with a liquid slightly below the specified temperature. As the contents warm up, the excess escapes through the hole and is removed. The filled cup is wiped clean on the outside and weighed. A relatively inexpensive balance having a sensitivity of 0.1 g provides sufficient accuracy. The difference between the full and the empty weights (measured in grams) divided by 10 is the weight in pounds of 1 gal of the paint. Complete instructions for the procedure are given in Test Method D 1475.

11.2.4 *Wet-Film Thickness Gages*—This type of instrument is used to measure the thickness of a wet film of paint immediately after it is applied to a surface. Note that erroneous readings may result when using the gage on fast-drying paints such as vinyls. If a wet-film gage is used to determine the thickness of coats subsequent to the first, great care must be taken that partially hardened undercoats are not indented by the gage, thus giving high readings. If the coat being measured has an appreciable softening effect on the previous coat, a wet-film thickness gage cannot be used with accuracy. It is very important to record and retain test results.

11.2.4.1 *Interchemical Gage*—This instrument is rolled over the newly applied wet film on a *smooth* flat portion of the surface and the thickness read directly in mils (or micromets). Complete details are given in Method A of Test Method D 1212.

11.2.4.2 *Notched Gage*—This device has a series of calibrated steps for measuring thin to heavy coats. This gage with the proper face is placed squarely on the fresh, wet film. It is then withdrawn perpendicularly *without a sliding movement*. The true wet-film thickness lies between the highest step coated and the next highest which was not coated. The procedure is described in Practice D 4414.

11.2.5 *Dry-Film Thickness Gages*—Dry-film thickness measurements are of great importance because the protection of the substrate is directly related to the thickness of the coating. The test involves penetrating or cutting through the film to the substrate with a needle or blade and measuring by some means the distance between the top and bottom of the film. This type of gage destroys the film, necessitating touch-up with primer and finish. One kind of cutting gage is described in 11.2.5.1. Methods for nondestructive measurement of coating thickness are described in 11.2.5.2.

11.2.5.1 *Gage*[9]—The inspection gage is designed to measure coating film thickness by microscopic observation of a cut into the film. The tungsten carbide cutting tip is specially shaped to slice a precise narrow groove through a film into the substrate at an angle to the surface. Thickness of coating on any type of stable substrate may be determined and individual coats may be measured separately providing they are distinguishable, for example, by color. The coating cannot be too brittle or soft, otherwise the cutting tip will tear rather than precisely cut through the coating, making accurate readings impossible. Test Method D 4138 presents the procedure for using this type of gage.

11.2.5.2 *Nondestructive Film Thickness Gages*—are based on magnetism or on inductance and eddy currents. As concrete and masonry are nonconductive, these common gages do not work unless a metal plate is placed on the surface. Test Methods D 1186 and D 1400 describe procedures for calibrating and using nondestructive film thickness gages. There is a new coating thickness gage that uses ultrasonic principles for measuring dry film thickness over non-metallic substrates as described in Test Method D 6132.

11.3 *Discontinuity (Holiday) Tester*—Dry films may be tested for discontinuities (holidays) as described in Practice D 4787. This technique is best used over a continuous conductive. A high voltage spark tester may be used for coatings of 20 mils (510 μm) thickness or greater to check for cracks, holidays, pinholes, and internal voids as presented in Practice D 4767.

12. Keywords

12.1 abrasive blasting; acid treatment (concrete); adhesion; chemical cleaning; coatings; concrete; detergents; inspection; laitance; masonry; moisture

APPENDIX

(Nonmandatory Information)

X1. INSPECTION CHECKLIST

X1.1 The checklist in Fig. X1.1 lists the key elements to be used for inspection of industrial coating work. Many of the details covered may be in a specification for a particular project. A job specification for painting should include the coatings to be used. The various items are explained in detail in the text of this guide.

TASK			
I	*Surface Condition Examination:* 1. Laitance, form release agents, curing compounds 2. Grease, oil, or chalk 3. Mildew 4. Protective coverings in place	*Test Method/Equipment:* 1. Visual observation and touch 2. Visual observation and clean white rag 3. Visual observation and magnifying glass 4. Visual observation	*Comments:* Many materials if not removed from the surface will affect the life of the coating. These include oil, grease, soil, laitance, for release agents, and curing compounds.
II	*Environmental Conditions:* 1. Air temperature 2. Surface temperature 3. Wind direction, velocity 4. Dew point, RH 5. Visible moisture	*Test Method/Equipment:* 1. Air thermometer 2. Surface thermometer 3. Wind gage 4. Sling psychrometer 5. Direct observation	*Comments:* Environmental conditions must be within specified limits to obtain adhesion and proper film formation.
III	*Safety on the Job:* 1. Protective clothing 2. Respirator 3. Safety glasses 4. Ear protection	*References:* 1. OSHA Hazard 2. Communication standard 3. Product MSD sheets 4. Municipal, state and federal regulations	*Comments:* There are a number of hazards associated with any painting operation; safety regulations should be observed and unsafe conditions or practices should be reported promptly to management
IV	*Blast Cleaning:* 1. Type and size abrasive 2. Clean and dry abrasive 3. Compressed air check 4. Nozzle air pressure	*Test Method/Equipment:* 1. Sieve analysis and visual observation 2. Visual observation 3. White blotter 4. Pressure gage	*Comments:* Blast cleaning is used to remove foreign materials from the surface and to provide a roughened surface by means of a dry sand, grit, or shot blast impinging the surface with hard abrasive particles impelled by air (5.3.4). Precautions should be taken that blasting equipment is operated properly.
V	*Surface Preparation:* 1. Dust and abrasive removal 2. Degree of cleanliness 3. Moisture content 4. Acidity 5. Roughness	*Test Method/Equipment:* 1. Visual observation 2. A job standard should be developed to determine the appearance of the cleaned surface 3. Plastic sheeting or moisture meter 4. pH paper 5. 100-grit sandpaper	*Comments:* Surface preparation is one of the most important factors affecting the performance of paint. The texture of the surface has a significant effect on the performance of coatings since it increases the surface area to which the coating can develop adhesion.
VI	*Coatings Application:* 1. Time from surface preparation to application 2. Coating viscosity 3. Compressed air check 4. Protective coverings in place 5. Time application began 6. Surrounding air cleanliness 7. Continue to monitor temperature and humidity conditions 8. Correct coating and mixing procedure 9. Induction time observed 10. Proper agitation 11. Film thickness—wet—dry 12. Recoat Times observed 13. Intercoat Cleanliness 14. Film Defects, Voids, etc.	*Coatings Application:* 1. Record 2. Dip-type viscosity cup, Test Method D 4212 3. White blotter 4. Visual observation 5. Record 6. Visual observation 7. Psychrometer 8. Record coatings batch numbers mixing procedure 9. Visual observation 10. Visual observation 11. Film thickness gages 12. Record time application completed 13. Visual observation 14. Holiday detector	*Comments:* Many factors are important in ensuring proper application of coatings. The details are covered in this guide (Section 9). In particular, note: Dry-film thickness measurements are of great importance because the protection of the substrate is directly related to the thickness of the coating.
VII	*Recordkeeping:* 1. Record all details Applicator Manufacturer Batch No.'s Container condition 2. Record observations from Sections I, II, IV, V, and VI	*Test Method/Equipment:* Inspector's log book	*Comments:* Maintenance of a record book documentating all communications between the inspector and the contractor is essential to eliminate contract disputes. Details of the many steps involved in proper coatings application should be recorded (Section 4).

FIG. X1.1 Inspection Checklist