Chapter 4.4
Inspection of Mixing, Thinning, and Coating Application

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I. REFERENCES

American Society for Testing and Materials (ASTM)
ASTM D 4212 Test Method for Viscosity by Dip-Type Viscosity Cups
ASTM D 4285 Method for Indicating Oil or Water in Compressed Air
ASTM D 4414 Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages
ASTM E 337 Test Method for Measuring Humidity with a Psychrometer (The Measurement of Wet- and Dry-Bulb Temperatures)
SSPC: The Society for Protective Coatings (SSPC)
SSPC-PA 1 Shop, Field, and Maintenance Painting
SSPC-PA Guide 4 Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems
SSPC-PA Guide 5 Guide to Maintenance Painting Programs

II. INSPECTION OF MIXING

The inspector should verify that all coating materials are properly mixed. SSPC-PA 1 and the sections following provide some general guidelines for mixing of paints.
More specific mixing instructions for specific coatings should be obtained from the manufacturer’s instructions.

A. SINGLE COMPONENT MATERIALS

All coatings should be completely mixed in clean containers before use. Where there is noticeable settling, and mixing is to be done either by power stirrers (Figure 4-39) or by hand, most of the paint should be poured off into a clean container. The settled material should first be lifted from the bottom of the container with a clean, flat paddle. Lumps should then be broken up and the settled material thoroughly mixed with the remaining material. The separated portion should then be returned slowly to the original container with simultaneous stirring. At this point, it may also be useful to mix or pour repeatedly from one container to another (boxing) until the composition is uniform. When power mixing water-borne coatings, care must be taken not to cause foaming by overmixing.

The bottom of the original container should be inspected for unmixed solids. If all such solids cannot be uniformly mixed in, it is an indication that there is something wrong with the material (e.g., it might have exceeded its shelf life), and it should be properly discarded. The inspector should ensure that a homogeneous blend is used. Color variation from that specified may be a problem with older coatings. The inspector should check to see that color variations do not occur.

B. MULTIPLE COMPONENT MATERIALS

Many materials such as zinc-rich primers and chemically-curing epoxies, and polyurethanes are manufactured with more than one component. They require mixing of precise proportions prior to application to obtain optimum film properties (Figure 4-40). In all cases, the manufacturer’s mixing instructions should be followed. It should be noted that with some products, hand mixing is unacceptable.

For mixing of multi-component materials, the inspector should:

- Verify that the proper components are mixed. Mixing of components from different coating products will result in an improper or incomplete cure.
- Verify that the proper proportions are mixed. It is good practice to mix complete kits (as packed by the manufacturer) rather than measuring out partial amounts. However, if only partial kits are necessary, they should be mixed carefully, using a measuring device or scale to ensure proper proportions. It is good practice to have a few small kits available when small quantities are required.
- Verify that each component is mixed individually prior to mixing the components together. All settled materials should be uniformly dispersed.
- Verify that all of the materials are uniformly blended. This may require the applicator to scrape material from
the sides or bottom of the cans. Materials with heavy pigments (e.g., zinc) usually require constant agitation during application. Whenever in-pot agitators are required, the inspector should verify that they are in place and working.

- For chemically-curing materials, verify that the proper induction time (if necessary) is observed. Induction time is the period of time required after mixing and before application. This time allows the components of the material to partially react before application to ensure complete film curing after application. The inspector should also verify that the material is homogeneous (and re-mixed, if necessary) at the completion of induction time.

III. MEASURING VISCOSITY

The viscosity of a paint (its ability to flow) is affected by temperature. As temperature decreases, viscosity increases, and the paint’s ability to flow diminishes. Thus, at low temperatures, thinning may be necessary to achieve a viscosity that will permit proper application.

The inspector should measure the viscosity of the paint before use, if required by the specification, or if viscosity is of concern due to weather conditions (e.g., during cold weather) or other circumstances. In the field, this can be done using a viscosity cup (ASTM D 4212; see Chapter 8, Figure 4-41). The manufacturer’s instructions for thinning should be followed.

IV. MONITORING MATERIAL THINNING

The inspector should verify that all coating materials are properly thinned. SSPC-PA 1 and this section provide some general guidelines for thinning of paints. More specific thinning instructions for specific coatings should be obtained from the manufacturer’s instructions.

Some job specifications do not permit field thinning of coatings. Others permit thinning with the specified thinner in limited amounts, under specified conditions, e.g., when cold weather increases the viscosity, making application difficult. Likewise, if the substrate is hot, it may be permissible to add a high flash point thinner for slower evaporation and reduced mud cracking.

When a coating material is thinned, the inspector should verify that the specified or recommended thinner is used. The inspector should also verify that the amount of thinner added does not exceed specifications, and that the thinner is added in measurable quantities (e.g., quart cans). Also, the amounts of thinner used should never cause the coating to exceed VOC limitations.

Before thinning, both the coating and the thinner should be allowed to reach the ambient temperature at which the material is to be applied. The thinner should be added into
the mixed coating material, and the thinned coating should be mixed to a homogeneous state before it is applied.

V. MONITORING STRAINING

The inspector should observe that all materials are strained per the manufacturer’s instructions or whenever lumps are observed (Figure 4-42). The strainers should be of a type to remove only lumps, etc., but not remove pigment. For example, a 30-60 mesh strainer is normally satisfactory for most coatings. (However, with high-performance flake-filled coatings, large flakes must remain to provide permeation resistance and other desired properties of the cured film.)

VI. ENSURING THAT COATING MATERIALS DO NOT BECOME CONTAMINATED

The inspector should verify that all necessary precautions are taken to avoid contamination of the coating materials. For example, for paints, the inspector should:

- Verify that lids are kept on mixed material to avoid dirt contamination prior to application.
- Verify that the open portions of buckets (e.g., in the case of airless spray application) are covered with cheesecloth.
- Observe that mixing equipment is cleaned with solvent or by mechanical methods at least after each day’s use, and that waste solvent used in cleaning is properly disposed of.

VII. INSPECTION OF COATING APPLICATION EQUIPMENT

The job specification usually permits the contractor to choose his own method of coating application, as long as the specification requirements are met. In some instances, special equipment may be required. The inspector should check to see if the application equipment is clean and has the ability to apply the materials to be used. Further instructions for inspecting conventional coating application equipment are given in the sections that follow. Also, some instructions for inspection of specialty coating application equipment (e.g., shotcreting, thermal spray, and powder coating equipment) are given in Chapter 5.

VIII. INSPECTION OF COATING APPLICATION METHODS

A. GENERAL REQUIREMENTS

The inspector should verify that all coating materials are properly applied. The sections below provide some general guidelines for application of paints. SSPC-PA 1 is also a useful general reference for the coatings inspector. It includes a discussion of the factors affecting paint application, and a description of many recommended application methods. More specific application instructions for paints and other types of conventional coatings should be obtained from the manufacturer’s technical data sheets.

- Monitor ambient conditions, as described in Chapter 4.1 Section IX. Verify that ambient temperature, surface temperature, relative humidity (ASTM E 337), and wind are in conformance with the job specification. For chemically-curing materials, also verify that the induction time is met and the pot life (useful life) of the material is not exceeded. The manufacturer’s technical data sheets specify pot lives of mixed multiple-component materials at specific temperatures. Pot life decreases at higher temperatures and increases at lower temperatures. The temperature of the mixed multiple-component material should therefore be measured and the manufacturer’s technical data sheet should be consulted to establish the pot life. Larger amounts of the mixed product will also reduce pot life because of the heat of reaction.

FIGURE 4-43. Monitoring spray application. SSPC file photo.
Monitor the application process to assure material is being applied in a smooth, continuous film of uniform specified thickness, and free of dryspray, runs, sags, or other application related defects (Figure 4-43). For coating materials that require in-pot agitation, also verify that coating materials are agitated sufficiently (if specified) during application to ensure homogeneity without overmixing. Overmixing may entrap air.

Measure (or assist/observe the applicator in measuring) wet film thickness to determine whether expected dry film thickness will meet specification requirements (discussed further in Section D, below).

Throughout the application process, the inspector observes the work and records what is observed. The inspector does not usually have the authority to interfere with the applicator’s work, i.e., he cannot require the applicator to change his technique, unless required by the job specification. The inspector’s main concern is that the end product meet all requirements. This is because specifications usually require a defined end product (e.g., dry film thickness) rather than a means of achieving it. Thus, he may advise the applicator that low wet film thicknesses may result in low dry film thicknesses.

B. APPLICATION BY BRUSH OR ROLLER

When the coating manufacturer recommends specific application equipment for brushing or rolling (Figure 4-44), its use should be verified by the inspector. The inspector should:

- Verify that brushes and rollers are the type and size recommended by the coating manufacturer, and are appropriate for use on the areas being painted. Special shaped brushes may be required for special applications, e.g., round/oval brushes may be required for rough surfaces, rivet heads, and constricted areas. Long nap rollers may be required for open work such as grills and cinder blocks. Also, the inspector should verify that the cores of rollers are compatible with the paint.
- Verify that brushes and rollers are clean and in good condition. Loose bristles and debris should be removed from brushes before they are used. The nap should be raised on rollers before they are used.
- Verify that the recommended amount of paint is applied to the brushes and rollers. Rollers should be loaded with paint then rolled out completely on newspapers (or the spreader screen, if used) to condition the fibers and to work out air bubbles.
- Verify proper techniques for coating outside and inside corners.

When application is performed using conventional spray (Figure 4-45) the inspector should:

- Verify that the particular tip sizes recommended by the coating manufacturer are used
- Verify by the blotter test (ASTM D 4285) that the air used for conventional spray, is free of oil and moisture. (For more details on this test, see Chapter 8.)
- Verify that two operating pressure regulators are present so that the pot pressure and atomization pressure can be independently adjusted.
- Verify (by checking the spray pattern) that pot pressure is sufficient to obtain adequate material supply at the spray gun.
• Verify that application conditions result in a uniform, continuous film free of defects.
• Verify use of proper overlapping and crosshatching techniques.
• Verify proper techniques for coating outside and inside corners to obtain uniform coating thicknesses in these locations.
• Verify that a material agitator is used where required by the specification or coating manufacturer.
• Verify that proper triggering, 50% overlap of strokes, and uniform distance from substrate (no arcing) is used to obtain uniform coating thicknesses.

D. APPLICATION BY AIRLESS SPRAY

When application is performed using airless spray (Figure 4-46), the inspector should:
• Verify that proper pump, pressures, and hose and tip sizes (as required on the manufacturer’s technical data sheet) are used.
• Verify that the pump pressure gages are in working order and the pressure relief valves are unrestricted. The pump should measure the air pressure in and the fluid pressure out.
• Verify that application conditions result in a uniform, continuous film free of defects.
• Verify that the applicator has not attempted to coat complicated areas such as bolt patterns. (Note: Conventional spray should be used to coat these areas.)
• Verify use of proper overlapping and crosshatching techniques.
• Verify proper techniques for coating outside and inside corners to obtain uniform coating thicknesses in these locations.
• Verify that a safety guard is used on the spray gun.
• Verify that proper triggering, 50% overlap of strokes, and uniform distance from substrate (no arcing) is used to obtain uniform coating thicknesses.

E. TROWEL-APPLIED COATINGS

For trowel-applied coatings (Figure 4-47), the inspector should:
• Verify that aggregates/fillers are completely wetted out.
• Ensure that adequate thickness is installed over welds and projections, and that uniform thickness is applied.

For fiberglass-reinforced, troweled linings, the inspector should:
• Ensure that fiberglass reinforcements are properly impressed in the basecoat to eliminate air pockets or wrinkles.
• Verify that fiberglass reinforcement is properly saturated. When properly saturated, fiberglass takes on the color of the saturant resin with no “white” showing. It is easiest to detect imperfections when clear saturant resins are used.
• Verify proper lapping of fiberglass sheet. Lap is normally 1 inch to 2 inch minimum.

IX. INSPECTION OF PRIMER, INTERMEDIATE COAT, AND TOPCOAT APPLICATION

A. PRIMER COAT APPLICATION

The inspector should verify the following conditions prior to primer coat application:

• The surface has the specified surface preparation (roughness and cleanliness), and is free of contaminants. A test for soluble salt contaminants is often performed after the steel has been prepared by blast cleaning.
• The specified time range has been observed between application of any chemical treatment (e.g., pretreatment wash primer) and application of the prime coat. This is necessary for complete chemical reaction of the pretreatment and tight adhesion of the primer.

B. INTERMEDIATE COAT OR TOP COAT APPLICATION

The inspector should verify the following conditions prior to intermediate coat or top coat application:

• The previous coat should be free of unacceptable defects such as dryspray, runs, sags (Figure 4-48), and other application-related defects. Also, the surface should be free of contaminants. A test for soluble salt contaminants is often performed after the steel has been prepared by blast cleaning. However, if a long interval occurs between coating layers, it may be advisable to check for contaminants on the existing coating to be overcoated.
• The previous coat should be dried or cured for the time required by the specification. (Information on testing for degree of cure is given in Chapter 4.5, Section V and in Chapter 8.)
• If the undercoat is a two-component, chemically-curing material, the overcoat should be applied within the recoat window time specified by the supplier of the undercoat.
• The dry film thickness of the previous coat should meet the requirements of the job specification. (See Chapter 4.5, Section II.)
• Each coat should completely obscure the previous coat. (Normally the colors are at least slightly different and contrasting.)

X. REQUIREMENTS FOR MAINTENANCE PAINTING

Specific guidelines for maintenance painting (Figure 4-49) are contained in and SSPC-PA Guide 4, “Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems” and SSPC-PA Guide 5, “Guide to Maintenance Painting Programs.”

According to Guide 4, the basic steps for maintenance repainting of oil-based, alkyd, and other conventional oleoresinous paint systems are:

• Determine the surface condition and recommended actions according to Table 1 of Guide 4.
• Choose the repainting system; spot test for compatibility with existing system, if necessary.
• Apply paint and touch up according to established procedures (SSPC-PA 1).
• Perform required inspection and testing of applied film and, if required, sampling of the paints used.

Guide 5 covers procedures for planning and carrying out a maintenance painting program. It applies to either one-time repaint or long-range repaint programs. Guide 4 covers the repainting of steel with the same generic paint system as the existing one. It applies to oil-based, alkyd, and other conventional oleoresinous paint systems.

According to Guide 5, the eight major tasks in maintenance painting are:

Task 1: Define Maintenance Painting Objective
Task 2: Plan and Conduct Condition Assessment
Task 3: Determine Corrective Action Required
Task 4: Establish Procedures for Corrective Action
Task 5: Prepare Contract
Task 6: Secure Contracts for Labor and Materials
Task 7: Monitor, Conduct, and Inspect Repainting
Task 8: Plan and Implement Follow-Up Activities

Task 7, “Monitor, Conduct, and Inspect Repainting,” includes a useful summary of the inspector’s general responsibilities during maintenance repainting. Other sections may also be of interest to the inspector. For example, Task 6, “Secure Contracts for Labor and Materials,” includes some information on the pre-job conference; and Appendix A to SSPC-PA 5 describes a procedure that can be used to determine the compatibility of new paint over existing paint.

During maintenance painting, the coating inspector’s basic responsibility is the same as for new construction painting: Verify compliance with the specification. However, some of the additional procedures that the inspector may be required to verify prior to maintenance painting are:
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- Verify that all loose, cracked, brittle, and non-adherent paint is removed.
- Verify that all rust spots and damaged areas are cleaned, with cleaning extending out far enough on all sides so that tightly adherent paint will be overlapped.
- Verify that all exposed edges on remaining thick paint are feathered to the extent required by the specification.

XI. WET FILM THICKNESS MEASUREMENTS

Wet film thickness (WFT) measurements (Figure 4-50), in conjunction with the known percent volume solids of the coating material, can be used to determine if the proper dry film thickness of each coat of material is being applied.

The wet film thickness gages most commonly recommended for field use are the notch type. Most of them consist of a four-sided metal plate with “teeth” of varying heights cut into each edge. To make a measurement, the edge that includes the desired wet film thickness is pressed onto the surface, and wet film thickness is determined by identifying the shortest tooth wet by the paint film.

**FIGURE 4-50.** Wet film thickness (WFT) measurement. Copyright Brendan Fitzsimons, 1996. This illustration is taken from the Painting Inspectors Manual (now called the Protective Coatings Inspection Manual) published by Elcometer Instruments Ltd.

Important precautions when making wet film thickness measurements are:
- Use gage immediately after paint application.
- Test flat areas if possible. For curved surfaces, test along the length, not the width.
- Test smooth surfaces (free from irregularities).

Several areas should be checked for WFT. Also, it should be noted that using a wet film gage on “quick drying” coatings (inorganic zinc, vinyls, etc.) will yield measurements that are somewhat lower than the actual WFT. The detailed procedure for the notch type wet film gage is given in Chapter 8 and in ASTM D 4414.

The manufacturer will often list the desired WFT as well as the DFT on the application instructions. However, if this information is not readily available, or if the coating has been thinned, the WFT necessary to produce a certain DFT can be calculated from the formulas below.

A. WITHOUT THINNING

\[
WFT = \frac{DFT}{\% \text{ Solids by Volume (in decimal form)}}
\]

For example, if the desired dry film thickness of a coating containing 50% solids by volume is 3 mils (76 micrometers), the wet film thickness must be:

\[
WFT = \frac{3 \text{ mils}}{0.5} = 6 \text{ mils (152 micrometers)}
\]

B. WITH THINNING

\[
WFT = \frac{DFT}{\% \text{ Solids by Volume (in decimal form)}} \times (1 + \% \text{ by volume of thinner added (in decimal form))}
\]
For example, if the above paint is thinned 10%, the wet film thickness must be:

\[
WFT = \frac{3 \text{ mils}}{0.5} \times (1 + 0.1) = 6.6 \text{ mils}
\]

\[
= 168 \text{ micrometers}
\]

XII. SUMMARY

The inspector should monitor the mixing and thinning of paint that is to be applied to concrete and steel surfaces. For single component materials, the inspector should verify that any settled solids are uniformly mixed into the liquid portion. For multicomponent materials, the inspector should verify that the components are mixed according to the specification and the manufacturer’s instructions. This entails verifying that:

- The proper components and the proper proportions are mixed.
- Components are mixed individually before being combined.
- The combined material is mixed.
- The proper induction time is observed.

As required, the inspector should measure the viscosity of the paint and monitor any thinning that is necessary. He should make sure that the paint is strained per the manufacturer’s instructions and that precautions are taken to avoid contamination of the coating materials.

Paint systems generally include primers, intermediate coats, and top coats. During application of all coats, the inspector has the following responsibilities:

- Monitor ambient conditions
- Monitor the application technique
- Measure or assist in measuring the wet film thickness to determine what the dry film thickness will be. The dry film thickness can be calculated from the wet film thickness, the % solids by volume of the paint, and the amount of thinning.

Depending on whether the paint is being applied as a primer, intermediate coat, top coat, or for maintenance, the inspector may be assigned additional responsibilities by the specification, e.g., for verifying that surfaces are properly cured and free of contaminants.

Coatings may be applied to concrete and steel structures by several techniques, such as:

- Brush and roller
- Conventional spray
- Airless spray

For all application methods, the inspector should verify that the application equipment is as specified, clean, and suitable for the materials and surfaces to be coated.