PAINTING INSPECTION

All coating of structural steel, which is incorporated into the work, shall be manufactured in the USA.

I. PAINTS

A. Zinc-silicate Primer

1. General: Zinc-silicate is the name used by the Iowa DOT for paints known in the industry as self-cured, inorganic zinc-rich primers. These coatings are noted for their excellent corrosion protection of steel and abrasion resistance and are considered to be as close to a permanent primer as is now available. They are also currently considered to be environmentally acceptable.

2. Composition: Zinc-rich coatings can be divided into organic or inorganic classes according to the resin or binder used. The organic coatings have organic binders (carbon-based compounds) such as linseed oil, epoxy resins, vinyl resins, etc. The inorganic coatings have binders consisting of compounds based on substances other than carbon such as silica. The pigment used in both classes is metallic zinc and the solvents used in zinc-silicate paints are alcohols or similar liquids and water in the case of waterborne zinc-silicate.

3. Specified Types: Specifications allow the use of only multi-component types. The two-component type is supplied with the pigment packaged separately to be mixed at the time of application. The pot life varies with temperature and is usually about eight hours at 77°F.

4. Characteristics:

   a. A solvent-borne zinc-silicate film does not dry in the usual sense but cures to a hardened state by reacting with moisture in the surrounding air. When the film is applied, the solvents evaporate rapidly and the film appears to be dry. At this stage, the binder has not cured and the film can be easily removed. The time required for thorough curing depends on the ambient temperature and relative humidity. The paint film must be thoroughly cured before it is Topcoated. (See Section B under "Paint Applications" for the test to check curing.)

   b. The cured zinc-silicate film is not continuous but is an open lattice network, which allows electrical, contact between zinc particles and between zinc and steel. The zinc can thus sacrifice itself for the steel without disturbing the integrity of the coating. This porous film will not blister or peel because it allows free transfer of air and vapors. However, bubbling of a topcoat can occur if air or vapors are entrapped in the film.

   c. A zinc-silicate film without topcoat will form deposits of white zinc salts on the surface when the film is allowed to weather for an extended period of time. These salt deposits slow down the further sacrifice of zinc but must be removed, if excessive, to obtain adhesion of the topcoat.

d. Intercoat adhesion between two coats of solvent-borne zinc-silicate paint is marginal because a cured film can absorb the binder of a second application so that adhesion will not occur. It is necessary to thin the primer (up to two quarts per gallon) before using it for a second application. The additional coat should be applied as soon as practical, not later than 24 hours.

ZINC-SILICATE PAINTS - A Historical Overview

Zinc coatings are considered one of the most effective ways of protecting steel products. Hot dip galvanizing for which a major amount of the zinc produced is being used was developed in France in the 1840s.

It was not until 1940s & 1950s that the beneficial effects of galvanizing could be applied to existing large structures when zinc-silicate coatings were introduced.

Zinc is a metal with unique properties. It is lighter in weight than iron and is more electrochemically reactive than iron, so zinc can protect the iron by sacrificing itself under corrosive conditions. This metal can also be melted and distilled under reducing conditions to form a pure fine metallic powder. This fine zinc powder is the main constituent of most zinc-rich coatings.

In the 1930s Victor Nightingale, the Australian inventor of inorganic zinc-rich coatings, mixed zinc dust with sodium silicate solution and applied it to cleaned steel and baked it to get a cure. He made more modifications to his formulation and applied this coating to a 250-mile long pipeline in Australia, which is still performing well today.

The baking or stoving process was not too practical and had to be eliminated. By the 1950s the chemistry of silicon compounds was understood quite clearly. So in 1952 new post-cured, inorganic, zinc coating was introduced which used an alcohol solution of dibutyl amine phosphate as a post-cure to a zinc-filled sodium silicate. This two-step process also had to be improved and further research brought forward the self-cured, inorganic, zinc coatings.

In this category two types of inorganic Zinc-silicate coatings were developed:

1. Solvent-borne: Ethyl silicate-based

2. Waterborne: Alkali silicate-based

Solvent-borne Zinc-Silicate:

The approach taken in this coating was using ethyl silicate as a binder for the zinc and applying it from an organic solvent in place of water. Most of the solvent-based inorganic Zinc-silicate coatings in the 1960s and 1970s used this technology. Another approach during the same period was the alkaline hydrolysis of ethyl silicate. Some of these types of coatings are still in use today. Further research with ethyl silicate produced the single-package, inorganic, Zinc-silicate. Later in the 1970s and early 1980s, further developments in ethyl silicate technology took place, which improved the application properties of the inorganic zinc-silicates.

Waterborne Zinc-Silicate:

In the last 20 years, the environmental laws have restricted the use of Volatile Organic Compounds (VOCs) and the laws are expected to become stricter in the future. VOCs react photo-chemically with oxides of nitrogen in the atmosphere to produce ozone, causing environmental problems.

Any coating containing solvents has become suspect and so VOC-compliant ethyl silicate-based products have been required. One of the most recent developments in the inorganic Zinc-silicate field has been the product originally developed by the NASA personnel at Cape Canaveral. It is based primarily on potassium silicate with silica to potassium ratio increased from 3.2:1 to 5.3:1. This is achieved by processing commercial potassium silicate to raise the silica content to the 5:1 ratio or better. The higher ratio silicate has increased the number of reactive groups (OH) all of which can react with metallic zinc to form a saturated zinc-silicate polymer. The reaction to insolubility and cure to saturation is quicker than coatings using the lower silica to alkali ratio. The small amount of potassium is removed by carbon dioxide in the air forming potassium carbonate. This higher reactive area on the molecule gives the coating its rapid insolubility, fast cure, quick metallic hardness, strong adhesion and rapid overcoat time.

We approve only one type of zinc-silicate paint for Iowa DOT use, namely multi-component, low VOC (less than 3.5 lbs./gal.), solvent-borne zinc silicate.

B. Waterborne Acrylic Topcoats for Zinc-silicate Primers

With the growing concern over pollution of the atmosphere and environment and the cost of disposal of solvent-based coatings containing lead and chromate pigments, the Iowa DOT has decided to use waterborne acrylic topcoats on zinc-silicate primers from the 1992 painting season.

Waterborne acrylic paints have been available for some years now and have proved to give equal or better performance compared to most solvent-borne topcoats. These waterborne acrylic paints do not use lead or chromate pigments and are VOC-compliant.

C. Aluminum-Filled, High-Solids, Epoxy Paints

The third group of paints we use on our bridges is the aluminum-filled, high-solids, epoxy paints. They are used as the primer in spot painting and as a two-coat system in repainting some of our older riveted truss bridges, where a good near-white abrasive blast cleaning is hard to achieve. Unlike the zinc-rich primers, the aluminum-filled, high-solids, epoxy paints give the steel a barrier protection by insulating the steel from the corrosive agents in the environment. The aluminum pigment, which is in the form of platelets, gives the paint film the ability to reflect away ultraviolet radiation and improve film durability. These paints usually have a very high solid content and hence low VOC content and adhere easily to reasonably prepared surfaces. The main concern while using this type of product is its tendency to be carried over long distances in the air causing oversprays problems. We have had good corrosion protection performance in the past using this paint.

There are two types of aluminum pigments used in this type of coating. A leafing type of aluminum pigment is specially treated to retard its wetting properties in the paint vehicle; hence it tends to float up to the outer surface of the paint film whereas the non-leafing pigment tends to be uniformly distributed within the paint film. In the case of a high-solids epoxy paint, because of the high viscosity involved, property difference between leafing and non-leafing pigments is greatly reduced as the leafing pigment does not get much of a chance to float up to the top. These paints can also be tinted to differentiate between coats.

D. Acceptance Procedures

1. General: Paints are accepted for project use on the basis of certification from an approved supplier. Office of Materials IMs cover acceptance procedures and include a list of approved suppliers, which is updated periodically. A copy of the relevant IMs should be requested from the Office of Materials.

2. Information Required for Acceptance: Project numbers and the name to which the paint was shipped, as given on certifications, may not correspond to the project being inspected because of paint stock transfers, etc. Therefore, paint may be accepted for project use if the batch numbers to be used are covered by any shipment certification from an approved supplier.

3. Obtaining Certification Copies: A master file of all paint certifications is maintained at the Central Laboratory in Ames, Iowa. Copies are available upon request, if needed, by providing the name of the paint manufacturer and batch numbers.

4. Using Paint Without Certification: Batch certifications are not always immediately available at the time the contractor wishes to begin painting. Painting can be allowed in this situation, if the paint is from an approved supplier and the contractor understands that applied paint found not acceptable must be removed. The Central Materials Office should be notified so that certifications covering the paint can be obtained as soon as possible.

E. Sampling

1. Required Samples: Sampling in the field is unnecessary unless paint appears questionable in some respect. Monitor sampling and testing is scheduled and handled by Central Laboratory Personnel.

II. SURFACE PREPARATION

A. Purpose

Steel surfaces are cleaned prior to the application of paints to obtain the best performance of the coatings consistent with the economics of expected exposure and preparation costs. Complete removal of all foreign matter is expensive and is not normally required for good performance of coatings on highway bridges.

Zinc-silicate paints in general require a good grade of cleaning and extra care should be taken to see that the substrate is sufficiently prepared as required in the specification. Epoxy mastic primers in the field can tolerate less stringent surface preparation and hence they are used where high-grade surface preparation is hard to achieve.

B. Cleaning Methods

The Steel Structures Painting Council (SSPC) classifies and specifies the different methods and grades of surface preparation achieved in their Standard Specifications for surface preparation.

SSPC descriptions of various cleaning methods appear in the Appendix.

1. Solvent Cleaning (SSPC SP-1)

   a. This method includes wiping surfaces with a solvent-soaked rag and the use of high-pressure water. It is used to remove dirt, salt, deposits, grease and other similar contaminants. Solvent cleaning should precede blast cleaning to remove heavy grease deposits or if the abrasive is re-circulated.

   b. Petroleum solvents or chlorinated hydrocarbons are commonly used to remove grease and oil. The rags and solvents should be clean to avoid spreading these contaminants on the surface.

   c. High-pressure water may be used to remove dirt and salt deposits. If detergent or soap is used, any residual soap film must be removed.

2. Hand and Power Tool Cleaning (SSPC SP 2 & 3)

   a. This method includes the use of wire brushes, scrapers, grinders, etc. Its use is limited to small areas for touch-up cleaning or repair work. Abrasive blasting is preferred, even for small areas, but practicality may dictate hand tool use.

   b. Wire brushes and scrapers are used to remove loose rust, zinc salt deposits, or poorly bonded paint.

   c. Grinders are used to remove mill scale from small areas protected by holding devices during blast cleaning or to remove small defects on the steel surface that are exposed by the blasting process. The ground surface should be rough to allow adhesion of the primer.

3. Abrasive Blast Cleaning

   Abrasive blasting is the most widely used method of surface preparation for steel bridges. SSPC specifies four grades of cleanliness using the abrasive blasting technique. They are:

Brush off Blast SSPC SP 7
Commercial Blast SSPC SP 6
Near White Blast SSPC SP 10
White Metal Blast SSPC S.P. 5
(See Appendix for definitions.)

a. This method involves propelling abrasives at the surface with a centrifugal wheel or by air blast. It is used for the overall cleaning of the steel in preparation for the prime coat and may also be used for touch-up cleaning and repair work. The abrasive used includes sand, minerals, slags, and steel or iron shot and grit.

b. Slag and mineral abrasives are usually used on field projects, depending on environmental regulations.

c. Grit and shot are used mostly in the fabricating shops or where recovery is possible. Grit provides a rough sharp, angular profile on the steel surface to which the primer can best adhere.

d. Shot has more impact power than grit and is often added to grit to aid in mill scale removal. New shot must not be used alone because the spherical shape tends to produce a peened surface to which the primer will not adhere.

C. Cleaning for Primer Application

1. General: Zinc-silicate paint requires an abrasive blast cleaned surface to obtain good adhesion and effective corrosion control. Adhesion depends not only on removing non-adherent or incompatible contaminants, but also on providing a surface to which the film can mechanically bond. To provide cathodic protection, the zinc must be in intimate contact with the steel, so most of the contaminants should be removed.

   Cleaning of new steel in the fabricating shops is usually excellent because of the surfaces of new steel are more uniform and most shops use the centrifugal wheel equipment. The surfaces on existing structures, however, vary considerably in the amount of corrosion that may be present and also involve removal of old paint. Uniform inspection on different structures that is carried out to the letter of the specification is, therefore, difficult to attain. Each situation must be judged separately with the primary considerations of obtaining a surface to which the primer can adhere and provide protection.

2. Specified Cleaning: The preparation required for different primer application is usually specified in the respective painting specification. Copies of the current set of painting specifications should be referred to. The required degree of cleaning is referenced to the corresponding SSPC cleaning specifications SSPC SP10 (Near White)

"Near-white" blast cleaning is a method of preparing steel surfaces which, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, and paint. Generally, evenly dispersed very light shadows, streaks, and discoloration caused by stains of rust, stains of mill scale, and stains of previously applied paint may remain on no more than 5% of each square inch of the surface.

3. Applying the Cleaning Definition: Describing a degree of blast cleaning that calls for less than complete removal of foreign matter is difficult because the descriptive terms are necessarily relative. The judgement decisions required to apply such a definition can therefore lead to misunderstandings. The following comments concern application of the cleaning definition:

   a. The foreign matter remaining on the cleaned surface should be slight. The shadows, streaks, and discoloration referred to are all very thin residues of contaminants that remain after removal of rust, mill scale, or old paint.

   b. All old paint must be removed except for the slight residues allowed in the definition. These residues should be limited to those remaining in the bottom of the surface profile pits. Zinc-silicate paint will not adhere to any smooth surface such as an old paint film.

   c. An objective method of measuring the amount of surface that complies with the 5 percent requirements is not available. The percentage must be determined by a visual estimate made from an overall view of the surface. This judgement cannot be made with exactness, but it is intended that the slight amounts of foreign matter remaining should be distributed uniformly over the surface and not concentrated in any area.

   d. The color and sheen of a prepared surface will not normally be uniform. The natural color of the blasted steel may vary, may be changed by the abrasives used, and a bright blasted surface may dull rapidly. Discoloration due to rust stains or old paint residues can usually be distinguished by their specific colors, while mill scale oxides appear as dark or black spots.

   e. Photographic standards are helpful when the standard photo is carefully compared with photos showing bracketing grades of cleaning. Their practical use is somewhat limited, however, because they cannot show all situations that may occur.

   f. Old paint on existing structures should be allowed to remain in the cracks between steel members such as a rivet head and a plate or between a splice plate and web. This may not always be possible, but any old paint remaining in the crack will help maintain a seal.

4. Surface Profile Height

   a. Profile height is the distance between the high and low points (peaks and valleys) of a blast-cleaned surface. If this dimension is too small, the primer may not bond. If it is too large, the possibility of a thin film over the peaks is increased.

   b. A nominal profile height of 1.0 to 2.5 mils is specified to indicate the minimum height for good primer adhesion and that a low profile is desirable. In practice, however, a profile height less than 1.0 mil is difficult to attain and a reasonable height over 2.5 mils is of little concern if the film thickness is as specified. Profile height measurements are therefore not recommended except in unusual circumstances.

   c. The dry film thickness measured by magnetic gauge is indicative of the thickness of the film over the profile peaks of average height. The possibility of a film thin enough to allow rusting, even on the highest peaks, is minimal if proper thickness measurements show compliance.

   d. A high profile will require the painter to apply more paint to obtain the specified film thickness. Paint quantities figured on the basis of a smooth surface will not be adequate.

5. Cleaning After Blasting: Dust, abrasives, and other loose blast products should be removed from the surface with brushes, compressed air, or by vacuum before primer is applied.

D. Cleaning the Primer Film

1. Primer Film Build-Up: When necessary to apply additional primer to obtain proper film thickness, some preparation of the initial coat may be necessary. The cleaning required depends on the curing status and the extent of weathering of the initial coat. Film build up should be done as soon as practical before the critical coat cures and not later than 24 hours.

   NOTE: Thinning of the primer is required for any second application.

2. Primer Touch-Up

   a. Unprimed field connection parts on new construction, including rivet heads, bolt heads, etc. are cleaned after erection by sand blasting or mechanical means before applying the prime coat.

   b. To repair damaged areas of the prime coat, the area should be sweep-blasted before touch-up with primer. Small areas may be cleaned with a wire brush, etc.

c. Pinpoint rusting, also called "salt and pepper rusting" occurs if the primer film thickness is not sufficient to cover the highest peaks of the blast profile. All rust should be removed by sweep blasting before applying additional primer.

3. Preparation for Topcoat

On existing structures this cleaning normally consists of removing dirt and dust. It may also involve removing loose zinc particles resulting from dry sprayed or over-sprayed primer. Cleaning methods include hand cleaning, high-pressure air, and high-pressure water.

E. Cleaning the Acrylic Topcoat Film

1. Topcoat Film Build-Up or Touch-Up

   a. Removal of contaminants by solvent washing is normally the only cleaning necessary. Small damage areas, not seriously involving the underlying prime coat, do not require any special cleaning.

   b. If the acrylic Topcoat has lost adhesion to the primer, the area should be sweep-blasted (silica sand is preferred) to remove any remaining loose acrylic paint leaving feathered edges. Small areas may be hand-cleaned. Removal of primer during this operation should be kept to a minimum.

2. Repairing Both Topcoat and Primer Film: If it is necessary to repair a prime coat that has been Topcoated, the repair area should be sweep-blasted before applying the approved organic zinc-rich primer. This repair primer does not require special cleaning before application of the acrylic topcoat.

3. Preparation for Last Coat of Acrylic: Removal of contaminants if any by solvent washing is the only cleaning necessary.

III. PAINT APPLICATION

A. Mixing & Thinning

1. Mixing During Application: It is usually difficult to keep zinc-silicate paints homogeneous during application because the heavy zinc pigment may settle rapidly. Agitated paint pots are required. If an agitated pot is not used, the zinc-silicate paint should be manually mixed frequently while it is being applied. Acrylic paints only require initial mixing.

2. Thinning for Proper Application: Thinning of both paints is often required to obtain proper application. Conventional thinners such as mineral spirits are not compatible with either paint and special solvents must be used. During hot or windy conditions, a slow-evaporating solvent may be used to obtain a sprayable consistency. Thinning will lower the dry film build-up that can be obtained for an applied volume of paint. In any case, the paint manufacturer's instructions should be strictly followed regarding the type and amount of thinners used.

B. Weather Conditions

1. Temperature

   a. A minimum surface temperature of 40°F is specified for painting. This limit helps assure a moisture and frost-free painting surface and is intended to allow the primer an opportunity to cure in a reasonable time.

   b. If the temperature falls below the minimum during the curing or drying period, damage to either paint is unlikely. However, the curing rate of the zinc-silicate paint will be slow and should be checked carefully.

   c. A maximum temperature is not specified, but high temperatures can cause application problems such as dry spray or pinholes. These problems can be avoided by thinning and proper application techniques.

   d. Any corrective action deemed necessary because of temperature-related failure should be based on indicated damage and not on temperature measurements.

2. Moisture

   a. Both paints must be applied to a dry surface. Requiring a temperature 5°F above dew point for painting ensures this.

   b. Damage to either paint is not likely to occur from moisture once the paint has been applied. Zinc-silicate paint can be moistened in a short time after application without affect, except for a faster curing rate.

   c. A wet paint film exposed to moisture should be permitted to dry. Damage such as erosion or permanent discoloration may require repainting.

   d. To avoid expensive re-cleaning of steel, application of primer over cleaned steel should be allowed, at the contractor's option, if the weather becomes threatening. Damage to the prime coating is extremely unlikely in such situations, but this should not preclude discontinuing painting for safety, traffic protection, or other reasons.

C. Curing Time of Primer

1. General: The zinc-silicate film must be thoroughly cured before the topcoat is applied. Higher temperatures or humidities both speed up the curing process. The inorganic zinc-silicate paint film will be considered cured and ready for shipment/top coat after achieving a resistance rating of 4 as verified by 50 MEK rubs as per ASTM D 4752.

2. Accelerating Curing: Occasionally a zinc-silicate film will not cure in a reasonable time. When this occurs it is recommended that the film be sprayed with water mist using a Hudson sprayer or similar equipment. This procedure will greatly accelerate the curing process and will not injure a film that is at least one hour old. The surface must be allowed to dry before subsequent paint is applied.

D. Film Thickness

1. General: Film thickness is a critical measurement for determining the adequacy of a paint film to protect steel. A thicker film will generally provide a longer protective life. The specified film thickness for each coat of paint is obviously important, but in practical situations, the relative importance of these measurements varies as follows:

   a. The total combined thickness of the primer and topcoat is the most critical measurement because it essentially decides the life of the paint system.

   b. On new construction, the thickness of the zinc-silicate applied in the fabrication shop is critical because this film will determine the effective life of the coating. The proper film thickness will avoid pinpoint rusting and minimize field repairs.

   c. On existing structures the prime coat will normally be topcoated within a short time. Therefore, prime coat measurements in this case, although important, are not as critical as those on new construction.

2. Specifications

   a. The film thickness requirements are detailed in the relevant specifications. The thickness measurement at a point consists of the average of at least five instrument readings taken in a small area (4 inch diameter or less). Individual gauge readings are not valid by themselves. The thickness requirement refers to the average thickness found on a large test area, one side of a beam web for example. This overall average thickness is obtained by averaging several point results taken at selected small areas representative of the larger test area.

   b. It is not intended that the thickness of topcoats is determined separately, but rather the total thickness of all paint applied. The overall average thickness and paint thickness of the two or three coats must meet the minimums specified. Deficient total thickness is corrected by adding more paint.

3. Gauge Operation

   The procedure for using the magnetic film thickness gauge is given in the Office of Materials IM 332 Appendix. Valid measurements with this gauge depend on use with close attention to procedure details.

   NOTE: These days direct reading digital Dry Film Thickness Gauges are most common.

4. When to Make Measurements: The ideal time to make film thickness measurements is when the coating has thoroughly cured or dried. The primer appears to dry rapidly, but curing is much slower and the film will shrink slightly during the curing period. Preliminary thickness measurements can usually be made about two hours after application to determine any need for film-build. Final measurements should be made after the film has been found to be fully cured.

5. Measurement Test Areas

   a. Test areas should be selected to represent the various components of the structure, with consideration of the exposure to which they will be subjected. Surfaces directly exposed to weathering such as outside web surfaces should always be checked. The bottom surface of the bottom flange is a difficult area to paint and should also be checked. Any steel above the bridge deck should be checked to at least a height of six feet.

   b. A test area may be any designated size of continuous flat surface such as a web on one side of a beam or one side of a small beam stiffener. Large areas can be divided into smaller areas at the discretion of the inspector. For example, if an initial check on a web indicated a thin coat at one end, this end could be re-designated as a separate test area and be rechecked. If found deficient, it would only be necessary to repaint that end of the web.

   c. The number of test areas selected will depend on the size and complexity of the structure, but should always be sufficient to reasonably assure the inspector that the proper amount of paint is being applied. If a deficient area is found, this warrants increasing the number of test areas.

6. Point Measurements

   a. Point measurements should be randomly distributed over the test area. The exact locations are decided solely by the inspector.

   b. The number of point measurements made within a test area depends on the dimensions of the area. Usually three to five points are sufficient.

E. Application Problems

1. Dry Spray

   a. Dry spraying occurs when semi-dry particles of paint hit and stick to the surface. The contributing factors are fast-evaporating solvents, hot ambient temperatures, and the distance the paint gun is held from the surface being painted. On hot days it is advisable for the painter to thin the paint for application. Dry spray, however, usually occurs on the web where the painter fans the gun as he paints along the beam. The dry spray appears at the ends of the swing of the gun where it is farthest from the beam. Dry-sprayed areas can usually be recognized by a shadowy appearance of glossy and dull areas of light and dark areas.

   b. Dry-sprayed zinc-silicate paint produces a lumpy texture on the surface caused by semi-adherent zinc particles, which can usually be removed by rubbing with the hand. To assure topcoat adhesion, wiping, brushing, or high-pressure water must be used to remove the loose zinc particles. In severe cases, it may be necessary to clean the surface by sweep blasting followed by repainting.

   c. A dry-sprayed film is more porous than a sound film and provides a bad appearance. It should be corrected by removing the loose particles and applying a new coat of highly thinned paint to make up the required film thickness.

2. Overspray: Overspray occurs when sprayed paint misses the target and lands semi-dry on other steel or painted surfaces in close proximity. When this occurs with the primer, the resulting loose particles of zinc must be removed before paint is applied to the affected surface. A stiff bristle brush can be used for removal or, in extreme cases, a wire screen. Loose particles should be removed with compressed air.

3. Mud-Cracking: Mud-cracking of a zinc-silicate film occurs when it is too thick. This is most likely to occur in areas where paint is applied from several directions such as inside corners. The condition appears as a network of cracks in the film. To repair, the film must be scraped back to soundly bonded paint and the area re-coated, if necessary, to obtain minimum film thickness.

4. Topcoat Bubbling

   a. Acrylic paint films dry from the top to the bottom and thus tend to form an impermeable skin on the surface. This surface skin may trap air or absorbed solvent in the porous zinc-silicate film. When the trapped air or solvent escapes, bubbles are formed in the coating. This phenomenon occurs when the topcoat is applied too thickly and is enhanced by exposure to the heat of the sun and by dry-sprayed zinc-silicate paint.

b. If the acrylic paint is properly thinned and applied at a rate suitable for the ambient conditions, the bubbles formed will break and the film will reseal. If the bubbles do not break, they will remain as blisters after the topcoat dries, leaving a poor appearance. Poor adhesion of the paint or pinholes can also result.

c. The need for repair of a bubbled or blistered topcoat depends on the presence of pinholes. When pinholes are formed or if a broken blister reveals the underlying prime coat, the blisters should be removed using a scraper and the area repainted with highly thinned paint. If appearance is the only problem, it is usually better not to attempt repairs. In any event, when bubbling first appears, corrective action should be taken before painting continues.

d. Bubbling of the topcoat is traceable to improper application of the coating or to application under poor ambient conditions. Weathering of the prime coat prior to topcoating, as occurs on new construction, usually allows zinc salts to seal the porous surface of the primer, which helps eliminate the bubbling problem. Bubbling can be avoided by one or more of the following procedures: (1) remove all dry-sprayed zinc particles from the surface of the prime coat, (2) apply a thin mist coat of paint to seal the prime coat and allow to dry for at least 20 minutes prior to application of the full coat. Allow at least 1/2 to 1-hour drying time between applications.

5. Topcoat Adhesion: Good adhesion of topcoat to the primer is generally achieved if the paint wets and penetrates the primer film. The amount of thinning of the paint is important in this regard. It must be thin enough to penetrate and to allow air and solvent to escape. If it is too thin, the coating may run or sag. The amount of thinning required is primarily related to ambient and surface temperatures and wind conditions. Strictly follow manufacturer instructions in all cases.

   The adhesion of topcoat to the primer increases with time as the last traces of solvent evaporate. Ultimate adhesion may not be reached for at least a month. In the early stages it may be easily scraped off but if it cannot be easily peeled off in sheets, good adhesion should eventually result. An easily removed sheet of topcoat film that has a coating of zinc on the backside indicates dry-sprayed primer or an uncured primer film.

   The following list summarizes the causes of topcoat adhesion failure:

   a. Use of an improper type of topcoat paint

   b. Application to an improperly cleaned primer film

   c. Application over frost or moisture

   d. Application to an uncured primer film

   e. Application over dry-sprayed primer or overspray

   f. Application on a hot surface causing premature evaporation of solvent before penetration

IV. INSPECTION

A. General

Painting cannot be adequately inspected by visual observation of the final product because a poor paint job often looks the same as a good one. Early failures due to poor workmanship often occur after the work has been completed and has been paid for. It is necessary; therefore, to inspect the work as it progresses if there is to be any reasonable assurance that a paint job was completed as specified.

The paints used with this sophisticated system are subject to some unique application problems not found when using conventional paints. To provide competent inspection of the operations, the inspector must receive special training regarding the use of these paints and the inspection procedures.

B. Records

The inspector should keep a daily log containing pertinent information concerning the painting and related operations. A complete record will be valuable to the inspector and the engineer if disputes arise as the work progresses and is also essential for any future evaluations of the painting.

In addition to the standard project information (project number, location, contractor, etc.), the record should include the following where applicable:

1. General Information

   a. Notes on safety, traffic protection, etc.

   b. Cleaning equipment used (wheelabrator, sand blast, etc.)

   c. Abrasive used (river sand, silica sand, shot, grit, etc.)

   d. Notes on cleaning procedures (removal of dust, grease, etc.)

   e. Paints to be used (manufacturer, batch numbers, etc.)

   f. Paint mixing and thinning procedures used (agitated pot, hand mixing, amount of thinning, etc.)

   Application equipment used (airless spray, conventional spray)

2. Daily Details

   a. Weather conditions (ambient temperature and humidity, sky conditions, wind, etc.)

   b. Notes on surface preparation (area cleaned, general surface condition, any unusual phenomenon)

c. Surface temperature at time paint was applied

d. Location on structure of area painted

e. Paints applied (batch numbers, thinning, etc.)

f. Dry film thickness measurements (test area description, point thickness values, average thickness)

g. Primer curing time allowed before topcoating

h. Application problems encountered (dry spray, bubbling, etc.)

i. Corrective actions taken to avoid application problems or to make repairs

C. Inspector Duties

1. General: Painting of structural steel and miscellaneous steel can be performed in preapproved shops only (see IM 568, Appendixes A & B). The inspector's primary job is to recognize and report sub-specification work. Unfortunately, it cannot always be assumed that the painter is completely knowledgeable about the paints to be applied and the specifications governing their application. Discussion with the contractor before the work begins, to clarify such things as degree of surface preparation, curing times, film thickness requirements and corrective actions to be taken if problems arise, will help avoid inspection difficulties.

   Experience and good judgement are of particular importance for inspection of this painting system. Technical assistance from the Central Materials Office should be sought if unusual problems arise.

2. Summary of Responsibilities: The major responsibilities of the painting inspector may be summarized as follows:

   a. Record keeping

   b. Approval of traffic control procedures

   c. Acceptance of paints

   d. Approval of surface preparation before paint is applied

   e. Checking cure of primer before topcoating or shipment from fabricating shop.

   f. Visual inspection of each coat of paint for defects

   g. Determining film thickness

3. Inspection Equipment: The inspector will need the following equipment:

    a. Field notebook

    b. Surface temperature thermometer

    c. Dry-film gauge and paint thickness standard

    d. Pocket knife

4. Scheduling Inspection: It is not always possible for the inspector to be on the job at all times because of other commitments and duties. Obviously it is important for the inspector to be familiar with the painter's operational schedule and for the painter to have a clear understanding of what the inspector wishes to check. An agreement between the inspector and painter can then be established so that the inspector can at least be present at the critical times and any hold-up of painting operations can be avoided.