STRUCTURAL STEEL PAINTING INSPECTION MANUAL

Highway Division
Office of Materials

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INTRODUCTION

The purpose of this manual is to provide information that will assist the painting inspector in performing his job more efficiently. It is intended to help the inspector, particularly if he is inexperienced, to be of real assistance to the Department of Transportation personnel and to the project contractor.

The manual includes information on paints, surface preparation, application of paint, and inspection duties. The significant value, however, is that it provides an insight to the complexities of paint as a material and the difficulties that sometimes arise with its use.

The information contained in this manual should not be considered as specification requirements but is intended to assist the inspector in their interpretation. Much of the material presented will be found in the various specifications for painting.

CONTENTS

PART I SHOP AND FIELD INSPECTION

1. Sampling Paint

Most of the paint used by the Department of Transportation is obtained by the contractor from approved stock at the paint manufacturer's plant. It is not necessary to sample this approved paint unless the paint is obviously deteriorated from old age, poor packaging, thinning, etc. This type of approval may be checked by phoning the Central Laboratory in Ames and giving them the name of the paint manufacturer and the batch or lot number. A laboratory report can be supplied if requested. Non-approved or questionable paint should be sampled and submitted to the laboratory in Ames.

A pint sample is sufficient for laboratory analysis. This sample should be obtained from the original container unless it is desired to check the thoroughness of mixing or thinning of paint in a spray pot. It is absolutely necessary to be sure that the paint has been thoroughly mixed at the time of sampling. This is best accomplished with a broad, flat paddle, used to break up lumps and lift any settled pigment off the bottom to the top. If the pigment has settled considerably, most of the liquid should be poured off into a separate clean container before mixing and then slowly returned as mixing progresses. Two-component paints should be sampled by individual components.

The sample identification should include the name of the manufacturer, lot and/or batch number, date of manufacture, type of paint, and intended use. If the specification only calls for the approval of the engineer, it is important to include the label analysis if available.

When a skin has formed in the container, the skin should be completely removed and discarded before mixing. Normally skinning does not significantly effect the composition of the paint, but if the skins are unusually thick the paint should be sampled for testing.

2. Mixing Paints

Paints must be kept homogeneous and at a uniform consistency during application in order to obtain their full benefit. Occasional stirring is often necessary to meet this requirement. This is especially true with paints containing heavy pigments.

Two-component aluminum paint is best mixed by placing the paste pigment in a separate container and then adding small increments of the vehicle while stirring, until a smooth homogeneous mixture is obtained. The remainder of the vehicle may then be stirred in easily.

Thinning of paint is not permitted. This insures that the maximum dry film thickness is obtained from a specified wet film thickness. Vinyl paints are an exception and often require thinning to avoid deposition of semi-dry particles on the surface. If the temperature at the site is cool the viscosity of the paint may increase to a point where application is difficult. In this case the paint may be heated by placing the containers in hot water, or on steam radiators. Direct application of flame to the containers is extremely dangerous.

3. Preparing Surfaces for Painting

It is generally recognized that poor surface preparation is one of the major causes of premature failure of a painting system. The extent of surface preparation, however, depends on the painting system used and the economic balance between life expectency and preparation costs. In any case, good surface preparation consists of removing all residues from the surface which are either nonadherent or are incompatible with the paint to be applied.

Nonadherent residues such as loose old paint, dust, soil, weld spatter, and loose rust which weaken adhesion of the paint must always be removed. Mill scale and some types of tight rust may be initially adherent, but will loosen up in service. Tight, stable rust that contains no water soluble contaminates would not ordinarily have to be removed but the safest procedure is to remove all rust.

Incompatible residues such as moisture, oil, grease, and asphalt are normally easily recognized. Previously applied paint films can be incompatible but specifications are written to avoid this possibility. There are other incompatible residues which are not so obvious. Water soluble salt residues such as road salts and industrial contaminants are incompatible but fortunately rainfall normally washes these residues away. Thin films of condensed moisture may not be visible and this condition has to be determined by test.

4. Surface Preparation in the Shop

The Department of Transportation specifications require that all new steel be blast cleaned to bare metal. This simply means that all nonadherent residues including all mill scale must be removed. It does not include discolorations left by rust stains or mill scale oxides. If any oil, grease, or greaselike contaminants are present on the surface it is much better to remove these residues by solvent cleaning prior to blast cleaning.

Blast cleaning is performed by centrifugal wheels or air blast. When compressed air is used, adequate separators and traps should be provided, to insure that the air used is free of detrimental amounts of condensed water and oil. The height of the profile of the anchor pattern has a significant effect on paint performance and it is therefore necessary to avoid

excessive roughening of the surface. This height is controlled by specifying the maximum size of the abrasive particle but it is also affected by the angle and velocity of the particles, by the hardness of the surface, by the amount of recycling of the abrasive, and by the thoroughness of the cleaning. If the anchor pattern produced is too high or too rough to be covered adequately by the shop coat it may be necessary to use a smaller abrasive size.

After blast cleaning the surfaces should be carefully examined. Any traces of oil, grease, or smudges should be removed by solvent cleaning. Any traces of blast products or abrasives should be removed by brushing or with clean compressed air. Pockets and corners should be particularly checked for these materials.

Blast-cleaned surfaces rust easily and should, therefore, be primed on the same day they are blasted, but in any event before any visible rusting occurs. If rusting occurs before the application of the shop coat, the surface must be blast cleaned a second time so that the shop coat can be applied while the surface is still in an acceptable condition.

5. Surface Preparation in the Field

Shop coated steel which has been shipped to the erection site should be stored on blocks to prevent contact with the ground and be placed where it is least likely to be marred, scratched, or subjected to harmful contamination by grease, oils, or salts. Insofar as practicable, the steel should be stored so as to avoid the formation of waterholding pockets.

After field erection has been completed satisfactorily, all damaged areas of the shop coat, bare areas, field rivets and field connections are cleaned, prepared, and given one new coat of shop paint. This cleaning is by spot-blasting.

Immediately before applying each field coat of paint, the previously painted surfaces are cleaned of dust and, if necessary, wiped with a specified solvent, that will not appreciably soften the film, in order to remove grim, grease, tallow and other oily substances.

6. Surface Preparation for Maintenance Painting

In cases where the specified cleaning is blasting to bare metal, the discussion given in the preceding paragraphs is applicable except that all old paint is also removed. Many times, however, the preparation specified will call for spot blasting small areas of visible corrosion and loose or deteriorated paint to bare metal. In these cases the surface should be cleaned in such a manner that sound paint is not damaged on adjacent areas and that the junctions between sound paint and spot cleaned areas present a smooth feathered appearance.

Before an overall finish coat of paint is applied, dust, grime, oil and other contaminants are cleaned from the old paint surface. The adhesion of the newly applied coat should then be checked carefully before the work has progressed too far.

7. Atmospheric Conditions for Painting

Most paints used for structural steel will not dry properly under extremes of temperature and high humidity, nor will they protect if applied over wet surfaces.

The Department of Transportation Specifications require a minimum ambient temperature of 40 degrees F. at which paint may be applied. Temperatures at or near the freezing point are not in themselves a detriment to a good paint job with solvent type paints providing the painting surface is dry. This minimum temperature helps insure that painting will not take place over condensed water, ice or frost and that the paint will dry normally in a reasonable time. Although a maximum temperature for paint application is not specified, a hot surface may evaporate the solvents in the paint so rapidly that detrimental blistering, pinholing or a porous film may result. The inspector should check for this condition when painting takes place in the direct sunlight on a hot day.

Paint should never be applied in rain, snow, fog or mist, or when the steel surface temperature is below the ambient dewpoint, resulting on condensation of moisture. This latter condition will be found especially in the spring and fall. The inspector may determine if this condition exists by the following test: Lightly moisten a small area with a damp cloth and observe evaporation and drying. The surface may be considered satisfactory for paint application from the standpoint of dampness and condensation if the dampness evaporates and decreases in area within 15 minutes.

Any wet paint exposed to freezing, excessive humidity, rain, snow or condensation should be permitted to dry. If damaged areas of paint result, all paint from these areas should be removed, the surfaces cleaned, and then repainted in the same manner as the undamaged areas.

8. Paint Application

The specifications covering the equipment and the use of equipment for the application of paint are explicit. Power spraying equipment is used almost exclusively but brush application is necessary in some instances such as surface irregularities, crevices, and corners or for brushing out runs and sags. Brushing is also specified sometimes for maintenance repainting to insure good adhesion to an old paint film. Regardless of the application method used this work must be done by skilled workmen, otherwise the expected performance from the paint coatings may not be realized.

The rate of application of paint is a very important factor because film thickness, to a great extent, will determine the life of the painting system. Most paints used for structural steel painting have a high hiding power which makes it possible to apply a thin coat of paint that presents the appearance of a good coating with uniform color. Film thickness measurements are therefore imperative to insure a proper coating.

It is difficult to obtain the necessary film thickness on edges, corners, rivet heads, bolts and nuts. Occasionally the specifications call for striping in order to increase the film thickness at these problem areas. Striping consists of brush painting these areas prior to the application of the regular coat to the other parts. The regular coat is applied before the striping dries.

9. Summary of Inspector Duties

The painting inspector need not be a painting expert but he should be observant and have the ability to read and understand specifications. His job is to recognize and report subspecification work which in most cases will be corrected by the contractor without the need for referral to higher authority. The duties of the inspector may be summarized as follows:

(a) Check the paints received by the contractor to see if they are acceptable. Sample if necessary.

(b) Check the application equipment for type, cleanliness and usability. Make sure that only the methods of application permitted are used.

(c) Observe whether the paint is properly mixed without thinning (if not allowed) before application.

(d) Observe the precautions taken by the contractor to prevent damage to adjacent properties, traffic, or other parts of the structure from cleaning and painting operations.

(e) Observe whether working practices are so scheduled that damage to newly applied paint is minimized.

(f) Observe the surface cleaning operation and check the cleaned surfaces.

(g) Check the ambient painting conditions.

(h) Observe the quality of the workmanship.

(i) Check the rate of application.

(j) Make sure the paint has dried properly before continuing further operations.

PART II INSPECTION EQUIPMENT

1. Wet-Film Gauge

The standard instrument used by the Department of Transportation is the Nordson Wet-Film Gauge. This instrument may be obtained at the Ames warehouse under Stock No. 020-398100. To operate, rotate the proper face to position. This would normally be the face reading from 2-1/2 mils to 4 mils. Place the gauge face squarely on the fresh wet film. Then withdraw without slide movement. The true wet-film thickness lies between the highest step coated and the next highest which did not coat.

2. Dry-Film Gauge

The dry-film gauge is not normally used by the Department of Transportation to check paint films but if a fast dry paint such as vinyl is being used it is necessary. Wet-film gauges in such cases will give erroneous results.

The instrument used by the Department of Transportation is the Mikrotest. This instrument is relatively expensive but they are available at each district office. The gauge operates on the attraction power of a permanent magnet through the non-magnetic paint film to the base steel. To operate, follow the instructions given with each gauge. In order to obtain accurate readings the gauge must be calibrated using standards covering the thickness anticipated, the coatings used and the type of base steel.

3. Thermometers

A pocket thermometer with a range of about 20 to 120 degrees F. is needed to measure the ambient air temperature. This same thermometer may be used to check the temperature of the paint or the metal surface. The metal surface temperature may be determined by placing the thermometer against the metal while shielding the outer side of the bulb by means of putty or similar plastic material, so that the reading is not affected by the ambient temperature.

4. Other Equipment

A sturdy pocket knife and an inexpensive pocket magnifying glass are handy tools for painting inspection. The knife can be used, for example, to determine the soundness of paint in spots suspected of blistering or of possessing corrosion beneath existing paint films. The magnifying glass can be used for close inspection of paint films and metal surfaces.

PART III PAINTS

1. General

The painting systems used by the Department of Transportation for structural steel are intended to provide surface protection against corrosion caused by the environment in which the structure exists and thus keep maintenance costs low. As previously mentioned, the most common causes of premature failure of a painting system on structural steel are poor surface preparation and inadequate film thickness. This is not to say that the paints used do not play an important role. Each type of paint is intended to carry out particular functions. The following material describes the types of paints normally used in terms of their specific functions and peculiarities.

2. Pretreatment

This type of coating, commonly called a "wash primer", is intended to provide as good adherent uniform base on which to bond the coats of paints to follow. It does not provide a protective film by itself and must therefore be covered with a regular prime coat on the same day as application or before the steel is exposed.

The two-component coating should only be applied to clean steel or to galvanized metal although very slight amounts of rust may be tolerated. It has a particular advantage when used in humid areas because it may be applied to a slightly damp surface without harm. It should not be applied to previously painted surfaces.

This coating is preferably applied by power spraying but brushing is permissible. When sprayed, it should be deposited on the surface wet and if not the gun should be held closer to the surface or adjusted. The application rate should be approximately 0.5 mil dry film thickness and this rate should never be greatly exceeded. The base metal will usually show through a proper application.

Wash primer will normally dry sufficiently to handle in about 15 minutes. Regular primer or other paints may be applied over the coating as soon as it is thoroughly dry which takes at least one hour, although a longer drying period not to exceed four hours is desirable.

3. Shop Coat Primer

This type of coating is used as the first coat of regular primer on structural steel. As such, its functions are to provide corrosion protection, good adhesion, and a satisfactory surface for recoating. It must provide adequate protection for steel for at least six months in most environments. The extent of surface cleaning for proper adhesion depends on it's specific composition.

These paints are easily applied by either power spray or brush. The application rate should be a minimum of 2-1/2 mils wet film on any given spot. This rate is easily obtained and should normally be between 3 to 4 mils when properly applied.

The drying time for these coatings depends on their composition but modern shop coats normally dry sufficiently for recoating within 16 hours. A longer drying period is preferred.

4. First Field or Intermediate Coats

The primary function of these paints is to provide an additional film of corrosion protection over the shop coat. Normally the only practical difference between these paints and the shop coat is the color. This difference enables the painter and inspector to readily see the areas which have been painted with this paint.

5. Second Field or Final Coat

This type of paint is intended to provide a relatively impermeable coating which resists direct exposure to the environment. It must protect the underlying coats of paint and be decorative.

A colored paint such as foliage green or an aluminum paint are normally used. They should be easily applied and should dry faster than the shop or intermediate coats.

6. Vinyl Paints

Vinyl paint is quite different from the oil type paints previously described. The basic differences are as follows:

(a) Drying of the paint film occurs as soon as the solvent has evaporated.

(b) The percent of non-volatile material by volume in the original paint is much lower.

(c) The paint does not necessarily contain a rust-inhibitive pigment.

(d) Special thinners are required.

These differences are so fundamental that the use of vinyl paint becomes a special subject which cannot be fully covered in this guide. Briefly, these paints are applied by power spray to sandblast cleaned steel. At least five coats of paint are usually required, two of which are applied on the same day the steel was cleaned. This is possible because the paint normally dries for recoating in less than 30 minutes.

PART IV INSPECTION OF THE ZINC SILICATE-VINYL PAINTING SYSTEM

GENERAL

This portion of the manual covers the painting of new structures and repainting of old structures with the zinc silicate-vinyl system. It is intended to assist the painting inspector in the interpretation of the specifications and provide an insight to this painting system and the difficulties that sometimes arise with its use.

PAINTS

1. Description

Zinc silicate paint is an inorganic zinc-rich paint which is supplied as either a two-component or a single component type. It cures by contact with moisture in the surrounding air. The higher the surrounding humidity, the faster a zinc silicate film will cure. Because of this property, gelation of this paint may occur if allowed to contact water before it is applied. The two-component type, once mixed, has a pot life which varies from at least 8 hours at 77 degrees F. to as low as 1 hour on a very hot summer day. In the latter case, cooling is necessary for practical use.

Vinyl finish coat is a fast drying enamel which is supplied in any of the standard colors. It dries by solvent evaporation.

2. Inspection and Acceptance

Paints for this system are accepted for use on the basis of a certification from an approved supplier. A list of approved suppliers is given in Materials I.M. 482.09. The inspector may sample any paint which is questionable either because of appearance or age.

Vinyl paint must be supplied by the manufacturer of the zinc silicate paint used.

If a district or residency does not have the required batch certification, copies may be obtained from the master file kept at the Central Materials Laboratory.

3. Sampling

Samples of these paints should be obtained from containers that have not previously been opened. All settled pigment must be thoroughly mixed in before sampling. If a considerable amount of pigment has settled, most of the liquid should be poured off into a separate clean container before mixing and then slowly returned as mixing progresses.

Individual components of two-component zinc silicate paint must be sampled and submitted for test separately.

4. Mixing Paints

It is difficult to keep zinc silicate paints homogeneous and at a uniform consistency during application because the metallic zinc pigment which they contain may settle rapidly. For this reason an agitated pot is recommended. If an agitated pot is not used, the paint should be manually mixed several times while it is being applied.

5. Thinning

Thinning of zinc silicate and vinyl paints is often required for proper application. In hot weather a slow-evaporating solvent may be added to avoid deposition of semi-dry particles on the surface (called "dry spray"). In cold weather a fast evaporating solvent may be added to obtain a sprayable consistency.

SURFACE PREPARATION

1. For Zinc Silicate Prime Coat

Zinc silicate paint requires clean metal and a rough surface for good adhesion and effective corrosion control. The pictorial reference standards showing the near-white condition specified is an important aide in the description of the extent of cleaning required. The blast cleaned surface should feel rough. A relatively smooth surface, as if peened, such as might be obtained with the use of new shot, is not adequate.

The height of profile of a blast cleaned surface is the distance measured from the bottom of the pits to the tops of the peaks. A nominal height of profile range is specified because this dimension is difficult to determine and enforce. The dimension is important because it affects the amount of dry film thickness obtained above the peaks. The only practical solution to an excessively high profile is to increase the amount of paint applied. This solution is somewhat built into the specifications because film thicknesses determined by magnetic gage are averages of the actual thicknesses obtained over both pits and peaks.

Zinc silicate paint will not seal cracks formed between metal contact surfaces. For this reason, the old paint in such cracks should not be removed when cleaning old structures. This will maintain a seal.

2. For Touch-up or Repair of Zinc Silicate Coating

If an additional coat of zinc silicate is necessary to obtain the specified film thickness, the extent of cleaning to obtain intercoat adhesion will depend on the degree of curing of the initial coat. If the initial coat has cured hard as indicated when the coating cannot be indented with a coin, the coated surface should be brush blasted before film build up. If the coating has not cured hard, no additional cleaning is required unless contamination has occurred.

A condition known as "salt and pepper rusting" may occur on surfaces primed without sufficient film thickness above the peaks of the blast cleaned profile. To repair such areas, all rust should be removed by brush blasting before repainting. Small areas may be cleaned by wire brush or power tools but brush blasting is the preferred and easiest method.

3. For Vinyl Finish Coat

Cleaning of a zinc silicate primed surface in preparation for the vinyl topcoat is not necessary except to remove contaminants. White salt deposits may develop on a zinc silicate surface, particularly after weathering. These deposits must be removed to insure adhesion of the vinyl coating. Removal may be by bristle brush or high pressure water.

4. For Touch-up or Repair of Vinyl Finish Coat

Intercoat adhesion between coats of vinyl paint is excellent and the only cleaning necessary is the removal of contaminants by solvent wiping. If damage to the vinyl coat includes damage to the zinc silicate coating, the area should be cleaned by wire brush, power tools, or brush blasting. A special organic zinc-rich coating is necessary to repair such areas because zinc silicate paint will not adhere to vinyl paint at the unavoidable overlaps.

PAINTING

1. Film Thickness

The operation and use of the magnetic film thickness gage is explained in Materials I.M. 332.

The average dry-film thickness as called for in the specifications means the average of all point readings taken on a inspection unit of continuous flat surface. Point readings consist of the average of at least 5 instrument readings taken in a small immediate area.

It is not necessary to attempt to determine the film thickness of the vinyl finish coat. Instead, the total thickness of the zinc silicate and vinyl coatings should be checked on the finished paint system. If the total thickness is less than the combined specified film thicknesses, an additional coat of vinyl paint should be applied.

Excessive film thicknesses of zinc silicate paint may result in a condition known as "mud cracking". This condition is recognized as an obvious network of cracks in the film. Such a film has poor adhesion and must be repaired as called for in the specification.

2. Application of Paint

This sophisticated paint system requires careful and skilled application of the paints to achieve maximum success. In addition to obtaining proper film thickness, dry spray is a common application fault with both paints. The contributing factors to dry spray are fast evaporating solvents, warm ambient temperatures, and the distance the spray gun is held away from the surface being painted during application.

Dry sprayed zinc silicate is evident if powered zinc can be rubbed from a dry painted surface. Such areas are repaired by removing all loose, powdered zinc from the surface by wire brush or brush blasting and then repainting the area involved with thinned zinc silicate to the specified thickness.

Dry sprayed vinyl can be recognized by a shadowy appearance of glossy and dull areas of paint. Such areas are corrected by repainting the entire area involved with highly thinned vinyl paint. A slow evaporating solvent should be used for thinning.

3. Curing Time of Zinc Silicate

The zinc silicate paint must be thoroughly cured before being topcoated with vinyl paint. Adequate curing is indicated by coin hardness.

4. Weather Conditions

The limitations on weather conditions given in the specifications should be followed closely.