10.0 PAINTING

10.0 PAINTING (New Structures)

10.1 General:

Painting protects steel bridge members from corrosion in two ways. First, the coatings provide a barrier between the steel and the environment. Secondly, metals in the primers provide galvanic protection. Galvanic protection works by allowing a sacrificial metal (those in the primers) to corrode, thus protecting the bridge steel.

Kansas bridges are built with both weathering steel and non-weathering steel. Field painting requirements are different for each of these materials. The common painting features for both of these materials, used in new structures, is that portions embedded in the abutments and areas around the expansion joints receive paint in the shop. In addition, if shear studs are applied in the shop the top of the top flange is prime coated in the shop.

Weathering Steel plate girder bridges are treated the same as weathering steel rolled beam bridges except that the exterior faces of the exterior girders are primed with inorganic zinc primer in the shop and then field painted to the limits shown in Standard Specification 714.

Non-weathering steel plate girder bridges have all surfaces shop coated with 75µm (3 mil.) of inorganic zinc primer except the top of the top flange, which has only 35µm (1.5 mil.).

The top of the top flange is blast cleaned to SSPC-SP6 in the field prior to the stud welding. After stud welding the top of the top flange is again blasted to SSPC-SP6 then coated with 75µm (3 mil.) of zinc rich, organic primer measured as dry film thickness.

10.2 Surface Preparation:

Surface preparation is the most important factor in obtaining good paint performance. The intent of surface preparation is to provide a clean, dry, roughened surface for the paint to bond to the steel. A smooth or slick surface will not allow the paint to bond correctly. The roughened surface is called an anchor pattern. This is a surface that has a profile (ridges and valleys) on the metal of approximately 35 to 70 µm (1.5 to 2.8 mils). For comparison, a dollar bill is about 100 µm (4 mils) thick. Measure the anchor pattern depth with a surface comparator, testex tape, or a dial surface profile gage. The tape is the most common.

Surface preparation required for new steel follows 702.08 of the Standard Specifications for State Road and Bridge Construction. Surface preparation is classified by SSPC (Steel Structures Painting Council) designations. The three SSPC standards used on Kansas bridges are as follows:

SSPC-SP1 *Solvent Cleaning* This standard is the prerequisite to all other cleaning standards. SP1 requires the removal of all grease and oil contamination from the steel.

SSPC-SP6 *Commercial Blast Cleaning* This standard requires the removal of all mill scale, rust and paint from the steel. Up to 33% of each 9 square inch area may have stains, streaks, discoloration only.

SSPC-SP10 *Near-White Blast Cleaning* This standard requires the removal of all mill scale, rust and paint from the steel. Up to 5% of each 9 square inch area may have stains, streaks, discoloration only. In addition, slight residues of paint and rust may be left in the bottom of pits if the original surface is pitted.

Weathering Steel rolled beam bridges are blast cleaned in the shop before shipment to the field. The top of the top flange is blasted to SSPC-SP6 prior the stud welding. After stud welding is complete, the top of the top flange and studs are blast cleaned again to SSPC-SP6 and prime coated with 75 µm (3 mil.) dry film thickness of zinc rich, organic primer. For high visibility structures, the plan notes may require blast cleaning of the exterior beams to achieve a final uniform appearance. The protection of the steel surfaces against abrasion and dirt is the responsibility of the Contractor. Quality control checks for sand blasting are to assure that the surface preparation will meet the intent of the Specifications:

- To insure that contamination does not occur due to oil in the compressor line, an oil-moisture trap between the compressor and sand-pot must be used. The sand supply should be shut off at each morning's start up and air should be blasted onto a flat white surface for a "blotter test". The surface should be clean and dry.

- Assure that Oil or grease is not blasted over because it will embed into the surface of the metal.

- A nozzle pressure of 690 kPa (100 psi) and flow rate of 9.9 CMM (350 CFM) is required. Less pressure will waste time and gives a poor anchor pattern.

- Blast-cleaned areas must be painted in the same day.

- In general blasting should not be done when the humidity is greater than 85% because rust will form quickly, primer is not to be applied over rust.

- Sand and residue must be removed just prior to painting by vacuuming, wiping off, or using clean compressed air. Special care must be used in corners or pocket areas.

- Use a clean white glove or rag to insure that the surface to be painted is clean. Do this just prior to painting.

- Some sand has excessive amounts of clay or fines that can be embedded in the surface. If this is suspected, clear scotch tape can be used to document surface contamination. The sand must be dry.

- Coatings should not be applied to areas that have over-spray on them. The paint will not stick and will fail prematurely. Oversprayed areas should be blasted clean or wire brushed prior to final coating. Over-spray is not harmful to finished surfaces. Low pressure water cleaning or steam cleaning is to be used to remove surface contamination. This works well if the steel has been walked on during the erection or storage. Solvent cleaning is required when oil or grease is encountered during the surface preparation.

10.3 Coatings :

10.3.1 General:

The manufacturer of the paint will supply a data sheet for the paint used. This sheet will address mixing, thinning and paint application setup. Read and understand the data sheet. The equipment will be set according to this data sheet. The pressure and orifice size settings are critical to achieve the correct spray pattern. The amount of thinner and the type of thinner used must strictly follow the manufacture's recommendations.
It is the Contractors responsibility to protect all shop-primed steel during transport, storage, and erection. The Inspector will identify any damage or flaws on newly-arrived steel and the Contractor will correct these as stated in the Standard Specifications with organic zinc primer before the top coat is applied.
The data sheet from the manufacturer lists pot life and shelf life. The pot life is the length of time that the mixed and or thinned paint can sit in the spray reservoir, usually less than three hours at 60° F. For moisture cured systems, the coating begins to cure when exposed to the atmosphere. Therefore, only paint from sealed containers should be used. The shelf-life is the time that the paint kept in a sealed container, within the proper temperature range, can be stored.

10.3.2 Mixing:

Before use, the inorganic or organic zinc primer should be mixed with an electric paddle type mixer in thoroughly cleaned containers. Pouring off the top half of the container into a clean container and using a paddle or flat clean board to scrape the settled material from the sides and bottom insures proper mixing. Then while mixing, with an electric paddle mixer, the contents from the original container are poured into the second mixing container. It is important that an air mixer is NOT used in that this can add air to the paint, which forms bubbles in the painted surface. After the paint is poured during mixing look at the bottom of the original container for evidence of unmixed solids. The mixture should be poured back and forth between containers to insure proper mixing. If thinning is required, it should be done by slowly pouring a measured amount of thinner (as per the coating data sheet) in the container while mixing with an electric mixer. During the mixing it is convenient to check that the proper coatings are being used and that the paint has not been opened for an amount of time exceeding the shelf life.

Paint should be strained after mixing if there is any evidence of skins, lumps, color particles or foreign materials. Straining is recommended if paint has been previously used and allowed to stand for any length of time or if the paint is going to be sprayed. Strain after completing all mixing, thinning, or tinting. Strain through a fine sieve (80 mesh) or a commercial paint strainer. Inorganic and organic zinc rich paints require the paint pot (reservoir) to have an agitator that will keep the solids suspended.

10.3.3 Applications:

Application methods commonly used for bridge coating include conventional spray, airless spray, brushes, rollers, and mitts.

Conventional or air spray is use for spray coating both large and complicated objects. Conventional sprayers have the advantage of total control over the flow of material and therefore are used to coat complicated areas such as bolt patterns. It can also be used for minor blow off operations by turning off the coating supply.

Adjusting the pressure in the spray pot (pot pressure) controls the flow of material. Atomization is accomplished by adjusting the atomization pressure at the spray pot to break up the stream of liquid coating into particles. Spray a test pattern, by holding the gun about 10" from the surface, swinging rapidly to produce a thin coat. If droplets of liquid hitting the surface appear to be less than 1/16" the air pressure is adequate and the paint will flow to a smooth, uniform coating. If the coating is spattered with drops appearing 1/8" or larger, the coating is not being mixed properly and will not flow to a smooth film. In this case the air pressure must be increased until the droplets become less than 1/16".

The main concerns of inspection personnel while observing conventional spray operations are:

a) Don't paint when sand blasting is going on.

b) The spray pot must have two operating pressure regulators so that the pot pressure and the atomization pressure can be independently adjusted.

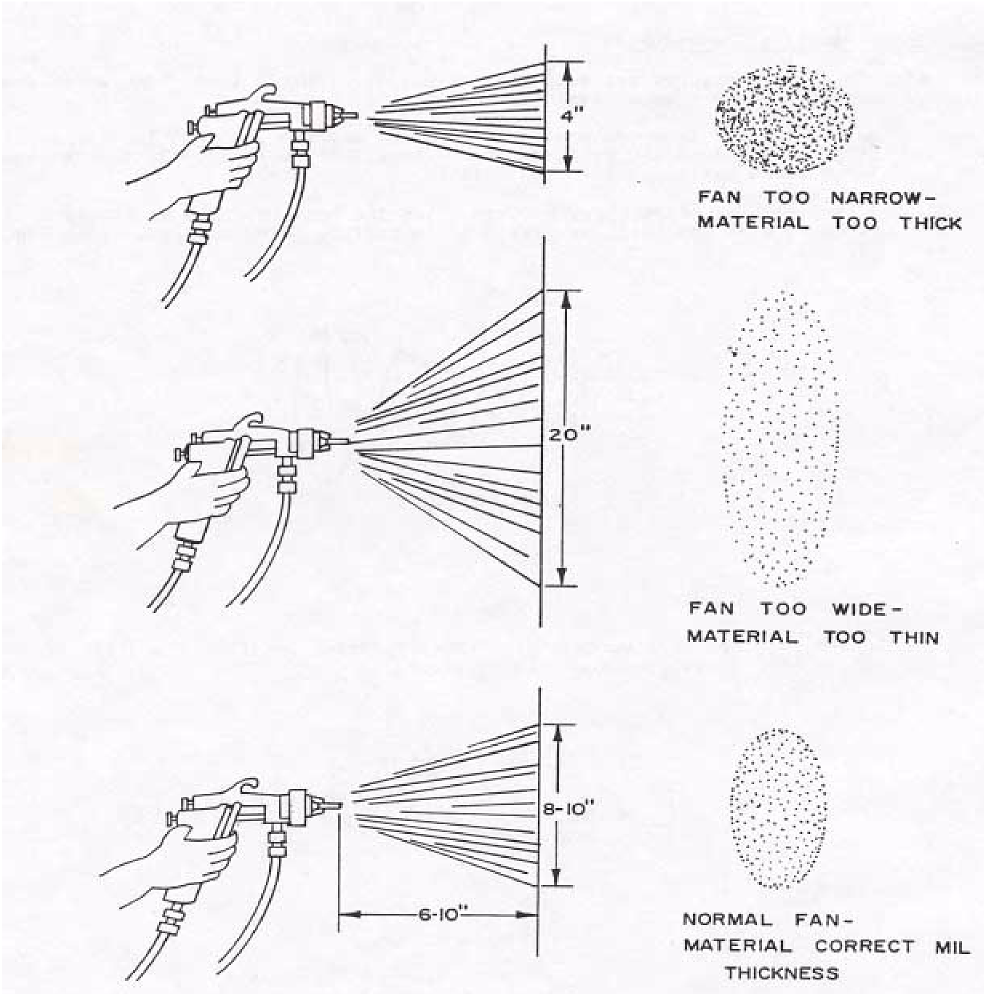
c) The pot pressure must be sufficiently high to obtain an adequate material supply at the spay gun. This is accomplished by shutting off the atomization air supply and observing the material flow. Ideally, the spray pot and the spray gun should be at the same elevation.

d) The atomization pressure must be just high enough to properly atomize the material. Over atomization causes dry spray which is detrimental to the film-forming characteristics of the coating.

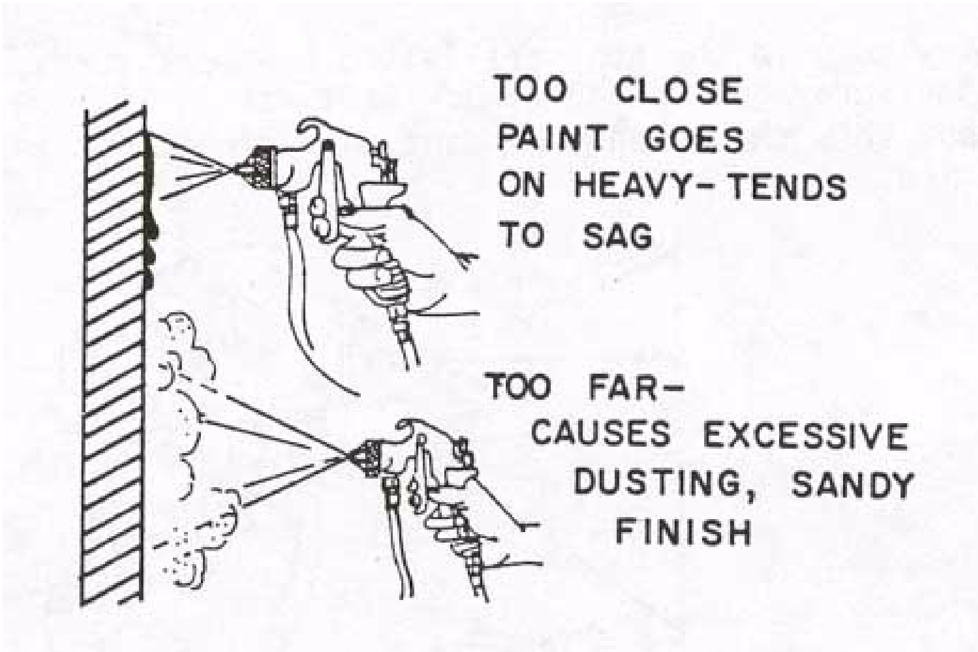
e) The spray gun must be held within about 10" from the surfaces being sprayed. Distances greater than this will cause dry spray.

f) The work being sprayed must be directly in front of the spray man. Reaching too far causes erratic thickness.

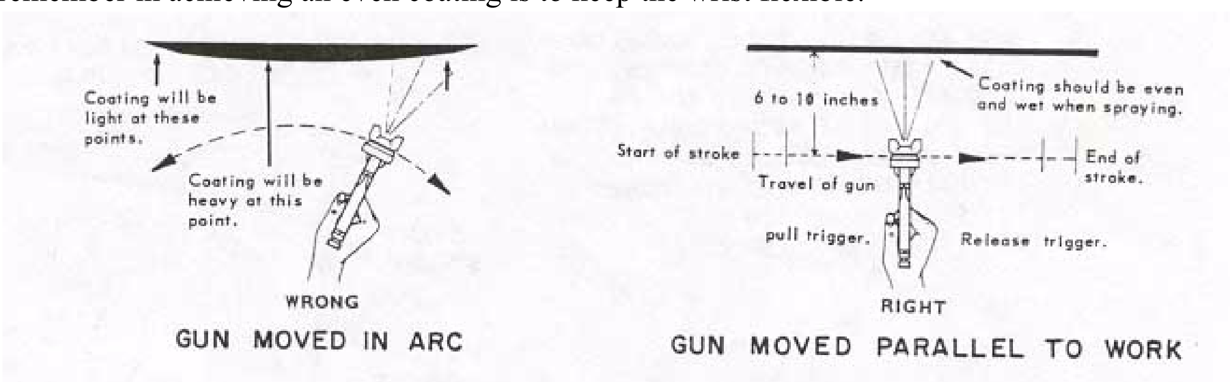
10.3.4 Spray Techniques:



The spray gun should be held at a right angle to the surface and moved parallel to the piece being painted. The distance should be about 10" from the surface. Holding the gun too far away causes "dusting" or 'dry spray' which means the paint dries before it reaches the surface. Holding the gun too close to the surface will cause excessive paint, runs, sags, and bowing of the paint.



The right and wrong ways to move a spray gun are shown below. The most important thing to remember in achieving an even coating is to keep the wrist flexible.



Triggering is drawing back and releasing the trigger and should be done with each stroke. The further the trigger is drawn back, the greater will be the flow of paint. To avoid paint build up at the ends of each stroke, the stroke should be started, then the trigger is pulled. The trigger is released before the end of the stroke. The gun is aimed at the bottom of the previous stroke to assure sufficient overlap. Triggering is very important. The triggering must be timed correctly to obtain full coverage without over spray.

The gun should be held parallel to the work surface at all times. At times, it will be necessary to tilt the gun, but this should only be done when the surface is not suited to the correct gun position.

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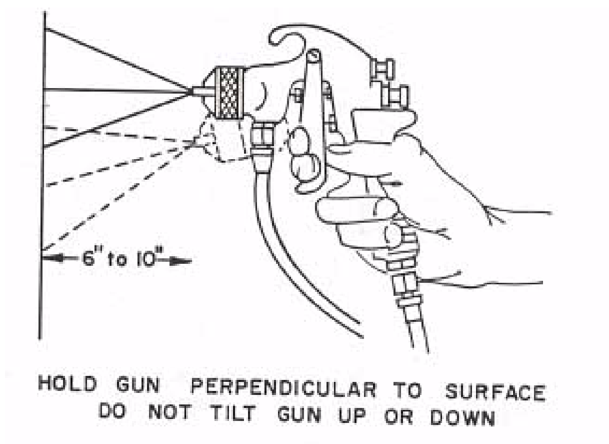
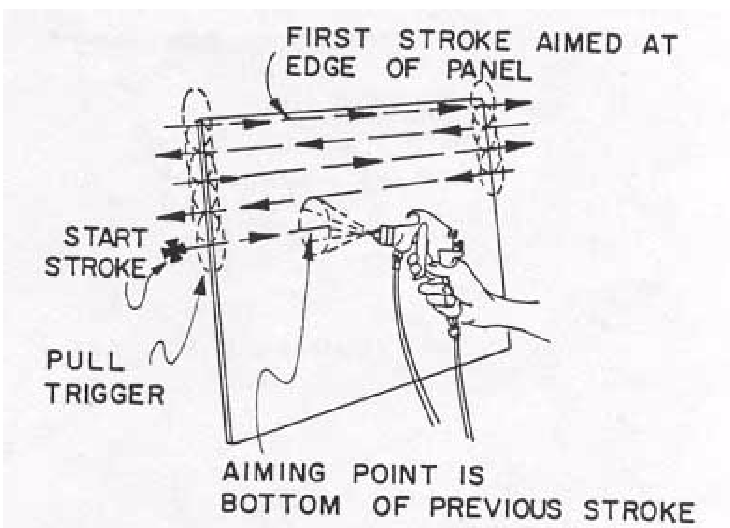
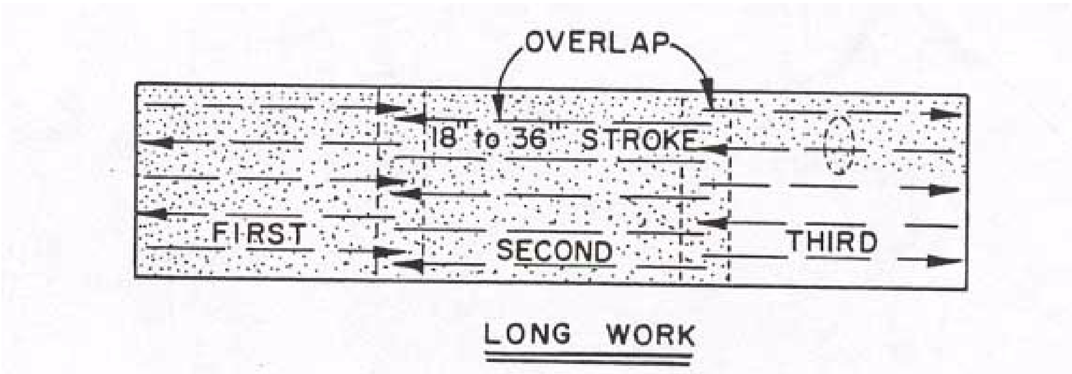


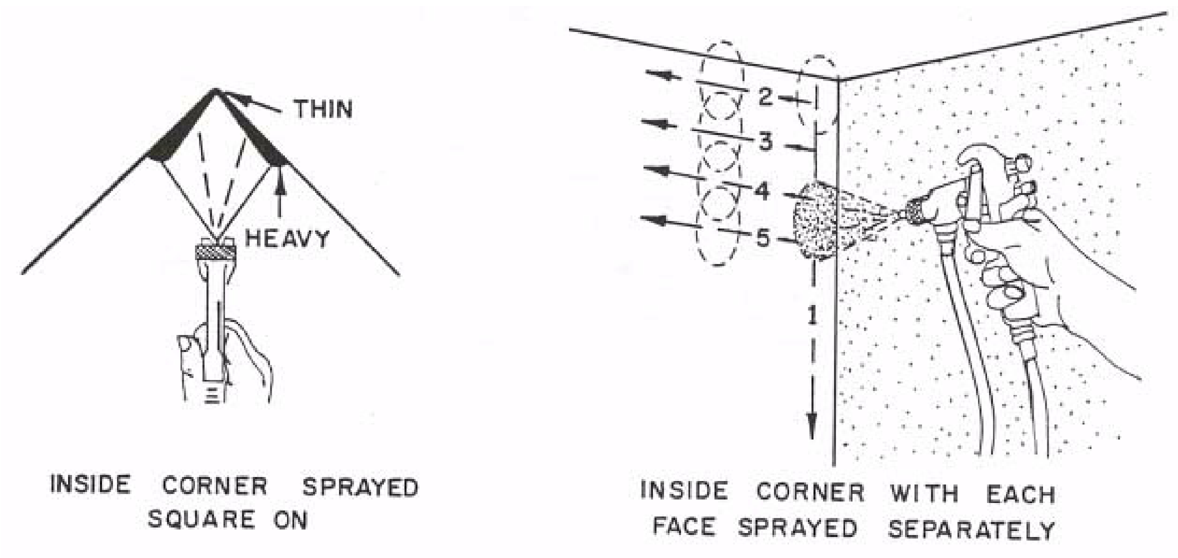
When spraying a panel alternate right and left strokes are used, triggering the gun at the beginning and end of each stroke. The spray pattern should overlap one-half the previous stroke for smooth coverage without streaks..



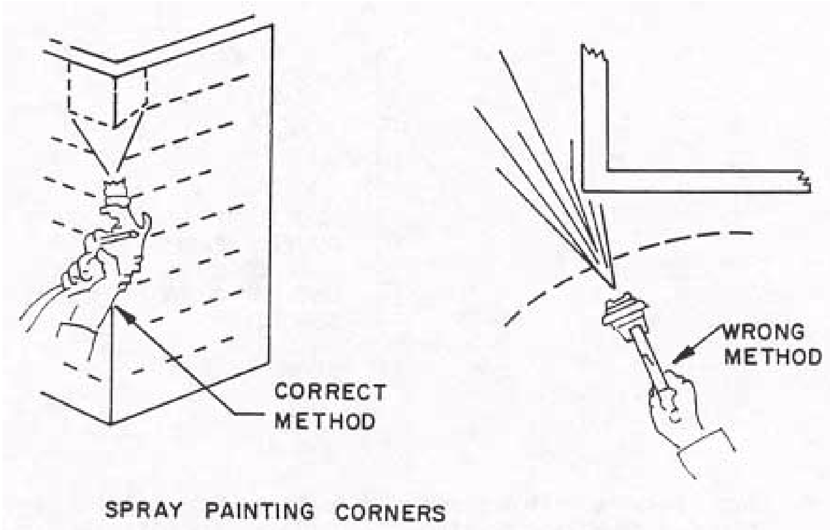
When spraying long sections, the work should be divided into convenient sized sections. These sections should not put the sprayer out of position. Then each section should be overlapped by 3" to 4".



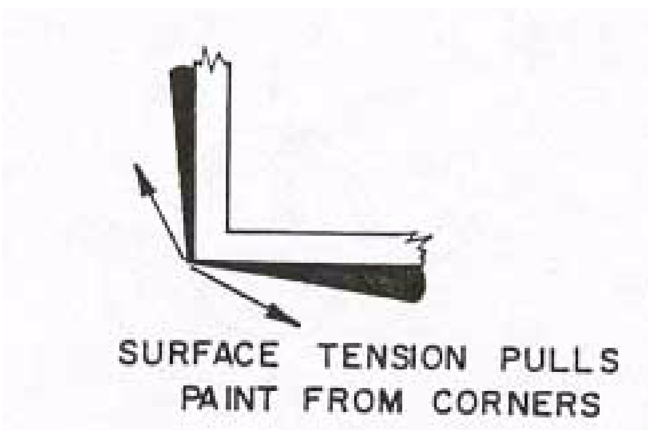
When spraying inside corners, each face should be sprayed separately with strokes going right up to the corner



Outside corners should first be sprayed 'square-on' as shown below. Then each face should be sprayed with strokes going right up to the corner to provide adequate coverage.



Extra care must be taken to be sure there is sufficient coating thickness on the corners because of the surface tension from either side. On each side of the corner, the tension makes the paint pull away from the corner leaving a thin coating. This is one reason corrosion is more likely to start on a corner than on a flat surface.



10.3.5 Surface Profile:

An important factor that affects the dry film thickness of a coating is the anchor pattern of the surface. The anchor pattern is the etched surface or tooth obtained when an abrasive strikes metal. The clean etched surface produced by sandblasting is necessary if modern coatings are to adhere properly. The anchor pattern depends on the size of the blasting shot or grit being used. An anchor pattern of 1 to 3 mils means the average heights for the valleys and peaks in the blasted surface range from 1 to 3 mils.

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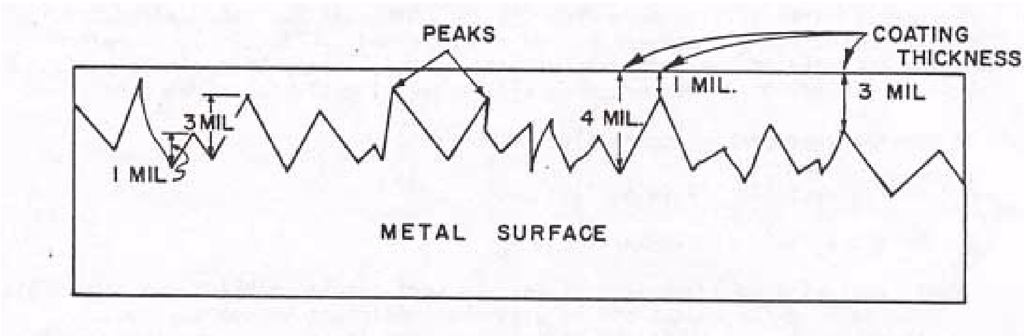
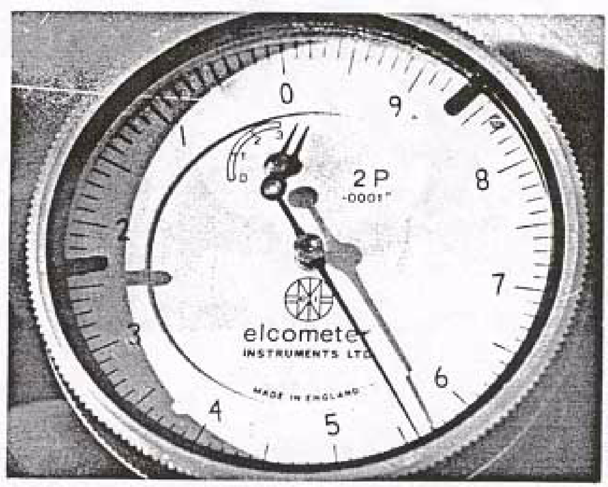


ANCHOR PATTERN

The anchor pattern is important in thickness measurement because it directly affects the reading of dry film gauges. If a surface has an anchor pattern of 1 to 3 mils, it means any thickness measurement taken on the surface can be incorrect by as much as 3 mils. For example: A thickness reading of 4 mils taken in a valley would mean a coating of only 1 mil exists above a 3 mil peak. To be sure dry film gauge readings indicate an average above the peaks thickness, take at least three or more readings in one area before moving to the next test site.

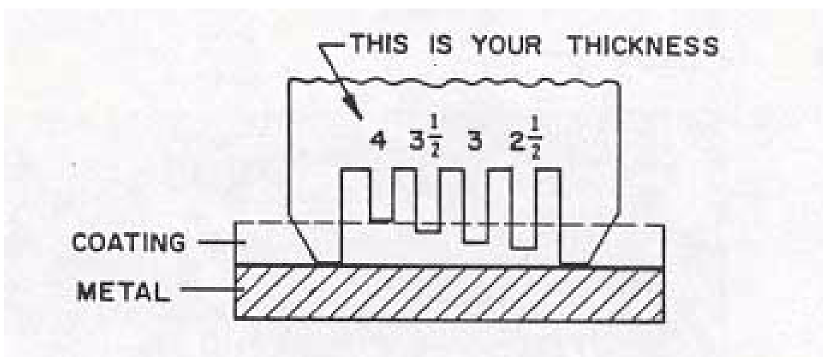


A surface profile gauge is used to measure the roughness of the sand, shot or grit blasted surfaces.

The probe on the gauge consists of a flat base with a spring loaded, hardened tip. The flat base rests on the peaks of the surface being measured, and the fine pointed tip projects into the valleys. The depth to which the sharp tip projects downward is registered on the dial in mils.
The gauge is Calibrated (zeroed out) using a clean piece of flat glass.

10.3.6 Coating Thickness:

As the paint is being applied and after it has dried, the thickness of the coating should be checked. This is to make sure enough paint is going on the prepared surface. There are two kinds of gauges for checking wet and dry paint thickness.
Wet film thickness gauge: As the paint is being applied, a wet gauge should be used to check the amount of paint going on the surface. To be sure enough paint is being applied, the coating thickness should be checked frequently during the paint operations.
It is easier to get the right thickness rather than having to apply another coat once the paint dries. After the coatings have dried it is too late to find that one layer that is not thick enough.



Wet paint is comprised of solids and thinner. The percent of solids (by volume) originally in paint is found on the paint label. Any thinner added to it reduces the percent solids. In order to determine the wet film thickness needed to produce the desired dry film thickness one needs to calculate the percent solids (by volume) in the paint after thinning:

% Solids after thinning =Orig. % Solids by Vol. (from the data sheet) / 100%+ %Thinner Added

Use the chart below the determine the approximate required wet thickness:

WET TO DRY MIL CONVERSION CHART

Solids in Paint - % by volume

Wet Mils (Before thinners evaporate)	100	90	80	70	60	50	40	30	20	10
10	10	9	8	7	6	5	4	3	2	1.5
9	9	8.1	7.2	6.3	5.4	4.5	3.6	2.7	1.8	1.3
9	8	7.2	6.4	5.6	4.8	4.0	3.2	2.4	1.6	1.2
7	7	6.3	5.6	4.9	4.2	3.5	2.8	2.1	1.4	1.0
6	6	5.4	4.8	4.2	3.6	3.0	2.4	1.8	1.2	.9
5	5	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	.7
4	4	3.6	3.2	2.8	2.4	2.0	1.6	1.2	.8	.6
3	3	2.7	2.4	2.1	1.8	1.5	1.2	.9	.6	.4
2	1.5	1.3	1.2	1.0	.9	.7	.6	.4	.3	.2
1	1	.9	.8	.7	.6	.5	.4	.3	.2	.15

Instructions for using chart:

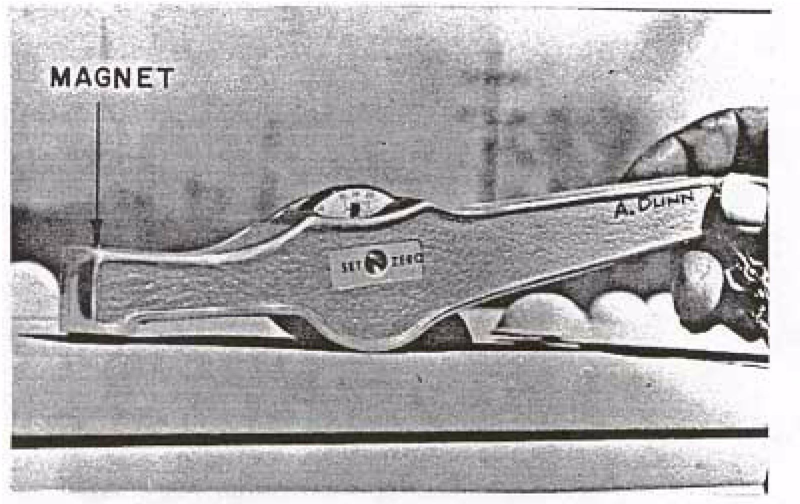
[1] Find the number of wet mils on left side based on the reading from wet mil thickness gauge.

[2] Find the percent of solids by volume at the top of the chart. (Check paint can label for this information.)

[3] Run you left finger along the number of wet mils and your right finger down the solids column. The square where these two meet gives the dry thickness.

<u>For example</u>: Say you apply 4 mils of paint that contains 70 percent solids. Where the 4 and 70 meet reads 2.8. You will have about 2.8 mils of paint when it dries.

Below is a photograph of a typical Dry film gauge that is used to insure the proper-finished thickness.
Dry film thickness gauge: The dry film gauge is used once the paint has dried. It is important to check each coat of paint before the next coat has been applied.
This gage is commonly called the "Banana Gage". It is a magnet that is attached to one end of a pivoting balance arm. This gage is used in accordance with Specification SSPC-PA2 (Measurement of Dry Coating Thickness with Magnetic Gages) & ASTM D 1186-93.



10.3.7 Painting Problems:

1. Alligatoring -

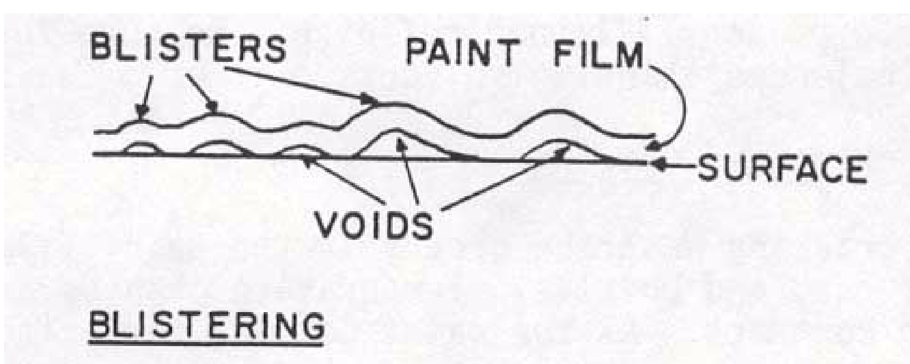
A condition which resembles alligator hide, with the coating pulling away from the surface and causing a rough finish. Applying paint (alkyds, some vinyl, etc.) when the weather is too cold usually causes alligatoring. Because it is cold, the surface of the coating dries while the under portion does not. As the whole coating dries and shrinks, it causes the ridges.

This can also be caused by not allowing sufficient drying of paint before re-coating, extreme temperature changes, and incompatibility between coats of paints, as when a vinyl is applied over an alkyd.

Remedy: The finish in the affected area should be removed down through the damaged paint film and refinished. Use of solvent recommended by the paint manufacturer, allowing sufficient drying times between coats of paint, and mixing paint thoroughly before applying will reduce the chance for alligatoring. Using only compatible paints will also reduce alligatoring. See Table VII on page 22.

2. Blistering -

There are many causes of blistering. This defect resembles blisters received on hands from using an unfamiliar tool.



Some of the causes of this problem are:

A. Failure of the topcoat to stick to the primer.

B. Painting over oil or moisture on the surface which prevents proper bonding of paint to the surface.

C. Applying too much paint at one time so that the solvents in the coating cannot escape before the top of the coating has dried.

D. Coating has been cleaned by steam and the steam has penetrated it and caused debonding.

E. Finger prints on metal.

F. Trapped air when very thick coatings are being applied.

Remedy: The blistered area should be sanded with #400 paper or a ball of screen wire. The area should then be refinished.

3. Blushing -

The surface of the coating turns milky. This is almost always a reaction of the coating with surface moisture or excessive moisture in the air. Using fast or unbalanced thinners in high humidity is the primary cause of blushing.

Just about any epoxy, no matter the curing system, can be made to blush because of moisture if the curing agent is not properly mixed in and allowed to set a while before application.

Remedy: Blushing may be overcome by the addition of a "retarder", which is a high boiling, slow evaporating solvent. However, in high humidity, this might fail and then painting must stop.

4. Chalking -

This is the result of weathering of the paint at the surface of the coating. The vehicle is broken down by sunlight and other forces, causing a loss of gloss and leaving a loose powdery pigment (similar to chalk) on the surface. Insufficient paint agitation or poorly balanced thinning solvents can also cause chalking.

Remedy: The powdery film should be removed and the area should be refinished. Proper agitation and the use of balanced thinning solvents should eliminate this problem.

5. Checking, Cracking and Crazing -

Checking and cracking describe breaks in the paint film that are formed, as the paint becomes hard and brittle.

Temperature changes cause the metal and paint to expand and contract. As the paint becomes hard, it cannot expand and breaks.

A. Checking consists of tiny breaks in only the upper coat or coats of paint and does not go all the way to the metal below (crows foot appearance).

B. Cracking, which looks like dried mud, extends through all coats of paint to the metal surface. These defects are caused by insufficient drying time between coats, extreme temperature changes, thick, heavy coatings which cannot expand and contract, and incompatibility of coatings.

C. Crazing is a series of tiny scales or cracks caused by thinner softening an acrylic coating.

Remedy: The finish down through defective paint film should be removed and the area should be refinished. Solvents recommended by manufacturer must be used. Allowing sufficient drying time before recoating, avoiding extreme temperature changes (cold-checking, cracking), avoiding heavy coats of lacquer, mixing paint thoroughly before applying, and using compatible thinners will reduce checking, cracking and crazing .

6. Cobwebbing -

A spider web effect caused by premature drying. A lack of solvent and low pot pressure can also cause a stringy, cobweb finish.

Remedy: Correct nozzle size, correct pressure, and a solvent balance with paint being used will eliminate cobwebbing..

7. Crawling -

Shrinkage of paint film to form an uneven surface shortly after application (Also called creepage). Crawling occurs when the new coating fails to wet and form a continuous film over the preceding coat. (Applying latex paints over high gloss enamels, etc.)

Remedy: The use of compatible paints will reduce crawling. See Table VII.

8. Dry Spray (Dusting) - Overspray -

A. Dry Spray or Dusting -

This is caused by holding the gun too far from the surface allowing solvents to evaporate in the air. When the paint reaches the surface, it is too dry to adhere properly. This can also be caused by wind blowing the paint, using a thinner which dries too quickly, insufficient thinner, or using too large a fan pattern. Dusting has a rough (sandy) texture and is easily brushed off.

Dry spray "drinks" up solvent from the coating applied over it and can cause poor adhesion of that coating because it will not let it "wet" the surface before it dries. Some of the quick-drying vinyls and inorganic zinc coatings are particularly prone to dry spray.

Remedy: Dry spray which falls on bare metal should be cleaned off by light sand blasting or rubbed with a pad or ball of screen wire and blown off. A new coat of paint should then be applied.

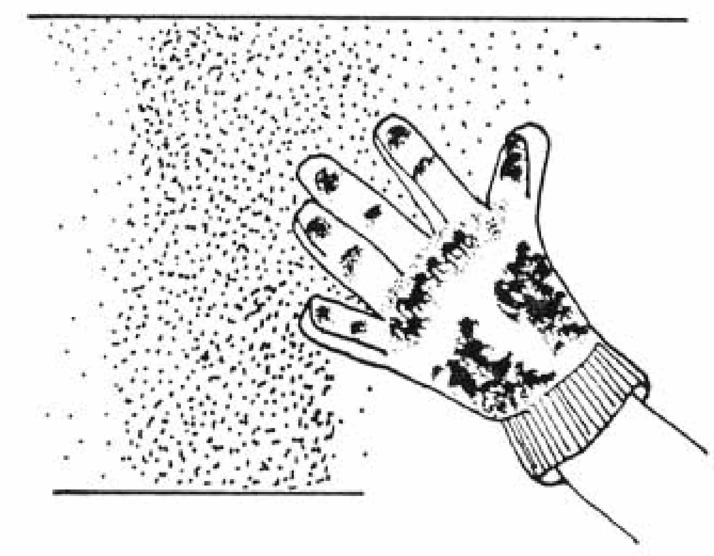
B. Overspray -

This is the result of paint particles falling on the surface outside of the normal spray pattern. These particles usually are dry by the time they reach the surface and this causes the dry spray effect described above. Over spray occurs due to excess air atomization pressure, wind blowing paint from target, or holding gun too far from work. One result of overspray is lap marks which are caused by spraying over an area already coated. The previous coat has already started to dry and does not blend in. Inorganic zincs are almost impossible to apply to large surfaces without some lapping showing. When applying inorganic zincs, extra care must be used to minimize lap marks.

Remedy: Overspray on the top coat of a surface results in poor appearance but is not too objectionable since it does not interfere with the adhesion of the coat below. (Rubbing with a rag or screen wire will remove overspray). Dusting which falls on uncoated metal or an intermediate coat of paint must be removed because it will prevent proper bonding when a full wet coat is sprayed on it. If metal is previously uncoated, overspray can be removed by sandblasting or by rubbing with a ball of screen wire or sandpaper. If metal has a coat of paint which is to be topcoated, overspray can be removed with a ball of screen wire or sandpaper.

9. Dirt or Sand in the Finish -

Lack of proper cleaning, blowing off, dirty work area, dirty air inlet filters, a dirty spray gun, dirt in the paint or failure to completely remove sandblasting sand and residue all lead to dirt in the finish. Any dirt or sand in the paint will keep it from adhering properly to the surface. If the surface wiped with a rag or glove shows residue, it is not properly cleaned.



Remedy: the affected area should be rubbed out with a polishing compound or sanded then refinished. The area to be painted should be "Tack wiped" or air cleaned with compressed air immediately before spraying in order to remove dust and dirt. Equipment should be kept clean and in proper working order. All sandblast sand should be removed from the roadway and work area before painting starts so that it is not be blown into the paint.
BLASTING SHOULD NOT BE PERFORMED NEAR AN AREA BEING PAINTED.

10. Failure to Dry -

There are four reasons why a coating fails to dry:

A. Wrong thinner.

B. Failure to add catalyst or curing agent to epoxies.

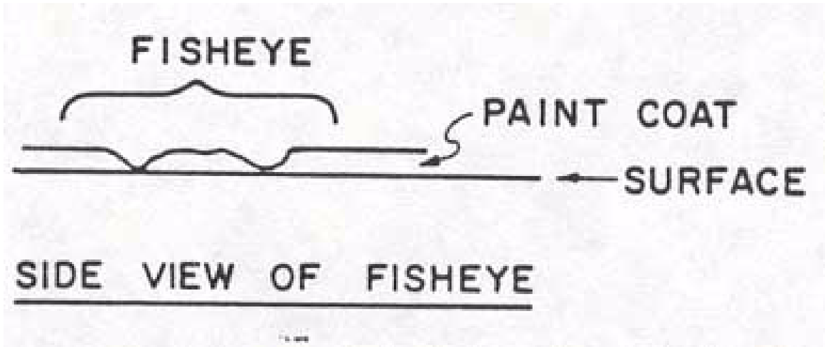
C. Applying a film so thick, that solvent cannot escape.

D. Weather is so cold that solvent cannot escape.

Remedy: Applying correctly mixed paint at the proper mil thickness when weather conditions are suitable should minimize failure to dry.

11. Fisheyeing -

This is the separation of the coating over slick surfaces or over oil or greasy surfaces. Silicone contamination from lubricants, greases, etc. can also cause this to happen, but this is rare. Fisheyes allow corrosion to start because of insufficient paint coverage.



Remedy: The affected area of wet paint should be washed off and the surface should be cleaned properly. The source of silicone must be removed. Silicone contamination on the surface must be removed by washing off with solvent. A fisheye preventer must be used in paint sprayed over old film containing silicone.

12. Gelling -

This is usually a factor with inorganic zinc-rich coatings based on ethyl silicate (solvent-based) and catalyzed products such as epoxies. It is solidification of a coating before it is applied to the surface to be painted.

Remedy: Inorganic zinc coatings, which are solvent-based, will gel in the pressure pot when there is moisture in the air line which leaks into the pot. Since this product is actually cured by reaction with water or moisture in the air, it would quite naturally gel when exposed to water. Keep all moisture separators in working order.

13. Lifting -

Sometimes incompatible coatings are used together, and they do not wrinkle or alligator. Instead, the application of the incompatible coating will cause the coating beneath it to lose its adhesion and make the entire layer peel away from the surface. This is caused by the solvent in the topcoat acting as a paint remover on the coating below. This softens and swells the coating causing it to lift from the surface. This is likely to occur when paints containing strong solvent such as xylene are applied over soft paints such as oils. Lifting can also occur if an undercoat is not allowed to dry properly before applying the next coat. Painting over dirty, oily, or greasy surfaces can cause lifting.

Remedy: The finish should be removed down through the damaged paint film. A solvent recommended by the paint manufacturer must be used. Sufficient drying times between coats of paint must be provided. Proper paint mixing is important. This problem can also be avoided by using compatible paints. See Table VII..

14. Mottling -

Clusters or streaks of metallic particles cause a mottled finish. This is caused by too much thinner, very wet or heavy coats of material, the puddling or lumping of particles caused by an electrostatic attraction, or improperly mixed paint.

Remedy: In severe cases the problem can be remedied by sanding with #400 paper and then applying an additional topcoat of reduced thickness according to label directions. To avoid mottling, the contractor should apply light coats of material, use fast evaporation thinners or reducers with no retarders, use higher air pressures, and properly ground the spray gun.

15. Mud Cracking -

This defect occurs only with inorganic zinc coatings. When they are applied too heavily (usually above 8 or 9 mils dry) the actual weight of the liquid coating will pull it apart and form a surface. The resulting finish resembles dried, cracked mud.

Remedy: The coating must be removed and reapplied. Applying several thinner coats and allowing them to dry completely before recoating will help eliminate this problem.

16. Orange Peel -

This defect resembles the skin of an orange, or ball peen hammer dents in the surface. The prime causes of the condition are improper solvents, insufficient atomizing air, or both. (Many coatings when sprayed will show an orange peel effect, but if the chemistry of the fluid is right, the finish will be correct by the time the flash-off and curing has taken place). Other causes of this condition are air pressure set too low, material too high in viscosity, or improper spraying (gun too close to work).

Remedy: Rubbing with rubbing compound when thoroughly dry will usually remedy this condition. If the condition is extremely bad, it must be sanded down and refinished. Using slower solvents, and increasing atomizing air pressure will help prevent orange peeling.

17. Peeling -

Peeling is the separation of the topcoat from the surface below. It is caused by improper surface cleaning, improper undercoats, and unbalanced thinning solvents.

Remedy: The damaged areas must be sanded and refinished. Thoroughly cleaning old surfaces, using recommended primers, and following recommended practices should prevent this.

18. Pinholing (Bubbling, Solvent Pops) -

These defects are quite common to coating application. Pinholing often is the result of water contamination in the air line. Or of a solvent imbalance (a solvent which is drying too quickly). If the solvent is too "fast," the coating will not have enough time to flow out before it becomes a solid and little holes are left in the coating. In addition, trapped solvents, settling of pigments and insufficient atomization of the material may cause pinholing.

Bubbling and pinholing are related to inorganic zinc coatings. These coatings are quite porous and, when a topcoat is applied over them, the pressure of the coating filling the voids in the zinc film forces air to the surface.

Remedy: Should pinholing occur, consult the Materials Laboratory so that the cause can be located and eliminated. The best remedy is to use a tie coat of primer thinned considerably, or to thin the topcoat 25 to 50 percent. If allowed to dry, this will seal the porous surface of the zinc-rich primer and allow the final topcoat to be applied without problem. If the use of a tie coat is not acceptable, a mist coat of the topcoat over the surface before following it with a full wet coat may prevent the problem. This acts very much like a tie coat. In extremely severe cases of pinholing, it may be necessary to sand down to a smooth surface and refinish. Prevention: The drain valve of the air line extractor should be opened daily to allow drainage of collected moisture. The internal cleaning section of older type extractors should be removed and cleaned at regular intervals. Paint needs to be applied in uniform, normal coats to allow proper evaporation of solvents. Using recommended thinners and increasing air pressure for proper atomization should prevent pinholing.

19. Runs -

When this defect occurs the wet paint film runs in rivulets. It is caused by over thinning, extra slow thinners, improperly cleaned surface, or the surface being too cold. Holding the spray gun too close to the surface and depositing too much paint on the surface can also cause runs.

Remedy: The affected area must be sanded, or washed off and refinished. Then the surface should be thoroughly cleaned; Thinning should be carried out as recommended using specified solvents.

20. Sags -

Sags consist of heavy thickness of paint which have slipped and formed curtains on the surface. This is caused by insufficient thinner, insufficient drying time between coats, low air pressure causing insufficient atomization, gun too close to work, or gun out of adjustment.

Remedy: The affected area must be sanded, or washed off, and refinished. Reducing viscosity as recommended; use proper thinning solvent; adjusting the air pressure and gun for correct atomization; and keeping the gun at correct distance from work should reduce sags.

21. Wrinkling -

This may occur either in cold weather when the thickened paint is improperly applied or in hot weather when the topcoat dries quickly but the paint underneath is still wet. The resulting stresses cause the paint to wrinkle.

Remedy: Paint should be applied within prescribed weather requirements.

22. Miscellaneous Problems -

A. Insufficient Cleaning

If the surface is coated with dirt, grease, sand, oil, or old paint, the coating will not adhere properly. The paint may dry very slowly, crawl, or alligator. Flaking and peeling from the surface will be sure to occur. Also, if the sandblast sand residue is not completely removed from anchor pattern it will affect adhesion and cause the paint to be more porous. (See Dirt or Sand in Finish).

B. Improper Repair

Holes and cracks that are not filled and repaired properly will allow moisture to get behind the coating. This will cause blistering, flaking, and peeling.

C. Insufficient Coating Application

Obviously, if too little paint is applied or the paint has been thinned too much, the coating will not last long. Chalking and erosion will wear through a thin film faster and the structure will have to be repainted sooner than when the correct thickness is applied. Care must be taken to see that there is sufficient paint over the top of the anchor pattern to prevent corrosion starting on the peaks. Corrosion can start in a relatively short period of time depending on thickness of paint over the peaks. With lead paints, pitting starts. With organic zinc paints, the breakdown is not as quick; stains show on peaks before corrosion begins.

RECOMMENDED PRIMER/TOPCOAT SYSTEM

PAINTS AND COATINGS COMPATIBILITY GUIDE

* INDICATES THAT "BLEED-THRU" MAY BE A SEVERE PROBLEM

NOTE: LDN MS-55 IS BASIC LEAD SILICO CHROMATE

KEY: G – Good, Recommended
M – Marginal
NR – Poor, Not Recommended

TOPCOAT	PRIMER OR PREVIOUS COATING																	
	Acrylic	Alkyd & LDN MS-55	Bitumen	Chlorinated Rubber	Epoxy-amine	Epoxy-Coal Tar	Epoxy-Ester	Epoxy-Polyamide	Latex	Oil-Base & LDN MS-55	Phenolic (Modified)	Polyester	Silicone	Silicone-Alkyd	Urethane (Modified) – Roughen Surface First –	Vinyl	Zinc-Inorganic	Zinc-Organic
Acrylic	G	M	M*	G	G	G*	M	G	G	G	G	G	G	M	G	G	G	G
Alkyd & LDN MS-55	M	G	G*	G	G	G*	G	G	M	G	G	G	G	G	G	G	NR	NR
Bitumen	G	G	G	G	G	G	G	G	G	G	G	G	M	M	G	G	G	G
Chlorinated Rubber	M	G	M*	G	G	G*	G	G	G	G	G	G	G	G	G	G	G	G
Epoxy-Amine	NR	NR	NR	NR	G	G*	NR	G	NR	NR	G	G	NR	NR	G	NR	G	G
Epoxy-Coal Tar	NR	NR	M	NR	G	G	M	G	NR	NR	G	G	NR	NR	G	NR	G	G
Epoxy Ester	G	M	M*	G	G	G*	G	G	G	NR	G	G	M	M	G	G	M	M
Epoxy-Polyamide	NR	NR	NR	NR	G	G*	NR	G	NR	NR	G	G	NR	NR	G	NR	G	G
Latex	M	M	M*	M	M	M*	M	M	G	M	G	G	M	M	M	M	G	G
Oil-Base	M	G	G*	G	G	G*	G	G	M	G	G	G	G	G	G	G	NR	NR
Phenolic (Modified)	NR	NR	NR	NR	M	M*	NR	M	NR	NR	G	G	NR	NR	M	NR	G	G
Polyester	NR	NR	NR	NR	M	M*	NR	M	NR	NR	M	G	NR	NR	M	NR	NR	NR
Silicone	G	M	M*	G	G	G*	G	G	M	M	G	G	G	M	G	G	G	G
Silicone-Alkyd	M	G	G*	G	G	G*	G	G	M	G	G	G	G	G	G	G	NR	NR
Urethane (Modified)	NR	M	M*	M	M	M*	M	M	M	M	G	G	M	M	G	M	G	G
Vinyl	M	NR	M*	G	G	G*	M	G	M	NR	G	G	M	M	G	G	G	G

Table VII

D. Improper Drying Between Coats

If the primer is not allowed to dry thoroughly before the topcoat is applied, several problems can be expected. Trapped solvent, which must eventually come out, will cause pinholing, blistering, or lifting.

E. Incompatible Solvents

To prevent separation of the coating due to incompatible solvents, only the solvents recommended by the paint manufacturer should be used. If another solvent must be used, a small portion of paint and solvent should be mixed and checked for separation. Then a small area should be painted with primer and then topcoat to see if any separation occurs before starting painting operations.

F. Incompatible Paints and Thinners

Each layer of a painting system must be compatible with the layer below. Any incompatibility caused by the addition of incorrect thinners, preservatives, or substitution of one of the coats in the system will result in defects in the finish. There will be a loss of adhesion, lifting, peeling, alligatoring, crawling, or intercoat peeling (separation of the topcoat and primer causing the topcoat to flake and peel). Table VII will act as a guide in determining which topcoats and primers are compatible.

Find the primer to be used at the top and desired topcoat on the left side of the chart. If there is a "G" at the intersection of the primer and topcoat, they are compatible. If the intersecting square has an "M" the compatibility is marginal and if the square has a "NR" the selected topcoat is not compatible with the primer. Remember that inorganics will not stick over organics.

Maintenance

Surface Preparation (maintenance painting):

Flame Cleaning: The removal of mill scale, grease, and rust from steel surfaces, immediately prior to priming with paint or other coating, is effectively performed with a de-scaling attachment for an oxyacetylene welding torch. This attachment is normally either 4 or 6 inches wide, permitting a broad, flat area to be covered with few passes. It is equipped with a hard skid or shoe, which protects the head from wear and spaces the flame with respect to the work. Circular tips are also available for working around rivet heads and at other than flat surfaces.

Painted surfaces can be cleaned in a similar fashion, since the flame burns the old paint away and cleans the original steel surface. Mill scale and rust expand as the steel surface is flame cleaned and thus break their bond with the base steel. The flame cleaned surface is ready for immediate painting since the cleaning and descaling remove all surface moisture. It is best to apply prime coating while the newly cleaned surface is still warm; otherwise atmospheric moisture will condense on the cool surface and initiate rusting or oxidation. This drying feature is of fundamental importance along waterways, in humid climates, and in corrosive atmospheres.

Painting - APPENDIX

A.1 Scope

The recommendations contained in this appendix are believed to represent current good practice, but are not to be considered as requirements of the specification.

A.2 Commercial Blast Cleaning should be employed for all general purposes where a high, but not perfect, degree of blast cleaning is required. It will remove practically all rust, mill scale, and other detrimental matter from the surface. The surface will not necessarily be uniform in color, nor will all surfaces be uniformly clean. If the cleaning done according to this specification is likely to result in a surface unsatisfactory to the owner or unsuitable for sever service, then Near-White Blast Cleaning or White Metal Blast Cleaning should be specified by the owner in the contract. The advantage of commercial blast cleaning lies in the lower cost for satisfactory surface preparation for most service conditions.

A.3 When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned in accordance with this specification and the amount of spot cleaning required. In maintenance painting it is not ordinarily intended that sound, adherent old paint be removed unless it is excessively thick or inflexible.

In preparing a previously painted surface, it is necessary to remove all corrosion and all paint which shows evidence of corrosion, peeling, excessive thickness, brittleness blistering, checking, scaling or general disintegration. It is essential that the removal of the old paint be carried back around the edges of the spot or area until an area of completely intact and adhering paint film, with no rust or blisters underneath, is attained. Edges of tightly adherent paint remaining around the area to be recoated must be feathered, so that the repainted surface can have a smooth appearance. The remaining old paint should have sufficient adhesion so that it cannot be lifted as a layer by inserting a blade or a dull putty knife under it. The rate of blast cleaning may vary from one area to the next in order to achieve the desired end condition.

A.4 The maximum permissible size of the abrasive particles will depend upon the allowable surface roughness or "maximum height of profile" of the surface; the allowable maximum height of profile is, in turn, dependent upon the thickness of paint to be applied.

The maximum height of profile is the height of the anchor pattern produced on the surface, measuring from the bottoms of the lowest pits to the tops of the highest peaks.

The maximum height of profile produced by a number of different abrasives in actual blast cleaning operations has been measured as follows:
Maximum profile will vary somewhat with the angle and velocity of particle, with the hardness of surface, with the amount of recycling of working mixtures (of shot and grit) and with the thoroughness of blast cleaning.

A.5 The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed over a smooth surface for the desired protection. If it is not possible to use an abrasive sized small enough to produce a desirable height of profile, the dry paint film thickness should be increased to provide adequate thickness above the peaks.

A.6 A suitable inhibitive treatment for blast cleaned surfaces is water containing 0.32 percent of sodium nitrite and 1.28 percent by weight of ammonium phosphate, secondary (dibasic), or as an alternate water containing about 0.2 percent by weight of (a) chronic acid of (b) sodium chromate of (c) sodium dichromate of (d) potassium dichromate. Note: If solutions containing either chromate's or dichromate's are used, precautions should be taken to protect personnel from hazards resulting from breathing spray or contacting the solution.

A.7 The blast cleaned surface must be treated or primed before any rusting occurs. Otherwise the benefit of the commercial blast cleaning is lost. The freshly exposed bare metal will rust quickly under conditions of high humidity, when wet, or when in a corrosive atmosphere. Under normal mild atmospheric conditions, it is best practice to prime or chemically treat within 24 hours after blast cleaning. Under no circumstances should the steel be permitted to rust before painting, regardless of the time elapsed.

Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is, therefore, recommended that dry blast cleaning should not be conducted when the steel surface is less than 5º F. above the dew point.

The permissible time interval between blast cleaning and priming will vary greatly (from minutes to weeks) from one environment to another, in order that the surface remains free of corrosion, oil, etc. as required by Sections 3.6, 3.7, and

3.10. If a maximum interval is desired, it shall be so specified in the contract covering the work.

A.8 Photographic standards of comparison may be used to define the final surface condition to be Supplied under this specification. For partially rusted mill scale, for completely rusted mill scale, or for completely rusted and pitted surfaces, the appearance of the surface after Commercial Blast Cleaning should correspond with pictorial standards B Sa 2, C Sa 2, or D Sa 2 of SSPC-Vis 1-63T.

The color of the cleaned surface may be affected by the nature of the shot used.

Commercial Blast Cleaning

This correlation is cross-referenced in these visual standards, which were developed by the Swedish IVA, and have been mutually adopted by the Swedish Standards Association, the ASTM and the SSPC. As additional standards become available, particularly for initial surface conditions such as previously painted steel, these may be included by reference in the contract.

A.9 Other visual standards of surface preparation may be used as required by the owner when they are specified in the contract to illustrate the degree of metal cleanliness required. The owner will provide the specified samples or standards of such size and condition that they may be compared during the entire contract. If blast cleaned steel samples are used, they should be completely protected form corrosion during the period of the contract.

A.10 Where a referee rate-of-cleaning test is desired, the contract may specify that the surface shall be cleaned at least as well as one which is nozzle blast cleaned with dry Ottawa Silica Sand, American Foundryman's Association Standard Grad No. 27*, through a new nozzle with a one-quarter inch diameter bore, using an air pressure of 90 pounds per square inch gage at the entrance to the nozzle. During this test, the nozzle shall be held at the optimum angle and distance for the particular surface being cleaned. In this test, a plane or slightly curved surface shall be cleaned at a rate of three square feet per minute. This test establishes a standard for surface preparation and shall not be considered as a production rate of cleaning.

If this rate of cleaning does not result in a satisfactory end condition, then a different rate of cleaning may be agreed upon to establish a standard; a standard end condition may be prepared in situ or on a test piece as provided under A.9.

A.11 If specified in the contract, a fraction other than two-thirds of the surface area may be designated in Section 2.2

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 1

10.4.1. SSPC SP-1 Solvent Cleaning

1. Scope

1.1 This specification covers the requirements for the solvent cleaning of steel surfaces.

2. Definition

2.1 Solvent cleaning is a method for removing all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from steel surfaces.

2.2 It is intended that solvent cleaning be used prior to the application of paint and in conjunction with surface preparation methods for the removal of rust, mill scale, or paint.

3. Surface Preparation Before and After Solvent Cleaning

3.1 Prior to solvent cleaning, remove foreign matter (other than grease and oil) by one or a combination of the following: brush with stiff fiber or wire brushes, abrade scrape, or clean with solutions of appropriate cleaners, provided such cleaners are followed by a fresh water rinse.

3.2 After solvent cleaning, remove dirt, dust and other contaminants from the surface prior to paint application. Acceptable methods include brushing, blow off with clean, dry air or vacuum cleaning.

4. Methods of Solvent Cleaning

4.1 Remove heavy oil or grease first by scraper. Then remove the remaining oil or grease by any of the following methods:

4.1.1 Wipe or scrub the surface with rags or brushes wetted with solvent. Use clean solvent and clean rags or brushes for the final wiping.

4.1.2 Spray the surface with solvent. Use clean solvent for the final spraying.

4.1.3 Vapor degrease using stabilized chlorinated hydrocarbon solvents.

4.1.4 Immerse completely in a tank or tanks of solvent. For the last immersion, use solvent which does not contain detrimental amounts of contaminant.

4.1.5 Emulsion or alkaline cleaners may be used in place of the methods described. After treatment, rinse the surface with fresh water or steam to remove detrimental residues.

4.1.6 Steam clean using detergents or cleaners and follow by steam or fresh water wash to remove detrimental residues.

5. Inspection

5.1 All work and materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this specification. In case of dispute, the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

5.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

6. Safety

6.1 All safety requirements stated in this specification and its component parts apply in addition to any applicable federal, state and local rules and requirements. The also shall be in accord with instructions and requirements of insurance underwriters.

7. Notes

7.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

7.2 A Commentary Section is available (Chapter 2 of Volume 2 of the Steel Structures Painting Manual) and contains additional information and data relative to this specification. The following table lists the subjects discussed relevant to solvent cleaning and appropriate Commentary Section.

11.1 SSPC-SP 1, "Solvent Cleaning": This solvent cleaning specification includes simple solvent wiping, immersion in solvent, solvent spray, vapor degreasing, steam cleaning, emulsion cleaning, chemical paint stripping, and alkaline cleaners.

Solvent cleaning is used primarily to remove oil, grease, dirt, soil, drawing compounds, and other similar organic compounds. Solvent cleaning may also be used to remove old paint by the use of paint removers or alkaline paint strippers. Inorganic compounds such as chlorides, sulfates, weld flux, rust, and mill scale are not removed by cleaning with organic solvents.

Many solvents are hazardous. Care must be taken when using solvents for solvent cleaning. Special safety precautions must be followed with regard to ventilation, smoking, static electricity, respirators, eye protection, or skin contact.

Alkaline cleaning compounds cover a very wide range in composition and method of use. These are discussed in detail in Volume 1 of the Steel Structures Painting Manual, along with suitable solvents. It is important that residues of alkaline compounds do not remain on the surface after cleaning. The clean surface may be tested with litmus paper or universal indicating paper to see that it is neutral or at least no more alkaline than the rinse water that is used.

11.1.1 Petroleum and Coal Tar Solvents, and Turpentine: These types of solvents clean the metal by dissolving and diluting the oil and greases which contaminate the surface. Some solvents, especially coal tar solvents (aromatics), will also dissolve the vehicle of paints so they can be removed. It is important that the last wash or rinse be made with clean solvent in every case or a film of oil or grease will be left on the surface when the solvent of the last washing evaporates; this film may interfere with the bond of the paint to the metal.

Petroleum base mineral spirits (aliphatics), with a minimum flash point of 100º F, or "Stoddard Solvent" as per ASTM Specification D 484 should be used as the general purpose solvent for cleaning under normal conditions. In hot weather, or when temperature is 80 to 95º F , high flash aliphatic mineral spirits with a minimum flash point of 120º F should be used. In very hot weather, when the temperature is over 95º F, heavy mineral spirits with a flash point of over 140º F should be used. All solvents are potentially hazardous and they should be used under such conditions that their concentration in air being breathed by workers is low enough for safety (see Table 10, Threshold Limit Values). When used in closed spaces where the safe concentration is exceeded, fresh air masks should be worn. The fresh air intake should be clear of carbon monoxide or other contaminants from engine exhausts of other sources. The concentration of solvent in air should not exceed the lower limit of flammability as fire or explosion may result. Gasoline and V.M. & P. Naphtha are too dangerous for use under ordinary conditions.

Aromatic or coal tar solvents may be used where greater solvency is required, but they are more toxic and the solvents generally available have low flash points. Benzol (benzene) is the most toxic and should not be used, particularly in view of its low flash point and attendant fire and explosion hazard. Xylose, toluol, and high flash naphtha may be used when their concentration in air that is being breathed does not exceed the safe limit (see Table 10). If the concentration is greater, fresh air masks should be worn. Because of the low flash points of these solvents, fire and explosion hazards are inherent with their use and great caution should be taken to ensure safe working conditions.

Chlorinated hydrocarbons may be used. However, due to toxicity, chlorinated hydrocarbons are not recommended for general use except with special equipment and trained operators. Chlorinated hydrocarbons should never be used where they may affect steel.

"Safety Solvents" are satisfactory for use provided that they meet the flash point requirements above and that they are used under such conditions that the concentration of chlorinated hydrocarbons in air does not constitute a health hazard (see Table 10).

11.1.2 Alkaline Cleaners: These cleaners saponify certain oils and greases; their surface active constituents wash away other types of contaminants, such as oil. They may be particularly effective in removing paint because the alkali saponifies the dried paint vehicle. Since the soaps formed are soluble in water, the contaminants are more easily removed by washing with water after saponification, and the adhesive nature of the old paint is reduced by chemical action on the paint.

The most commonly used alkaline cleaner is trisodium phosphate, but there are other alkalies which are used. Some of these are mixtures with wetting agents and detergents. They are available as proprietary products and should be used in accordance with directions of the manufacturer.

Because of the paint removal action of many alkaline cleaners, the actual cleaner to be used should be chosen after consideration of the extent to which the paint may be damaged.

If no manufactured alkaline cleaner is available, good results may be achieved by the use of two ounces trisodium phosphate per gallon of water, to which is also added one to two ounces of soap or other suitable detergent. This solution is best used hot; if used cold, it may be advisable to increase the concentration. This solution is suitable for spraying or scrubbing; if used in dip tanks, the concentration may be tripled. If not washed from the surface, this mixture will soften and eventually loosen most paints. Where complete paint removal is the primary object, caustic soda (sodium hydroxide) may be substituted for the trisodium phosphate.

A soap film left on the surface is just as damaging to the paint bond as is an oil or grease film; therefore, the surface should be thoroughly washed (preferably with hot water under pressure) to remove this soap and other residue. Moreover, all alkali must be thoroughly removed from the surface or the new paint will be saponified and damaged by it. To test the effectiveness of the wash, universal pH test paper should be placed against the wet steel. The pH of the washed surface should be no greater than the pH of the wash water.

Following the rinsing, steel surfaces should be passivated with an acidic wash containing about 0.1% by weight of chromic acid or sodium dichromate, or potassium dichromate, to overcome the harmful effect of traces of alkali on paint adhesion. This passivating treatment may be applied by brushing, spraying, or dipping, but should not be used when the chromate-free phosphatizing operations are to follow.

Alkaline cleaners must be used with caution since bad burns may result from contact with some solutions. Particular care should be paid to protecting the eyes of workers; safety goggles or eye shields should be worn. Rubber gloves should be worn if the solutions will contact workers' hands. Chromic acid and the chromate's may cause dermatitis and precautions should be taken to protect the skin and hands of workers. Where alkaline cleaning compounds, chromic acid, or chromate's are sprayed, respirators should be worn.

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 6

10.4.2. SSPC SP-6 Commercial Blast Cleaning

1. Scope
1.2 This specification covers the procedure required for the Commercial Blast Cleaning of structural steel surfaces prior to painting or coating.

2. Definition
2.1 Commercial Blast Cleaning is a method of preparing metal surfaces for painting or coating by removing mill scale, rust, rust-scale, paint, or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels, to the degree hereafter specified.

2.2 A Commercial Blast Cleaned Surface Finish is defined as one from which all oil, grease, dirt, rust scale and foreign matter have been completely removed from the surface and all rust, mill scale, and old paint have been completely removed except for slight shadows,streaks, or discoloration's caused by rust stain, mill scale oxides or slight, tight residues of paint or coating that may remain; if the surface is pitted, slight residues of rust or paint, may be found in the bottom of pits; at least two-thirds of each square inch of surface area shall be free of all visible residues and the remainder shall be limited to the light discoloration, slight staining or light residues mentioned above. Photographic or other visual standards may be used as provided in the Appendix to modify or further define the surface if specified in the contract.

3. Procedures

3.1 Commercial Blast Cleaning shall consist of the following sequence of operations:

3.1.1 Heavy deposit of oil or grease shall be removed by the methods outlined in Spec. SSPC-SP 1063, "Solvent Cleaning." (See page 3) Small quantities of oil or grease may be removed by the blast cleaning operation. If oil and grease are removed by blast cleaning, the abrasive shall not be reused if such reuse is detrimental to the surface.

3.1.2 Excessive rust-scale may be removed by impact tools, as outlined in Spec. SSPC-SP 2-63, (See page 4), "Hand Tool Cleaning," or SSPC-SP 3-63, "Power Tool Cleaning" or by special blast cleaning equipment.

3.1.3 The surface of the metal shall be blast cleaned to a commercial finish by any of the following methods:
3.1.3.1 Dry sandblasting using compressed air blast nozzles and dry sand of a maximum particle size no larger than that passing through a 16 mesh screen, U.S. sieve series.

3.1.3.2 Wet or water-vapor sandblasting using compressed air blast nozzles, water and sand of a maximum particle size no larger than that passing through a 16 mesh screen, U.S. sieve series.

3.1.3.3 Grit blasting using compressed air blast nozzles and crushed grit made of cast iron, malleable iron, steel, or synthetic grits other than sand, of a maximum particle size no larger than that passing through a 16 mesh screen, U.S. sieve series. The largest commercial grade of metal grit permitted by this specification is SAE No. G-25 abrasive material.

3.1.3.4 Shot blasting using compressed air nozzles and cast iron, malleable iron, steel, or synthetic shot of a maximum size no larger than that passing through a 16 mesh screen, U.S. sieve series. The largest commercial grade permitted by this specification is SAE No. S-330.

3.1.3.5 Closed, recirculating nozzle blasting using compressed air, vacuum, and any of the preceding abrasives.

3.1.3.6 Grit blasting using centrifugal wheels and crushed grit made of cast iron, malleable iron, steel, or synthetic grits of a maximum particle size no larger than that passing through a 16 mesh screen, U.S. sieve series. The largest commercial grade of metal grit permitted by this specification is SAE No. G-25.

3.1.3.7 Shot blasting using centrifugal wheels and cast iron, malleable iron, steel, or synthetic shot of a maximum particle size no larger than that passing through a 16 mesh screen, U.S. sieve series. The largest commercial grade permitted by this specification is SAE No. S-330.

3.2 The surface, if dry blasted, shall be brushed with clean brushes made of hair, bristle or fiber, or blown off with compressed air (from which detrimental oil and water have been removed), or cleaned by vacuum, for the purpose of removing any traces of blast products from the surface, and also for the removal of abrasive from pockets and corners.

3.3 The surface, if wet sandblasted, shall be cleaned by rinsing with fresh water to which sufficient corrosion inhibitor has been added to prevent rusting, or with fresh water followed immediately by an inhibitive treatment. This cleaning shall be supplemented by brushing, if necessary, to remove any residue.

3.4 The compressed air used for nozzle blasting shall be free of detrimental amounts of condensed water or oil. Adequate separators and traps shall be provided.

3.5 Blast cleaning operations shall be done in such a manner that no damage is done to partially or entirely completed portions of the work.

3.6 Dry blast cleaning operations shall not be conducted on surfaces that will be wet after blast cleaning and before painting, or when ambient conditions are such that any visible rusting occurs before painting or coating. **If any rust forms after blast cleaning, the surface shall be re-blast cleaned before painting.**

3.7 The blast cleaned surface shall be examined for any traces of oil, grease, or smudges. If present, they shall be removed as outlined in Spec. SSPC-SP 1-63, "Solvent Cleaning."

3.8 The height of profile of the anchor pattern produced on the surface shall be limited to a maximum height that will not be detrimental to the life of the paint film. The maximum particle sizes specified in paragraphs 3.1.3.1 to 3.1.3.7 may produce an Anchor pattern that is too high or too rough for the paint system to be used. In such cases, the abrasive sizes should be reduced. If the application of the second coat of paint is deferred, an adequate reduction in anchor pattern height shall be made.

3.9 The height of the anchor pattern can be determined by grinding a flat spot on the blasted surface until the bottoms of the pits are almost reached. The height may be measured with a micrometer depth gauge graduated to read 0.001" and with a base having a bearing length of two inches and a measuring rod of 3/32" diameter.

3.10 The blast cleaned surface should be further treated or primed, as specified in the agreement covering the work, preferably within 24 hours after blast cleaning when practicable, but in any event before any visible or detrimental rusting occurs. Where chemical contamination of the surface may occur, the steel should be painted as soon as possible after blast cleaning.
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4. Safety Precautions

4.1 If fire or explosion hazards are present, proper precautions shall be taken before any work is done. If the structure previously contained flammable materials, it shall be purged of dangerous concentrations.

4.2 Nozzle Blast operators exposed to blast dust shall wear a U.S. Bureau of Mines approved helmet connected to a source of clean, compressed air.

4.3 Filter type air respirators should be worn by all others who are exposed to blast dust environment. Adequate protection for personnel from flying particles shall also be provided in any blasting operation.

4.4 Safety goggles shall be worn by all persons near any blasting operation.

4.5 Blast hose shall be grounded to dissipate static charges.

5. Inspection

5.1 All work under this specification shall be subject to inspection by the owner of his representative.
Surface Preparation Specifications
All parts of the work shall be accessible to the inspector. The contractor shall correct such work as is found defective under the specifications. If the contractor does not agree with the inspector, the arbitration or settlement procedure established in the contract, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

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Steel Structures Painting Council
10.4.5. Inspection (By K. Tator and K. Trimber)

An analysis of the reasons for premature coating failure - deterioration of a coating system resulting in rusting, pitting, chemical attack or other deterioration - in most cases leads to a finding of either improper surface preparation of deficient coating application. While there may be potentially many other reasons for premature failure such as poorly written specifications, choice of the wrong coating or paint for given environment, coating misinformation, or a service environment more severe than originally anticipated, it is estimated that approximately 75% to 80% of all premature coating failures are caused in whole or in part by deficient surface preparation and/or coating application.

It is said that "a painter covers his mistakes." This is unquestionably true. Unfortunately, after the surface has been coated, it is exceedingly difficult to verify the adequacy of surface preparation - especially blast cleaning. Furthermore, without the use of appropriate instrumentation, it is impossible to determine coating thickness or, in many instances, even the number of coats applied. However, during the course of application, these items - as well as many others that might affect the ultimate coating quality - can be readily witnessed and easily verified. Accordingly, formal coating inspection, following established guidelines or procedures, is mandatory on many large projects (such as nuclear power plants) and is often a requirement on smaller, critical applications such as tank lining coating work. Where the consequence of failure is expensive, the coated steel is inaccessible after erection or the magnitude of painting great, formal inspection can often be justified.

It must be recognized that any inspection, even the most casual kind, is an expense. Even during the performance of the work, fundamental inspection requires time. Inspection, in its simplest form, occurs when a painter stops after a certain portion of his work is completed and examines it for adequacy. Has he missed any areas? Are there any runs or sags? Is the blast cleaning pattern uniform and the cleanliness adequate - or in the case of hand or power tool cleaning, are there loose mill scale or rust deposits remaining? Formal inspection is more costly. Inspection procedures must be written, and the quality of work witnessed and documented on a periodic (often daily) basis. The inspector must have access to the work area, and be allowed sufficient time to complete his inspection work. Often this must be done at the expense of continuing coating operations - and although other tasks can be done during the inspection period, the net result is that the more stringent the inspection requirements, the longer it takes to complete the coating work. The direct costs of inspection must be considered because the inspectors are specially hired, trained, and equipped with expensive instruments in order to verify the quality of the work. Accordingly, inspection is often considered as an insurance against the possibility of a highly expensive premature coating failure.

The purpose of this chapter is to outline the inspections required to assure quality coating work. In addition, paint inspection equipment is described and summarized, including advantages and disadvantages, calibration and use. This chapter is presented in the chronological order of the inspection sequence beginning with pre-surface preparation inspections and continuing through final dry film thickness and holiday testing.

1. THE FUNCTION OF THE COATING INSPECTOR:

Throughout this discussion, the term "inspector" shall be used to indicate an individual or a group of individuals whose job it is to witness and document the coating work in a formal fashion. While informal inspection may be done by the painter, the painter's supervisor, or other persons directly involved with the coating work, this type of inspection shall not be considered in the course of this discussion.

The inspector's purpose is to ensure that the requirements of the coating specification are met. Their function is analogous to that of a police officer; they enforce the rules (specifications) without exception even if they deem them to be inadequate. The authorization to deviate from the specification I the responsibility of the "judge," usually the specification writer, contract administrator, or engineer in charge of the job. The inspector certainly may venture their opinion and give recommendation to the engineer, but cannot unilaterally deviate from the specifications at the working level.

Besides specification enforcement, a thorough coatings inspector provides a job documentation including a commentary on the type and adequacy of equipment at the jobsite, the rate of work progression, information regarding ambient conditions and controls, and verification that the surface preparation, coating application, coating thickness and curing are as required. This is supplemented with any other information they deem of consequence to the quality and progress of the work.

The amount and type of inspection will vary according to the size of the project and the type of application contract. There are a number of types of contracts, but for simplicity, two general categories, "fixed price" and "cost plus" will be addressed.

Inspection under "fixed price" application contract may be oriented to ensure that the contractor does not "cut corners" in order to hurry the job. While an evaluation of the equipment, work procedures, and sequence, etc., is important, the equipment and methods by which the contractor accomplishes the job are essentially at his/her discretion, provided the requirements of the specifications are met. When performing inspection services for a "cost plus" application contract, a knowledgeable inspector must be able to evaluate the contractor's equipment for adequacy and must be able to assess whether the rate of progress is reasonable.

2. SAFETY CONSIDERATIONS:

Safety is paramount on any job. Coating inspectors should be aware of basic safety requirements. Although the inspector is not expected to be proficient in all safety codes and regulations, common sense should certainly prevail. If lighting, scaffolding, or equipment malfunctions present safety hazards, the appropriate safety personnel should be notifies. Paint application inherently presents some dangers because the solvents used are flammable and because many objects to be painted are relatively high or inaccessible. To paint these areas requires elaborate staging or the use of spiders or swing scaffolding for accessibility. The knowledgeable inspector will assure himself/or herself of the safety of these appurtenances before he/ or her becomes involved. Other safety concerns are addressed more specifically in SSPC-PA 3, "A Guide to Safety in Paint Application."

3. INSPECTION SEQUENCE:

Inspection often begins with a pre-job conference at which the ground rules are set. The inspector is responsible for witnessing, verifying, inspecting, and documenting the work at various inspection points. The following points will be reviewed along with the appropriate instruments used for each:

1. Pre-surface Preparation Inspection
2. Measurement of Ambient Conditions
3. Evaluation of Compressor (Air Cleanliness) and Surface Preparation Equipment
4. Determination of Surface Preparation Cleanliness and Profile
5. Inspection of Application Equipment
6. Witnessing Coating Mixing
7. Inspecting Coating Application
8. Determination of Wet Film Thickness
9. Determination of Dry Film Thickness
10. Evaluating Cleanliness Between Coats
11. Pinhole and Holiday Testing
12. Adhesion Testing
13. Evaluating Cure

4. PRE-SURFACE PREPARATION INSPECTION:

Prior to the commencement of surface preparation or other coating activities, it may be necessary to inspect to determine if the work is ready to be prepared and painted. Heavy deposits of grease, soil, dust, dirt, cement, splatter and other contaminants must be removed. Removal of such large oil and grease deposits prior to blast cleaning assures that they are not redeposited onto freshly cleaned surfaces. This removal is accomplished by following the steps outlines in SSPC-SP 1, "Solvent Cleaning." This is particularly important when abrasive recycling, blast cleaning methods are used so that the abrasive itself does not become contaminated. Such contamination would be deposited onto any steel subsequently cleaned with the same abrasive.
The specification may require that weld splatter be ground or otherwise removed and that sharp edges be rounded. Laminations in plate steel, if detected prior to blast cleaning, should be opened. If deep enough, they may require weld filling and, if sufficient deterioration has occurred to the structure, replacement of some structural members, "fish plating" or other repair may be necessary. Responsibility for such repair should be specified in procurement documents but is not ordinarily considered to be part of the coating contract.

As a prelude to most painting operations, taping, masking and protections of adjoining surfaces not to be painted must be accomplished.

Inspection of all of the above is done visually or by touch. Except perhaps for a radius gage or inspection mirror, no readily accepted instruments and standards are used (although NACE, ASTM and SSPC are recurrently working on standards in these areas).

If the work involves maintenance painting, a determination of the percentage of rusting in an area will be helpful. It should be made in accordance with SSPC-Vis 2 "Standard Methods of Evaluating Degree of Rusting of Painted Steel Surfaces." In addition, the coating type should be ascertained in order to assure compatibility with subsequently applied coats. Although there is no quick "foolproof" field method for determining the type of coating present on a structure, a chemical test series developed by the U.S. Naval Civil Engineering Laboratory is available for general field studies. Alternately, and perhaps best, is a test patch application of the new coating over the old, two weeks or more in advance of production painting. The test patch is then examined for adhesion, signs of wrinkling, lifting, or other laboratories for quick, inexpensive determination of generic type (by infrared spectroscopic analysis).

5. MEASUREMENT OF AMBIENT CONDITIONS:

While this is not specifically an inspection hold-point, it is implicit that surface and coating work be done only under suitable ambient conditions of temperature, humidity, and dew point. For most catalyzed coatings, specific minimum temperatures must be met. Many zinc-rich coatings require certain minimum humidity's as well. The inspector should be cognizant of weather forecasts, particularly if coating work is to be done outdoors.

Other ambient conditions that might affect painting operations should be noted such as potential industrial or chemical airborne contamination, water spray downwind from a cooling tower, leaking steam or chemical lines, and contamination from normal plant or adjacent operations.

Often, a heater or dehumidifier is used to control ambient conditions for painting operations. Ideally, a heater should be indirectly fired so it does not contaminate the surface with products of combustion. Ventilation, if required, should provide for sufficient air flow and adequate ventilation of all areas where work is being performed. Most solvents are heavier than air, thus, the dangers of explosion and flammability are greatest in low-lying areas. Control of airborne contaminants such as dust and abrasive must also be effective in order to prevent contamination.

While much of the above is inspected visually with the acceptance criteria governed by safety requirements and common sense, the ambient conditions of air temperature, relative humidity, and dew point are determined using instrumentation. This includes psychrometers or instruments are taken before the work begins each day and periodically throughout the day. A suggested minimum frequency is every four hours, or sooner if weather conditions appear to be worsening.

The psychrometer consists of two identical tube thermometers, one of which is covered with a wick or sock that is saturated with water. The covered thermometer is called the "wet bulb" and the other is the "dry bulb." The dry bulb gives the ambient air temperature while the wet bulb temperature results from the latent heat loss of water evaporation from the wetted sock. The faster the rate of water evaporation, the lower the humidity and dew point.

There are generally two types of psychrometers: the sling psychrometer and the fan or motor-driven psychrometer.

When using the sling psychrometer, the wet bulb sock is saturated with water, the instrument whirled rapidly for approximately 20 seconds, and a reading of the wet bulb quickly taken. The cycle is repeated (spinning/reading without additional wetting) until the wet bulb temperature stabilizes. Stabilization occurs when three consecutive readings of the wet bulb remain the same.

When using the fan-operated psychrometer, the wet bulb sock is saturated with water and the fan is started. Approximately two minutes are required for stabilization, and one need only observe the wet bulb thermometer and record both temperatures when the wet bulb temperature remains unchanged.

When the instruments are used in air temperatures less than 32º F, the accuracy of readings is questionable. The wet bulb thermometer will drop below the 32º F temperature to a certain point (e.g., 27º F) then "heat up" rapidly to the 32º F freezing point. Quite often when using a sling psychrometer, this will take place during the whirling of the instrument; therefore, a wet bulb temperature of 32º F may always be obtained. When using the motor-driven psychrometer, one can observe the wet bulb temperature drop below freezing, then rise rapidly to 32º F. However, the low value may still be incorrect. Thus, if the temperature is below 32º F, the ambient conditions will have to be established by other means. This could be accomplished by obtaining the humidity on a direct read-out instrument using sophisticated equipment or even inexpensive humidity indicators available for home use. The ambient temperature will still be obtained using a standard thermometer.

After the dry bulb and wet bulb temperatures are determined, a psychrometric chart or table is used to determine the relative humidity and dew point temperatures of the air. Charts require plotting the dry bulb and wet bulb temperatures on different lines and interpolating the relative humidity and dew point from their intersection.

The U.S. Department of Commerce Weather Bureau Psychometric Tables consist of individual tables for relative humidity and dew point. To use the table, the wet bulb temperature is subtracted from the dry bulb temperature and the difference found along the top row of the table. The dry bulb temperature is found down the left column and the intersection of the two is either the humidity or the dew point, depending upon which table is used. Other tables, such as the U.S. Department of commerce, NOAA-WSTA B-O-8E (5-72), "Relative Humidity and Dew Point Tables," include the relative humidity and dew point on the same table.

Dew Point is defined as the temperature at which moisture will condense. Dew point is important in coating work because moisture condensation on the surface will cause freshly blast cleaned steel to rust, or a thin, often invisible film of moisture trapped between coats may cause premature coating failure. Accordingly, the industry has established an arbitrary dew point/surface temperature safety factor. Final blast cleaning and coating application should not take place unless the surface temperature is at least five degrees Fahrenheit higher than the dew point. Although, theoretically, a surface temperature just infinitesimally above the dew point will not permit moisture condensation, the safety factor of five degrees Fahrenheit has been established to allow for possible instrument inaccuracies or different locations where readings are taken.

Different field instruments are used for determining surface temperature. One of the most common is a surface temperature thermometer, which consists of a bimetallic sensing element that is shielded from drafts. The instrument includes two magnets on the sensing side for attachment to ferrous substrates. Two or three minutes are required for temperature stabilization of this instrument. Other filed instruments for determining surface temperature are direct reading thermocouple/Thermistors. These instruments have a sensing probe touched to the surface, resulting in a direct temperature readout. Only a few seconds are required for a temperature reading to stabilize.

With any of the instruments used for determining ambient conditions and surface temperatures, the readings should be taken at the actual locations of the work. For general readings, however, one should consider the coldest point on the structure because a surface temperature considerations are also important to ensure that coatings are not applied outside of their temperature limitations - in areas too cool or too warm. Accordingly, readings for this purpose should be made at the coolest or warmest areas.

Typical requirements for ambient painting conditions are given in SSPC-PA 1.

6. EVALUATION OF SURFACE PREPARATION EQUIPMENT:

The air compressor and other equipment used for blast cleaning, and any hand or power tools, should be inspected. The inspector need not have an extensive technical background on the equipment, but should be familiar enough with it to determine its suitability.

A. Air Compressor and Air Cleanliness - When an air compressor is used - for blast cleaning, power tool cleaning, or the operation of spraying equipment - the compressor should be appropriately sized and have a suitable volume to maintain the required air pressures. Equipment suppliers have charts and data available which are excellent aids for determining required sizes of compressors, air and abrasive lines, nozzles, and so forth.

The compressed air used for blast cleaning, blowdown, and spray application should be checked for contaminants. Adequate moisture and oil traps should be used on all lines to assure that the air is sufficiently dry and oil-free so it does not interfere with the quality of the work. A simple test for determining air cleanliness requires holding a clean white piece of blotter paper approximately 18 inches from the air supply downstream of moisture and oil separators. The air is permitted to blow on the blotter paper for a few minutes followed by an inspection for signs of detrimental amounts of moisture or oil contamination on the blotter. Obviously, if there is no discoloration on the blotter, the quality of the air is excellent, while streams of moisture and oil running down the sheet indicate unsatisfactory air.

Unfortunately, the point where good air becomes bad is difficult to determine. However, by use of the blotter paper (or a clean cloth, handkerchief, or paper), one can make their own judgments as to the air quality. A thorough inspection of the surface after blast cleaning for signs of moisture or oil contamination should be made and these results correlated with the results of the blotter test. In addition, the proper functioning of in-line moisture and oil traps can be evaluated on a comparative basis from the results of the blotter test. For work requiring that absolutely no moisture or oil be permitted on the compressed air, oil-less compressors and sophisticated air drying equipment are available.

B. Blast Cleaning Machine - The blast cleaning machine mixes the abrasive with the air stream. The abrasive metering valve regulating the flow of abrasive into the air stream is perhaps one of the most overlooked but important considerations affecting the work rate. Generally, too much abrasive is injected into the air stream, resulting in both decreased production and increased abrasive costs. The machine should be equipped for "dead man" capability so that it can be shut down from the nozzle in the event the nozzle is dropped. It should also be equipped with moisture and oil separators, or external separators should be provided. Since the tank of the blast cleaning machine is a pressure vessel, it should be constructed according to pressure vessel codes.

C. Abrasive - There is a great variety of abrasives available for blast cleaning. The size, type, and hardness of the abrasive have a significant impact on the surface profile and speed of cleaning. Steel shot and grit, because they can be recycled, are most commonly used for rotary wheel blast cleaning. Where permitted by law, sand is a very common abrasive for most field operations. Various slag abrasives, due to lesser hazards from silica, are also widely used, particularly in tanks, ship holds and other relatively confined areas. Sand and slag are disposable abrasives and should not be recycled, whereas most metallic abrasives, such as iron and steel shot and grit, aluminum oxide, and expensive abrasives such as glass beads can be recycled if fines, paint, rust and mill scale can be adequately separated from the abrasive stream.

D. Sharp constrictions or bends in these lines should be eliminated, and they should be kept as short as possible to avoid friction and loss of pressure. For the same reason, internal couplings should be avoided. For safety purposes, the couplings should be wired together to assure secure closure, and the blast hoses should be equipped with static wire grounding.

E. A great variety of nozzle sizes, and lengths are available for cleaning purposes. The specific nozzle chosen will depend upon the specific cleaning job. Venturi type nozzles provide a higher abrasive velocity than straight barrel types of the same orifice size. In general, the longer the barrel, the larger the orifice and the faster the cleaning rate. Cracked nozzles and worn nozzles, even if not cracked, will reduce the rate of blast cleaning. As a rule of thumb, a nozzle that has been worn beyond 25% of its original inner diameter (I.D.) should not be used. A nozzle orifice gage is available from equipment suppliers for determining the orifice size after use. The number etched on the nozzle housing indicates the size when new. Nozzles are designated in sixteenths of an inch. Therefore, a Number 8 nozzle is equivalent to ¾ inch.

The amount of air pressure at the blast nozzle is a determining factor in cleaning rate production. The optimum nozzle pressure is 90 to 100 psi. The blasting air pressure should be determined at the nozzle rather than at the gage on the compressor because there will be pressure drops in the system due to hose length, bends, restrictions, blast pot, and moisture traps. Air pressure at the blast nozzle can be determined using a hypodermic needle air pressure gage. The needle of the gage is inserted through the blast hose as close to the nozzle as is practical. The direction of needle placement should be toward the nozzle. Pressure readings are taken with the nozzle in operation (abrasive flowing). At the same time, all other pneumatic equipment using the same compressor system must be in operation.

F. Rotary Wheel Blast Cleaning Equipment - Many fabricating shops and painting sites are equipped with rotary wheel blast cleaning equipment in order to effectively prepare a surface for painting. The number of wheels directly affects the area that can be cleaned, and the type of structural shapes that can be cleaned. Adjustments can be made to direct the blast pattern from each wheel to the desired location in order to provide a uniform cleaning pattern. The rate of speed through the machine determines the degree of cleaning; the slower the material goes through the machine, the greater the degree of cleaning.

Complex structural shapes are particularly hard to clean using automated equipment. The interior of box girders, enclosed shapes, and shielded members can not be cleaned, unless leaning is done prior to fabrication. In many instances, fabricators will employ handheld blast cleaning equipment in tandem with the automated equipment in order to reach the inaccessible areas.

G. Other Methods of Surface Preparation Methods such as vacuum blast cleaning, water blasting with or without sand injection, wet blast cleaning, hand and power tool cleaning will not be discussed here.

7. DETERMINATION OF SURFACE PREPARATION CLEANLINESS AND PROFILE:

A. Cleanliness - All surfaces should be inspected after surface preparation to assure