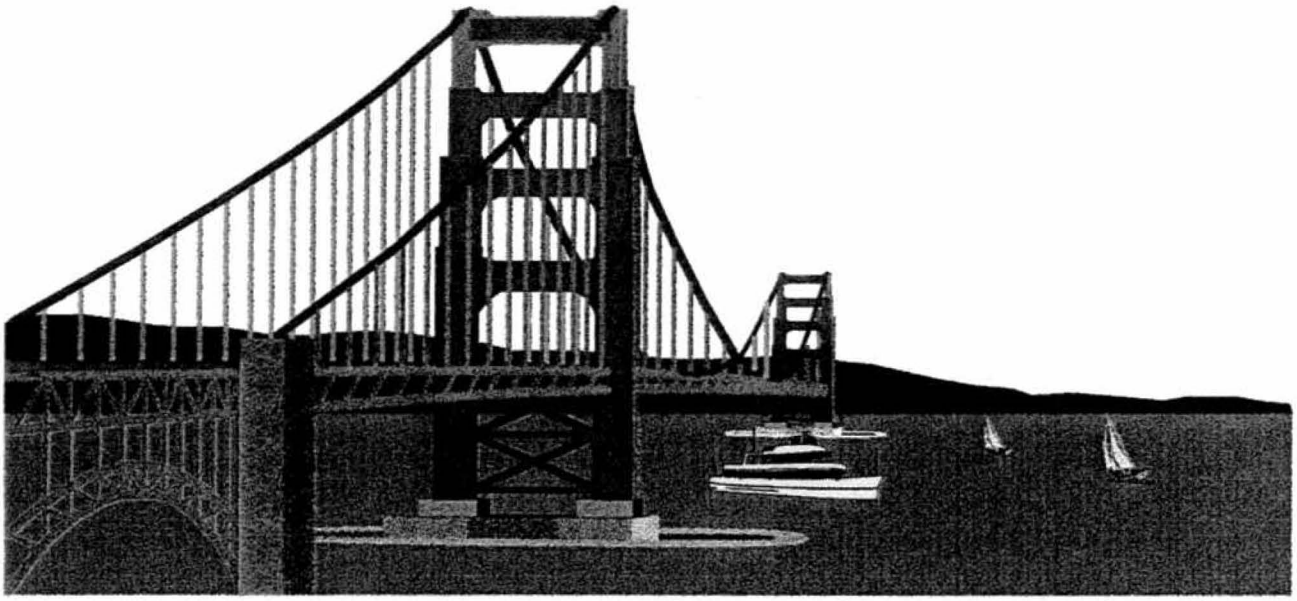
FHWA Field Manual for Bridge Paint Inspection



FHWA Bridge Coatings Technology Team

October 1997

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INTRODUCTION

Bridge paint inspection is far from "glory" work. It is often the least desirable aspect of the activities on a given project. It is dirty work. Not only is there an exposure to paint fumes and lead dust, but there are also various EPA and OSHA regulations that must be followed. Frequently, the person assigned the duties of bridge paint inspection is that with the least amount of experience or formal training on the task; and yet, he or she is expected to learn the complexities of the task while on the job. This manual is a self-contained document that provides the core information necessary to guide and instruct inspectors in the performance requirements of the job.

Cleaning and painting a bridge has become an expensive operation. There is growing emphasis on environmental, safety, and health related issues. Consequently, it is more important now than ever to obtain the longest possible life from our bridge coatings. Like all high quality products, bridge coatings require adequate specifications, high quality materials, proper usage and maintenance of equipment, and last, but not least, effective inspection.

An inspector may often ask himself, "Why am I inspecting this operation? How important is this really?" In the case of bridge coatings, the importance of inspections and the role of a motivated inspector cannot be overstated. It has been estimated that 75% to 80% of all premature coating failures are caused, partially or completely, by deficient surface preparation and/or coating application. This makes it abundantly clear that you, the inspector, are a vital part of the bridge painting process.

We all like to be associated with quality work and a quality product. By following the guidelines provided in this manual and diligently carrying out your duties, you can help assure that the painting project that you inspect will perform throughout its service life.

THE MANUAL

This manual is a model to be followed by bridge paint inspectors on how to perform inspection duties properly. To the maximum extent possible, we have followed the Federal Highway Administration's (FHWA) model specifications. However, we recognize that these requirements may vary individually according to different State or local Departments of Transportation. Given that most of today's bridge-paint work is being done on existing steel, this manual is geared toward people working in the field on existing steel. Some of the principles we discuss may also apply to shop-painted steel; however, shop painting may require additional considerations that are beyond the scope of this manual.

This manual was developed using several sources. These sources include the manual from the NHI Training Course for Bridge Paint Inspectors, ASTM D 3276-86--Standard Guide for Painting Inspectors, process review guidelines from the FHWA New York Division, the Construction Inspector's Checklist for Cleaning and Painting Steel Structures from the Illinois DOT, and the experience of the members of the FHWA Bridge Coating Technology Outreach Team.

The manual is broken down into three primary sections. The first section covers the pre-painting operations requirements. The second covers the inspection of the painting operations. The third section consists of two appendices. Appendix A contains inspection checklists that correspond with individual inspection tasks. These checklists are intended to serve as a reminder of the major items to be checked at each stage of the operation. You may need to refer back to the text of the Manual for additional information. Appendix B contains pictures and descriptions of the equipment typically used by the inspector.

This manual is written so that the novice inspector can follow the instructions, step by step, and perform the required duties in a competent manner. The manual should also benefit the experienced inspector who will now have a systematic method for assuring that nothing is inadvertently overlooked. We encourage the inspector to share this manual with the contractor prior to the beginning of the painting process. We feel that the more involved all parties are in the process, the less chance there will be for any conflicts or disagreements to arise and that a better product will result. By showing the contractor what exactly it is that you will be looking at and the reason for doing so, he will understand what is required of him and how you intend to verify his compliance with the Specifications.

We, the FHWA Bridge Coating Technology Outreach Team, hope this manual is useful to you. If you have any comments regarding this document, please provide them to your FHWA Division Office and ask that they forward the information to us. Your feedback on this material and other paint-related issues is important to us.

FHWA Bridge Coating Technology Outreach Team

The individuals listed below comprise the FHWA Bridge Coating Technology Outreach Team. This Team was formed to promote new paint technologies and innovations along with proper practice of current techniques. They have assembled this manual for your use. This manual is one of a series of modules dealing with the process of bridge painting. For more information please have your FHWA Division Office contact any of the team members listed below.

Bob Kogler Research Materials Engineer Turner-Fairbanks Highway Research Center McLean, VA (703) 285-2018	Mike Praul Construction & Materials Engineer Maine Division Augusta, ME (207) 622-8350 Ext. 11
Shuang-Ling Chong Research Chemist Turner-Fairbanks Highway Research Center McLean, VA (703) 285-2726	Carl Highsmith Structural Engineer Region 3 Baltimore, MD (410) 962-0077 Ext. 3066
Joe Huerta Group Leader Construction and Maintenance Group Washington, D.C. (202) 366-1556	Larry O'Donnell Division Bridge Engineer Massachussetts Division Boston, MA (617) 494-2518
Ron Andresen Pavement Engineer Central Federal Lands Highway Division Lakewood, CO (303) 236-4394	Mark Clabaugh Structural Engineer Eastern Federal Lands Highway Division Sterling, VA (703) 285-0228
Dan Brydl Division Bridge Engineer Illinois Division Springfield, IL (217) 492-4632	Dave Calabrese Assistant Bridge Engineer Michigan Division Lansing, MI (517) 377-1880 Ext. 48

SECTION 1

Inspector Preparation

1. General - As with any assignment, the first step is to become familiar with the overall project and learn how the painting fits into the scope of the entire project. To do so, review the plans, specifications, and any special provisions for the project.

Become familiar with the project site. Note areas that may be difficult for equipment access, sensitive areas such as homes, schools, playgrounds, and other areas of public activity. Painting operations generate dust, solvent fumes, and noise. Every effort should be made to minimize the impact of these operations on the surrounding community. This can best be accomplished through a cooperative effort between the contractor and the community itself.

Review the contractor's schedule. Look for times when weather conditions may complicate the proposed work. Bring any concerns or questions you have to the attention of the Project Engineer. Some issues may need to be referred to the project designer or to an outside party.

2. Existing Structure - Inspect as much of the existing paint system as you can. Some things to look for include the coating type, thickness, adhesion, localized rust, and presence of mill scale on the surface of the steel (the bluish oxide that results from the hot-rolling process). Coating type, thickness, and adhesion can provide you some insight into the effort required to remove the existing paint and can also help you forecast or justify various rates of paint application progress throughout the structure.

Pay particular attention to areas of localized rust because these are the areas that have shown to be prone to premature coating failure. Extra effort should be made to ensure that both the proper degree of surface preparation and the proper coating thickness are achieved in these areas. The presence of mill scale under the existing paint indicates a potential need for additional surface preparation. If mill scale is observed and abrasive blasting is not specified, the project Engineer should be notified since abrasive blasting may be required.

3. Equipment - Inventory, inspect, and calibrate your equipment. Equipment is discussed in Appendix B of this manual, but now is the time to make sure you have what you need and that it is in good working order. Backup equipment and batteries should be readily available. Report any concerns or needs to the Project Engineer.

4. Conference Preparation - Your Specification may or may not mandate a pre-painting conference. If so, schedule one with the contractor. If not, inform the contractor you would like to have a pre-painting conference. In either case, use the next chapter to guide your discussion with the contractor.

Pre-Painting Conference

There are several reasons for having a pre-painting conference with the contractor. It provides an opportunity for discussions on safety measures, adherence to contractual details, and, perhaps most importantly, on your expectations from him and the manner in which you will be inspecting and measuring his work. Think of this meeting as a "mini-partnering" session. Things will go much smoother if everyone has a clear understanding of what is expected right from the beginning.

The following items should be covered at this meeting:

1. The contractor's proposed operation, including equipment and personnel - This will allow you to verify that he understands the magnitude of the work at hand and that he is prepared to do it in a satisfactory manner. You will gain some insight on the experience of his personnel and will also be able to get additional information about his equipment.

The contractor should have a job-specific worker health and safety plan for all jobs involving lead paint removal. Discuss monitoring and sampling requirements. Discuss the manner in which the contractor is planning to protect his workers and the environment from contamination including shower/washing facilities, work clothing, debris containment, and the handling of emergencies. You should discuss proper location of the contractor's recycling and dust collection and storage equipment. As much as possible, these should be located out of the way of potential vehicle collisions. Generally, the lead-contaminated waste cannot be stored on site for more than 90 days. Make the contractor aware of this.

This is the time to voice any concerns you might have with the work schedule. Be prepared to discuss them, and, if possible, propose some mitigating measures.

2. Inspection Safety and Proper Access - Inspectors should have safe and proper access to all job sites at all times. Inspection staff should not be expected to risk their safety at any time on the job site. Discuss how access will be provided to all areas.

Means for protecting inspectors from health hazards should be discussed. For example, will the inspectors have access to the contractor's decontamination facilities on lead removal jobs?

3. Inspection and Measurement - Explain your inspection and measurement procedures, especially those related to payment. Payment should not be made for partially completed work. This will encourage the contractor to complete the work as he progresses and to immediately correct any deficiencies or sub-standard work.

Inform the contractor of the inspection control points, that is, the things that must be inspected and approved before he is allowed to proceed. Suggested control points are:

- After a water blast and SP-1 cleaning
- After the completion of surface preparation
- After individual paint coating applications

Discuss control areas where work must be approved prior to work being initiated in the next area. Discuss inaccessible areas, how they will be identified, and what will be acceptable treatment of these areas. Inform the contractor that you expect him to bring potentially inaccessible areas to the inspector's attention. The inspector will make the final decision of what is acceptable treatment for the area in question.

4. Product Information - Obtain a copy of the Product Data Sheet and Materials Safety Data Sheet for the paint system and any solvent that will be used during the project. These sheets contain a wealth of information on the materials to be used and are necessary to complete the materials inspection.

5. Visual Standard - Show the contractor the visual standard he must meet for his cleaning operation and provide him with a copy for his use during the project. Alternatively, have the contractor supply the visual standards. A good practice is to have the contractor blast a section of the bridge or a separate steel plate and seal with clearcoat. This can then be used as an on-site reference for the rest of the project.

6. Documentation - Document all discussions and instructions given at this meeting and, particularly, any agreements that were reached that may modify the contract proposal or specification requirements. An effective way of doing so is the signing of minutes by all in attendance, including an authorized representative of the contractor. All in attendance should receive a copy of the minutes.

SECTION 2

Inspecting the Enclosure

This chapter deals primarily with the aspects of lead containment under the purview of the field inspector. For a more detailed discussion of environmental and worker health issues related to lead paint, the FHWA Bridge Coating Technology Outreach Group has developed a guideline which addresses the impact of various EPA and OSHA regulations on bridge painting operations.

A containment system, or enclosure, is needed to prevent the debris generated during the surface preparation activities from entering the environment and to facilitate its gathering and disposal. Enclosures are generally made up of combinations of cover panels, scaffolds, supports, screens, and tarps. The complexity of any given enclosure will vary depending on the method of paint removal being employed and the degree of surface preparation that is specified. For a simple scraping operation ground-covering tarps may be sufficient while for a blasting operation, the enclosure could be a designed structure with a negative pressure ventilation system.

The following guidelines provide a basic overview of some of the most important points you should address in your role as engineer and inspector on a bridge painting job. These guidelines are not intended to substitute for detailed expertise or training required by some contracts, or for other provisions of the painting specification or contract requiring trained inspection staff.

Adequacy of the Containment System - Regardless of the system being used, you should check that it is capable of achieving the purposes noted above. The work area should be clearly distinguishable from the surroundings. Tarps should be overlapped with seams fastened and should be in good condition and free of holes. During blasting operations with negative pressure, the tarps should have a concave inward appearance. Check for any signs of escaping dust; the containment should be tightly sealed to prevent any dust from escaping. Check the ground around the containment. Dust collectors should be operated at the rated capacity or at a capacity consistent with the ventilation design of the containment system.

The containment must also be able to support workers, construction loads, spent abrasive loads and wind load without placing undue stress on the bridge. For that reason, you should assure that the containment is constructed in accordance with the approved plan.

Assessment of Containment Design and Function in the Field

Containments for abrasive blast (and other paint removal) operations are designed to protect the surrounding environment and the public from debris (flying abrasive) and potentially hazardous material (lead-containing dust) during a paint removal operation. In addition, these containment structures are intended to help contain and collect the lead-containing debris for proper treatment and disposal.

As the use of containments for paint removal jobs has become more common over the past several years, the design of containment structures has evolved. Currently, there are standard features to each containment, but in large part, containments are custom-designed for each bridge job. The standard features are described in detail in the "SSPC Guide 6 - Containment." This guide is not all inclusive, but it is the industry standard for description and classification of paint removal containments. In addition, several States have their own classification systems, but most of them are somewhat similar to those in the SSPC Guide 6.

It is important to remember that the purpose of a containment is to do a conscientious, "state-of-the-practice" job in containing and collecting debris. There are many ways to do this. Contractors as well as equipment and containment materials manufacturers have been quite innovative in accomplishing this goal. After you have been on a few jobs, you will realize that a goal of "100% containment" is not very practical. However, with appropriate specifications, and designs, and a cooperative effort between the owner and contractor, very near 100% containment and collection of debris can be approached.

The control of dust from abrasive blasting jobs is not always easy. While regulations are clear in dictating that solid waste containing lead must be controlled, treated, and disposed of in very specific ways, the rules governing the emission of lead containing airborne dust are less clear. Currently, there is no Federal requirement which gives performance measures for dust emissions on construction jobs. A select few localities have regulations, but, for the most part, the industry has been left to "do the right thing" in controlling lead-containing dust. Without getting into the details and tradeoffs of containment design, just remember this: Containment of abrasive blast jobs involving lead are mandatory because the law requires collection of the hazardous waste. While there is no specific rule governing the "fugitive emissions" of lead-containing dust, this dust can be controlled by designing and maintaining the containment and ventilation system properly.

Components of a Containment System

Support Structure - Containments can be scaffolded from the ground or rigged to hang from the bridge structure. The key issues to consider are structural integrity under wind load, abrasive waster load, and dynamic loads on the bridge. Access, air movement, and visibility should also be considered.

Ventilation - Without ventilation, workers and inspectors will not be able to see within minutes of blasting commencing. Ventilation also reduces the concentration of lead-dust in the work environment and makes clean up operations prior to painting easier.

Lighting - Proper lighting is often neglected. Inadequate lighting poses obvious safety concerns as it makes proper surface preparation and painting almost impossible.

Debris Handling - The manner in which spent debris is collected is a key element to the quality and timeliness of the job. It is critical to clear debris and dust prior to paint application. Debris handling is a major part of bridge painting jobs.

Some Helpful Hints:

The following are items to consider when reviewing the design and construction of a containment system.

Abrasive selection - There are many types of abrasive on the market. Recyclable abrasives have gained popularity in recent years because their use can reduce waste handling and disposal by 90%.

Location of dust collectors - Airborne emissions are often highest adjacent to dust collectors. While emissions should be minimized, they are unavoidable. Dust collectors should be located in areas where emissions will have minimal effect on sensitive surrounding environmental or public areas.

Ducting efficiency - Ventilation ducting efficiency depends on the duct diameter and length, and on minimizing the number of sharp bends in the duct.

Monitoring - Air and soil monitoring are becoming more common on lead removal jobs. Monitoring protocols differ, and there is no current consensus on what should be done in this area. Soil sampling near and under containments is generally a good idea from a liability standpoint. Air monitoring becomes more important if sensitive public access is nearby.

Air Movement - For work inside an enclosure air movement is necessary to avoid a build-up of dust. High dust concentrations impair visibility and increase hazardous exposure levels to workers. You can check for air movement with an anemometer, or you can get a rough idea of the amount of airflow using a smoke bomb. Air movement is dependent upon the capacity of dust collectors, the volume of air input by makeup fans and blast nozzles, and interferences to airflow caused by the bridge structure itself.

Debris Storage - Lead-contaminated paint waste can be classified as hazardous material. As such, it is subject to strict disposal requirements. The contractor may wish to temporarily store barrels containing this waste on site prior to hauling them to an approved disposal site. If the barrels are stored on site (remember the 90-day requirement), they should be clearly marked as containing hazardous waste. The barrels should be stored in a location inaccessible to the public, and they should also be in a location where they are not at risk of being hit by traffic.

Surface Preparation

As stated in the introduction, proper surface preparation, along with proper paint application, are the two most important factors needed for the development of high quality products. Cleanliness is essential since the presence of oil, grease, dust, or soil prevent the paint from bonding. Mill scale, rust, and the existing paint may also increase the chance of failure of the new coating. Clean surfaces must also have an appropriate anchor pattern (surface roughness). This roughness helps the new paint to mechanically bond to the surface, promoting adhesion.

The Society for Protective Coatings (SSPC) has developed a nomenclature for the different types of surface preparation methods. These are listed below so that you can understand what is involved with each type of method and the expected level of performance of the contractor.

SP-1 - SP-1 denotes "solvent" cleaning and can refer to solvent wiping, water washing, or steam cleaning. The surface is cleaned to remove oil, grease, etc. This must be done prior to ALL other cleaning operations as some final surface preparation methods will actually force the contaminants into the steel, which can lead to poor bonding and premature failure.

SP-2 - SP-2 denotes hand tool cleaning. Hand tools are used to remove loose mill scale, loose rust, loose or otherwise defective paint, weld flux, slag, and spatter. This is done by brushing, sanding, chipping, or scraping the surface. Tools used include wire, fiber, or bristle brushes, sandpaper, steel wool, hand scrapers, chisels, or chipping hammers. Tightly adhering rust, mill scale, and paint are allowed to remain. This method is generally confined to small areas.

SP-3 - SP-3 denotes power tool cleaning. This is very similar to SP-2 except that power tools are used instead, thus making this a more viable and efficient cleaning method for larger areas.

SP-11 - SP-11 denotes power tool cleaning to bare metal. This method uses power tools to remove ALL paint, rust, and millscale and to roughen the surface to promote paint adhesion. SP-11 offers performance advantages over SP-2 and SP-3, which result in an irregular surface of bare steel, rusted steel, mill scale, and paint but it tends to be quite expensive because of the labor involved.

Blast cleaning - It is the most effective method for surface preparation is blast cleaning. Blast cleaning is broken down into four levels according to the desired condition of the base metal. Keep in mind that blast cleaning does not get rid of oil and grease, which is done by solvent cleaning. The following methods are presented in order of ascending cleanliness (i.e., SP-5 is most clean):

SP-7 - SP-7 denotes brush off blast cleaning. The resulting surface should be free of oil, grease, dirt, loose mill scale, loose rust, and loose coatings, retaining only tightly bonded mill scale, sound rust, and previous coatings.

SP-6 - SP-6 denotes commercial blast cleaning. The resulting surface should be free of oil, grease, dirt, all rust, mill scale, paint, and foreign matter (except for slight shadows, streaks, or discolorations caused by rust stains, mill scale stains, and tight residue of previous coatings). At least two-thirds of each 150-cm^2 (9 in^2) area must be free of all visible residue and the remainder limited to those discolorations just mentioned.

SP-10 - SP-10 denotes near-white blast cleaning. The resulting surface should be free of oil, grease, dirt, rust, mill scale, paint, and any foreign matter (leaving only slight stains from rust and mill scale). At least 95% of each 150-cm^2 (9 in^2) area should be free of all visible residue with the remainder limited to slight discoloration.

SP-5 - SP-5 denotes white metal blast cleaning. The resulting surface should be free of oil, grease, dirt, rust, mill scale, all paint, and foreign matter leaving only a uniform grey-white color. This level of cleaning is costly and is rarely specified for use on bridges.

The most common surface preparation specified for bridge use is SP-6, which also requires SP-1. When repainting an existing structure, the Specifications may call for SP-2 or SP-3 in areas of limited accessibility. Recent research indicates SP-10 may be more cost effective than SP-6, particularly in more corrosive environments. Your inspection should verify that both the proper level of cleanliness and the proper anchor pattern have been achieved.

Inspection of SP-1 - Clean, lint-free rags and clean solvent should be used to avoid the spreading of contaminants. Once the contaminants have been visibly removed, a final wiping should be done with clean rags and solvent. The use of solvents dictates that several safety measures must be followed. Workers should wear goggles, protective clothing, rubber gloves, and petroleum jelly on exposed body parts and should be equipped with appropriate respirators to avoid hazardous fumes. Benzene and carbon tetrachloride are poisonous and should not be used as solvents and neither should materials with low flash points such as gasoline, methyl-ethyl ketone (MEK), and acetone. Consult the Materials Safety Data Sheet to determine the specific hazards and protection procedures to be followed for the solvent being used.

Inspection of SP-2 and SP-3 - You should verify that the level of cleanliness noted above (SP-1) has been achieved. Pay particular attention to the problem areas such as the top side of bottom flanges, the backside of nuts and bolts, the interior of box beams, and those areas where climbing is difficult and access is limited. SP-3 requires that you check that the power tools have not placed any oil or grease back onto the surface. If they did, the surface should be recleaned per SP-1. Paint, rust, or millscale that can be removed with a hand scraper should not remain after a proper SP-3 surface preparation. A "dull putty knife" can be used to assess the acceptability of the surface.

Blasting operations require that several other checks be made. The contractor's equipment and material must be checked along with the resulting anchor pattern.

Inspection of the Abrasive - The contractor will select the abrasive to be used based on the specified anchor pattern. The chosen abrasive should be free of toxic heavy metals such as lead, chromium, and cadmium and should not contain any free silica (sand) either. Prior to delivery of the first load of abrasive, you should receive a sieve analysis from the abrasive supplier.

Once the abrasive is on site, obtain a sample of the stored abrasive material. It should be stored in a dry environment and should be clean, uniform, and free of any sign of moisture. To check, drop some of it into deionized water and shake. Watch for a film of grease or oil indicating the presence of contaminants. Keep a small sample of abrasive from each subsequent delivery. This will allow for a future analysis in the event that changes occur in the anchor pattern.

Inspection of the Air Supply - This is necessary to ensure that the air supply is not introducing neither contaminants that will be embedded in the steel nor oil or water into the system.

Inspect the air compressor for contaminants. The compressor should have moisture and oil traps on all lines. Shut off the flow of abrasive. Place a white blotter cloth in the air flow. It should be placed approximately 0.6m (24 inches) from an outlet downstream from the oil separator and moisture traps. Let free air flow for two minutes. Check for visible contaminants in the air flow; if there are any, corrective action is needed. This test should be repeated every four hours or more frequently when the humidity is high.

Blasting Pressure - The blasting pressure should be at least 620 kPa (90 psi); any less than this can result in a lower anchor pattern and in slower production. However, jobs that use recyclable steel grit often use higher pressures. All high pressure air supplies and devices should be gaged for easy reading. For blasting, the critical pressure is located at the end of the blast nozzle. This pressure will be lower than that measured at the air supply due to loss in the hose. Hence, limiting the length of air hose is often a critical factor in the efficiency of a blasting operation. A pressure needle gage may be used at the nozzle to measure the true blast pressure.

Inspection of SP-6 and SP-10 - Once again, verify that the level of cleanliness noted above has been achieved including the referenced problem areas. If cited in your Specification, you may be provided with a set of visual standards from either the National Association of Corrosion Engineers (NACE) or the Society for Protective Coatings (SSPC) to aid in this effort. Interpretation of the visual standards may take some discretion as well as some practice. When in doubt, let the wording of the level of cleanliness govern or, better yet, use the job-specific test section described previously. If these standards are not referenced, the use of a test section is imperative.

It is important to note that both SP-6 and SP-10 standards require the removal of ALL paint, rust, and mill scale. They only differ in the amount of staining allowable on the bare steel surface.

The inspection and acceptance of blasted steel surfaces can be a source of conflict on bridge painting jobs. This is because blast cleaning is a very expensive and time consuming component of the repainting job. Also, the visual and written standards used for SP-6, SP-10, and SP-5 are often interpreted differently by different contractors and inspectors. On flat, easily accessible steel, there is usually no problem; however, most bridges have complex areas with difficult access, rivets and fasteners, and corroded and pitted areas. In these areas it may be very difficult to achieve an absolute standard of cleanliness. Remember that, as the inspector, it is your job to ensure that the contractor is doing a conscientious job of achieving the standard in all areas, but the progress of the job and reasonable demands on the contractor must be considered as well. You have to be tough but reasonable. Establishing a good working relationship with the contractor and making your expectations clear up-front in the job is an effective way of avoiding disputes as the schedule gets tight later in the job.

Inspection of the Anchor Pattern - The anchor pattern needs to be checked to ensure that proper paint adhesion will occur. Profile inspection requires the use of a micrometer and replica impression tape. Comparison coupons can also be used for a qualitative visual comparison of the profile. Instructions on how to do this are included in the Appendix B.

Materials/Pre-Painting

By this time, you should be with the Product Data Sheets for the paint system being used on your project. Requirements for each of the items discussed in this section are listed on the Product Data Sheet.

1. Shelf Life - Shelf life is the length of time, from date of manufacture, that a paint will remain usable when stored in its can. Check the date printed on the can with the shelf life to make sure the paint has not "expired." Some suppliers use a special code on the can which contains the date of manufacture. You may need to call the supplier to learn how to read this code and assure that you have fresh paint. Keep in mind that two-component paint systems often have a different shelf life for each component.

Consequences of exceeding the shelf life include: gelling, odor, changes in viscosity, formation of lumps, pigment settling, and color and liquid separation.

You may face a situation where the paint has exceeded its shelf life and still appears to be usable with none of the above-mentioned problems. If the contractor desires to use this material, he may submit a sample to the manufacturer's laboratory for analysis and possible re-certification. Do not allow the contractor to use the material in question until written certification is received from the manufacturer.

2. Storage/Storage Temperature - Each lot of paint should be stored together. Two-component systems should be stored close to each other, but be distinguishable from one another. If the paint will be stored over several months, the cans should be inverted at monthly intervals to avoid excessive settlement and ease future mixing. When opening the paint, the oldest paint should be used first. Look for signs of aging listed above.

Note the required temperature range for proper storage. Adherence to the temperature requirements noted on the Product Data Sheet is essential. The contractor's storage site should be monitored with a high/low thermometer.

Going beyond the acceptable temperature range can cause changes in viscosity and shelf life. Water-based paint will spoil when stored below freezing. Solvent-based paint, on the other hand, may gel or become flammable or explosive when stored at high temperatures.

Contractors often like to store the paint on site in a trailer. This is generally not a good idea because these trailers tend to get very hot during the summer and have limited ventilation. Paint should be stored in a climate-controlled environment.

3. Pot Life - Pot life refers to the length of time a paint is useful after it's original package has been opened or, for two-component systems, the length of time after it has been mixed. Pot life is temperature dependent. The pot life on the Product Data Sheet is generally for 21 C (70°F). Contact the manufacturer for additional pot life information if the paint has been stored ib temperatures outside of this general range.

Exceeding the pot life can result in sagging of the fresh paint along with poor performance attributable to film porosity and/or poor paint adhesion. Two-component paints tend to become unworkable at or beyond their pot life.

4. Mixing - Upon opening the can, check the surface of the paint for "skinning over" of the paint. Any skin should be removed prior to mixing. All paint must be thoroughly mixed in a clean container. Check the bottom of the original can for evidence of unmixed pigment. Different paints have different mixing requirements. The instructions on the Product Data Sheet should be strictly followed. For two-component paints, verify that they are mixed in the proper proportion. You should witness and document the mixing operation.

Unused paint that will be used the next day should not be left in buckets or spray pots. It should be placed in a container and re-mixed prior to use.

5. Thinning - Thinner is a liquid added to the paint at the time of application to modify its viscosity. The Product Data Sheet will indicate the specific type and maximum amount of thinner to be used. Thinner should be used only to achieve optimum viscosity for proper application and is not always necessary.

You should witness and document each and any addition of thinner. Adding too much thinner can prevent proper application thickness and cure of the paint and may result in the mixture exceeding acceptable limits for volatile organic compounds (VOCs).

6. Drying Schedule and Curing Time - Drying and curing time are not the same. Drying time refers to the length of time a coating is sensitive to local damage. Curing time refers to the length of time it takes for a paint to reach structural integrity and be ready for service.

The drying schedule on the Product Data Sheet will show how long it takes until the paint is dry to the touch, dry to tack free, and dry to recoat. Dry to the touch implies the paint won't collect dust; tack-free implies the paint does not feel sticky and can be handled without damage; dry to recoat implies the time needed to dry until the next coat of paint can be applied.

Note that these drying times vary significantly with temperature. This is particularly important in determining when the next coat of paint can be applied. Recoating before enough time has passed

can seriously affect the curing and integrity of the layer being overcoated. Some paints, particularly two-component paints, have a maximum time to re-coat as well. Exceeding this could jeopardize the adherence of the top coat.

Painting

Once the proper level of surface preparation has been achieved and the quality of the coating system has been verified, the contractor is ready to paint. To prevent "rust-back" of the cleaned surface, the first coat of paint (primer) should be applied as soon as possible (within a few hours) after blast cleaning. Painting should begin at a practical time to avoid weather changes that could cause significant changes in the surface condition of the steel, i.e. nightfall.

Environmental Conditions

The following steps should be followed to ensure that the paint is applied and allowed to dry and cure under reasonable environmental conditions. Excessive high or low temperatures or the presence of surface moisture, including frost, can have a negative effect on paint films. In addition to the following, some common sense should also be used. For example, painting just before the onset of poor weather is not advisable. The current and expected weather, along with the curing time of the paint being used, should be considered prior to beginning the application process. To verify proper ambient conditions, Steps 1, 2, 3, and 4 listed below should be followed every 4 hours.

1. **Temperature** - The Specification will place limits on the ambient temperature to ensure proper curing. Most Specifications will require the temperature to be between 4 C or 10 C and 38 C (40 or 50°F and 100°F). Check that this is the case.

2. **Relative Humidity** - Again, due to of curing requirements, the Specification will limit the maximum permissible relative humidity, which is commonly limited to 85%. Appendix B gives a description on how to use a sling psychrometer to determine relative humidity.

3. **Dew Point** - Using the relative humidity, determine the dew point. The temperature of the steel should be at least 3 C (5°F) higher than the dew point. This "dew point spread" is used to ensure that no moisture is present on the steel prior to paint application.

4. **Surface Temperature** - The surface temperature of the steel should not exceed 52°C (125°F) during the painting process, and, again, it should be at least 3°C (5°F) higher than the dew point.

5. Wind - Heavy winds can cause problems. Airborne overspray, for example, may be carried onto adjacent houses, cars, etc. and can also result in premature drying of the paint. If heavy winds are present, it may be best to delay the painting operation or to restrict spray application.

Application

To apply the paint, the contractor may use sprayers, brushes, rollers, or a combination of these. Spraying varies significantly from the other techniques. Listed below are several "good practice" tips for spray applications.

6. Proper Pot Pressures - The spray pot should have two pressure regulators, one for pot pressure and one for atomization pressure. The pot pressure regulator should be high enough to provide enough material to the spray gun. The atomization pressure regulator should be set just high enough to atomize the material. Too high a setting will result in the paint drying before it hits the surface. Too low a setting will cause the paint to clump and could clog the gun.

7. Proper Spray Gun Technique - The gun should be held perpendicular to the work surface and approximately 45 cm (18 in.) away from the work surface. Angling the gun or holding it too far away could also result in the paint drying before hitting the surface. The spray pattern should overlap the previous pass by approximately 50%, with the stroke length of each pass between 45 and 90 cm (18 and 36 in.). A good sprayer will make a pass of the spray gun by moving his arm and body rather than rotating his wrist to "fan" the gun.

The following section applies to brush, roller, or mitt application.

8. Material Compatibility - The material used in brushes or rollers may not be chemically compatible with the paint being used. Make sure this is not the case by testing a small piece of the material with the paint. In general, natural bristled brushes are recommended for solvent based paints, while synthetic bristles work better for waterborne paints. Ensure the nap of the roller is that recommended by the coating manufacturer for the desired finish.

9. Proper Technique - Brushing should be done as neatly as possible to ensure a uniform coating thickness. Rolling should be done in a "W" pattern and finished by rolling in one direction. Avoid rolling the coating out over too large of an area because this can cause thin spots or holidays.

The following section applies to all application methods.

10. Defects - All unsightly runs, drips, or pinholes should be repaired immediately.

11. Wet Film Thickness - Wet film thickness is important for two reasons: (1) It allows you to verify that a consistent thickness of paint is being applied, and (2) it also allows you to predict the resulting dry film thickness. Instructions on how to check wet film thickness and using it to predict dry film thickness are included in Appendix B. A good painter will periodically check his wet film thickness because it will vary according to the spray pressure, the "load" of paint on the brush or roller, and the orientation of the surface being painted.

12. Dry Film Thickness - It is important to check the dry film thickness after application of each coat as this is the most direct measure of the contractor's work. The thickness should be checked at five locations in every 9 m^2 (100 ft^2). Take three separate readings at each location. Each reading should be not less than 80% of the specified thickness nor greater than 150% of the specified thickness. The thickness at any location should be reported as the average of the three tests. Equipment for taking these readings is described in Appendix B.

As a general rule, a manufacturer's data sheet will include a range of application thicknesses for its coatings. It is important to monitor for areas which are too thin and too thick. It is not necessarily true that "thicker is better." Excessively thick application can cause the coating to sag or even never fully cure.

Safety

No manual of this type would be complete without a word about safety. Being a bridge paint inspector will most likely put you in the position of climbing ladders and/or scaffolding, walking on exposed steel girders, or potentially expose you to lead-contaminated hazardous waste. In addition to general project worksite safety provisions, the following items should be specifically checked:

1. **Materials** - Some of the paints you may deal with will contain hazardous components such as solvents. These are listed on the Materials Safety Data Sheet. Become familiar with this information and be aware of any symptoms of health problems.

2. **Ladders** - The contractor must provide safe access to inspection areas at all times. Make sure the ladders are in good repair and are securely fastened. Fall protection should be provided.

3. **Scaffolding** - The contractor must provide safe access. Make sure that the scaffolding is secure and that there are no missing handrails or steps. For scaffolding extending to significant heights, it is desirable for it to be wrapped in orange safety mesh.

4. **Working at Heights** - If you will be exposed to falls of more than 2 m (6 ft.) in height, you should be securely tied off with a safety harness. Harnesses are preferred over traditional belts because they can spread the shock of the fall more evenly over your body. Recently, OSHA standards have become more stringent in this area since falls have been identified as a primary source of serious injuries in construction work.

5. **Lead exposure** - During blasting operations it is important that you observe the containment structure and look for any signs of dust leakage. During clean-up operations, make sure that no lead-contaminated debris is left on the ground nor allowed to enter any nearby waterways. In addition, as mentioned previously in the section on Inspecting the Enclosure, barrels of contaminated waste should be stored in areas that are both away from traffic and are inaccessible to the public.

Few Words About Lead

Lead is a very common element in our environment and has been used in materials such as paints and car batteries for many years. Lead can also be hazardous to humans, particularly children, under certain conditions. Lead was a common component of industrial paints until the 1980's,

and many of the steel bridges in the highway system are still coated with paint that contains up to 50% lead by weight.

High lead-containing primers can often be identified by their red or bright orange color. However, not all red and orange paints contain lead, and some paints of different colors can also contain a significant amount of lead.

Lead is hazardous to humans if it is **inhaled** or **ingested**. Lead dust on your skin is not hazardous as long as it is not transferred to the mouth and ingested. Particles of lead created during surface preparation are often too small to see, and these are the particles that pose the highest inhalation threat.

Lead hazards should be taken seriously for a relatively small amount of ingested or inhaled lead dust can elevate a person's blood lead level. Protection from lead hazards is not difficult to achieve. Proper respiratory protection should be worn. "Proper" protection consists of either air-fed, positive pressure respirator hoods (as worn by abrasive blasters), or negative pressure, filter-cartridge respirators. Filters should be color-coded bright pink for fine dust particulate (i.e., HEPA filters). The required level of respiratory protection depends on the concentration of lead in the breathing air, and on the amount of time you are exposed. For most short-term inspections of jobsites without ongoing blasting, or outside of containments, a half-mask with appropriate HEPA cartridge is enough. However, while inside of containments during or immediately after abrasive blasting, an air supplied hood is likely to be required.

Washing your hands and face prior to eating or smoking is essential to avoid ingestion of lead particles. Studies have shown a direct correlation between elevated blood lead levels in workers and "hand-to-mouth" lead ingestion.

A final point. It is important to leave the lead hazards from a paint removal job on the jobsite. At times, the Tyvek® suits, gloves, and bootcovers may seem somewhat extreme, but, these devices help keep lead dust off of you and your regular work clothes so that you do not carry the lead into your vehicle or even home with you.

Summary

- Wash your hands before eating or smoking.
- Wear respiratory protection appropriate to the concentration level and length of time of exposure.
- Leave the lead hazards on the jobsite.
- Protect yourself, but don't let the presence of lead in paint prevent you or the contractor from properly completing the job.

APPENDIX A - INSPECTION CHECKLISTS

Inspector Preparation

Project #_____ **Date:**_____

Inspector:_____

Review of plans and specifications. ☐
Comments:

Field review of site, including surrounding area. ☐
Comments:

Inspection of structure and existing coating. ☐
Comments:

Inventory and calibration of equipment. ☐
Comments:

Scheduling of pre-painting conference. ☐
Comments:

Pre-Painting Conference

Project #_____ **Date:**_____

Inspector:_____

The following issues should be addressed in this meeting. Minutes should be kept and a copy should be given to all meeting participants. Document any agreements reached.

- The nature of the work and its effects on the surroundings, including possible mitigation measures.
- Contractor's method of operation, including equipment and personnel.
- Contractor's schedule. Discuss weather-related concerns.
- Contractor's job-specific worker health and safety plan (if lead paint is present).
- Proper storage of material and equipment.
- Location of recycling and dust collection and storage equipment.
- Inspector safety, including provision of safe access and safety from lead contamination.
- Inspection and measurement procedures, including control points.
- Identification and treatment of inaccessible areas.
- Product Data Sheets and Materials Safety Data Sheets for all relevant materials.
- Visual standards to be met. Discuss contractor's preparation of field reference sections.

Inspecting the Enclosure

Project #_____ **Date:**_____

Inspector:_____

Verify adequacy of the containment system. ☐

- Containment built according to the approved plan.
- Tarps free of holes with seams overlapped and securely fastened.
- No visible dust escaping from containment.
- No signs of surrounding ground or water contamination.

Comments:

Evidence of proper air movement within the containment. ☐

Comments:

Proper storage of debris. ☐

- On-site storage of waste should not exceed 90 days.
- Contaminated waste is not accessible to the public and is not subject to traffic collision.

Comments:

Surface Preparation

Project #_____ **Date:**_____

Inspector:_____

Hand Cleaning Methods

SP-1: Surface has been cleaned. No remaining dirt, oil, or grease. ☐

SP-2: Surface has been hand tool cleaned and is free of all loose mill scale, loose rust, loose/defective paint, weld flux, slag, and spatter. ☐

SP-3: Surface has been power tool cleaned and is free of all loose mill scale, loose rust, loose/defective paint, weld flux, slag, and spatter. Power tools have not put any grease or oil back onto the surface. ☐

Blast Cleaning

Sample the abrasive. Verify it is free of grease, oil, or other contaminants. ☐

Inspect air supply. Verify, with blotter cloth, air is free of oil, water, and other contaminants. ☐

Blasting pressure is at least 620 kPa (90 psi) or higher if recyclable grit is used. ☐

SP-6: Surface has been blast cleaned and is free of all rust, mill scale, paint, and foreign matter (except for slight shadows, streaks, or discoloration caused by rust stains, mill scale stains, and tight residue of previous coatings). At least two-thirds of each 150-cm^2 (9 in^2) area must be free of all visible residue with the remainder limited to the discolorations noted in the standard. ☐

SP-10: Surface has been blast cleaned and is free of all rust, mill scale, paint, and foreign matter (leaving only slight stains from rust and mill scale). At least 95% of each 150-cm^2 (9 in^2) area should be free of all visible residue with the remainder limited to slight staining. ☐

The anchor pattern has been verified using a micrometer and replica tape. ☐

Materials/Pre-Painting

Project #_____ **Date:**_____

Inspector:_____

Verification that the paint has not exceeded its shelf life. ☐
Comments:

Verification that the paint is not stored in areas subject to temperatures beyond the recommended limits. ☐
Comments:

Verification that the paint has not exceed its pot life. ☐
Comments:

Documentation of any use of thinner. Do not exceed recommended maximum. ☐
Comments:

Verification of curing time. After painting, inform the contractor of the estimated time that should be allowed for the paint to cure. Do not allow another coat to be put on until the appropriate amount of time has elapsed per the existing weather conditions. ☐
Comments:

Painting

Project #_____ **Date:**_____

Inspector:_____

Environmental Conditions

Check the following prior to beginning painting operations and at 4-hour intervals:

- Temperature--------Specification limits_____ Measured_____
- Relative humidity-------Specification limit_____ Measured_____
- Dew Point_____
- Steel surface temperature (should be min. of 3 °C (5 °F) above dew point) _____
- Excessive wind not present. ☐

Application

For spray applications:

- Pot pressure set to provide adequate paint supply to spray gun. ☐
- Atomization pressure set just high enough to atomize paint . ☐
- Proper technique used. ☐

For brush, roller, or mitt applications:

- Verify material compatibility. ☐
- Proper technique used. ☐

For all methods:

- Immediate repair of unsightly runs, drip, and pinholes. ☐
- Check wet film thickness. Verify acceptability. ☐
- Check dry film thickness. Verify acceptability. ☐

Safety

Project #_____ **Date:**_____

Inspector:_____

Possess all relevant Materials Safety Data Sheets and be familiar with the information they contain. ☐
Comments:

Ladders and scaffolding are in good condition and provide safe access to all necessary areas. Any needed changes should be immediately brought to contractor's attention. ☐
Comments:

If working at heights greater than 2m (6 ft.), proper fitting safety harnesses or belts have been provided. ☐
Comments:

During blasting operations, no dust leaks are visible outside the enclosure. If working inside the enclosure, appropriate breathing apparatus has been provided. ☐
Comments:

Once blasting is completed, there is no lead debris is present on the ground or in any waterways. ☐
Comments:

Hazardous waste is stored away from public access and in an area where it is not subject to being struck by traffic. ☐
Comments:

APPENDIX B - EQUIPMENT USED DURING FIELD INSPECTIONS

Field coating inspections are performed with several pieces of equipment. Most of the equipment described below is easy to use and can easily be carried by an inspector to a job site.

Environmental Conditions

Most good painting specifications require that certain environmental conditions are met prior to surface preparation and paint application. In general, the temperature of the steel surface should be at least 5 degrees F higher than the dew point of the ambient air. The temperature of the steel surface can be checked with a surface thermometer. The dew point can be obtained by measuring the wet and dry bulb temperatures of the air with a sling psychrometer (figure 1). Wet and dry bulb temperatures are used to read the dew point from a psychrometric chart.

For the most part, the paint application contractor is responsible for checking that the temperature of the steel surface is higher than the dew point of the ambient air. However, on-site inspection staff should also double check that these conditions are met on a regular basis.
Failure to do so could alter the performance of the paint, especially in the event that abrasive blasting, paint application, or curing occur at a time of moisture condensation on the steel surface.

Surface Preparation

Proper surface preparation is essential for the long term performance of paint coatings. However, given that its cost often represents a large portion of the total cost of the job, it is important that the engineer, contractor, and inspector reach an agreement as to what is the required for proper surface preparation to be accomplished prior to the beginning of a painting job. Traditionally, the most difficult task of a bridge painting job involves reaching an agreement on the visual assessment of the surface preparation. Disputes often occur when it comes to determining the visual assessment of surfaces which may be pitted and corroded and thus appear to be more stained than others even after surface preparation has been completed, and surfaces where cleaning operations are difficult to perform due to difficult access.

Figure 2 shows a replica tape and a micrometer which may be used to measure the profile of an abrasive blasted surface (i.e., surface roughness). Figure 3 shows sample visual surface preparation standards for the four most common surface preparation grades: (1) white metal (SSPC SP-5), (2) near-white metal (SSCP SP-10), (3) commercial (SSPC SP-6), and (4) brush-off blasting (SSPC SP-7). These grades are presented in order of decreasing cleanliness. It is important to note that many specifications nowadays require a visual reference to be blasted and sealed on the job site at the beginning of a job to avoid the possibility of subsequent disputes.

Chemical contamination of bare steel surfaces may also be detrimental to paint performance. Most current specifications require only visual assessments of surface preparation, but an increasing number of owners are requesting additional measurments of chloride (and sometimes sulfide)

contamination. These measurements can be performed by extracting the invisible salts from an area of cleaned steel with the use of deionized water. The results are reported in micrograms of salt per square centimeter of area. The test can be performed with cotton swabs and deionized water, or with one of several test kits. The extracted water is measured for chloride content by titration and observed for any color changes that might occur. In general, a level of 20 micrograms per square centimeter can be tolerated by most coatings.

Coating Film Thickness

Coating thickness is measured for quality control and quality assurance purposes. During application, a Wet Film Thickness gauge, which has a stepped profile on at least one side, is used to measure the applied wet thickness of a paint film on a flat surface (see figure 4). After drying, various types of dry film thickness gauges can be used to measure the thickness of various coat layers. Figure 5, for example, shows a digital magnetic gauge and a Tooke gauge. The Tooke gauge makes a scribe in the paint at a known angle. The sight glass on the gauge allows the inspector to view the thickness of the various paint layers (e.g., primer, intermediate coat, topcoat). The magnetic gauge, on the other hand, measures the total thickness of the paint system at a specific point. Magnetic gauges can also be used to measure the thickness of each coat at hold points prior to the application of the next coat. The standard procedure for measuring dry film thickness is specified in SSPC PA-2. This standard requires that several measurements be taken within a given area and then be averaged together. Inspectors are recommended to examine and obtain measurements on several types of surfaces within the structure, particularly on vertical and horizontal surfaces and on those with limited access.

Adhesion

Adhesion is the technical term which defines the ability of a paint to stick to the surface. It is an important factor when it comes to determining the condition of an existing paint or coating and whether or not it can be maintained or overcoated successfully with a maintenance paint. In addition, adhesion can be used to determine a paint's proper application and its cure of a new coating.

Adhesion can be measured with a cross-hatch or X-cut adhesion test, or with a pull-off adhesion tester. The cross-hatch or X-cut adhesion tests rate coatings on a qualitative basis and require the judgement of the inspector. The ASTM standard (ASTM D4541) for performing these tests require a rating scale of 1 to 5, but, for many bridge coatings (especially the older ones), adhesion can be labeled as either "good" or "poor." Figures 6 and 7 show what relatively "good" adhesion is according to the X-cut and cross-hatch methods. Figure 8 illustrates "poor" adhesion according to the X-cut method. These tests are performed by cutting through the coating to the steel substrate and then applying a piece of masking tape over the cut area. When the tape is quickly removed, the area of paint that comes off of the surface is estimated and compared to the rating charts in the standard (see attached). Often times, older coating systems will simply crumble when cut through by a blade, thus indicating poor adhesion.

The pull-off adhesion test, on the other hand, measures adhesion in a quantitative form (strength is measured result in PSI). In the field, however, its results can also be labeled as "good" or "poor." Figure 9 shows the pull-off adhesion test equipment. This device uses a small metal "dolly" which is glued to the surface then pulled off with a tensile pull tester. When the dolly pops off of the surface, the tension required for pull-off is recorded. The failure mode of the coating can also be evaluated by looking at the failure surface of the dolly and the remaining coating on the bridge. The failure will either be in the glue, the topcoat, or the intermediate or primer coat. This information can be used to determine which layer is the "weak link" in the system.

It is worth noting that both of these tests are destructive in that they may damage a small area of the coating. Inspectors should also realize that the adhesion of a coating system may vary significantly on different areas of the bridge.

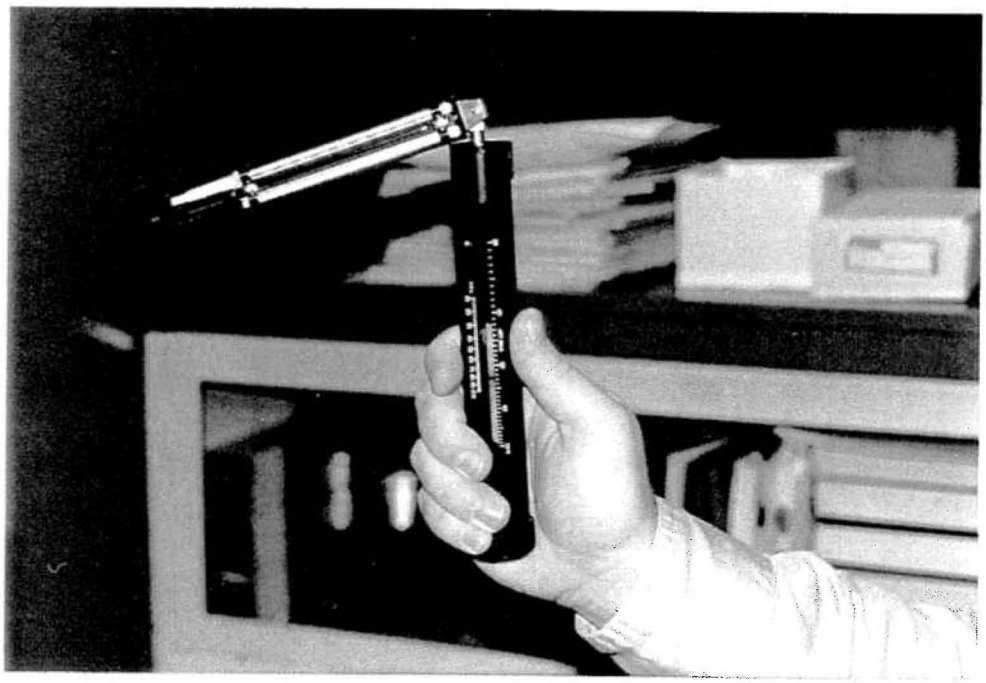

Figure 1: Sling Psychrometer for checking proper environmental conditions for blasting and painting.

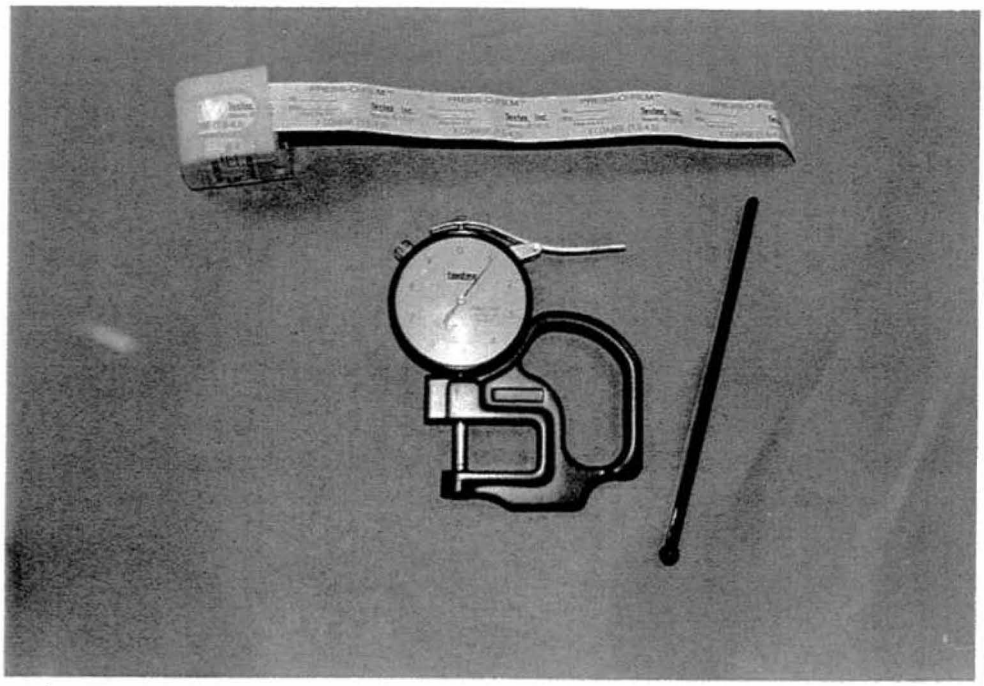

Figure 2: Replica tape and micrometer used for measurment of a surface profile after abrasive blasting

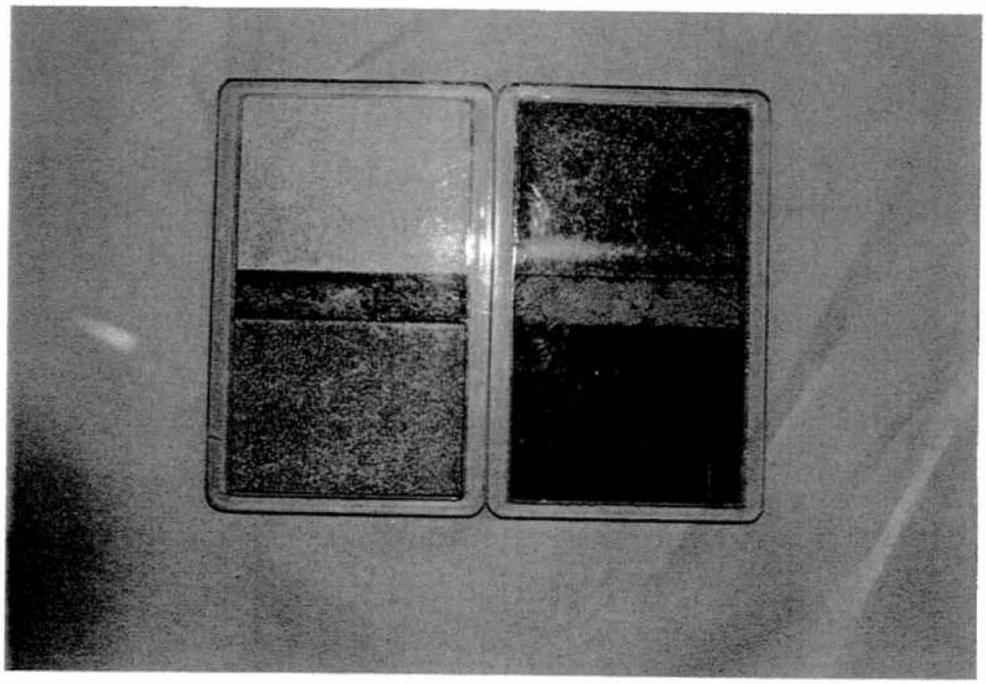

Figure 3 shows sample visual surface preparation standards for the four most common surface preparation grades: (1) white metal (SSPC SP-5), (2) near-white metal (SSCP SP-10), (3) commercial (SSPC SP-6), and (4) brush-off blasting (SSPC SP-7)

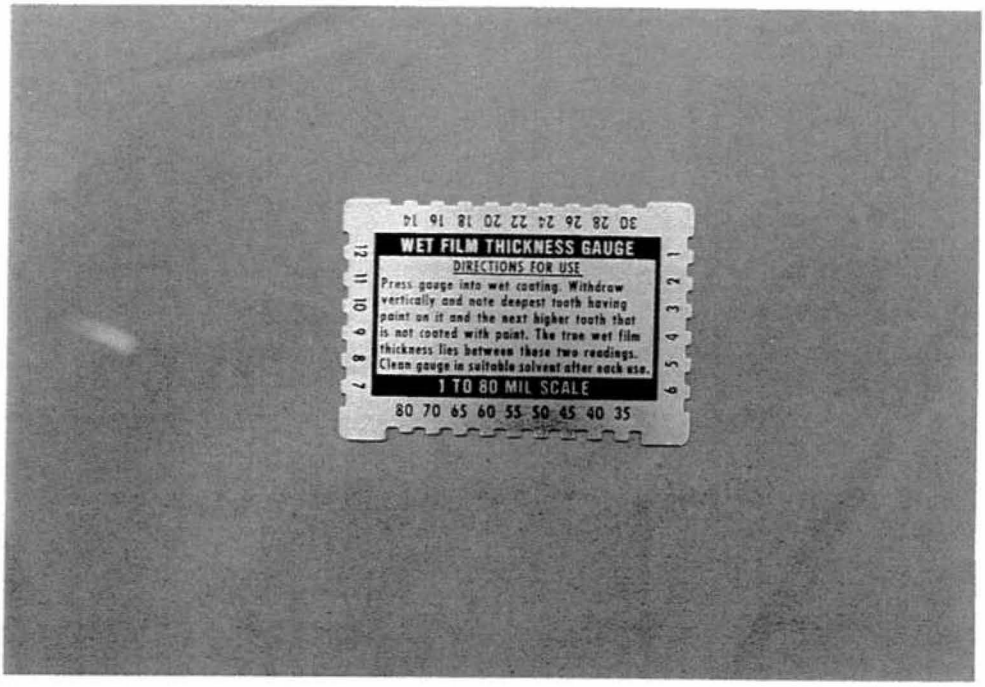

Figure 4: Wet film thickness gauges for use during coating application

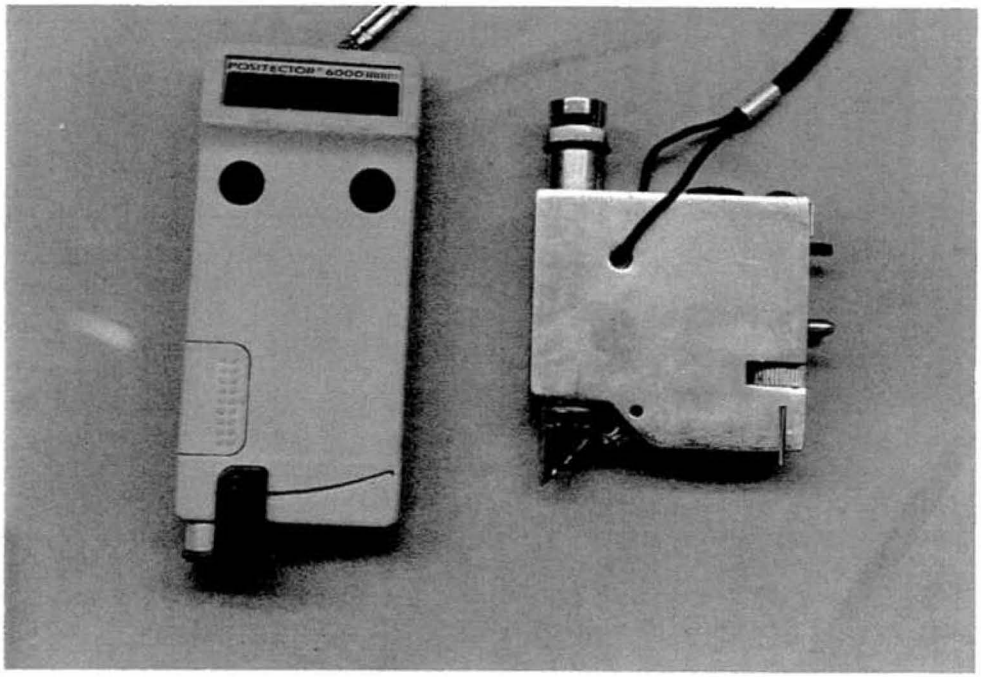

Figure 5: Dry film thickness gauges: Magnetic gauge (left) and Tooke gauge (right)

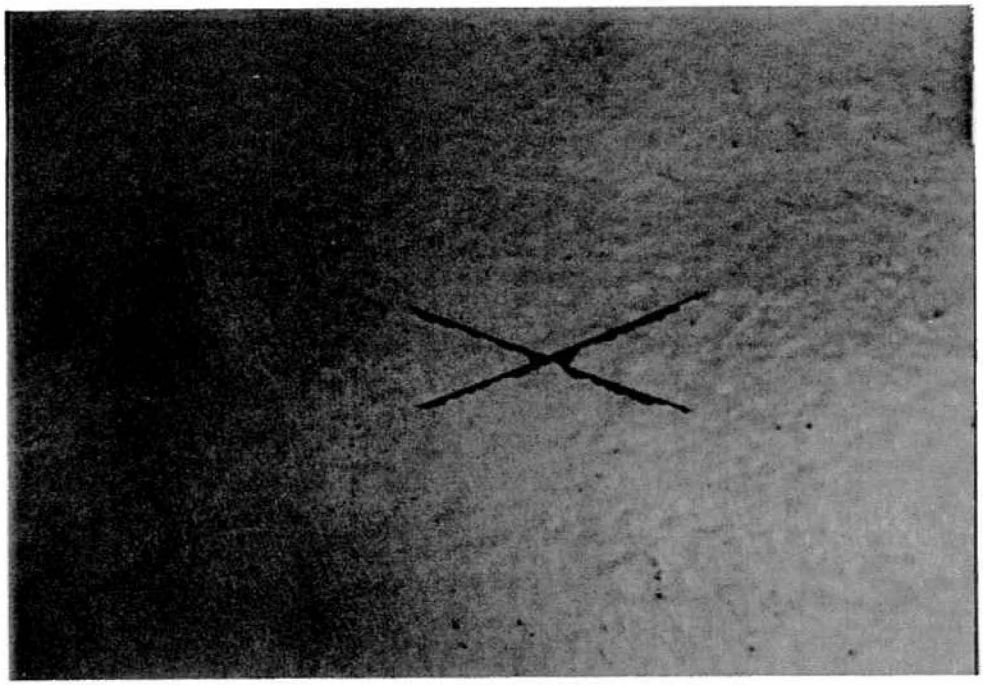

Figure 6: "Good" adhesion according to the X-cut Test Method

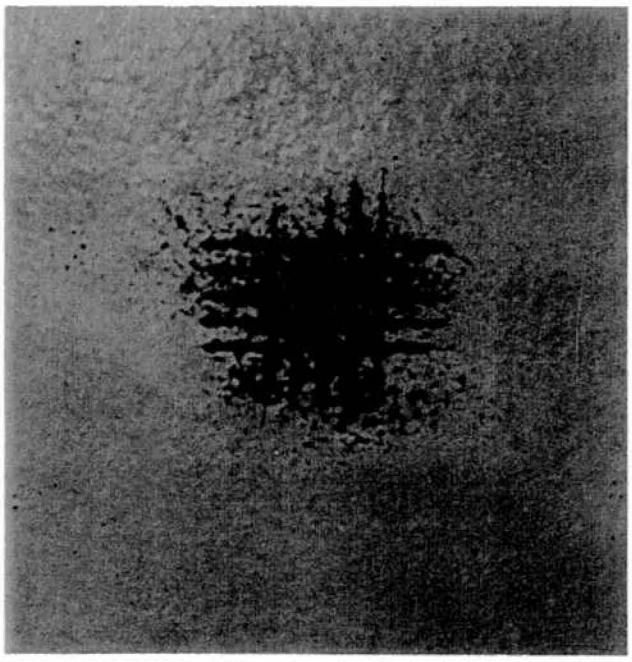

Figure 7: "Good" adhesion according to the cross-hatch method

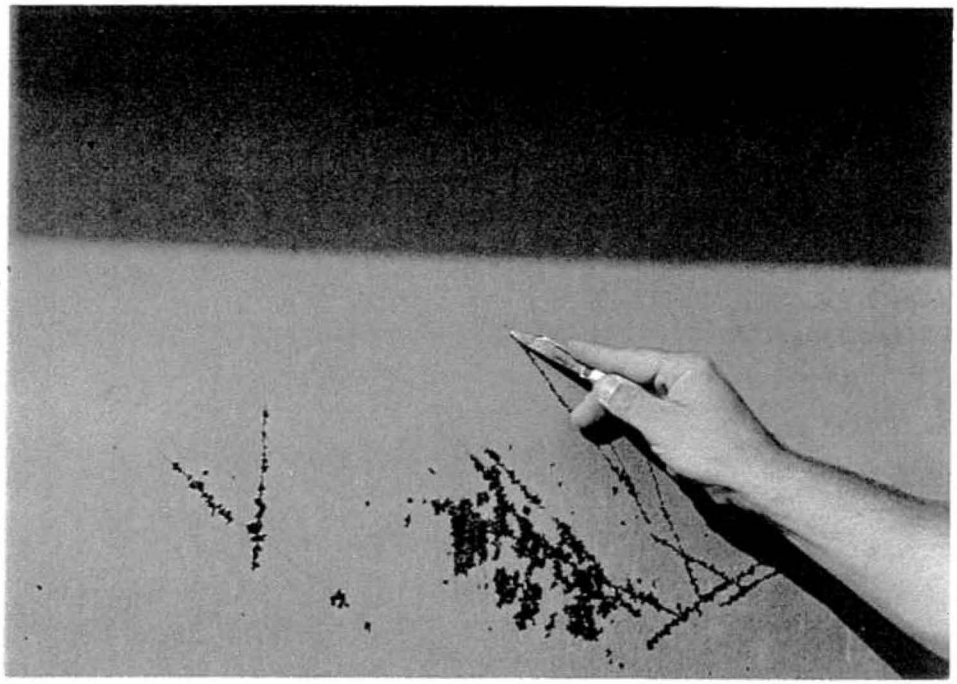

Figure 8: "Poor" adhesion according to the X-cut Method

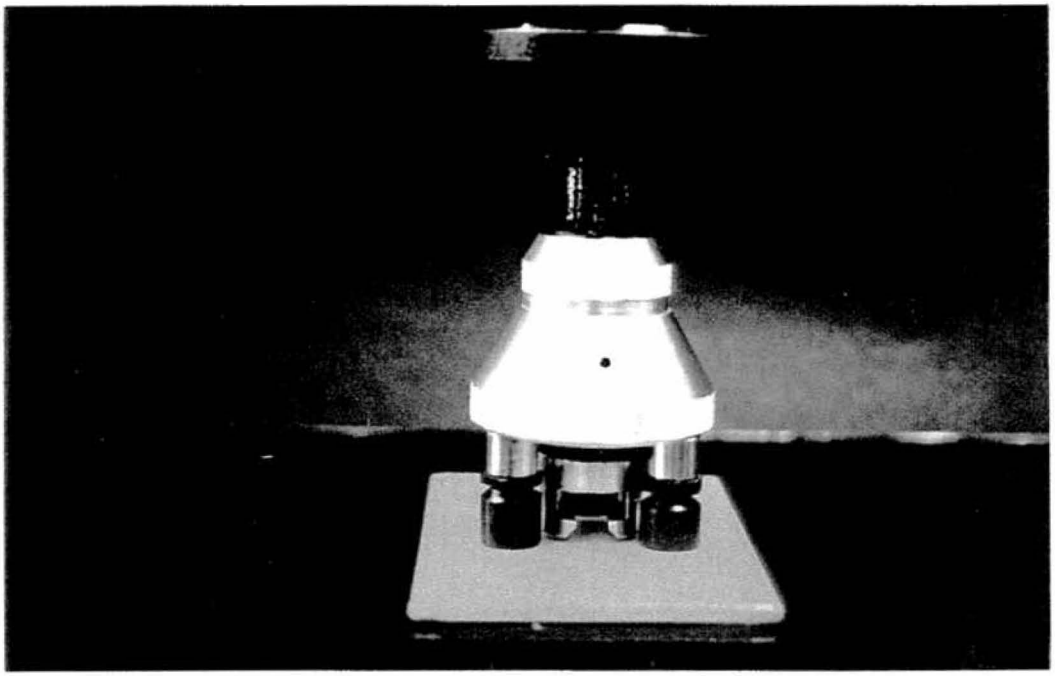

Figure 9: Pull-off Adhesion Tester