Cleaning and Painting of Structural Steel

General Information

The cleaning and painting of structural steel bridges is a vital, specialized, and often controversial phase of bridge construction and maintenance.

Structure Representatives are responsible for the satisfactory completion of cleaning and painting work in accordance with the contract specifications, Attachment No. 3 to this Bridge Construction Memo is a check list which may be used to aid the Structure Representative in obtaining a satisfactory painting project.

The following information on cleaning and painting methods, procedures and precautions, paint material, inspection techniques and record keeping is intended to provide the Structure Representatives and their assistants with a rudimentary knowledge of the cleaning and painting work. Of course, any specific instructions in the contract specifications will supersede or modify these instructions.

Any special problems with regard to cleaning and painting, which cannot be solved by the Structure Representative, should be referred to Office of Structure Construction.

Purpose of Painting

The paint on structural steel may be described as a relatively impervious barrier imposed between the steel surface and its environment. Paint retards the corrosion of the steel. Corrosion may manifest itself in many forms, and it may have many causes, but the effect is always the same: metal is consumed or deteriorated.

Paint, then, may be considered a low-cost renewable or repairable shield or membrane which is sacrificed to the elements to protect the metal. The service life expectancy of paint coats in California as affected by climatic conditions, is illustrated by the chart shown on Attachment No. 1 to this Bridge Construction Memo.

The service life of a paint coat is also a function of the quality of the paint coat. Paint must be properly formulated and prepared from ingredients having certain necessary qualities. It must be properly applied to clean surfaces of steel, and the completed film must have adequate thickness. Shortcomings in any of these requirements result in a decreased service life of the paint coat. In California, atmospheric conditions affecting the service life of paint coats vary between two extremes: the saline humidity of the sea coast and the hot aridity of the desert. Between these two extremes are regions where milder weather conditions prevail. Obviously, the need for protection

is considerably less under mild exposures than it is under severe exposures. The paint system specified is therefore designed to meet the needs of the area, and conform to the latest pollution regulations imposed on solvent content of paint materials.

Current paint systems consist of either phenolic, or water-borne undercoats and water-borne finish coats. The thicknesses required varies according to the corrosion potential at the site.

Due to air pollution regulations, a paint system consisting of water-borne primers and top coats has been developed. This system consists of 4 mils of undercoat applied in 2 or more applications and 4 mils of finish paint applied in 2 or more applications. No vinyl wash primer is used.

Water-borne paints generally require higher temperatures and lower relative humidities than some other paints to dry properly. Care should be taken not to permit painting when the atmospheric or surface temperature is at or below 50 F, or when the relative humidity exceeds 75 percent. Temperature and relative humidity should remain within the above limits for approximately 4 hours after application to permit adequate drying.

From past experience with paint systems; the specification of multiple coat applications and the minimum dry film thicknesses of paint coats have evolved. Most paints used on structural steel contain varying amounts of volatile solvents which, when they evaporate during the drying process, leave minute holes in the paint film. The application of multiple coats of paint, not too thin or too thick, tends to overcome the adverse pin-hole pattern in each coat and assures a truly impervious membrane. On any particular job, the specification of paint coat thickness of either paint system is adapted to the prevailing exposure conditions.

Most paints will not tolerate extra thick applications or puddles. If too much paint is applied, or puddles of the material are left on the surface, the coating will crack and lose bond with the steel or underlying coat. Each application should be held to near the amount specified.

Surface Preparation

The most important factor affecting the protective service life of a paint is the surface preparation prior to painting. The best paint available will not give optimum service when applied over improperly cleaned surfaces. It is essential, therefore, that paint is applied only to clean, sound, dry surfaces.

Although several methods of surface preparation are employed in the painting industry, it has been found that blast-cleaning and steam-cleaning are the most effective and least expensive methods. These two methods are specified almost exclusively. Occasionally, in mild exposure areas or where the type and amount of rust does not warrant the expense of blast-cleaning, hand cleaning methods may be specified.

Blast-cleaning is frequently referred to as sandblasting. However, since the abrasive used need not be limited to sand, the Office of Structure Construction has adopted the less restrictive term, blast-cleaning, in its specifications.

Blast-cleaning is simply the propulsion of an abrasive against an object, and the cleaning is accomplished by abrasive action. Various sources of power may be used to propel the abrasive, but the one most commonly used is compressed air. Another source is centrifugal force as used in large machines designed for the purpose. These machines are used only in shop installations because of their size and immobility. In field work, compressed air seems likely to remain the chief power source for some time. When dictated by adverse environmental impact, wet blast-cleaning may be specified. The power source for this method is either high pressure water or steam.

Sand, because of its abundance and consequent low cost, is the principal abrasive used. The only requirement imposed in the specifications is that the material be clean, dry, of proper grading, and meet requirements of the Air Resources Board for "Dry Unconfined Blasting". The degree of hardness is not specified.

Sand, obtained from commercial sources generally meets our requirements. Use of unwashed beach or river sand is not permitted because contaminants or too many fines are often present. It does not meet ARB requirements.

Other abrasives used on a lesser scale are steel shot, steel grit and slag from copper, nickel, and silver smelting processes. The use of steel shot or steel grit is usually limited to shop blasting where recovery for reuse is possible. High initial cost and lack of a practical recovery method prohibit the use of these abrasives in the field.

In the 1988 Standard Specifications "Blast-Cleaning," has been described in a different manner. This description is not intended to lower the degree of cleanliness of the steel from past years, but conforms more closely to language used in outside Industry.

Steam-cleaning consists of washing the surface to be painted with steam in which a biodegradable detergent soap has been incorporated in the feed water, or applied directly to the surface to be cleaned. The steam is directed against the surface, and the contaminants, loosened by the detergent, are carried away by the flushing action of the condensed steam. Any residue remaining on steam-cleaned surfaces should be flushed with fresh water before painting.

Steam-cleaning is used principally in maintenance work when spot-cleaning and painting are specified, although it may occasionally be used on shop-coated steel in new construction work if the surfaces have become contaminated by dust, oil or other contaminating products. The primary purpose of steam-cleaning is to remove surface contaminants which would impair bonding of new paint to existing coatings. Steam-cleaning will not remove rust, and if rust is present after steam-cleaning, the operation will generally be followed by spot blast-cleaning.

An interval of at least 24 hours should elapse after steam cleaning before paint is applied.

A steam-cleaning supplement which describes the operation, equipment used and the detergent intermingling procedure in more detail is available upon request from the Office of Structure Construction.

Paint Application

The paint coats specified generally consist of one or more undercoats. The various coats or layers are planned and specified:

1. To achieve an impervious membrane which inhibits corrosion.
2. To protect the steel against impact or abrasion.
3. To give the structure a pleasing appearance.

The normal functions of undercoats are to inhibit corrosion, to provide a suitable base for the finishing coats and to present a secondary barrier to any moisture penetrating the finishing coats.

Finishing coats comprise the tough outer layer of the paint film which is directly exposed to the weather. They are the weathering or wearing coats of a paint system and must, therefore, have a harder, more impervious surface than the undercoats. Two applications of finishing coat paint are normally specified.

Paint may be applied to structural steel by brush, roller or spray, but regardless of the method used, care must be exercised in the application in order that the maximum service-life may be realized. It is the responsibility of the Structure Representative to see that the paint is applied properly. The paint should be well mixed and uniformly applied, and any skips or holidays should be picked up before subsequent applications are allowed, since the smallest break or thin spot in the paint film is a potential trouble spot.

All formulations now in use, EXCEPT the inorganic zincs can be applied by any of the previously mentioned methods. Spraying is the only satisfactory method for application of inorganic zincs to large surfaces. However, small holidays or skips which sometimes occur around rivets or bolts can be picked up with a brush, and areas inaccessible with a spray gun should be swabbed or brushed.

Experience has taught us that "Airless" spray is inferior to conventional spray, on most bridge structures, due to lack of control of the amount of paint material being dispersed from the nozzle.

Paints for use on structural steel, except inorganic zinc primer, are manufactured ready for-application and thinning is not necessary, nor should it be tolerated. Inorganic zinc primer may be thinned as recommended by the manufacturer.

Painting for appearance may be considered of secondary importance to painting for protection, but it is evident that the public is aware of bridge appearance. Both maximum protection and pleasing appearance can be achieved by a paint job properly done. The most common causes of poor appearance are runs or sags in the paint film and paint spray or splatters on the concrete portion of the structure. By using care and precaution, it is far easier to prevent these defects than it is to correct them.

Thickness of Paint Film

Dry film thickness of the paint film is always specified in either the special provisions or, by reference, in the Standard Specifications. In all cases, the specified mil thickness is the minimum on all surfaces and does not mean the overall averages.

Paint dry film thickness is measured by a magnetic flux gauge called "E1cometer" or "Positector." Gauges are supplied by the Office of Structure Construction with instructions for their use. These devices are delicate and expensive instruments and should, therefore, be handled with care. Gauges should not be stored near active electrical circuits, and they should not remain near welding equipment longer than absolutely necessary. Periodic checks to determine the accuracy of the gauge is necessary. These checks may be made by using the shims provided. It is not the intention of the Office of Structure Construction to penalize a Contractor by requiring more thickness than specified, but, on the other hand, we should be sure that we do not get less. All measurements should be taken with the gauge placed firmly at right angles to the area being measured, even a slight slanting of the device gives a high reading, as will lack of solid contact. Recalibrate gauges on different types and sizes of steel. Reading differences have been noted between webs, stiffners and braces.

It is often necessary on small jobs or near the completion of large ones to measure a film thickness of paint which is not hard enough to prevent indentation by the film-thickness gauge. If a close inspection shows such a condition, the reading is certain to show less thickness than is actually on the steel. Correction can be made by placing a shim between the paint film and the film thickness, gauge and deducting the thickness shown on the shim from the reading taken.

The importance of adequate paint film thickness cannot be overstressed. All other things being equal, it is one of the factors that determine the service life of a paint job. It follows, therefore, that sufficient measurements should be taken to assure specified thicknesses in all places.

Protective Measures

Inherent in a bridge painting operation is the possibility of the creation of a nuisance or of the physical damage to adjacent property or to the traveling public. This is particularly true on contracts involving the repainting of structures under traffic.

Although the responsibility for the prevention of damage rests with the Contractor, the Structure Representative must constantly be aware of the job situation and should not hesitate to call the existence of hazards or potential sources of damage to the Contractor's attention.

In the event passing automobiles are spattered with paint, little damage will occur if the paint is immediately removed with mineral spirits or with water for water-borne paints. However, this should not be a common occurrence. A prudent Contractor will use drop cloths, screens, overhead tarps, and the like to adequately protect passing traffic or adjacent property.

Particular emphasis should be placed on the protection of concrete surfaces which are a part of the structure. The Contractor should not be allowed to mix paint or charge paint pots on bridge decks without adequate drop cloths. It is next to impossible to remove paint from concrete, and particular care should be exercised to prevent spattering such surfaces. Thinners and paint removers should not be used in attempting to remove paint from rough concrete surfaces. After the paint is dry, the area should be rubbed with a stone and wire brushed, or lightly blast-cleaned.

Paint which is being sprayed can drift as much as a quarter mile or more, and Contractors should be reminded of this possibility, particularly if automobiles are being parked nearby.

In general, the best protective measure is the anticipation of possible damage and prevention of its occurrence.

Paint Records and Reports

The Office of Structure Construction has developed a series of special record forms for use in keeping daily job records on each phase of the cleaning and painting operation. These forms will be furnished to the Structure Representative at the beginning of his assignment to a particular project. Samples of these forms (DH-OS M5, DH-OS M8, DH-OS M11, and DH-OS M78) are included in Section 16 of the Bridge Construction Records and Procedures.

Paint record sheets were developed to simplify the reporting of statistical data as well as to ensure uniformity in record keeping. Structure Representatives should be familiar with the use of the sheets and should enter the required information in accordance with procedures recommended by the painting section.

In addition to the paint records, the Resident Engineer's and/or Assistant Resident Engineer's Daily Reports (HC-1O and HC-1OA) are required for the painting operation.

The Blast-cleaning and paint record form (DH-OS M8, Daily clean and Paint Record), is a diary form used by the Structure Representative for the various phases of the cleaning and painting work. These diaries have the same significance as the general diary forms HC-10 and HC-1OA and should, therefore, receive the same degree of care in their preparation and distribution.

Form DH-OS M78, is a record of spot-blast-cleaning performed. The purpose of this form is to have the Structure Representative and the Contractor's representative agree, on a daily basis, on the amount of spot-blast-cleaning performed.

On repainting projects, the Structure Representative will prepare, from the information gathered in the daily diaries, cost data for the various phases of blast-cleaning and painting. This data will be entered on the paint data sheets, Form DH-OS M5, Clean and Paint Cost Summary. Use of this form aids the Structure Representative in making a systematic and uniform record of cost data.

Following completion of the painting operation, statistical information included on the paint record sheets is summarized on a special summary sheet, Form DH-OS M11, Paint Record. The

primary purpose of the information summarized on this form is to provide a sound basis for estimating the cost of future painting projects.

It also provides information regarding the type and quantities of paint used, which information will be valuable when negotiation with pollution agencies in regards to removing paint and repainting the structure on future painting projects. Therefore, the form must be carefully and accurately completed if it is to have any real value.

The original Form DH-OS M11 and supporting paint record forms are retained in the job files until project completion, at which time they are submitted to the Sacramento Office with the Report of Completion. One copy of Form DH-OS M11 should be sent to the Office of Structure Construction as soon as the painting is completed.

Surface Area Computations

The area to be painted is an important part of the paint inspection procedure. The surface area must be known to enable the Structure Representative to determine the true rate of progress and to calculate coverage rates. Surface area calculations are also of great value in the planning of future painting contracts. Surface areas of most structures are available in the Sacramento Office of Structures Maintenance. If they are not available, it will be the responsibility of the Structure Representative assigned to the project to calculate them. All calculations should be clearly shown so they may be easily checked by another person. Include subtotals for each span and separate summary sheet for each structure in the project.

Surface area computations will be submitted with Form DH-OS M11 as an attachment to the Report of Completion.

On request, charts to assist in the calculations of surface areas will be furnished to the project by the Office of Structure Maintenance.

Standard Paints Used by the Office of Structure Construction

The different types of paint currently being used by the Office of Structure Construction are identified on Attachments No. 2 and 3 of this Bridge Construction Memo. Attachment No. 2 is a list of the standard paints used by the Office of Structure Construction and Attachment No. 3 is a working list of approved water-borne inorganic zinc rich primers. No paint brand shall be used unless it is on the Departments current list of approved paints or meets the specifications of the Departments standard paints. In order to give a complete listing of all paints which may possibly be specified in Office of Structure Construction work, we have included the specifications and descriptions of wood and concrete paints in the tabulation, although the painting of wood or concrete is not discussed in this memo.

Environmental Protection

It is the intention of the Office of Structure Construction to comply with regulations imposed by various public environmental protection agencies. These enforcement agencies are now operative

in most areas of the state. Their primary concern is air and water pollution as well as noise abatement.

In order to comply with present and foreseen regulations, new cleaning and painting procedures have been and are being developed. In general, dust created by blast-cleaning, ground pollution from old lead and zinc paints, and overspray from paints are the chief offenders to the environment.

Curtailment methods for dust and waste products include confinement within the immediate work area and use of abrasives which create less dust. Wet-blast cleaning may be another alternative, subject to approval of the engineer.

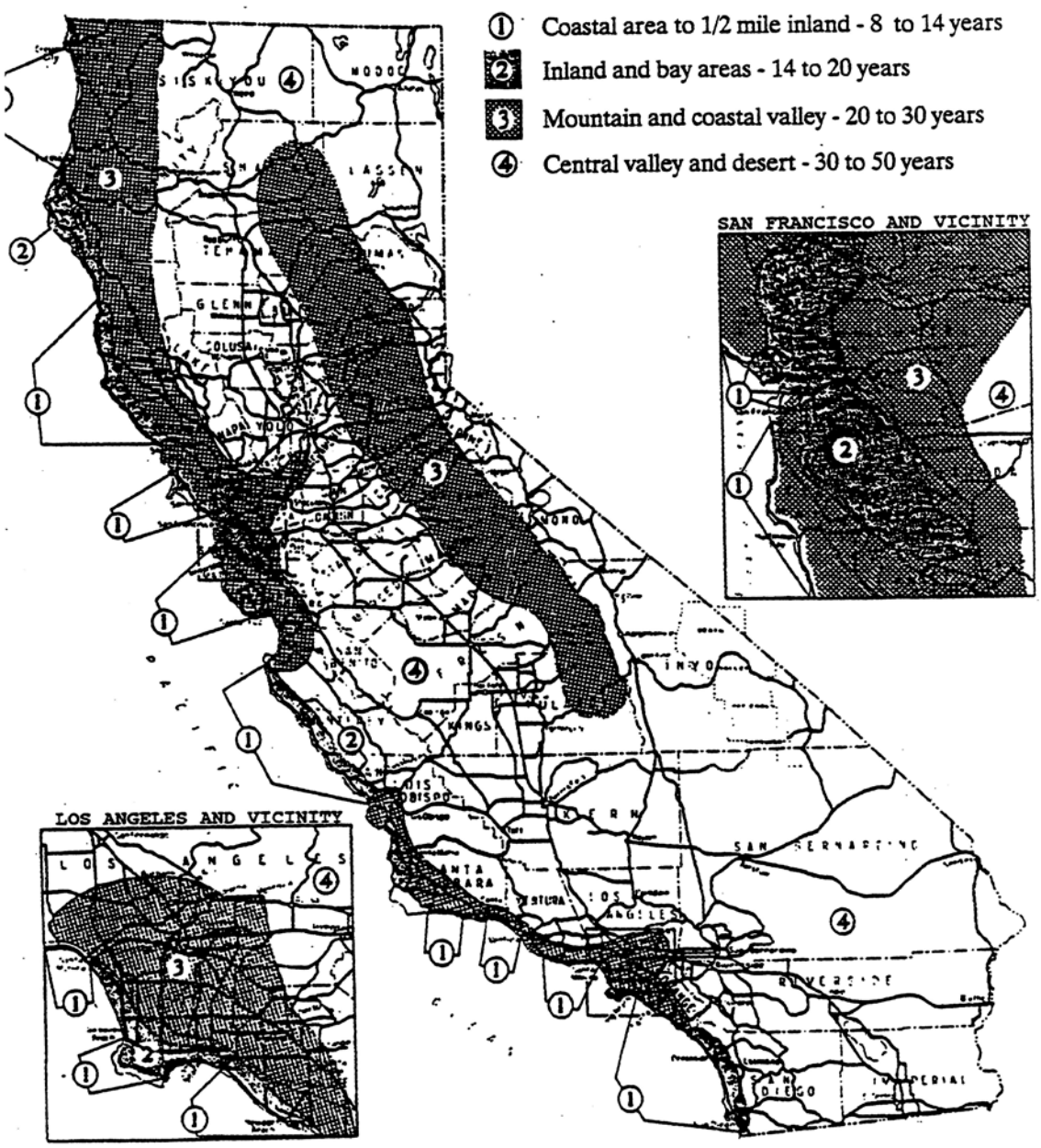
Confinement of waste products and dust is accomplished by using water curtains, planking, or by draping tarps, potato sacking, heavy-duty polyethylene bags or sheets, or similar materials around and under the work space. The confined waste materials are then collected and hauled to an approved dump site by an authorized transporter.

Copper, silver and nickel slags are sources of abrasives now in fairly common use. These abrasives are more expensive than sand. All abrasives, for dry, unconfined blasting including sand, must be approved by the Air Resources Board.

Wet-blast cleaning when it is specified may be done by two methods. One method is the so-called "ring" method. It consists of a perforated ring attached to the blasting nozzle. Water mist forced through holes in the ring mixes with the abrasive at the nozzle and effectively inhibits dust. However, rusting starts immediately on -freshly blasted metal, and the method is impractical for that reason. It is an effective method to use when blast-cleaning concrete, stucco or wood. The other method uses high pressure water or steam as the abrasive impellent. A dilute solution of sodium nitrite added to the water or steam inhibits rusting until the prime coat can be applied. The later method can be used, when necessary, provided excess water can be controlled. Both methods are more costly than dry blast-cleaning and will not be specified unless necessary to meet environmental regulations.

Lead pigmented paints are no longer being specified for use on structural steel because of their toxicity.

PAINT SERVICE LIFE ON STRUCTURAL STEEL BRIDGES



Information shown is approximate only, compiled from records of the Division of Highways for existing bridges on the State Highway system.

STANDARD PAINTS USED BY OFFICE OF STRUCTURE CONSTRUCTION

Phenolic Paints

Spec. No.	Name	Function	Used on
PB-201	Red Primer, High Solids Phenolic Type	Primer	Steel
PB-202	Pink Primer, High Solids Phenolic Type	Primer	Steel
PB-199	Aluminum Phenolic Tung Oil	Finish Paint	Steel

Water-Borne Paints

Spec. No.	Name	Function	Used on
PWB-142	Red Water-borne,	Primer	Steel
PWB-143	Pink Water-borne,	Primer	Steel
PWB-145	Red Water-borne,	Primer	Steel
PWB-146	Pink Water-borne	Primer	Steel
PWB-87	Flat Gray Water-borne	Finish Paint	Steel
PWB-88	Light Tan Water-borne	Finish Paint	Steel
PWB-89	Tan Water-borne	Finish Paint	Steel
PWB-151	Aluminum, Leafing or Nonleafing Water-borne	Finish Paint	Steel
PWB-82	Light Green,Water-born	Weathering Coat	Steel
PWB-83	Green, Water-borne	Weathering Coat	Steel
PWB-86	White Tintable, Water-borne	Weathering Coat	Steel
TT-P-19	Acrylic Emulsion -Tintable	Weathering Coat	Masonry
Fed. Spec. TT-P-001984	Wood Primer	Primer & Undercoat	Wood
Fed. Spec. TT-P-96D	White Wood Finish Coat	Weathering Coat	Wood

CALIFORNIA DEPARTMENT OF TRANSPORTATION

QUALIFIED PRODUCTS LIST

WATERBORNE INORGANIC ZINC RICH PRIMER

The following products have been evaluated and determined to provide a material meeting specification requirements for a waterborne inorganic zinc rich primer used in undercoating properly prepared structural steel in transportation maintenance and construction projects.

INORGANIC COATINGS INC.
IC 531 INORGANIC ZINC RICH PRIMER
(800) 345-0531

VALSPAR CORP.
MZ-6 HI-RATIO INORGANIC ZINC RICH PRIMER
(818) 334-8251

DEVOE COATINGS CO.
CATHACOTE 309 WATER BASED INORGANIC ZINC COATING
(504) 272-2470

DU PONT COATINGS CO.
GANICIN 347WB WATER BASED INORGANIC ZINC
(800) 346-4748

The effective period for this list is indeterminate. Other products will be considered for inclusion on this list subject to evaluation and approval by:

California Department of Transportation
Office of Transportation Materials and Research
5900 Folsom Boulevard
Sacramento, CA 95819

CHECK LIST FOR BRIDGE PAINTING PROJECTS

1. Check to see that steam cleaning is doing a satisfactory job of removing all dirt, grease, loose chalky paint, or other foreign materials.

2. Check to see that the specified biodegradable detergent is being used.

3. Check spot-blasting to be assured that all rust has been removed.

4. Check 100% blasted areas to be assured that all rust and old paint has been removed.

5. For "Spot Jobs", check to see that the air pressure and nozzle size meet the specifications.

6. Measure and record spot blast areas daily.

7. Check to see that the first coat of paint is being applied daily. If not, be sure that areas are reblasted before paint is applied.

8. Visually inspect backsides of rivets, tops of diaphragms, tops of bottom flanges, and other hard to reach areas to be assured that they are properly cleaned, and have the required paint coverage.

9. Check to be sure that the access to the work is adequate and that work areas are safe.

10. Observe mixing of paint materials to be assured that the mixing is being properly done.

11. Require the Contractor to provide safe access to the work so that it can be properly inspected.

12. Check the temperature and humidity at intervals as required to be assured of specification compliance.

13. Check structural steel to be assured that it is dry when paint is applied.

14. Check undercoat for proper thickness before permitting the application of finish coats.

15. Record the quantities of abrasives and paint materials used daily. Also record man hours and hours of equipment use daily. This information is required for the Final Report

16. Enforce the specification requirements concerning the containment of fall-out materials.

17. Enforce the specification requirements concerning the disposal of used sand and old paint.

18. Check to see that the Contractor is properly protecting deck soffit concrete, concrete caps, concrete piers and other concrete from overspray paint. Areas not so protected must be cleaned before the project is accepted.

19. Check to see that the Contractor is taking proper precautions to prevent damage to adjacent trees, rocks, and property improvements.

20. Check to see that the Contractor is complying with the OSHA safety requirements.

21. Check to see that waste materials are collected and disposed of properly.