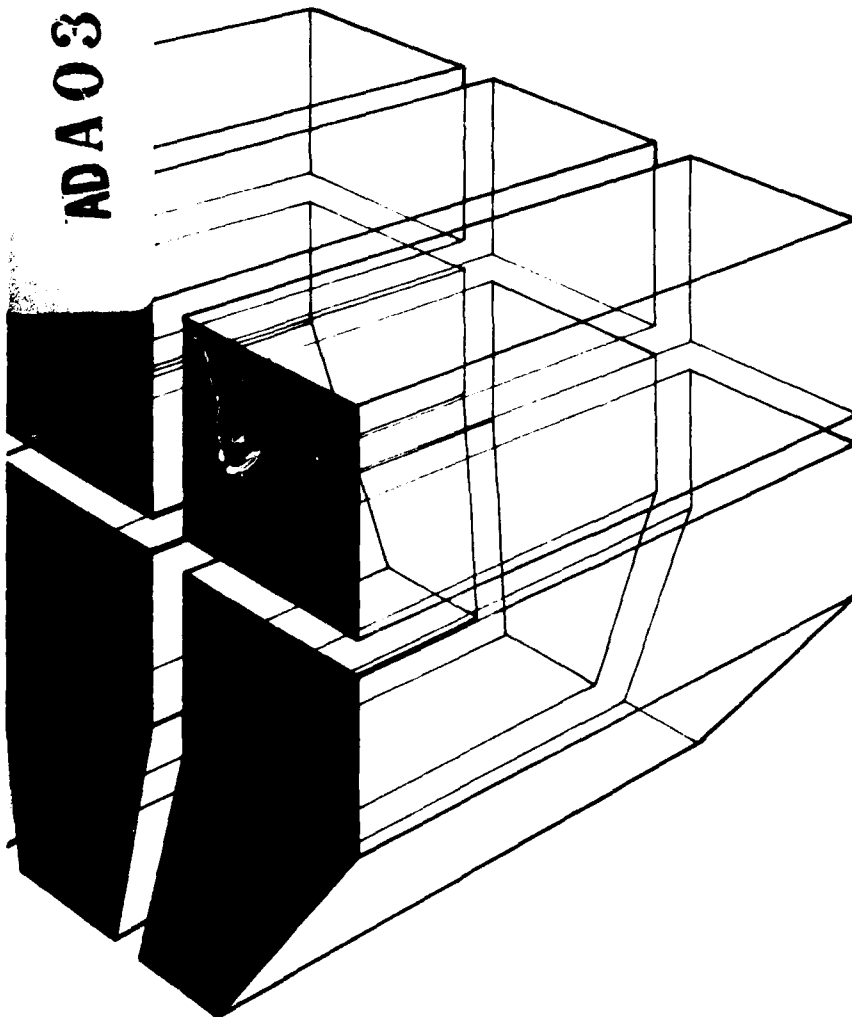


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September 1976

MAINTENANCE PAINTING OF STEEL STRUCTURES

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by
Alfred Beltelman

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FOREWORD

This paper was presented by the author at the Maintenance Engineering Seminar, 29-30 June 1976, at Greenup, KY. The seminar was sponsored by Louisville District, U.S. Army Corps of Engineers. Mr. Beitelman is a chemist in the Materials Construction Branch, Materials and Science Division, U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, Illinois.

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MAINTENANCE PAINTING OF STEEL STRUCTURES

Introduction

Maintenance painting is generally more difficult and often more costly than the original construction painting. Engineers responsible for maintenance often do not recognize the problems and difficulties involved in repainting structures, and consequently devote insufficient time to this phase of their work. Although some maintenance engineers are fully aware of the problems and importance of maintenance painting, they are handicapped by the incomplete understanding of their superiors, who fail to furnish adequate funds or give high enough priority to the proposed work. In either event, lack of knowledge is the fundamental cause for inadequate or uneconomical maintenance painting. The scarcity of information on maintenance painting and the complexity of the problem frequently cause dependence on the recommendations of paint manufacturers' representatives, which seldom results in use of the most economical painting practices.

The purpose of the information presented in this paper is to focus attention on maintenance painting work and to assist those responsible for mitigating corrosion on existing structures. The following factors involved in maintenance painting are discussed: (1) degree of destruction of existing coatings which can be allowed before repainting is required; (2) determination of the most economical surface preparation; (3) selection of the paint system which gives the most economical performance; (4) preparation of specifications covering the work to be done; and (5) inspection of the cleaning and painting operations.

Field Investigation

Before detailed plans for maintenance painting can be formulated, inspecting the structure to be maintained is obviously necessary. The information which should be obtained during this inspection is described below.

a. Integrity of Existing Coating. Many inspections of paint films are too cursory. To avoid erroneous conclusions, typical areas must be carefully examined using a knife blade to ascertain the film's brittleness, strength, and adhesive strength, depth of pits under rust nodules, extent of corrosion under blisters, and intercoat adhesion. Typical areas observed should include all exposure conditions involved, such as continuously wet, intermittently wet and dry, southern atmospheric, northern atmospheric, erosion and abrasion, high humidity, and semiprotected surfaces.

b. Surface Condition of the Metal. Noting the presence of mill scale is important, since it allows the examiner to determine whether the metal has previously been blast cleaned, if this fact is not known from records. This knowledge is often helpful in evaluating the existing coating's performance. More important, if mill scale is present, and it is decided to remove it, the cost of cleaning will be affected. Since the amount of pitting and rust scale may determine the method of cleaning and its cost, noting this factor is necessary. If heavy corrosion is prevalent on only part of the structure, the location should be noted, because a combination of cleaning methods may be employed, i.e., blast cleaning for the heavily corroded areas and power wire brushing for other areas.

c. Accessibility and Complexity of the Structures. The difficulty and amount of work required to prepare a structure for cleaning and painting

usually influence greatly the selection of the paint system to be used. The greater the preparation cost, the more durable the paint system should be. Underwater surfaces of a lock gate, penstock, or surge tank, for example, are inaccessible unless costly dewatering procedures are followed. Less obvious examples of areas which are difficult to clean and paint are interior surfaces of open-type, built-up columns, narrow and deep recesses between structural members, and interior surfaces of confined, poorly ventilated spaces. A structure made up of a large number of small structural members is much more difficult to clean and paint than one composed of a few large structural members, even though the surface areas of the two may be the same. The information gained by observation of the difficulty of preparation will be helpful in preparing specifications covering cleaning and painting and in estimating the cost of the work.

d. Incidental Factors. Fixed machinery is often located in the structure to be cleaned and painted. If the cost of protecting gears and other moving parts from damage by sandblast dust is greater than the advantage gained by the use of blast cleaning, another cleaning method should be selected. Commonly, however, the decision to omit blast cleaning is made without thorough study, because of the possibility rather than the probability of damage to machinery. The unjustified prejudice against blast cleaning can often be dispelled by actual trial tests which furnish evidence that damage can be avoided by reasonable care. Since the coating system selected may be governed by the type of surface preparation, and since the specification writer must know these details, it is important to note them during the field inspection.

Another factor to note is the proximity of foreign structures or objects which might be damaged by paint overspray; the presence of such objects may require that the structure be brush-painted. Insurance companies have paid large sums for refinishing automobiles that were parked several hundred feet from a structure that was spray-painted. The type of paint used, direction of prevailing winds, and height of structure are the main factors determining how much consideration should be given to the effects of overspray. A lacquer type paint which dries within a few feet of the spray nozzle will cause less difficulty in this respect than a paint that remains wet for a longer period of time.

Facilities available for storing cleaning and painting materials, equipment available for handling materials and personnel, ventilating equipment, and scaffolding on hand (if needed) are other items which should be noted.

All of the incidental factors discussed in this section give the person selecting the coating system and preparing the specifications a good idea of how, as well as what, work is to be accomplished.

e. Exposure Conditions. In general, the exposure conditions (underwater, atmospheric, high humidity, etc.) are known before the inspection is made. The most important observation to be made here is the importance of each structural member in the more severe exposures to the structure's overall stability. Complete protection during the structure's entire life is not generally economically justified; the experienced corrosion engineer must balance the protection he prescribes against obsolescence and a reasonable amount of repair. Therefore, if only a small and relatively noncritical item or area of the structure is subject to a

severe exposure condition, giving it special attention may be impractical. However, if corrosion of the area subject to a severe exposure condition will seriously affect the structure's stability, or if the area amounts to a relatively large proportion of the total area to be painted, using the most severe exposure condition as the basis for selecting the coating system will probably be the most economical method.

Selection of Coating System

The information obtained from the field inspection, combined with unit cost data for maintenance painting work, permits the engineer to make an intelligent selection of the coating system--including metal preparation--which will provide the most economical protection. The basis for determining costs is not the initial cost of cleaning and painting, but rather the cost per year of protection, including touch-up painting, if feasible. This requires that the engineer have a tentative maintenance painting program in mind; the program might cover a period of 10, 20, or 30 years, depending on the exposure conditions involved, the durability of the contemplated coating, the accessibility of the structure for painting, the probable availability of funds for continued maintenance, and other factors. Because each maintenance painting job presents a problem which must be solved individually, covering each type of problem in this paper would be impossible. However, a few general rules which may be helpful are given below.

a. Decision on the Method of Cleaning. Of the two common cleaning methods available for field maintenance--blast cleaning and power wire brushing--blast cleaning is normally much more efficient and produces a

cleaner surface. Also, it produces an anchor pattern which provides for better adhesion of paint coats. It is generally considered necessary to blast clean to white metal all surfaces which are subject to immersion or severe condensation, because coatings which are durable in this type of exposure will not otherwise perform satisfactorily. Although power wire brushing is occasionally used for touch-up painting small underwater areas, spot blast cleaning will give a better job and will often be more efficient in these areas. Therefore, the maintenance engineer should normally plan to use blast cleaning for this type of exposure.

For atmospheric exposure where primers with good wetting properties can be used, relaxing the requirements on metal preparation is generally economical. Normally, removing only loose mill scale, blistered and deteriorated paint, and loose corrosion products will provide satisfactory paint system performance when the system uses a primer having good wetting and adhesion properties on such a surface. The selection of power wire brushing for cleaning would therefore be adequate for most structures in atmospheric exposure. However, old structures that have not been maintained and have corroded badly, resulting in formation of a heavy rust scale and pitting of metal, can be cleaned economically only by blasting.

In addition, structures for which a planned paint program has never existed may have a large number of coats of paint of different types which have failed and must be removed, either because of excessive film thickness or because the various coats are not compatible. Covering such a coating with more paint is certainly not the solution to the problem. Blast cleaning is considered the most economical method of removing such coatings.

Blast cleaning of metal subject only to atmospheric exposure need not be as thorough as that of metal in more severe exposures, but the degree of cleanliness desired must be carefully described in the specifications covering the work. The corrosion engineer should not be reluctant to specify blast cleaning for fear of increasing costs. Many contractors select this method of cleaning even when wire brushing is allowed, since they have found it to be more economical.

Often conditions exist which make using a combination of cleaning methods on the same structure desirable. For example, because deicing salts accelerate corrosion on specific areas of a bridge, those areas require a coating resistant to such attack. Using a wire brush on these areas would not provide a sufficiently clean surface for such a paint. Another example is badly corroded angles and recesses that cannot be reached satisfactorily with a wire brush. Where the area requiring blast cleaning is small compared to the area which can be cleaned satisfactorily by other means, a combination of the two methods should be adopted. On the other hand, where the area to be blast cleaned represents a large part of the total, it is likely that the use of blast cleaning only will prove more economical.

b. Decision on the Coating System. Selection of the coating system is dictated by the exposure conditions, the metal preparation planned, the desired life of the coating, the drying time available, the maintenance planned, and the application conditions. The durability of a coating for a particular set of exposure conditions is generally the most important factor to consider. The coating which will afford satisfactory protection for the longest time will usually be the most economical, because metal preparation and paint application generally represent from 70 to 80 percent

of the total cost of painting. The unit price of the paint, therefore, will have little effect on the yearly cost of protection.

Although brevity prohibits discussion of the relative merits of the many coating systems available to the corrosion engineer for various exposure conditions, it is pertinent to mention that the serviceable life (without maintenance) of properly designed and applied modern paint systems is much longer than commonly thought. For instance, certain phenolic paint systems on blast-cleaned steel will give 15 or more years of satisfactory service when exposed intermittently or continuously to relatively quiet, neutral waters. In continuous fresh water immersion, properly applied vinyl systems have been known to provide complete protection for over 25 years; their ultimate life is as yet unknown. In normal atmospheric exposure, maintenance-free protection for periods of up to 15 years can easily be obtained with numerous paint systems. Salt-water conditions and marine atmospheric conditions present a more difficult protection problem, but even here certain paint systems will serve well for long periods of time.

An important factor to recognize with respect to the effect of metal preparation on the selection of a paint is that a slow drying, good wetting primer must be used on poorly prepared surfaces. Also, a good wetting primer will generally not perform well under water or on surfaces subjected to severe condensation, regardless of the type of finish coats used. A paint system which performs fairly well on a less than clean surface will perform even better on a blast-cleaned surface.

The drying time that can be allowed for each coat of paint will often influence the selection of the coating materials. If a rapid schedule is

needed to avoid costly downtime or to increase appreciably the efficiency of application, a rapid drying paint system should be selected, provided blast cleaning has also been selected. Fortunately, the paint industry can supply the user with paints which will air-dry in minutes and will have excellent durability. However, if the surfaces are not cleaned thoroughly, a much slower drying paint system must be used.

The maintenance required by or planned for a paint system once it has been applied is generally an important factor to consider when selecting the paint system. The maintenance plan and paints to be used should be on record and readily available to the maintenance engineers in charge at the time maintenance is required. If the surface is to be spot cleaned, spot painted, and occasionally given an overall topcoat, the maintenance paints selected should be identical to those originally used. If not identical, the maintenance paints must at least be compatible with existing paint which is not removed. If the existing coating is to be removed completely and a new system started, the paint selected should be one which fits well with the planned subsequent maintenance painting. An extreme example of the difficulty that can be encountered in this respect is the use of hot-applied coal tar enamel in an exposure condition involving both sunlight and immersion. When this coating fails, which it will in this exposure condition, the residual coating is very costly to remove by any method, including blast cleaning. Moreover, it is not practicable to patch a badly deteriorated coal tar coating with the same material or any other type of paint.

The accessibility of a structural component for painting will obviously influence the selection of what paint to use; the less accessible the

component, the more durable the coating system should be. It is also apparent that a metal component which is very important to the stability or uninterrupted use of a structure should receive more consideration in the maintenance painting plan than a component which could easily be replaced if failure occurred as a result of corrosion.

Preparation of Specifications

The engineer preparing the technical section of maintenance painting specifications should have the foregoing observations in mind when starting the job. Since writing specifications for cleaning and painting work does not differ greatly from writing them for other construction work, only common deficiencies which are not readily apparent and which are related only to painting work are discussed. One such deficiency is that almost all specifications fail to describe the work to be done in sufficient detail. For instance, the section on surface preparation may state in detail that the cleaning is to be done on all metal surfaces, but does the writer actually mean all metal surfaces or only those surfaces which are readily accessible? How thorough should the surface preparation on the interior areas of built-up columns, which will require an amount of work disproportionate to the benefit obtained if thoroughly cleaned, be? If the work required is not carefully described in the specifications, the bid prices received will probably vary greatly. Moreover, the person inspecting the work will too often differ with the contractor in interpretation of the specification.

Another common deficiency in specifications covering cleaning is that the method of cleaning is not specified. For example, although the

specification writer often knows that blast cleaning is the only feasible means of obtaining the desired surface, the specification may describe the results to be obtained by the contractor in great detail without mentioning the method of cleaning. If a contractor intending to superficially clean the steel is the successful bidder, obtaining a satisfactory job will be extremely difficult. However, if the specification writer states in the specifications that the steel shall be blast cleaned, this difficulty can probably be avoided.

The specification writer should always consider the feasibility of furnishing the paints to be used, rather than having the contractor obtain them. This procedure has the advantage of reducing the size of the specifications; it also relieves the contractor of procuring paints to meet a certain specification, a task with which most contractors have little experience because of their custom of buying commercial products. Moreover, maintenance paints which have been tested and found to meet the specifications are often stocked by the agency in charge of the structure. Drawing on these stocks and supplanting them with new is often a more economical method of supplying paints for a job than having the contractor furnish them.

Inspection of Painting Operations

A trained, conscientious paint inspector will obtain a good job if he has a good specification, and if he is assigned the work. Too often maintenance painting is not inspected, and the results are consequently often poor. Whether the work is performed by hired labor or contract, it should be inspected throughout the operation. The principles involved in

good inspection work can be found in the literature; the point which must be emphasized here is that the work should be inspected by a competent person.

Records of Painting Operations

Much too frequently, the only available records concerning the painting of a large important structure are the mental ones of the individuals who were directly concerned with the work. The shortcomings of such records are apparent to anyone who has attempted to determine the paint history of a structure several years after the coating application was completed. A complete history of a structure's paint system is of great value not only in assessing the durability of the coating but also in determining the scope and direction of future maintenance work. The record should cover the most recent painting operations on the structure as well as the history of each paint coat remaining from previous applications.

Conclusion

Thus, a properly conducted maintenance painting operation must include more than simply "putting out a contract." It should start with a field investigation by someone familiar with both coating materials and their application and performance. The proper selection of a coating system must include more than simply accepting the salesman's recommendation. It must be based on knowledge of the surface preparation required for both the environment and the coating, the type of application that is practical, and the life expectancy of the proposed coating system. The prepared specifications must do more than tell the contractor to paint the structure:

they must tell him in detail what the surface preparation shall be, what the coating shall be, and what quality of workmanship is required. Conscientious inspection of the entire painting operation is of utmost importance. Contractors or painters cannot be expected to provide unbiased inspections of their own work. Finally, the value of up-to-date painting records should not be overlooked, both in evaluating the life expectancy of a given coating system and in selecting the proper maintenance paints for touch-up work.

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