

CHAPTER 10

PAINTING OF RAILROAD BRIDGES AND STRUCTURES

by

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Procedures and materials presented in this chapter are guides only. Other methods and materials may be of equal value. All known methods that have proved desirable are included. Details of cleaning and painting in the shop are not included since they are covered in other chapters.

In preparing this chapter current industry practices were surveyed through a questionnaire circulated with the cooperation of the American Railway Bridge and Building Association (ARBBA) and Committee 15 of the American Railway Engineering Association (AREA). Much of the technical information has been supplied from work by the Steel Structures Painting Council. Any reference to blast cleaning refers to conventional dry sand blast cleaning.

where salts are present, in designs where water can collect or in chemical atmospheres unless it is painted in the same manner as conventional steel.¹ Galvanized steel is becoming more common and is the preferred treatment for new gratings, handrails and other small incidental items.

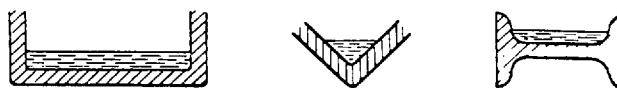
Improvements in surface preparation, in treating cleaned steel, in applying paint and paints themselves are made periodically. Sometimes, a less expensive method with a shorter life is more economical than an expensive

I. GENERAL DISCUSSION

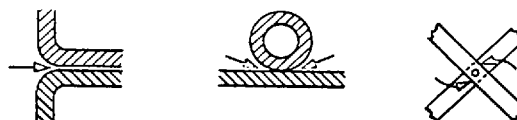
The cost of painting a structure can be estimated, but the cost of deferring painting is much more difficult to assess, particularly for railroad structures, though it is clear that a good painting program is less costly than frequent steel replacement. In every location there is slow rusting of unprotected ferrous metals representing loss of sound metal. Since a single railroad may have several thousand steel bridges, the situation cannot be allowed to get out of hand. But painting programs of many railroads have been restricted by a lack of funds in recent years, and 70% of those responding to the questionnaire indicated maintenance painting was not sufficient to protect the steel. Funds have been concentrated on a small number of structures in particularly corrosive environments. The frequency of repainting ranged from 5 to 40 years, with an average of 16.5 years. It is common to see railroad bridges entirely covered by rust.

Most of these structures are in an environment where the corrosion rate is slow. The menace of dripping salt brine from bunker refrigerator cars has passed into history. However, deep corrosion pits formed by dripping brine are still present and are sites for active corrosion. The main problems for most railroads are marine environments.

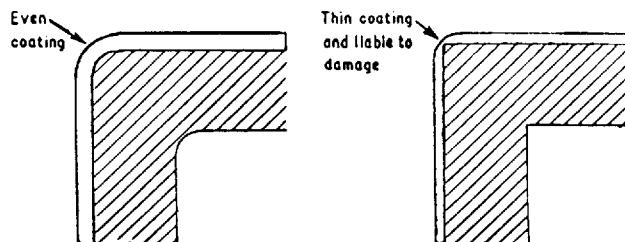
One line of attack is to attempt to use a construction material that needs little or no corrosion protection. In new construction many structures are built from concrete, and others are a combination of steel and concrete with a weathering steel. ASTM Type A-242 is also being used alone in larger structures. Weathering steel is not suitable



Water trapped by structural members



Types of crevices



Effect of surface contours

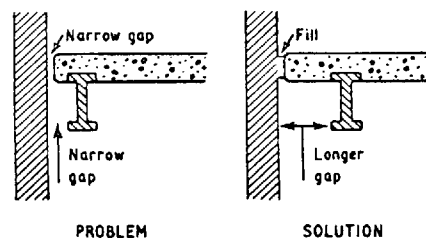


FIGURE 1

A few design features to be avoided¹⁵

method with a long life. On the other hand, there is only false economy in using inexpensive short-lived paints when cleaning and application costs are the same.

The majority of bridge engineers realize the solution to corrosion problems cannot be obtained with a magic paint that is cheap, has great coverage, is easily applied, requires no surface preparation and has a long life. There is a never-ending search for better paints, but the potential life of good paints is seldom reached because of improper surface preparation and application. The fault is not always that of the railroad, or painter, because adverse conditions may make it impossible to do a good job. Paints that do the best job possible under adverse conditions should be chosen.

A. NORMALLY DRY (RURAL) — ZONE 1B

Of all corrosive atmospheres and environments to which railroad bridges and structures are subjected, the rural is the mildest, its severity depending upon climatic variations, particularly humidity. But even in a rural location, a structure may be subject to corrosive attack. For instance, one end of a long bridge may be exposed to a mild rural environment while the other end may be exposed to corrosive gases or mists from a chemical plant; or the steelwork of a bridge above the trackline may be exposed to a mild rural atmosphere while the floor system may be severely attacked by the spray of de-icing salt slush from a high-speed expressway passing underneath.

TABLE 1
Survey of Environmental Zones for Railroad Bridges

		<u>Location</u>
Zone 1A	Normally Dry — Interior	92.1%
Zone 1B	Normally Dry — Exterior (or rural)	
Zone 2A	Frequently Wet by Fresh Water (splash, condensation, immersion)	5.6%
Zone 2B	Frequently Wet by Salt Water (Marine or de-icing salts)	
Zone 3	Chemical Exposure	2.3%

Design is an important part in corrosion prevention. Narrow cracks and crevices that result in inaccessible surfaces, box members that allow only very limited access and sections that trap water are to be avoided. Some other undesirable features are shown in Figure 1.

II. ZONES

The first consideration in any paint job is to determine the environment in which the structure is exposed, keeping in mind that different parts of a single structure may be subject to different environments. Standardized environmental zones (defined by the SSPC) are widely recognized as outlined in Chapter 1 of Volume 2 of the *Steel Structures Painting Manual* and in Table 1 below: The percentages in Table 1 are based upon the foregoing survey and show that the vast majority of railroad bridges are in Zone 1B. Figure 2 illustrates some of the many SSPC tests conducted on railroad bridges in a wide range of environments.

Table 2 illustrates typical paint systems used in these environments. These are discussed in Section VII-D.

One SSPC test in a rural environment is illustrated in Figure 2b. In a rural atmosphere, only natural elements of water and oxygen are subjecting the bridge to corrosion. Therefore, if oxygen and water cannot come into contact with the steel, little or no corrosion occurs.

There is no paint or organic coating known that is completely impermeable to oxygen or water, but increasing the thickness of the coating provides added resistance to passage of water and oxygen through the coating to the steel.

Gradually, outer coats of even the best paint system deteriorate and erode from exposure to sun and moisture, exposing underlying coats or primer. This is a natural process and indicates that steel has been protected to the limit of the paint system. The steel has not corroded and the structure is ready for repainting, which requires only minor cleaning, spot priming, and a new topcoat or two. If deterioration is permitted, the exposed primer rapidly fails and leaves steel unprotected. Rusting begins and failure of the remaining paint is greatly accelerated. Now the cost of surface preparation alone may be greater than the cost of

repainting, had the repainting been done before the onset of rusting.

When rust appears in pinpoints on the surface or causes blisters under the surface, the paint has failed. Such a shortening of the paint life is probably caused by improper surface preparation, improper application, improper paint, or a combination.

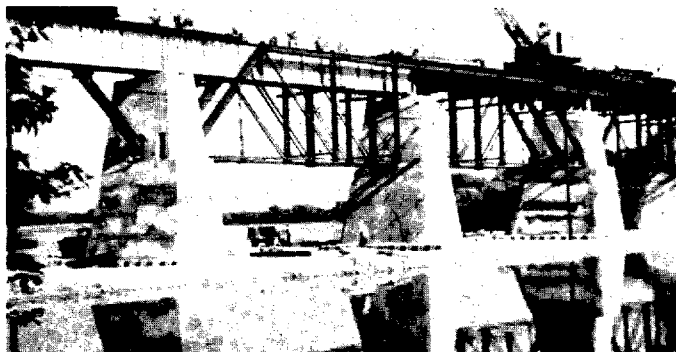


FIGURE 2a



FIGURE 2d

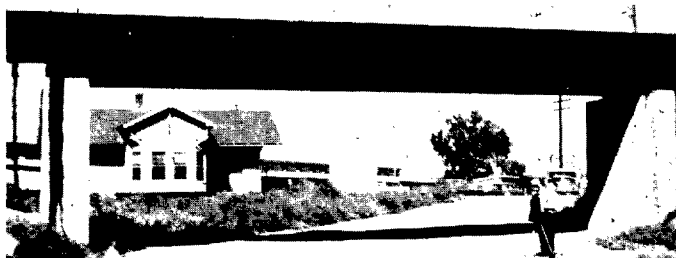


FIGURE 2b



FIGURE 2c



FIGURE 2e



FIGURE 2f

FIGURE 2

The SSPC has conducted a number of extensive paint tests on railroad bridges in the past. Examples of these shown above, include: (Figure 2a) test on Protecting Load-Bearing Surface of Steel Bridges on the Chicago-Great Western; (Figure 2b) Painting of Steel Bridges for Mild Exposures on the Atchison, Topeka and Santa Fe Railroad System; (Figure 2c) Bridge Paints with Resistance to Salt Brine on the Missouri-Pacific Railroad; (Figure 2d) Paints over Hand-Cleaned Steel on the Seaboard Cost Line Railroad; (Figure 2e) a series of tests of Oil-Base and Urethane Paints on the Bessemer and Lake Erie Railroad from 1965 to the present time; (Figure 2f) Paint Systems over Hand-Cleaned Steel. Other empirical paint evaluation tests were carried out with the cooperation of the Association of American Railroads on the bridges of the Southern, Great Northern and Penn Central Railways.

TABLE 2
TYPICAL RAILWAY BRIDGE PAINTING SYSTEMS*

ZONE	ENVIRONMENT	TYPICAL SYSTEMS**	ALTERNATIVE SYSTEMS**
1A	Interior, normally dry Steel used in dry railroad buildings.	SSPC-PS 18.01, Latex Paint System SSPC-PS 14.01, Steel Joist Paint System TT-P-664, Primer Coating, Alkyd, Corrosion- Inhibiting, Lead and Chromate Free, VOC Compliant CAN/CGSB 1.40-M89, Primer, Structural Steel, Oil Alkyd Type Finish Coat Optional	SSPC-Paint 15 (Type I), Steel Joist Shop Paint
1B	Exterior, normally dry. Includes many railroad structures	See SSPC-PS Guides 1.00 and 2.00 Also SSPC-PS 1.09 Oil Base Paint System or proven proprietary systems. Surface Prep: Commercial Blast Clean (SSPC-SP 6) Primers: SSPC-Paint 11, Alkyd-Linseed Oil Primer with Red Iron Oxide, Zinc Chromate TT-P-1757, Primer Coating, Zinc Chromate, Low-Moisture-Sensitivity CAN/CGSB - 1.40 - M89, Primer, Structural Steel, Oil Alkyd Type Intermediate Coats: SSPC-Paint 101 (Type II), Aluminum Alkyd Paint Any of the above primers, tinted. Topcoats: SSPC-Paint 101 (Type I), Aluminum Alkyd Paint TT-P-38, Paint, Aluminum, Ready Mixed AASHTO M-69, Aluminum Paint CAN/CGSB-1.69-M89, Paint, Aluminum SSPC-Paint 102, Black Alkyd Paint SSPC-Paint 104, White or Tinted Alkyd Paint TT-P-81, Paint, Oil: Ready-Mixed, Exterior, Medium Shades AASHTO M-68, Black Paint for Bridges AASHTO M-70, White and Tinted Ready Mixed Paint CAN/CGSB - 1.59-M89, Enamel, Exterior, Gloss, Alkyd Type	Surface Prep: Hand Clean (SSPC-SP 2) or Power Tool (SSPC-SP 3) Primers: TT-P-1757, Primer Coating, Zinc Chromate, Low-Moisture-Sensitivity SSPC-Paint 25, Red Iron Oxide, Zinc Oxide, Raw Linseed Oil and Alkyd Primer (Without Lead and Chromate Pigments) Surface Prep: Near White Blast Clean (SSPC-SP 10) Primers: SSPC-PS 12.00, Guide to Zinc-Rich Coating Systems MIL-P-38336, Primer Coating, Inorganic Zinc Dust Pigmented, Self Curing Topcoats: SSPC-PS 4.02-4.05, Vinyl Painting System SSPC-PS Guide 15.00 Chlorinated Rubber Painting Systems SSPC-PS 13.01 Epoxy Painting System Proven proprietary systems of either multicoat or single high-build coat type
2A	Frequently wet by fresh water. Includes conden- sation, splash, spray or frequent immersion.	Paint Systems: See SSPC Paint System Guides 4.00 (Vinyl), 12.00 (Zinc-Rich), 15.00 (Chlorinated Rubber), PS 11.01 (Coal Tar Epoxy), PS 13.01 (Epoxy), or proven proprietary systems. Surface Prep: White Metal Blast Clean (SSPC-SP 5) or Near-White Blast Clean (SSPC-SP 10) Primers: SSPC-Paint 20 or Paint 29 (Type I—Inorganic) Zinc-Rich Primer MIL-P-38336, Primer Coating, Inorganic, Zinc Dust Pigmented, Self Curing, for Steel Surfaces AASHTO M300 Inorganic Zinc-Rich Primer 1 GP-171M and amendment, Coating, Inorganic Zinc Topcoats: The topcoat and/or a tie-coat shall be supplied by the same manufacturer as the Inorganic Zinc Primer	Surface Prep: White Metal Blast Clean (SSPC-SP 5) Pretreatment: SSPC-Paint 27, Basic Zinc Chromate—Vinyl Butyral Washcoat Primers: MIL-P-24441, Paint, Epoxy-Polyamide, General Specification for MIL-P-15930, Primer Coating, Shipboard, Vinyl-Zinc Chromate (Formula No. 120) CAN/CGSB 1.122-M91 (Type I), Primer, Vinyl, Anti-Corrosive Organic Zinc-Rich System Specifications (Example: SSPC-Paint 20, Type II—Organic) Proven proprietary systems Intermediates: SSPC-Paint 8, Aluminum Vinyl Paint SSPC-Paint 9, White (or Colored) Vinyl Paint Topcoats: SSPC-Paint 8, Aluminum Vinyl Paint SSPC-Paint 9, White (or Colored) Vinyl Paint 1-GP-182M, Paint, Vinyl, Exterior

TABLE 2 (Continued)

ZONE	ENVIRONMENT	TYPICAL SYSTEMS**	ALTERNATIVE SYSTEMS**
2B	Frequently wet by salt water. Includes condensation, splash, spray or frequent immersion.	Paint Systems: See SSPC Paint Systems and Guides 12.00 (Zinc-Rich), 4.00 (Vinyl), 15.00 (Chlorinated Rubber), 13.00 (Epoxy), PS 11.01 (Coal Tar Epoxy) or proven proprietary system. Also see recommendations for Zone 2A.	Paint Systems: See Alternatives to Zone 2A.
3	Chemical Exposure.	Others as for Zone 2A, but the zinc base coatings must be used with caution when conditions are strongly acid or strongly alkaline. Topcoats required. (pH 5.5 or lower) Acidic — SSPC Paint System Guide 4.00 (Vinyl). (pH 5.5 to 10.5) — SSPC Paint System Guide 12.00 (Zinc-Rich) (pH 10.5 or above) Alkaline — SSPC-PS 11.01, Coal Tar Epoxy, SSPC Paint System Guide 13.00 (Epoxy) and 15.00 (Chlorinated Rubber).	

*The following specifications have been removed from the revised table to reflect current practice: SSPC-Paint 1, SSPC-PS-1.04 - 1.08, SSPC-PS 4.01, SSPC-PS 7.01, TT-P-86, TT-P-615, TT-P-636, MIL-P-15929, DOD-P-23236, AASHTO M-72, 1-GP-14, 1-GP-140, 1-GP-166, 1-GP-167, CISC/CPMA 1-73a

**All coats of a paint system should be provided by the same supplier.

B. FREQUENTLY WET BY FRESH WATER — ZONE 2A

Water is the primary cause of corrosion. Without water, corrosion would normally stifle itself, even with a plentiful oxygen supply. Dangerous corrosion can occur under some circumstances in the absence of oxygen.

Corrosion can occur when soluble matter dissolves in water, such as the electrolytes formed by the solution of salts or corrosive gases. In the absence of oxygen, the damage is usually caused by galvanic action of mill scale and steel, or rust and steel. Stray electric currents can do great damage in localized areas, causing complete failure of some steel work.

With a plentiful supply of oxygen, water becomes very corrosive and the condition is accelerated by the presence of salt or corrosive gases. If the structure is completely immersed, cathodic protection used in conjunction with suitable coatings provides adequate protection in salt or fresh water. The steelwork in the splash zone above the water is the most difficult to protect as is witnessed by the severe corrosion that takes place in the region just above the waterline on pilings or groins. Here, the best practice may be enclosing the vulnerable portion of the steel in thick concrete. Problems encountered and possible solutions are discussed and summarized by La Que.²

The portion of piling driven into the earth below the water does not corrode once available oxygen is used. Oxygen seldom can be replaced, so that portion of the piling presents no problem. The section of the piling in the mud is subject to corrosion because oxygen is usually present in decaying organic matter and because of its constant turmoil and replenishment. In the water region, the piling is also free to corrode, and the portion just above the water corrodes quickly. It is best to design steel structures to minimize the immersion. Other structures that are accessible for inspection, cleaning and painting can be protected at reasonable expense.

C. FREQUENTLY WET WITH SALT WATER — ZONE 2B

The protection of steel structures in marine atmospheres and those exposed to de-icing salts presents severe conditions for railroad structures.

High humidity and salt are the culprits. Sea water consists of about 3 percent sodium chloride in water, along with a number of other salts present in small quantities. Common sodium chloride, salt, is one of the worst inciters of corrosion when wet or in solution. Its electrolytic action causes rapid corrosion in localized sites of steel and protects other areas. The result is pitting of the steel, weakening the structure more than if the corrosion occurred uniformly over the entire structure.

This electrolytic corrosion can easily perforate a steel member. Corrosion products create an alkaline condition under the paint, which chemically attacks oil- and alkyd-based paints, and they soon disintegrate and wash away. The result is exposure of more steel, an increase in electrolytic action and more intensified paint deterioration. This is a cycle that, once started, is very difficult and expensive to stop. The electrolytic action cannot take place without moisture. High humidity drives water into the paint film and keeps it wet, permitting the flow of localized electric current to corrode the steel. No organic protective coating is impermeable to water.

There is no protective coating that adequately protects steel if salt remains on the steel before it is painted. The problem is solved if no salt is allowed to come in direct contact with steel.

Not all portions of a steel structure exposed to marine atmospheres are uniformly attacked. Exposure varies from complete immersion of steel piling, footings and groins in sea water, to the much less severe exposure of high structures to salt-laden wind, rain and mists.

The severest attack is not on steel immersed in the salt water but on steel in the splash zone just above high

tide. Here, although steel is never completely immersed, it is always wet, making it difficult to paint, and there is plenty of oxygen to corrode it. This portion of a structure has a tendency to provide cathodic protection to the steel completely immersed in the sea water by sacrificing itself. An excellent discussion of this situation is given by Humble.³ Escalante and Iverson studied the protection of steel pilings in sea water.⁴

The right way to protect a structure exposed to marine atmosphere is to begin at the design stage. The steel should be blast cleaned and shop coated with a synthetic resin paint that has proved capable of standing up against marine atmospheres. If field coats are applied, any salt contamination must be removed from the surfaces by washing or steaming with salt-free water. Finish coats must be resistant to salty atmospheres.

Maintenance painting of existing structures must include removal of salt contamination from painted or rusted surfaces along with the rust and scale. Hand cleaning is not adequate, but steam cleaning after thorough wire or power brushing is effective. The primers and finish coats must then be applied over salt-free surfaces. Another factor, not ordinarily encountered in fresh water, is the abrasive action of sand on piling. At the sand line, where the sand is moving because of wave action, any organic protective coating is quickly cut through and protection is very difficult.⁴

D. CHEMICAL EXPOSURES — ZONE 3

Steel in chemical or industrial atmospheres corrodes much faster than in rural atmospheres. The life of any paint can be shortened by chemical attack of corrosive gases, mists and dusts found in industrial atmospheres, though the rate depends upon the kind of chemical or industrial atmosphere and climate. While it is possible for paint to have a shorter life in a rural atmosphere in Florida than in an industrial atmosphere in Pennsylvania, paint generally has a shorter life in an industrial atmosphere.

Accelerated corrosion in industrial atmospheres is caused mainly by the presence of sulfur dioxide and trioxide. These gases, when dissolved in water, form acids; and the dew, rain or mist in industrial areas is actually a weak acid that acts as an electrolyte.

Soluble gases and salts ionize and penetrate protective coatings along with oxygen and water. The result is accelerated corrosion caused by direct chemical attack of the steel and the electrolytic action set up. The paint film itself may be damaged by the active chemical nature of the contaminants.

The effects of corrosive industrial atmospheres are evidenced in the early failure of galvanized iron in such exposure. The life of galvanized roofing may be cut 50% to 75% by the failure of a zinc coating to form a protective layer of corrosion products as it does in rural or marine atmospheres. It is not surprising to find that galvanized roofing must be painted to obtain an economical life in industrial plants or in smoky atmospheres. Paint systems

used in rural atmospheres may be inadequate in industrial atmospheres.

E. BURIED STRUCTURES

Buried structures are in the soil or are in contact with soil under conditions in which oxygen can be replaced. This exposure is very severe. Protection must be adequate for many years because of the expense in excavating to make structures available for repainting. This environment is discussed in the chapter on pipelines.

All soils are not equally corrosive. Some soils are neutral, dry and well packed, and little corrosion occurs. Unfortunately, much of the steel along the railroads is subject to corrosive conditions when buried. Possibly the worst condition is encountered when the steel is buried in cinders. Cinders are acidic and, when wet, are very destructive to any coating. Even galvanized iron fails rapidly in this environment.

Brine drippings and de-icing salts also soak into the soil and have the same corrosive effect. Other contributing factors are ladings and drippings from cars carrying high sulfur coal.

Stray electric currents are encountered along railroad tracks, particularly along electrified systems. Direct current can cause great damage where it leaves the steel and enters the ground. To protect against stray currents (where the amount of steel corroded is directly proportional to the flow of direct current) steel must be insulated by a protective coating. Concrete permits flow of current, and disruption of the concrete is caused by the tremendous force exerted by the corrosion products on the surface of reinforcing steel.⁵ Even without stray current, spalling of concrete is caused by the rusting underneath the concrete when the concrete is too thin, improperly made or applied, or when water creeps in around the edge of the concrete and rusts the steel.

Buried steel can be protected by application of thick coatings such as coal tar enamels or asphalts, but under very severe conditions steel is best protected by coating in conjunction with cathodic protection. If possible, steel should not be buried. Pipelines, conduits and other steelwork should be supported above the ground where it can be protected by conventional means.

When steel is buried, as in culverts, the nature of the fill must be taken into account. Basic conditions should be maintained. Cinders should not be used as a backfill, but limestone may be used as a fill around the buried steel or to support steel. Because fills are porous and act as a sponge to maintain wet conditions around the pipe, drainage provisions should be made.

For a further discussion of the effect of burial on steel surfaces, see the chapter on protection of underground structures and pipelines.

F. TIMBER AND TIE BEARING SURFACES

Damage that occurs to steel when it is in contact with timbers and ties is usually aggravated by the fretting ac-