Painting Structural Steel

JOHN D. KEANE

EACH MATERIAL of construction requires its own provision for maintaining appearance and protection. For structural steel, this provision usually takes the form of painting.

It has been estimated that about 2 million dollars per year are spent in protecting all kinds of structural steel surfaces, including railroad bridges, highway bridges, buildings, tanks, towers, power plants, water works, refineries, vessels, hydraulic and marine structures, public edifices, underground facilities, and industrial structures of almost infinite variety. Paint not only provides corrosion protection for these structures, but also makes valuable contributions to their safety and appearance. In fact, the painting of structural steel could be described as the principal means of protecting steel against its principal limitation — corrosion.

The following discussion is intended to provide architects and engineers with a better understanding of some of the concepts and features of current practice in the painting of structural steel.

CHOICE OF A PAINT SYSTEM

At the outset it should be emphasized that there is no one best paint system, but rather a dynamic competition among alternative paint systems, some of which are best for one purpose and others for another. Usually, six factors must be considered by the corrosion engineer in choice of a paint system:

1. Environment—This is probably the most important single factor. When available, the results of past exposure tests in a given area are the best bases for paint selection. The severity of environment can vary drastically over a small distance, even from one part of the structure to another. Therefore it is difficult and perhaps impossible to show environmental zones properly on a map.

In Table 1 it can be seen that corrosiveness of outdoor atmospheres may vary by a thousand-fold, bearing in mind that corrosiveness is not always the only factor, nor even the most important factor, in paint life.

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Table 2 outlines a typical pattern of recommendations for the choice of paint systems. A chart such as this attempts to reflect in six "zones" the immense range of atmospheric exposures found in the world and to illustrate one preferred system for each. (A complete recommendation should show the alternates for each zone. Since environment is only one of the six main factors to be considered in selecting a paint system, there should be considerable latitude in the recommendations for each zone, depending upon requirements for costs, appearance, design, etc.)

Zone 1A, for example, represents normally dry interiors where long paint life can be obtained without extensive cleaning. Here, one coat of quick-drying primer is often sufficient. It is well, however, to avoid the use of cheap asphaltic materials if it is likely that further painting or a colored topcoat will ever be required.

Zone 1B covers most past and present atmospheric paint systems. Such a system is economical in areas where ordinary oil base systems now last 6 years or more. It entails hand or power tool cleaning, followed by application of an inhibitive oil base primer pigmented with red lead, basic lead silico chromate, or other inhibitor, usually applied in the shop. This is followed in the field by two additional coats of oil- or alkyd-paint for a total film thickness of 4.5 to 6 mils.

Table 1. Relative Corrosiveness of Various Atmospheres[a]

Number	Location	Type of Atmosphere	Relative Rating[b]
1	Normal Wells, N. W. T.	Rural	0.02
2	Saskatoon, Sask.	Rural	0.2
9	State College, Pa.	Rural	1.0
17	Pittsburgh, Pa. (roof)	Industrial	1.8
27	Bayonne, N. J.	Industrial	3.4
28	Kure Beach, N. C. (800 ft site)	Marine	3.6
30	East Chicago, Ind.	Industrial	5.2
33	Point Reyes, Calif.	Marine	9.5
37	Kure Beach, N. C. (80 ft site)	Marine	33

[a] Adapted from report of ASTM Committee B-3, Sub VII, for one-year exposure (1960–61); Materials Research & Standards, December 1961, p. 977.

[b] State College, Penna., taken as unity. Fortuitously, a corrosiveness of 1.0 represented about 1 mil loss the first year.

Table 2. Typical Zone Defense Systems

ZONE [a]	ENVIRONMENT	PREFERRED SYSTEM	ALTERNATES
1A	Interior, normally dry (or temporary protection) Unusual in hwy. work, very mild (oil base paints would last 10 yr or more)	One coat of fast-drying shop paint (example: SSPC-Paint 13) over nominally hand-cleaned steel. Finish coat optional. (See SSPC-PS 7.01)	(1) Other one-coat primers (example: TT-P-636) (2) Rust proofing (SSPC-PS 8.01), or (3) More durable systems as per Zone 1B, or (4) Approved proprietary paint.
1B	Exteriors, normally dry (Includes most highway areas where oil base paints now last 6 yr or more)	Apply 2 coats oil base primer (example: SSPC-Paint 14) over wire-brushed steel. 1-2 finish coats of long oil alkyd (SSPC-Paint 101 aluminum or SSPC-Paint 104 white, gray or green) 4.0 mils or more thickness (5.0 mils for 4 coats). (See SSPC-PS 1.01, 1.02, or 1.03)	(1) Blast clean (SSPC-SP 6) and use same paints or shorter oil alkyds. (2) Alternate primers (SSPC-Paint 2; TT-P-57, Type I; AASHO M72-57, Type I or II; or TT-P-615, Type V) or (3) Alternate intermediate TT-P-86, Type II or non-leafing aluminum, or (4) Equivalent state system, or (5) Same systems as Zone 2A or 2B, or (6) Proven proprietary system.
2A	Frequently wet by fresh water Involves condensation, splash, spray, or frequent immersion. (Oil base paints now last 5 yr or less)	Near-white blast clean surface; 4 coats (4.5 mils) of vinyl system (example: SSPC-Paints 8 or 9) (See SSPC-PS 4.04 or 4.02)	(1) Pickle (SSPC-SP 8) instead of blast cleaning. (2) Alternate vinyls are VR 3 or approved proprietaries. (3) Epoxy system guide (SSPC-PS 13.00), coal tar epoxy (SSPC-PS 11.01), chlorinated rubber system, or approved proprietary system.
2B	Frequently wet by salt water Involves condensation, splash, spray or frequent immersion. (Oil base paints now last 3 yr or less)	Near-white blast clean surface; apply zinc-rich primer (example: SSPC-PS 12.00 or MIL-P-23236 or California Highway Spec. 66-G-55) followed by approved wash primer and finish coat. (Example: SSPC-PT 3 plus SSPC-Vinyl Paint 8 or 9, 3+ mils) Assure satisfactory adhesion of finish coats.	(1) Use finish coat with same vehicle as zinc-rich primer (inorganic, epoxy, chlorinated rubber, vinyl, etc.) (2) Use vinyl paint system with wash coat and inhibitive primer (example: SSPC-PS 4.01 or 4.03) (3) Use as alternate finish coats or by themselves, coal tar epoxy (SSPC-PS 11.01), epoxy (guide SSPC-PS 13.00), or approved chlorinated rubber system, or other proven proprietary system.
3	Chemical exposures (Acidic, alkaline, oxidizing, solvents, etc.)	Same as for Zone 2B, but with chemically resistant finish coat system specially chosen to protect primer and base metal against specific chemical agent. (Zinc-rich unsatisfactory for very acid or very alkaline conditions.) Assure satisfactory adhesion of finish coats.	Same choices as for Zone 2B, but with special finish coats. (1) Coal tar epoxy (SSPC-PS 11.01) (at least 16 mils). (2) Straight vinyls for acid and alkali (SSPC-PS 4.01 or 4.03). (3) Epoxies for alkalies, salts, aliphatics, acid splash; not for strong solvents. (4) Neoprenes and other proven proprietary systems to resist specific conditions.
4	*Special Conditions*		
	Painting galvanized steel	Solvent clean to remove oil and grease. Wire brush to remove any rust. Apply zinc dust-zinc oxide paint TT-P-641 (Type II for new steel, Type I for old, as per SSPC-PS 2.05 and 1.04). Somewhat better adhesion if surface is weathered before painting.	(1) Chemical pretreatment of new work by commercial hot phosphate or wash primer. (2) Zinc-rich primer (example: Guide SSPC-PS 12.00). (3) Prime with SSPC-Paint 5. (4) Prime with proven proprietary cement-base, polyvinyl acetate emulsion, or acrylic latex.
	Mildew	After surface preparation, wash mildewed surface with trisodium phosphate and dry. Add mildewcide to each coat of paint (example: 8-quinolinoleate). Vinyl, chlorinated rubber resins, and barium metaborate and zinc-rich pigmentations tend to resist mildew.	Alternate mildewcides and fungicides include copper naphthenate, chlorinated phenols, phenyl mercuric dodecylsueinate, proprietary agents. Add in amount recommended by the manufacturer.
	Temporary protection and rustproofing	See system for Zone 1A. Also see SSPC-PS 8.01, "Rust Preventive Compounds" (thick non-hardening films over minimum surface preparation)	Soft, heavy, or hard film compounds as per 52-MA-602, Type B, C, or D; or use proprietary rustproofing compounds.
	Painting welds	Before welding, do not paint within 2 in. of edges. Blast clean after welding. See SSPC-PA 1, Sections 3.5.2.4 and 3.5.2.5.	Chip and wire brush weld thoroughly. Wash with 5% phosphoric acid and rinse. See SSPC-SP 1, Section 3.1.6.

[a] These are intended as specific exposure zones of the portion of the structure under consideration rather than geographic zones. Severity of exposure can change sharply over very short distances due to such factors as wind, spray, condensation, and use of de-icing chemicals.

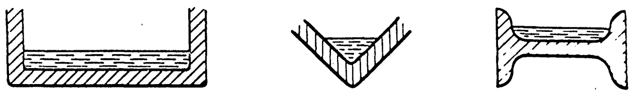


Fig. 1. Water trapped by structural members (courtesy British Iron & Steel Research Association).

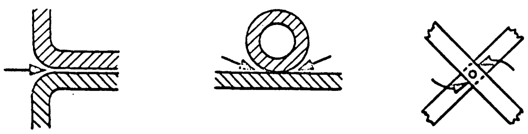


Fig. 2. Types of crevices (courtesy BISRA).

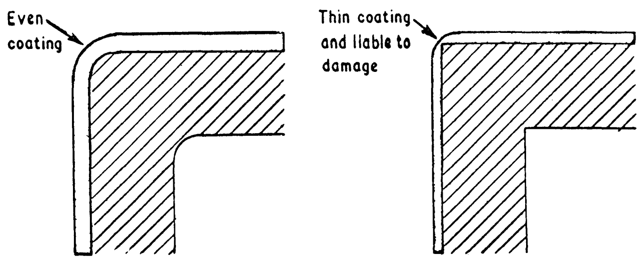


Fig. 3. Effect of surface contours (courtesy BISRA).

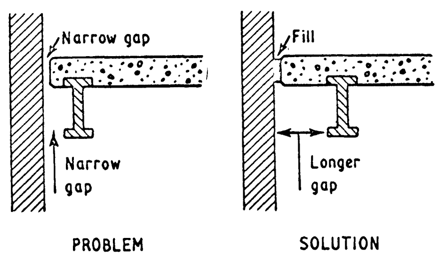


Fig. 4. Insufficient access for maintenance (courtesy BISRA).

Zone 2A is frequently wet by fresh water, condensation, spray, etc., and one system of choice is a four-coat vinyl system such as SSPC Paint System 4.00 over a blast cleaned surface.

Zone 2B, which is frequently wet by salt water, usually results in a paint life of 3 years or less for ordinary oil base systems. Here, the system of choice is often a zinc-rich primer with or without a finish coat.

Zone 3, on the other hand, represents a chemical exposure where a zinc-rich system, if used, requires a very careful choice of topcoat.

Zone 4 represents special recommendations for a wide variety of special conditions, such as painting of galvanized steel, painting mildewed surfaces, rust-proofing, underground painting, painting of welds, etc.

Standard references such as the *Steel Structures Painting Manual* and the SSPC report on highway painting give specific details for each of these systems and for alternates which may be used when desired.

2. Costs—In many locations, painting is infrequent, with little or no protection required, while at the other extreme there are cases where the total cost of protecting a structure throughout its lifetime may considerably exceed the entire original cost of that structure.

Costs are the subject of a chapter in Volume 1 of the *Steel Structures Painting Manual* and of many articles in the literature. Ideally, one should try to minimize the cents per square foot per year cost. To be entirely logical, the engineer would need to consider the results of tests, the risk of paint failure, and the initial cost versus later maintenance cost. In addition, he realizes that labor costs are from two to ten times the material costs. Therefore, the cheapest paint per gallon is seldom the most economical, nor is the newest or more expensive paint necessarily the best. In SSPC studies of highway structural paint, little incentive was found for changing a sound, inexpensive paint system if it was giving ten years of service; however, good incentive was found to change from a system giving less than five years of service.

3. Appearance—Aesthetic considerations play a large role in structural painting, but corrosion protection is necessary to retain that appearance. The range of colors, glosses, and textures is continually being widened.

4. Design—Planning for corrosion protection at the steel design stage makes the work of coatings much easier and more effective. Figure 1 illustrates corrosion conditions which may be easily avoided by the designer. In each case water is trapped in structural members. Figure 2 shows types of crevices which make the job of painting difficult or impossible. Figure 3 illustrates how difficult it is to apply a uniform coating over sharp edges. Often these can be avoided by using standard rolled members. If not, provision must either be made for grinding off sharp edges or for striping with an additional coat of paint. Figure 4 illustrates the important concept of allowing sufficient access for maintenance. Narrow gaps between members should either be filled in or lengthened to provide sufficient room for access in maintenance painting.

5. Available Facilities—Increasingly, fabricators and contractors have the necessary equipment and skills for blast cleaning and for applying specialized coatings. In some areas, however, these matters still limit the choice of paint systems.

6. Paint Specifications—Many engineers prefer to stipulate paint systems for which adequate specifications are available, since public policy encourages the procurement of materials on an open competitive basis. They also find that specifying proprietary "product X or equal" is usually unenforceable, and leads to endless controversy. Large agencies and companies can establish a qualified product list, based upon field tests, laboratory performance tests, composition or past performance, but this is often difficult to administer. In theory, performance tests would be ideal, but the necessary correlation between laboratory tests and actual performance is seldom achieved. Although composition specifications are the most frequently used, they may automatically exclude new or improved formulations.

7. **Special Considerations**—There are often other considerations, such as air pollution control requirements and maintenance policy, which must be weighed in the final choice of a paint system. Such special requirements must be considered on an individual basis.

PAINT SYSTEM CONCEPT

It is seldom sufficient for the architect or engineer merely to specify a product or type of product. Instead his stipulations should deal not only with the materials used in each paint coat, but also the conditions of surface preparation, application, and thickness which are necessary for proper performance of those materials. At the same time, the specifications should not include provisions which add unnecessary and costly complications.

A *paint system* is made up of the following four elements:

1. Surface preparation
2. Application
3. Number of coats
   a. Primer
   b. Touch-up
   c. Additional coats
   d. Alternates (if any)
4. Thickness

A typical paint system specification is outlined in Table 3. This is a four-coat vinyl paint system issued by the SSPC. Here, each of the four principal elements is designated. The complete paint system specification occupies only two sides of a single sheet of paper, since each procedure or material required can be designated by its own code.

Table 3. Summary of Paint System 4.04

Sec.	Item	Specification
3.1	Surface Prep.	SSPC-SP 6-63 or SSPC-SP 8-63
3.2	Pretreatment	Only if specified
3.3	Paint Appl.	SSPC-PA 1-64
3.4	No. of Coats	Four (minimum)
3.5	Primer	SSPC-Paint 9-64 (tinted)
3.6	Touch-up	SSPC-PA 1-64, Section 3.5.3
3.7	2nd Coat	Same as finish coat
3.8.1	3rd Coat	Same as primer
3.8.2	4th Coat	SSPC-Paint 9-64
3.8.3	(Alt. Fin. Coat)	(SSPC-Paint 8-64 or Paint 106-64)
3.9	Thickness	First coat 1.2 mils. Total 4 coat system 4.5 mils.

Following is a discussion of some of the factors entailed in the choice of each of the elements of a paint system. In many cases the specifications of the Steel Structures Painting Council are used as illustrations. These specifications are available through SSPC for use in preparing project specifications and contracts, and may be incorporated into such documents or referred to by reference.

Surface Preparation—In many ways, surface preparation, paint application, and thickness overshadow in importance any differences which exist among the many kinds of paints used to protect metal. Most paint systems fail prematurely because of loss of adhesion or disruption of the film by rusting of the steel. This type of failure can be minimized by careful surface preparation. The method used should remove oil and grease (which are particularly detrimental to the adhesion of paint), salts and other contaminants which incite corrosion, and all loose mill scale. If the steel is to be exposed to strong chemical environments or water immersion, it is important that all rust and mill scale be removed. For ordinary atmospheric environments, however, the extra expense of removing the last trace of mill scale oxides and contaminants is not usually justified. For this reason, the SSPC does not recommend that the ultimate in surface preparation be required in each job. Rather, the minimum degree of surface preparation should be determined by the exposure and by the type of paint system used.

Table 4 shows by title ten types of surface preparation most commonly used on structural steel, the corresponding SSPC surface preparation number, and the pictorial standard which may, at the option of the specifier, be used to supplement the written specification.

Solvent cleaning simply removes oil, dirt and other soluble material, and is often considered a preliminary to the other surface preparation methods.

Hand tool cleaning removes loose rust and loose mill scale. It is gradually being supplanted by the other methods, due to high costs of labor, or the difficulty in obtaining adequate hand cleaning, and the need for higher quality cleaning.

Table 4. Typical Surface Preparation Specifications

	SSPC Spec.	Photo Vis 1#
Solvent Cleaning	SP-1	—
Hand Tool Cleaning	SP-2	B-C-D St 2
Power Tool Cleaning	SP-3	B-C-D St 3
Flame Cleaning	SP-4	—
White Metal Blast Cleaning	SP-5	A-B-C-D Sa 3
Near-White Metal Blast Cleaning	SP-10	B-C-D Sa 2½
Commercial Blast Cleaning	SP-6	B-C-D Sa 2
Brush-Off Blast Cleaning	SP-7	B-C-D Sa 1
Pickling	SP-8	—
Weathering	SP-9	—

Power tool cleaning is more economical and thorough, but is also losing ground to blast cleaning.

Flame cleaning loosens more mill scale before brushing.

There are four principal grades of *blast cleaning*, the most thorough of which is known as the *white metal* grade. For most structural steel paint systems, the *near-white* grade is quite satisfactory. For many, *commercial* blast cleaning may be successfully used at a considerable savings in cost. *Brush-off* blast cleaning is often used where hand or power tool cleaning had previously been specified. *Pickling* is an alternate to blast cleaning. *Weathering* before blast cleaning is a practice seldom followed in modern usage, since it has been shown to make blast cleaning less effective.

Figure 5 is an outline of a typical surface preparation specification. The definition section describes specifically the kind and amount of residue which may be left upon the surface after cleaning and permits the use of SSPC surface preparation photographs or other illustrations when specifically agreed upon by buyer and contractor.

The definition and reference to visual standards, however, are only part of the content of a good surface preparation specification. The procedures to be used are also specified, including preliminary cleaning with solvent and power tools, and the kind of equipment which may be used under this specification. The specification outlines the better procedures which must be followed in order to avoid abrasive being left on the surface, deposition of moisture by the blast cleaning air, rust-back, excessive profile, etc. It also contains an appendix suggesting how the desired results can best be obtained.

SSPC-SP10-67T, Near White Blast Cleaning

1. SCOPE
2. DEFINITION
   End Result (Photos, if specified)
3. PROCEDURES
   3.1 Sequence
      3.1.1 Solvent Clean
      3.1.2 Power Tools
         3.1.3.1 to 3.1.3.7 Methods
            Dry sand, wet sand (sizing
            Grit, shot (sizing, etc.)
            Nozzle—air or vacuum
            Centrifugal recirculating
   3.2 Remove dry abrasive
   3.3 Wet—rinse and inhibit
   3.4 Clean air
   3.5 No damage
   3.6 No rust-back
   3.7 No oil, grease
   3.8 Profile limits
   3.9 Profile measurement
   3.10 Paint promptly
4. SAFETY
   Fire, explosion, dust, filters, goggles, grounding

APPENDIX

A.1	Scope	A.6	Inhibitor
A.2	Where Use	A.7	Paint Promptly
A.3	Maintenance Use	A.8	Photographic References
A.4	Particle Sizes	A.9	Other Visual Standards
A.5	Thickness Over Peaks	A.10	Alternate % Cleanliness

Fig. 5. Outline of a surface preparation specification.

Table 5. Minimum Surface Preparation Required by SSPC Paint Systems

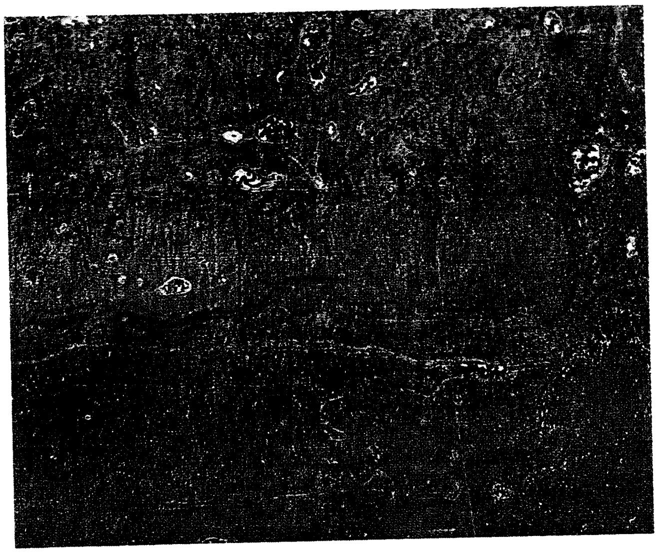
SSPC Paint System		Minimum Surface Preparation
No. 1	Oil Base	Hand Tool Cleaning (SP 2)
No. 2	Alkyd	Blast Cleaning (SP 6 or 8)
No. 3	Phenolic	Blast Cleaning (SP 6 or 8)
No. 4	Vinyl	Blast Cleaning (SP 6 or 10)
No. 6	Vessels	Blast Cleaning (SP 6 or 10) (most areas)
No. 7	One-Coat Shop Paint	Nominal Cleaning (St 1)
No. 8	Rust Preventive Compounds	Solvent Cleaning (SP 1) and/ or Nominal Cleaning (St 1)
No. 9	Bituminous Coatings	Blast Cleaning (SP 6 or 10)
No. 10	Coal Tar	Blast Cleaning (SP 6)
No. 11	Coal Tar Epoxy	Blast Cleaning (SP 6 or 10)
No. 12	Zinc-Rich	Blast Cleaning (SP 10 or 6 or 5)
No. 13	Epoxy	Blast Cleaning (SP 6 or 10)

Table 5 is a list of types of paint specifications and the minimum surface preparation which each requires. It is noteworthy that some types of paints, because of their ability to wet a steel surface, require much less stringent surface preparation than others, particularly when they are used in a fairly mild environment. Many of the newer types of paints, such as zinc-rich, certain vinyls, etc., do require very careful and sometimes expensive surface preparation in order to take best advantage of their characteristics.

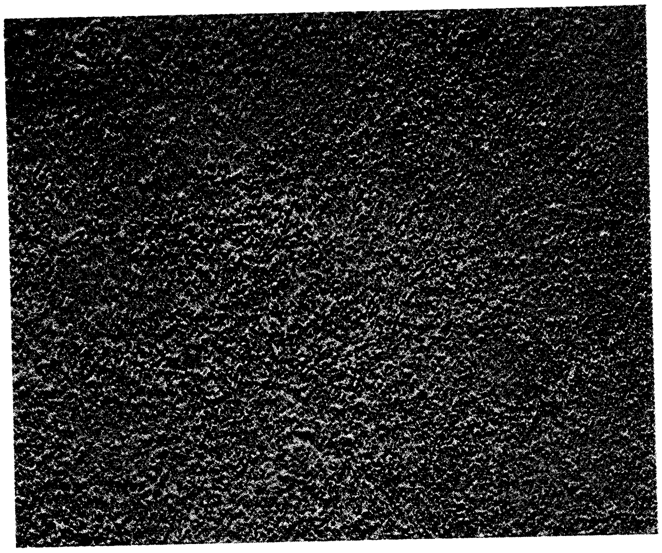
Pictorial Standards—The heart of the surface preparation specification is, of course, the definition, which specifies the end result and the amount of rust, mill scale, or other contaminants which are permitted to remain. As an aid in judging this end condition, the Council has developed, in cooperation with the ASTM and the Swedish Royal Academy, a set of visual standards. This development represents an excellent example of international cooperation, since most of the pictures were originally developed by the Swedish Standards Institute, and the remainder, such as the near-white and the newer commercial blast cleaning photographs, by the Steel Structures Paint Council.

The pictorial surface preparation standards are available in the form of a booklet of realistic color photographs (SSPC-Vis 1). Some of the photographs from this booklet are presented in this article for illustrative purposes. The quality of photographs herein may or may not be representative of that in the standard booklet. Figure 6 represents the four standard rust grades of new steel: (A) Adherent Mill Scale; (B) Rusting Mill Scale; (C) Rusted; and (D) Pitted & Rusted. It is exceedingly important that the visual standard take into consideration the initial condition of the steel before surface preparation, which influences markedly the appearance after

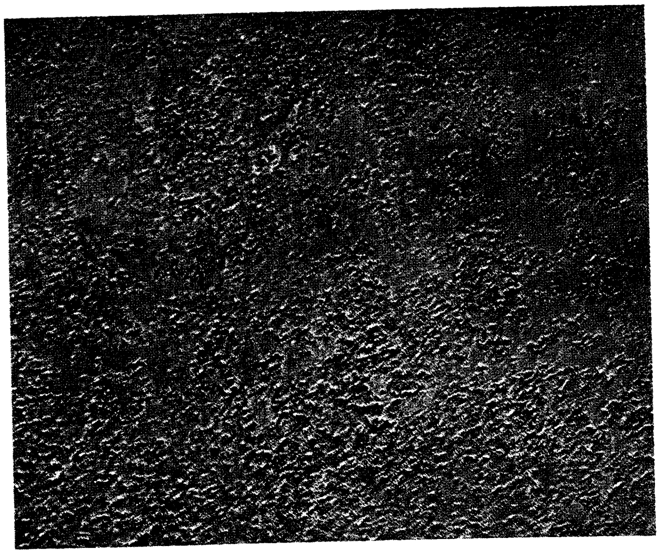
RUST GRADES



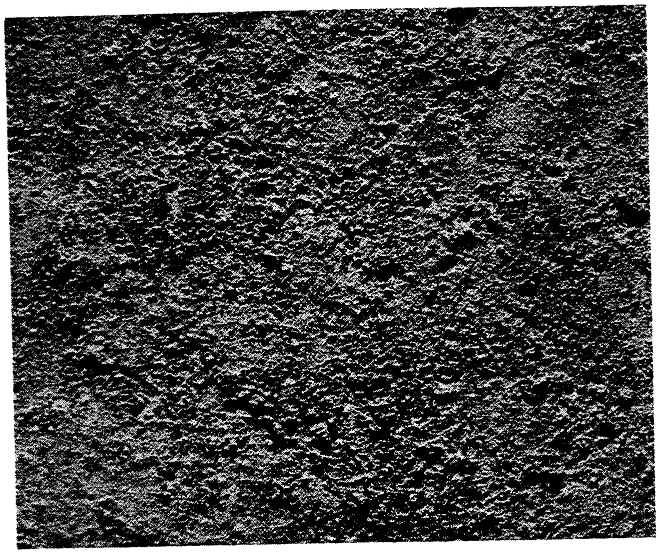
A
Adherent Mill Scale



C
Rusted



B
Rusting Mill Scale

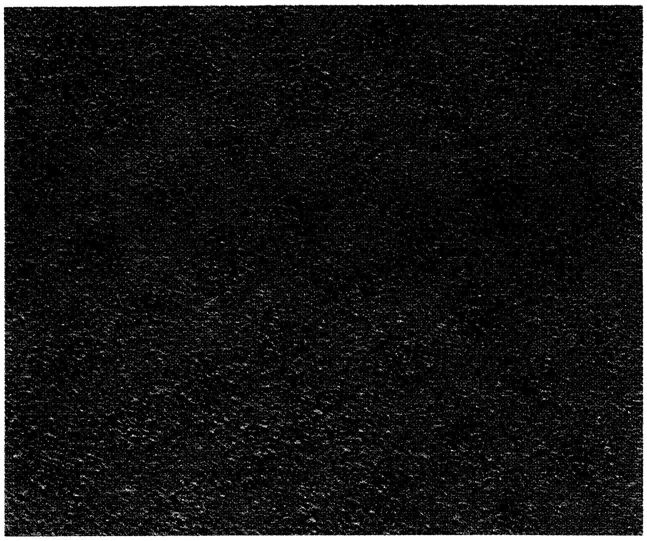


D
Pitted & Rusted

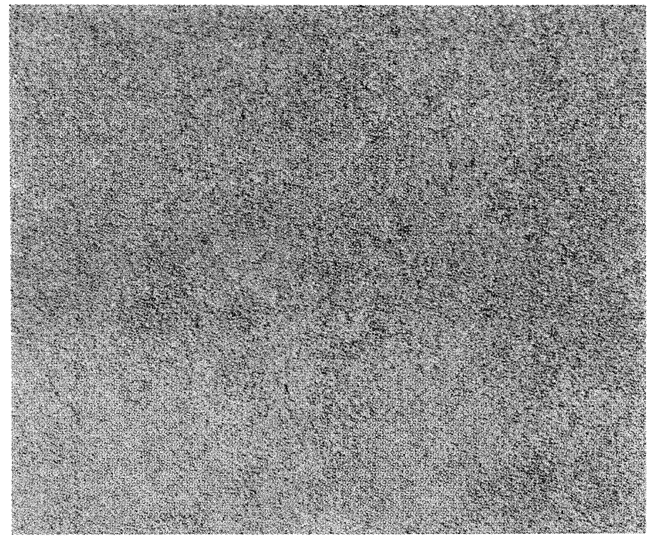
Note: These color reproductions may not be representative of the colors in the standard booklet. They are shown only for illustrative purposes.

Fig. 6. Four rust grades of structural steel (based on SSPC-Vis 1/SIS 05 59 00).

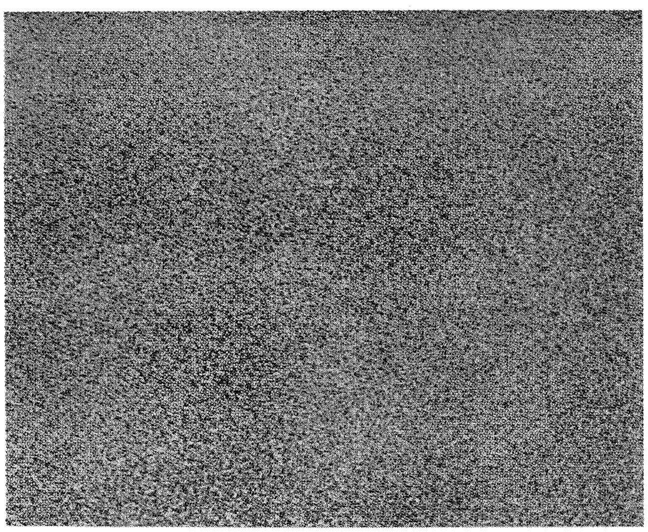
RUST GRADE C—RUSTED



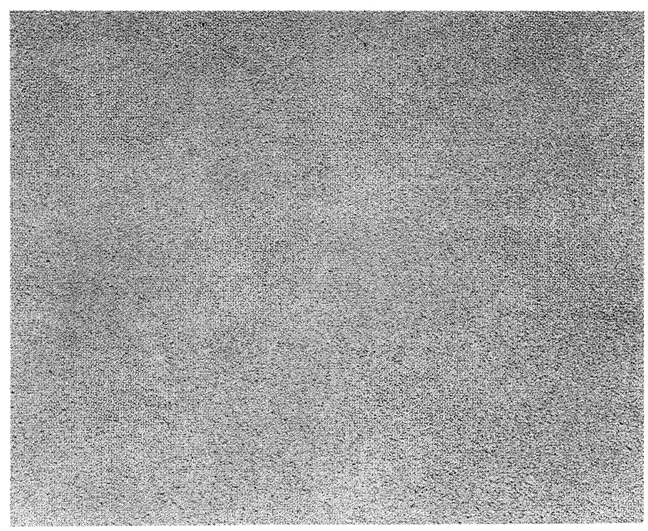
C Sa 1
Brush-Off



C Sa 2½
Near-White



C Sa 2
Commercial



C Sa 3
White Metal

Note: These color reproductions may not be representative of the colors in the standard booklet. They are shown only for illustrative purposes. The standard booklet contains equivalent photographs for Rust Grades A,B, and D, as well as for wire-brushed steel.

Fig. 7. Four grades of blast cleaning (based on SSPC-Vis 1/SIS 05 59 00).

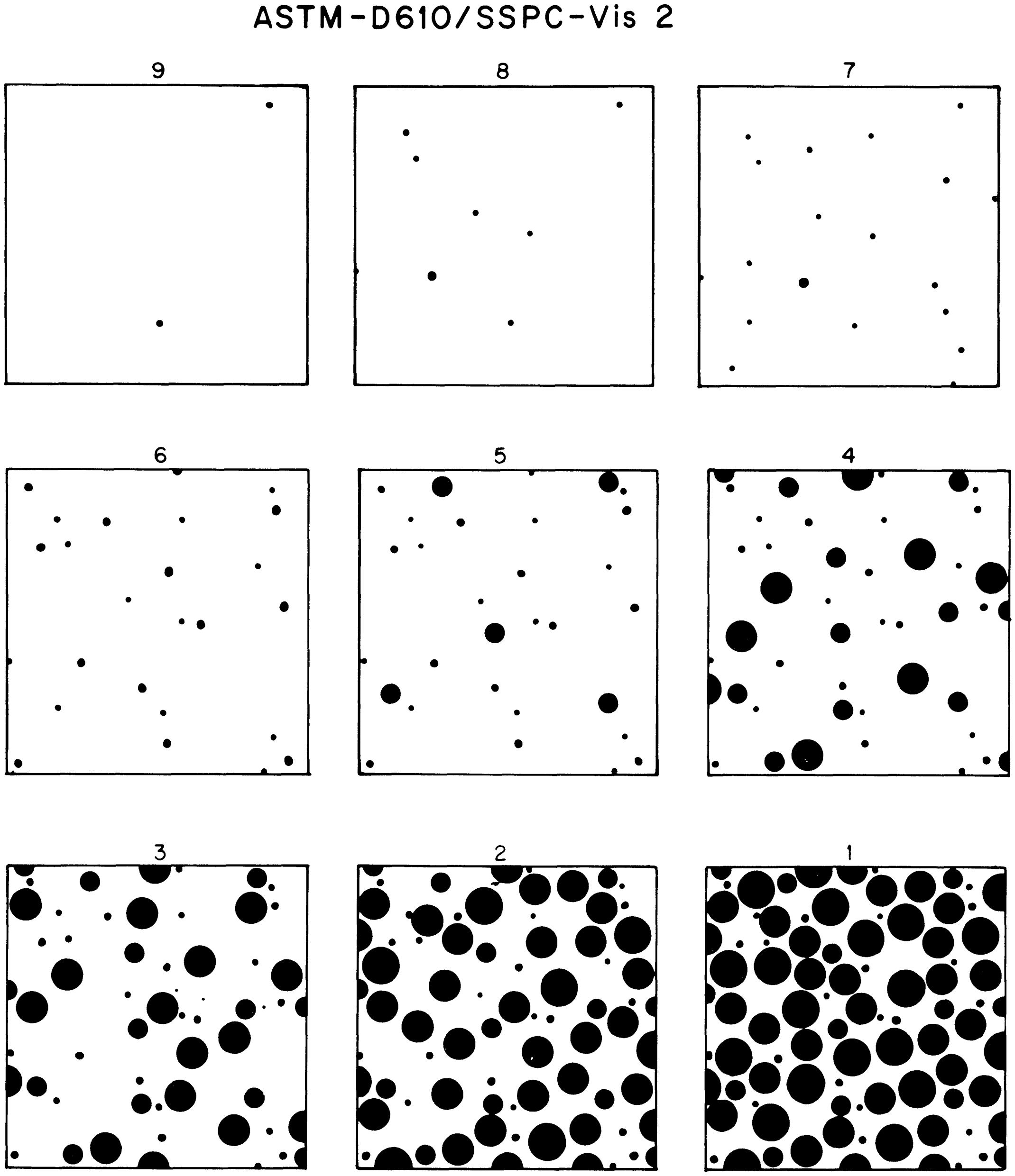


Fig. 8. Rating of painted steel surfaces as a function of area percent rusted.

surface preparation. Furthermore, recent work now indicates that not only is paint performance influenced by the degree of surface preparation (commercial, near-white, etc.), but it is also strikingly affected by the condition of the mill scale before the surface preparation is initiated (rust grades A, B, C, or D).

Figure 7 represents the appearance of rust grade C, for example, after being subjected to each of the four standard degrees of blast cleaning. In the standard booklet itself, similar photographs are included illustrating each degree of blast cleaning and wire brushing for each of the four rust grades.

Visual references may also be used in maintenance painting. For this purpose, SSPC-Vis 2 has been established, including color photographs of standard rust grades corresponding roughly with the above rust grades for new steel. In addition, this standard includes a black-and-white diagrammatical representation of various area percentages as shown in Fig. 8.

If it is specified, for example, that maintenance repainting be undertaken at rust grade 8 (when rust occupies one-tenth of one percent of the surface area), most of us, without these diagrams, would tend to overestimate the percentage of rust present.

Paint Application—Many architects, engineers, and owners have developed their own paint application specifications. Some prefer to emphasize in the paint contract a few provisions that pertain to a specific job and then state that in all other respects the provisions of a public specification, such as SSPC-PA 1, be applied. It may be productive, therefore, to briefly review the requirements of a typical painting specification such as SSPC-PA 1. This specification includes a statement of scope, definitions, procedures, safety precautions, inspection, and an appendix.

The procedures section includes a provision for cleaning, pretreatment, storage, and mixing to be used in the absence of any other specific provision. In accordance with good painting practice, a provision is made for application methods (brush, spray, airless or hot spray, etc.) If application is to be limited to any one of these methods, this requirement must be stipulated. The specification sets limits for the temperature of application, the amount of moisture and humidity which may be present, as well as provision for cover, damage to the paint, and striping. It provides for continuity of the paint film, thickness, recoating time, and tinting of successive coats to provide a contrast between coats. It also sets forth what is regarded as best current practice with regard to painting of contact surfaces of all types. These include contact surfaces joined by high-strength bolts in friction-type joints, in contact with concrete or wood, encased or embedded in concrete or enclosed in masonry, or inaccessible after assembly. Detailed provisions are given for shop painting, field painting, and maintenance painting, and special provisions for the application of certain classes of materials. Provisions are also given for the drying and handling of painted steel, safety, and inspection.

Although these specifications sometimes seem unnecessarily detailed, their very completeness forestalls difficulties so often occasioned by failure to anticipate all the conditions encountered in shop, field, and maintenance situations.

Paint Thickness—Paint thickness and its proper measurement deserve a special place in the paint system concept. In a recent survey which SSPC made of each of the 50 state highway departments, the majority of the states listed paint thickness and its measurement as one of their outstanding problem areas. For this reason, the Council has undertaken, in behalf of the Pennsylvania Department of Transportation and the Federation of Societies for Paint Technology, a thorough investigation and evaluation of paint thickness and its measurement.

One facet of the Council's work on paint thickness is illustrated in Fig. 9. This is a summary of some of the results of 10 years' work conducted in cooperation with the Federation of Societies for Paint Technology. The results of thousands of panels exposed for 10 years shows clearly

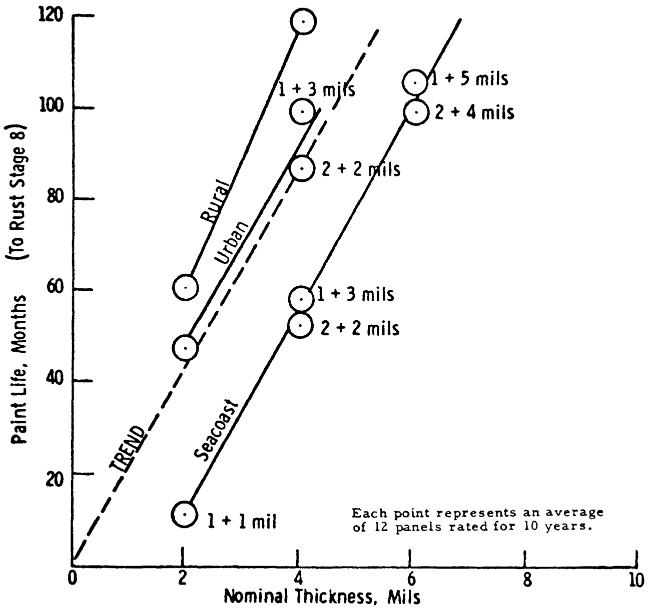


Fig. 9. Average paint life vs. thickness (oil and alkyd paints).

the same results in three widely varying types of environment. For each thousandth of an inch of paint thickness (mil), 20 additional months of paint life were obtained. It was also found that, for each type of paint and each environment, there is a critical (or minimum) paint film thickness that should be applied if long-term protection is desired. This critical thickness can be decreased for mild environments, or for durable, impermeable paints. The study also indicated that it is better to apply a sufficiently heavy film at the beginning than to repaint more frequently.

Each SSPC paint system specification stipulates the minimum total thickness of dry paint, in mils, required for 2, 3 and 4 coat systems. A wide variety of devices are available for measuring paint film thickness. These are the subject of an intensive study currently being conducted by SSPC.

Paint Specifications—There are basically three types of paint specifications: proprietary, performance, and composition specification. Each has advantages and disadvantages.

When a paint is specified by its proprietary name, it is presumed that the product is backed by the reputation of the supplier. However, this type of specification does eliminate open competitive bidding and introduces the disadvantages of depending upon a single source, with the possibility of composition changes, and limited opportunity for quality inspection. It is generally agreed that specifying "product X or equal" tends to lead to enforcement problems and considerable controversy.

Ideally, a good performance specification would permit advances in the art of paint development. In practice, however, accelerated tests have repeatedly shown poor correlation with actual performance. Furthermore, the required tests are often long and expensive, especially for the small user. Several agencies, including SSPC, have established a few good performance specifications and have included performance requirements wherever practicable, even in composition specification paints.

Composition requirements permit open, competitive bidding, provide a floor on quality, and are quick and definite. They do, however, require detailed quality inspection, do not always guarantee top quality, and tend to limit the user from full participation in the advances of paint technology.

SSPC-Paint 101-67T, Aluminum Alkyd Paint (Leafing-Type 1) and (Non-Leafing-Type II)

1. SCOPE
2. DESCRIPTION
3. REQUIREMENTS
    3.1 Composition (Table 1)
    3.2 Manufacture
    3.3 Quantitative Requirements (Table 2)
    3.4 Qualitative Requirements (Odor, Color, Compatibility, Working Properties, Condition in Container, Skinning, Appearance, Flexibility, Water Resistance, Gasoline Resistance)
    3.5 Specifications for Ingredients
    3.5.1-2 Aluminum Paste Type I and Type II
    3.5.3 Alkyd Resin
    3.5.4-8 Thinners and Driers
    3.6 Thinning
    3.7 Directions for Use
    3.8 Marking Containers
    3.9 Revisions
4. SAFETY
5. INSPECTION

Appendix

Fig. 10. Outline of a paint specification.

Figure 10 outlines a typical paint specification — in this case an aluminum alkyd paint. The first table (not shown) in such a specification visually lists the composition of the paint. Ordinarily the paint is made up of three types of ingredients: pigment, vehicle, and volatile thinner. It should be noted that primers for the protection of steel and other metals are unique in requiring inhibitive pigmentation such as zinc metal, red lead, chromate, etc. In addition to the composition and other quantitative requirements, this typical specification also lists a number of qualitative requirements that are really performance requirements — particularly flexibility, water resistance, and gasoline resistance. The specification also covers the ingredients used, thinning, directions for use, marking containers, safety, and inspection.

Substitutes for Paint—Although not within the scope of this paper, several non-paint methods of protecting steel should be considered. These include galvanizing, metallizing, use of painted or unpainted high-strength low-alloy steels, use of unpainted low carbon steel, grease paints, etc. Each is finding its own place along with paint in modern technology and in the market place.

SOURCES OF FURTHER INFORMATION

This discussion of the painting of structural steel has merely highlighted some of the considerations and problems of interest to architects and engineers. For those interested in further information on any aspects of the subject, some typical sources of additional information are listed below:

1. Journal publications and books
2. Proprietary manuals
3. SSPC Manual—Volume 2, "Systems & Specifications"
    (a) Guides and paint systems
    (b) Surface preparation, application
    (c) Pretreatment, paints
4. SSPC Manual—Volume 1, "Good Painting Practice"
    (a) Corrosion, surface preparation, costs, inspection, shop painting
    (b) Painting for: railroads, highways, water, sewage tanks, vessels, underground, refineries, plants, etc.
5. Other recent SSPC publications
    (a) Surface Preparation of Structural Steel
    (b) Painting Highway Bridges
        Summary report
        Literature
        Practices
    (c) Zinc-rich Paints
    (d) Optimum Paint Thickness
    (e) Effect of Painting Temperature and Moisture
    (f) Tank Painting
    (g) Inhibitive Primers
    (h) Railroad Bridge Painting
    (i) Painting Steel Plate
    (j) Shop Painting of Structural Steel (draft)

Published articles in trade journals and a few books on the subject contain much valuable information. There are excellent guides to particular types of paints published by paint manufacturers and a few of the government agencies have published painting manuals dealing with their particular application. The Council has prepared a bibliography for the Highway Research Board, outlining many of these sources.

Another source is the *Steel Structures Painting Manual, Volume 2, Systems and Specifications* which gives recommendations and details concerning most of the matters discussed in this paper, including surface preparation, application, paints, and paint systems.

The *Steel Structures Painting Manual, Volume 1, Good Painting Practice*, has chapters on a wide variety of subjects, including corrosion, surface preparation, costs, inspections, and shop painting, as well as separate chapters discussing painting for railroads, highways, water works, plants, vessels, underground, refineries and various kinds of plants.

SSPC reports and articles include a definitive report on surface preparation (just prepared), a broad discussion of zinc-rich paints, results of a 10-year project on determining optimum film thickness, an exhaustive report on painting highway steel, a report on painting of wet and cold steel, and others on tank painting, inhibitive primers, bridge painting, and painting of steel plate.

For more detailed information on SSPC books and other publications, the reader is invited to write to Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, Pa. 15213.

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American Institute of Steel Construction
American Iron & Steel Institute
American Petroleum Institute
American Society for Testing & Materials
American Water Works Association
Canadian Institute of Steel Construction
Federation of Societies for Paint Technology
Lead Industries Association
Metal Powder Industries Federation
National Association of Corrosion Engineers
National Paint, Varnish & Lacquer Association
Painting & Decorating Contractors of America
Steel Plate Fabricators Association
Texas Structural Steel Institute
Zinc Institute

Each of these is the outstanding organization in its field, representing user, supplier, or public interest.