Technical Note

STEEL SURFACE PREPARATION

(For purposes of this Technote, painting and coating are interchangeable. Also, this Technote deals with carbon steel, stainless steel, and other ferrous metals only. Preparation of non-ferrous metals is dealt with separately.)

1. General Discussion

The life of a coating depends as much on the degree of surface preparation as on the subsequent coating system. Surface preparation, therefore, should receive thorough consideration. The primary functions of surface preparation are to clean the surface of material that will induce premature failure of the coating system and provide a surface that can be easily wetted for good coating adhesion.

All coating systems will fail eventually. However, most premature coating failure can be attributed to inadequate surface preparation or lack of coating adhesion.

Typical contaminants that should be removed during surface preparation are:

- Corrosion by-products
    a. Soluble salts
- Dirt
- Grease
- Moisture
- Oil
- Rust

Rust will be stressed in this Technote. But, since long-term performance is the prime objective, anything that interferes with or lessens adhesion is of concern. Most preparation methods will remove dirt, grease, and oil.

The presence of soluble salts will significantly change the chemistry of the steel environment and rust is one of the places where these salts can hide.

Additionally, mill scale is erratic in its effect upon the performance of coatings. Tightly adhered or intact mill scale does not have to be removed for mild atmospheric exposure. If, however, the steel surface is to be coated with primers with low wetting properties or exposed to severe environments such as chemical exposures and immersion in fresh or salt water, then removal of mill scale is necessary.

You can rest assured that you will be called upon to install polyurea in conditions where other systems have failed. Polyurea has some very attractive features that will capture the attention of an Owner. Its general chemical resistance and speed of return to service will be attractive. In such cases the difference between polyurea fulfilling its function and another system that has failed may well be the expertise of the preparation, rather than the properties of the coating itself.

There is no trade off between cost of proper preparation and the cost required to do a job over again. While removal of an existing coating may seem expensive, or proper removal of

underlying rust or salt contamination may appear unnecessary, the time and expense of re-doing the work makes the dollar or two required for proper preparation pale.

The cost of the proposed coating system, likewise, should not be a determining factor in the cost of proper preparation. Hopefully, the system proposed is based upon the system's ability to perform a particular function, and not its cost per square foot. Whether a ten-cent coating or a ten-dollar coating is proposed, preparation should be adequate regardless of the cost.

2. Initial Steel Surface Condition

The amount of work, time, and money required to achieve any particular degree of surface preparation will depend upon the initial condition of the surface to be cleaned. It is more difficult to remove contaminants from rusty steel than from intact mill scale. Therefore, it is necessary to consider the amount of mill scale, rust, old paint, contamination, and pitting on the surface to be protected. Although there are almost an infinite number of initial conditions, they can be broadly divided into categories as follows:

1. New construction - steel not previously painted;
2. Maintenance - previously painted steel;
3. Surface imperfections - common to both new construction and maintenance;
4. Retrofit with varying degrees of inaccessibility.

Note: Figure 1, below, depicts various degrees of rusting. Table 1, below, contains a description of the type of cleaning according to SSPC. Table 1 also lists some visual standards not included in this Technote. It should be noted that conditions A, B, C, and D are specifically treated in the Table. Minimum acceptable preparation levels for proper adhesion are SP 5, SP 6, SP 7, or SP 10. Lesser standards of preparation may be employed, however, they are not recommended for the installation of polyurea for use in immersion or chemical attack environments.

2.1 New Construction

The first four surface conditions (designated A through D) are based upon the rust grade classifications of SSPC - Visual 1-89, "Visual Standard for Abrasive Blast Cleaned Steel." Normally, a more thorough surface preparation should be used with rust grades C or D compared with rust grades A or B.

A. Steel surface covered completely with adherent mill scale; little or no rust visible (SSPC-Visual 1-89 - Rust Grade A).
B. Steel surface covered with both mill scale and rust (SSPC-Visual 1-89 - Rust Grade B).
C. Steel surface completely covered with rust; little or not pitting visible (SSPC-Visual 1-89 - Rust Grade C).
D. Steel surface completely covered with rust; pitting visible (SSPC-Visual 1-89 - Rust Grade D).

2.2 Maintenance

The pictorial standard SSPC - Visual 3, Visual Standard for Power- and Hand-Tool Cleaned Steel, defines conditions E, F and G for previously painted surfaces.

E. Light-colored paint applied over a blast-cleaned surface, paint mostly intact.
F. Zinc-rich paint applied over blast-cleaned steel, paint mostly intact.
G. Painting system applied over mill scale-bearing steel; system thoroughly weathered, thoroughly blistered, or thoroughly stained.

In maintenance repainting, the degree of surface preparation required depends on the new painting system and on the extent of degradation of the surface to be painted. The amount of rusting on a surface is based on the numerical scale of 0 to 10 given in SSPC-Visual 2 (ASTM D 610), Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces, where a rating of 10 indicates no rust and a rating of 0 indicates totally rusted. SSPC-PA Guide 4, Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems, suggests the minimum surface preparation needed for each degree of rusting.

In estimating of rust percentages, photographs and schematic diagrams of the type shown in SSPC-Visual 2 can serve as practical aids. Figure 1 of the Guide to SSPC-Visual 2 shows a series of 1.5-inch squares with black dots representing various area percentages. These diagrams are not intended to reproduce the appearance of actual rust patterns but merely to serve as a guide for judging the percentage of surface covered by rust (after removal of stains) or rust blisters. The SSPC Painting System Commentary will also help in estimating surface preparation requirements.

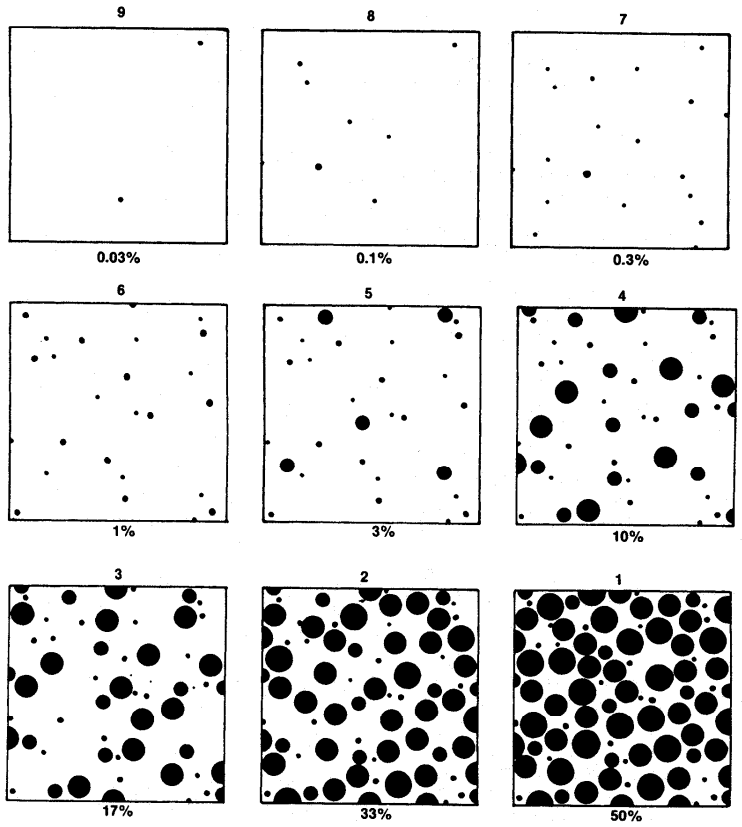

FIGURE 1
Diagrams Representing Rust Grades and the Corresponding Area Percentages

Comments on surface preparation for maintenance repainting are given in SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems." This guide includes a description of accepted practices for retaining old, sound paint, removing unsound paint, feathering, and spot cleaning.

2.3 Steel Surface Imperfections

Surface imperfections can cause premature failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features that are difficult to properly cover and protect include crevices, weld porosity, laminations, etc. They are discussed below. The high cost of the methods to remedy the surface imperfections requires weighing the benefits of edge rounding, weld spatter removal, etc., versus a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the actual surface preparation operation (e.g., blast cleaning). Alternately, other surface defects such as steel laminations, weld porosities, or deep corrosion pits may not be evident until the surface preparation operation has been done. Therefore, the timing of such surface repair work may occur before, during, or after preliminary surface preparation operations have begun.

The below table is extracted from SSPC. It gives the level of preparation, the visual standard, and a description of preparation standard.

2.3.1 Crevices: Areas of poor design for corrosion protection, such as tack or spot welded connections, back-to-back angles, crevices, etc., may require special attention. Where possible, such deficiencies should be corrected by structural or design modification. Where this is not possible, particular consideration should be devoted to minimize the effect of such deficiencies.

2.3.2 Laminations, Slivers: Rolling discontinuities (laps) may have sharp protruding edges and deep penetrating crevices and such defects should be eliminated prior to painting. Various methods can be used to eliminate minor slivers (e.g., scraping and grinding). All sharp fins, projections, or edges should be removed.

2.3.3 Pits: Deep corrosion pits, gouges, clamp marks, or other surface discontinuities may require grinding prior to painting. The surface will require filling.

2.3.4 Porosity: Areas of unacceptable porosity as de- fined in the American Welding Society standard AWS DI.1 should be filled with acceptable filler material or closed over with a needle gun or peening hammer prior to painting. Acceptable weld profiles, arc strikes, and weld cleaning are also addressed in Section 3 of "Structural Welding Code" AWS DI. 1.

2.3.5 Sharp Edges: Sharp edges, such as those normally occurring on rolled structural members or plates, as well as those resulting from flame cuffing, welding, grinding, etc., and especially shearing, may be removed by any suitable method (e.g., grinding, mechanical sanding, filing). Care should be taken to ensure that during the removing operations, new sharp edges are not created.

2.3.6 Weld Spatter: Weld spatter should be removed prior to blast cleaning. Most weld spatter, except that which is very tightly adhered, can be readily removed using a chipping hammer, spud bar, or scraper. Tightly adhering weld spatter may require removal by grinding.

TABLE 1
SUMMARY OF SURFACE PREPARATION SPECIFICATIONS

SSPC Specification	SSPC-Vis 1-89 Reference	Description
SP 1, Solvent Cleaning		Removal of oil, grease, dirt, soil, salts, and contaminants by cleaning with solvent, vapor, alkali, emulsion, or steam.
SP 2, Hand Tool Cleaning		Removal of loose rust, loose mill scale, and loose paint to degree specified, by hand chipping, scraping, sanding, and wire brushing.
SP 3, Power Tool Cleaning		Removal of loose rust, loose mill scale, and loose paint to degree specified, by power tool chipping, descaling, sanding, wire brushing, and grinding.
SP 5/NACE No. 1, White Metal Blast Cleaning	A, B, C, D SP 5	Removal of all visible rust, mill scale, paint, and foreign matter by blast cleaning by wheel or nozzle (dry or wet) using sand, grit, or shot. (For very corrosive atmospheres where high cost of cleaning is warranted.)
SP 6/NACE No. 3, Commercial Blast Cleaning	B, C, D SP 6	Blast cleaning until at least two-thirds of the surface area is free of all visible residues. (For conditions where thoroughly cleaned surface is required.)
SP 7/NACE No. 4, Brush-Off Blast Cleaning	B, C, D, SP 7	Blast cleaning of all except tightly adhering residues of mill scale, rust, and coatings, exposing numerous evenly distributed flecks of underlying metal.
SP 8, Pickling		Complete removal of rust and mill scale by acid pickling, duplex pickling, or electrolytic pickling.
SP 10/NACE No. 2, Near-White Blast Cleaning	A, B, C, D, SP 10	Blast cleaning nearly to White Metal cleanliness, until at least 95% of the surface area is free of all visible residues. (For high humidity, chemical atmosphere, marine, or other corrosive environments.)
SP-11, Power Tool Cleaning to Bare Metal		Complete removal of all rust, scale, and paint by power tools, with resultant surface profile.
Vis 1-89, Visual Standard for Abrasive Blast Cleaned Steel		Standard reference photographs; recommended supplement to SSPC Surface Preparation Specification SSPC-SP 5, 6, 7, and 10.
Vis 2, Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces		A geometric numerical scale for evaluating degree of rusting of painted steel. Illustrated by color photographs and black and white dot diagrams.
Vis 3, Visual Standard for Power- and Hand-Tool Cleaned Steel		Standard reference photographs; recommended supplement to SSPC-SP 2, 3 and 11.
AB1		Definition of requirements for selecting and evaluating mineral and slag abrasives used for blast cleaning.

2.4 Inaccessibility

Retrofit presents its own set of problems. The Owner should be made aware that such conditions exist. Partial or full disassembly of some structure components may be required for adequate preparation and installation of a subsequent coating or liner system. Often, Owner imposed time constraints will not allow this to occur. The Contractor should not be held liable for such a condition beyond his control. Exceptions could be made in warranty or guarantee circumstances.

3. Previously Applied Coatings

Previously applied coatings may have to be removed prior to preparation of the steel substrate or prior to applying a coating to the steel. Several conditions need to be evaluated prior to use of previously applied coatings. Among them are:

1. Ability of the proposed overcoat to fully hide the existing coating
2. Adhesion of the existing coating to the steel substrate
3. Adhesion of the proposed overcoat to the existing coating and preparation required to bond the proposed overcoat to the existing coating
4. Amount of unbonded, blistered, or peeled existing coating
5. General condition of the existing coating
6. Rust present under the existing coating
7. Salt contamination in the existing coating or in the steel substrate
8. Will the existing coating cause unsightly "orange-peel" or other deficiencies in the proposed overcoat

If any of these items prove problematic, the previously applied coating should be removed.

4. Galvanizing, Galvaneal, or Metalizing

Galvanizing is a process of dipping steel in a sacrificial coating element that will bar oxidizing components access from contact with the underlying steel. Galvaneal and metalizing are similar processes to galvanizing in that they are a sacrificial barrier coating applied to steel. They are electrostatically deposited on the steel substrate.

These sacrificial barriers will acquire a bond-breaking surface film that is the natural process of its function. The metals contained in the process will combine with moisture and oxygen, changing their chemical composition to a material that is resistant to rusting. This produces a protective barrier over the underlying steel.

This film must be removed prior to overcoating or the film must be prepared to take a suitable primer. An acidic wash is most often used. Once the film has been removed, test the galvanizing for proper adhesion of the primer or coating system.

If the process is left in place the material to which a coating system is being bonded is not the steel substrate but the galvanizing, galvanealing, or metalizing. Care should be taken that the proposed system will adhere adequately to the protective barrier, even it the barrier is clean and apparently ready for overcoating. In some cases special primers may be required to achieve proper adhesion and system function.

5. Salt Contamination

See Technote: Soluble Salts

6. Moisture and Relative Humidity

Moisture can contaminate newly prepared substrates and interfere with bond. High relative humidity will provide the moisture necessary to promote flash rusting or "rustback". Depending on the amount of remaining steel surface contamination and the amount of moisture available, re-rust may occur quickly or over a more prolonged period of time.

Do not overcoat rustback. It is an indication of inadequate surface preparation. While some authorities state that coating steel prior to rustback is acceptable, the presence of underlying contamination may cause coating failure. Allow the steel to thoroughly dry after wet cleaning and test dry cleaned surfaces for salt contamination prior to overcoating. Apply primer only after adequate preparation and, whenever possible, do not use the primer as a barrier.

7. Cathodic Protection

Cathodic protection of steel produces an environment that promotes the disbondment of certain coating systems. In cases where active cathodic protection is being used choose a system that has been approved for use.

8. Bond Strength

Bond strength to steel depends on the adhesive quality of a coating and the profile of the steel substrate. While some porosity exists in steel, most coatings will not be able to penetrate the pore structure, thus the coating must depend on its adhesive qualities rather than the mechanical lock that penetration affords.

Recommended profile for application of a high-build polyurea system is 3 to 5 mils. If lesser profile is achieved ***VersaFlex*** strongly recommends use of a primer. Polyurea sprayed directly to 3 - 5 mil-profiled steel will develop bond strength of 1000 psi in most cases. Use of a proper primer may increase the bond strength to as much as 2000 psi. On steel with a lesser profile, use of a primer will assure that adequate bond strength is achieved.

How much bond strength is enough? There is no hard and fast rule, but the more the better. In cases of:

1. Full immersion lining service 1200 - 1500 psi would be adequate.
2. As a paint-like coating to steel members 1000 psi would be adequate.
3. In a salt environment (osmotic transfer likely) a full immersion lining would require the maximum of 2000 psi.

9. Quality Assurance of Preparation

Visual inspection is important before, during, and after preparation. Development of an inspection program is essential. Initial condition survey, intermediate preparation inspection, final preparation inspection and testing are required.

9.1 Testing may consist of:

1. Previously applied coating adhesion testing
2. Bond of proposed coating to existing coating testing
3. Salt contamination testing
4. Film thickness testing
5. Spark or dielectric testing

Personnel must be trained in the testing methodology and the use of available testing equipment. As always, step by step testing saves money in the long run, assures adequate preparation, and reduces the cost of the work.

10. Primers

After all other preparation criteria have been fulfilled primers provide an additional safety factor when installing polyurea on steel substrates. Use of a primer cannot be a substitute for proper preparation. There are those cases, however, where use of a primer may be the only method of preparation available, as in the case of inaccessibility during retrofit polyurea lining or coating installations.