LIA07135

FOREWORD

In previous Red Lead Technical Letters, the Red Lead Technical Committee of the Lead Industries Association has confined itself to the recommendation of red lead primer formulations and has left other considerations involved in painting to be secured by the user from other sources. The extreme importance, however, of surface preparation for the proper performance of any metal protective paints, has now led the Committee to prepare the recommendations contained in this Technical Letter to aid the industrial user in getting the longest possible service life out of his paint. The success or failure of a paint system, after all, very often depends upon the adequacy of the surface preparation. A quality paint may fail quickly over a dirty, ill-prepared surface while an inferior quality paint may perform satisfactorily over a clean surface. Proper surface preparation cannot be stressed too strongly.

This Technical Letter includes a short discussion of surface preparation to emphasize the differences and completeness of surface contaminant removal by the most widely used methods. A listing of surface preparation requirements applicable to a number of painting conditions for which red lead primers are recommended is also included. Formulas for all the paints listed are contained in previous Red Lead Technical Letters (these are available, at no charge, upon request to the Lead Industries Association).

Inquiries regarding this Technical Letter or specific painting problems are welcome and should be addressed to the Lead Industries Association or to the designated individuals in the cooperating companies listed below.

Cooperating Companies

N2780

RECOMMENDED SURFACE PREPARATION OF STEEL FOR RED LEAD PAINTS

WHY SURFACE PREPARATION?

The purpose of surface preparation is to remove contaminants and improve adhesion of a priming paint. Adhesion is the bonding of the priming paint to the surface to which the paint is applied. Paint will fail in direct proportion to the lack of adhesion.

Mill scale, rust, dirt, grit, oil, grease, chemicals, and other surface contaminants make good paint performance impossible by preventing wetting of the metal. Rust, while it may be painted over, continues to form and eventually destroys the adhesion of the paint film. Likewise mill scale may be undermined by rust.

Mill Scale

Most structural steel is hot formed. It is covered with a mixture of iron oxides called mill scale, which is of variable thickness, continuity and adhesion. Mill scale is brittle and is mainly magnetic iron oxide, Fe_3O_4. Due to flexing or the difference in coefficient of expansion between the mill scale and the base metal, the mill scale cracks when changes in temperature take place. If moisture enters a crack in mill scale, rusting of the base metal begins. As the rust creeps under the mill scale, adhesion is destroyed.

Paint applied over loose or semi-loose mill scale in time becomes completely detached from the base metal. Rupture and scaling of the paint coat follows. Tightly adhering areas of mill scale, through electrochemical action may provide sufficient localized corrosion to produce pits, which may in time penetrate the base metal.

Grease and Oil

Grease and oil are detrimental to adhesion between the priming paint and the metal surface. Small objects may have the grease and oil removed by a number of vapor degreasing commercial techniques. On large objects, due to their size and shape, the grease and oil are removed by washing or wiping with a suitable solvent.

Welds

Weld deposits such as weld flux slag, weld flux fumes, weld heat oxides, and weld metal spatter, are surface contaminants. Electric arc weld seams in particular and, to a somewhat lesser extent, the acetylene weld seams must be cleaned before painting.

The weld flux slag remaining adjacent to the weld seam is strongly alkaline. Under humid conditions it saponifies the paint vehicle, forming fatty acid soaps which reduce adhesion of the paint film and, either through actual pores in the film or by osmotic action, water is drawn through the film to promote further corrosion.

The weld flux fumes after condensation are deposited noticeably in a band 2 to 8 in. on either side of the weld seam. Spray painting fails to disturb the condensate, which in conjunction with weld flux slag may cause corrosion to spread several feet from the weld seam. Brush applied paint dilutes the weld flux fume condensate and lessens the intensity and area of action.

The weld heat oxides are concentrated on the weld seam in a band 2 in. wide on either side of the seam. These oxides form irregular and rough deposits and create unequal paint film thickness. The thin spots in the paint thereby promote early film failure and serve as corrosion centers.

The weld metal spatter deposits range from microscopic particles to particles 1/4 in. in diameter. The larger the spatter the more firmly the spatter is welded to the surface. Paint films over these spatters fail prematurely due to inadequate film thickness on the top of the metal spatter or to the inability of paint to enter the junction between the spatter and the metal.

Since paint film failure, in general, radiates from pinhead rust spots associated with flux, slag and spatters, these deposits must be removed by grinding or blasting or both before painting if an adequate, uniform film thickness is desired. When cleaned, the weld seams may be expected to give almost as good service as the adjacent metal surfaces.

WHAT TO CONSIDER IN SELECTING A METHOD OF SURFACE PREPARATION

The question of selecting a method of surface preparation depends upon a number of factors other than the economic conditions involved. Among these are:

1. Condition of the surface to be painted,
2. Service to which the metal and paint will be subjected,
3. Practicality of using a particular method because of environment, and
4. The type of paint which is to be applied.

The requirements for surface preparation are more severe as the wetting abi of the paint decreases. One reason why the anticorrosive red lead pigment in li seed oil paint, L.I.A. Formula 6-1 (the same as Fed. Spec. TT-P-86a, Type I, or SSPC Paint 1-55T) has achieved an eminent reputation for protection of steel is due to its superior wetting characteristics. It has demonstrated excellent anti corrosion performance when used over steel where small amounts of rust and tight adherent mill scale are present. A surface condition such as this is often the that can practically be obtained in the field. Equally good results are being obtained by similar high red lead in oil systems, which have good wetting charac teristics, as used by railroads, public utilities, highway departments, and othe

The linseed oil vehicle, however, is slow drying and it is often necessary to use a faster drying oil-resin vehicle combination such as L.I.A. Formula 6-7 (TT-P-86a, Type II). Such a paint is limited in its wetting ability by the pres ence of synthetic resins. Therefore, surfaces receiving paints of this type mus be more carefully cleaned of corrosion products and contaminants if maximum perf mance is expected.

Going still further, painting requirements may necessitate the use of the very rapid drying synthetic vehicle type paints, such as L.I.A. Formulas 3-7, or 6-13 (TT-P-86a, Type III) or 6-16, (MIL-P-17545) (Ex Ships Paint Formula No. 116) These paints are useful and excellent when applied over carefully prepared surfac

The following are the recommended methods for the surface preparation of ste to which red lead paint is to be applied, along with a table indicating the type

of structural steel, the exposure, drying time, L.I.A. recommended red lead paint and specification for the recommended cleaning methods.

SURFACE PREPARATION METHODS

Factors to be considered in selection of any metal protective paints are surface preparation and the condition of the surface at the time of application, the character of the base metal and the environmental exposure.

Only those surface preparation methods which are pertinent to structural steel cleaning and which are most generally used are considered in this Technical Letter. The major methods of surface preparation of steel may be classed under three categories:

I. Mechanical surface preparation
  1. Hand cleaning
  2. Power tool cleaning
  3. Sand or shot blasting
  4. Flame cleaning

II. Chemical surface preparation
  1. Weathering
  2. Chemical cleaning
    a. Alkali cleaning
    b. Pickling
    c. Steam cleaning
  3. Phosphate surface treatment

III. Solvent cleaning and degreasing

Each paint job presents factors which require a more or less specific type of surface preparation. The most common surface contaminants are grease-like substances, oxidation products such as mill scale and rust, moisture, salt deposits and those resulting from industrial chemical fumes.

Grime, grease and chemical deposits prevent contact between the metal surface and the primer paint. Moisture not only reduces the adhesion between the metal

surface and the paint, but also promotes the formation of corrosion products under the film by electrochemical processes. For the best service of a paint system the importance of intimate contact between the base metal and the prime coat cannot be overemphasized. Hence, in the preparation of structural steel for successful painting, complete removal of surface contaminants is mandatory.

The following are general descriptions of the more common surface preparation methods. Under each heading will be found a reference to the detailed specification for that method, which appears in Volume II, Steel Structures Painting Manual, published by Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh 13, Pa.

MECHANICAL SURFACE PREPARATION

Hand Cleaning

Hand cleaning is best adapted to spot cleaning for maintenance repainting and is not recommended for use over large areas where more effective methods are available. It hits only the high spots of a surface. The operation is most commonly accomplished with stiff, springy wire brushes, abrasive paper or cloth, scrapers, knives, chisels, or chipping hammers.

The hand cleaning operation varies with the type of mill scale and depth of corrosion. Wire brushing is one of the oldest methods of mechanical surface preparation and generally removes only loosely adhering mill scale, rust, old paint films, and dried or caked soil. It does not remove adhering mill scale. If stratified rust is present, it should first be removed by chipping and scraping before hand brushing. A surface which is flat and free of obstructions and irregularities may be hand brushed at a rate of two square feet per minute.

Chipping hammers remove most of the mill scale, but if the action is too vigorous over thin metal, it may deform or even pierce the metal. Chipping may drive mill scale or corrosion products into a soft metal surface. Chipping is usually followed by either wire brushing or scraping or both to remove loose mill scale or paint films. Unless care is exercised, some imbedded mill scale may remain which may cause localized early paint failure.

Hand scraping alone with a sharp-edged scraper is probably one of the least effective methods of surface cleaning of metal as it removes only semi-adhering mill scale and old paint films.

If oil or grease are present, solvent cleaning with frequent changes of the solvent should precede hand cleaning; otherwise oil or grease will spread over the descaled base metal. Should explosive vapors be present, a special non-sparking wire or tool must be employed.

SSPC-SP 2-52T

Power Tool Cleaning

Hand cleaning methods are duplicated by power tools designed for brushing, sanding, grinding, scaling, impact cleaning or chipping. The general sequence of operational techniques are the same as under hand cleaning. Power tool cleaning is more effective and more economical than hand cleaning for larger surfaces.

A large variety of shapes and sizes of brushes, grinders and sanders are available and are mostly of the rotary type. The electrically operated rotary brushes are effective at operational speeds of 300 to 3000 r.p.m. under load, while the rotational speed of the pneumatic driven brushes is regulated by the air pressure and the volume of the air. Power brushes may cut through thin mill scale but the wear on the brush is excessive. The power brush must be kept moving to prevent burnishing which produces a poor surface for painting.

Grinders and sanders are effective in the preparation of a surface when the abrasive grit size is carefully selected for the job at hand.

While power operated scaling and chipping hammers are faster than the hand operated type, they are slow as compared to other available methods. For very thick surface accumulations, they have merit. The tool must be kept sharp. The operator must be careful not to remove sound metal, drive mill scale into soft metal, or leave metal burrs on the surface, the latter two conditions contributing to early paint failure.

Oil and grease should be removed by solvent cleaning before power tool cleaning to prevent spreading.

In either hand cleaning or power tool cleaning a primer coat of red lead paint should be applied before any rusting becomes visible. A paint system of two initial coats of red lead primer followed by suitable finish coats will give excellent service.

SSPC-SP 3-52T

Sand or Shot Blasting

Sand or shot blasting procedures are employed where all the mill scale, rust, rust-scale, foreign matter (except heavy deposits of grease or oil), or paint are to be removed and the base or "white" metal exposed for paint application. Both processes are based upon the abrasive action on the surface of various sized particles of sand, shot, grit or other abrasives being discharged, either wet or dry, at high pressure. Metal or non-metallic synthetic shot or grit is usually employed where recovery of the abrading agent is possible, while sand is used primarily for operations in which the abrading agent is expendable.

Successful blasting techniques require careful consideration of pressures, size of nozzle, distance of nozzle from the surface, kind of material to be removed, type of abrasive, loss of abrasive, health hazard, cost of abrasive, and type of surface preparation required.

The grit should be of sufficiently small size to remove effectively the surface contaminants without excessive working of the metal surface or the formation of crater-like surface depressions, ridges or metal hairs. The paint may not provide adequate film thickness over the ridges or tips of the metal hairs, and thus they become focal points of premature paint film failure. Excessive surface working of the metal may develop unequal stresses in some surface areas and become cathodic to adjacent areas. This will accelerate corrosion as the paint film commences to fail.

Dry sandblasting, although widely used, should be done with due health precautions, not only to protect the operator from fine abrasive dust but also other

workmen in the immediate environment. Machinery in the vicinity of sandblasting operations should be shielded.

Wet or hydraulic sand or shot blasting eliminates abrasive dust hazards, but if water soluble inhibitors such as chromate or phosphate types are used, they present different health hazards which must be met with proper precautions.

The time lag between completion of blasting and priming is dependent upon the type of blasting, the humidity of the surroundings or the presence of soluble inhibitors in the wet blasting fluid. Any blasted surface should be further chemically treated or primed with red lead paint before any visible rusting occurs.

On surfaces prepared by sand or shot blasting two primer coats of red lead paint followed by a suitable finish coat should give 10 to 12 years of service.
SSPC-SP 5-52T

Flame Cleaning

Flame cleaning may be used on many fabricated shapes where the structural sections are of proper stock thickness, are readily accessible, not subject to warping, and where dehydration of the surface is mandatory. Flame cleaned surfaces must be painted before condensation commences; hence, they should be painted while still warm and dry. Recommended practice requires painting within two hours.

Flame cleaning is used to remove unbonded mill scale and old mill scale which has been previously painted. Rarely does flame cleaning remove all the mill scale. It must be followed by wire brushing and dusting before priming. Flame cleaning should not be used on stock less than 3/16 in. thick.
SSPC-SP 4-52T

CHEMICAL SURFACE PREPARATION

Weathering

Possibly the oldest surface cleaning operation is atmospheric weathering, a process whereby the removal of the mill scale is primarily dependent upon the corrosion of the metal and the subsequent loosening of the mill scale by creeping of the rust between the mill scale and the base metal. In six months to a year most of

the loosened mill scale will have fallen off. Any remaining products of corrosion and partially loosened mill scale must be removed by sandblasting, wire brushing, scraping, or chipping before the surface is primed. Areas of tightly adhering mill scale can only be completely removed by sandblasting. Once the base metal is exposed, it should be immediately coated with a red lead primer. Usually, in clear weather, six hours or less will serve as a safe time interval between completion of sandblasting and application of a red lead primer.

Field reports indicate this method of surface preparation followed by two coats of a red lead primer paint and a suitable top coat will provide from 8 to 10 years of adequate protection.

SSPC-SP 9-52T

Chemical Cleaning

Alkali Cleaning

Alkali cleaning is more efficient and less hazardous than solvent cleaning. Alkali cleaners include soak tank cleaning, pressure spray cleaning, electrolytic cleaning, scrubbing and brushing for structural steel assemblies.

Alkali cleaning removes oil, grease and soluble rust stimulators. Alkali cleaning does not remove heavy or carbonized oils or rust inhibitive oils. The surface is left alkaline and before painting it must be rinsed in a dilute acid water solution to prevent saponification of a primer vehicle.

Pickling

Pickling is an effective method of surface preparation for painting. Mill scale and corrosion products are completely removed by pickling degreased iron or steel in dilute acid solution.

The main disadvantage of this method lies in the necessity for following the pickling with a neutralizing and water rinsing operation to remove all free acid and reaction products, and then a rinsing in either dilute phosphoric acid or chromic acid solution or mixtures of these to create an inhibited metal surface effect with a pH between 3 and 5. This must be followed by a thorough drying of the metal surface prior to painting.

The undesirable attack of the base metal by the pickling acid is minimized and regulated by the use of suitable inhibitors which may be dissolved in the pickling bath. These inhibitors create and regulate a preferential selective attack on the mill scale and corrosion products. The surface should not be etched excessively, but slight etching of the surface aids in the mechanical adhesion of the paint film.

This type of surface preparation is limited mainly to either small size objects or structural shapes that are easily handled.

Red lead primer painting of the pickled surface should be done before the thin surface left by the chemical treatment shows any visible signs of corrosion.

After this type of surface preparation, two coats of red lead primer paint followed by a suitable top coat should give adequate service for 10 to 12 years.
SSPC-SP 8-52T

Steam Cleaning

Where the size, shape or location makes it impossible to solvent wipe the surface, steam cleaning is becoming quite general in field surface preparation. Steam cleaning removes dirt and grime or existing paint, but does not remove rust or mill scale. Steam cleaning removes oxidized paint more efficiently than wire brushing alone.

The most efficient steam cleaning includes the addition of detergents to the steam-water mixture. If the detergent-steam-water mixture is sufficiently alkaline, it will remove grease also.

The surface after steam cleaning is usually alkaline and must be adequately rinsed to prevent saponification of the paint vehicle.

Phosphate Surface Treatment

Phosphate treatment leaves the surface in a satisfactory condition for maximum paint life, but it does not remove mill scale. Therefore, for the most efficient treatment the surface should be pickled or blasted prior to phosphate treatment. Insoluble metal phosphates resulting from the phosphate treatment extend the life of the paint film by improving adhesion, retarding underfilm corrosion, reducing

electrochemical action and the decomposition of the paint vehicle by corrosion products. The metal phosphate surface is strong and flexible enough to withstand thermal shock.

The phosphate treatment has been applied by spray process, immersion, brushing, or portable spray equipment.

The MIL-C-10578 specification may be consulted for details. The U. S. Corp of Engineers Manual for Painting (1953) refers to cold phosphate or chemical metal conditioners.

When properly applied, phosphate surface treatment has been successfully used on ship plates, river dam gates, locks, etc. The paint application and service are the same as for pickled iron or steel.

SSPC-PT 2-53T

SOLVENT CLEANING AND DEGREASING

Structural steel may be solvent cleaned by wiping, dipping, or spraying, depending upon the size of the members. Wiping is widely used. It removes the oil and grease readily and rapidly and requires a minimum of floor space.

In the use of solvent cleaning by wiping the solvent must be changed frequently to prevent spreading of the oil and grease, and due precaution, depending upon the solvent employed, must be observed to guard against fire hazards and toxicity of the solvent. Solvent cleaning does not remove rust or mill scale.

Military Specification, MIL-P-116a, gives cleaning methods for steel and mentions the type of petroleum solvent to use. Federal Specification P-S-661 or ASTM Specification D484-40 cover the use of the "Stoddard Solvent." Federal specifications are available for most of the important solvents.

SSPC-SP 1-52T

SURFACE PREPARATION OF STEEL RECOMMENDED FOR RED LEAD PAINTS (Quick Reference Summary)

IF YOU HAVE TO PAINT:	FOR THIS TYPE OF EXPOSURE:	AND THE DRYING TIME REQUIRED IS	THEN THE * RECOMMENDED RED LEAD PRIMER IS:	AND THE ** FOLLOWING SURFACE PREPARATION IS RECOMMENDED:	BUT THESE STEPS MAY ALSO BE REQUIRED:
Structural Steel	Atmospheric	36 Hr.	L.I.A. 6-1	Hand Cleaning SSPC-SP 2-52T or Power Tool Cleaning SSPC-SP 3-52T	Solvent Cleaning to precede other cleaning. SSPC-SP 1-52T
Structural Steel, Oil Storage Tanks	Chemically Contaminated Atmospheres and Marine Environments	24 Hr.	L.I.A. 3-7	Blast Cleaning SSPC-SP 5-52T or Pickling SSPC-SP 8-52T	
Structural Steel	Atmospheric	16 Hr.	L.I.A. 6-7	Blast Cleaning SSPC-SP 5-52T or Pickling SSPC-SP 8-52T	
Structural Steel	Atmospheric	24 Hr.	L.I.A. 6-3	Hand Cleaning SSPC-SP 2-52T or Power Tool Cleaning SSPC-SP 3-52T	Solvent Cleaning to precede other cleaning SSPC-SP 1-52T
Structural Steel	Atmospheric	4 Hr.	L.I.A. 6-13	Commercial Blast Cleaning SSPC-SP 6-52T or Pickling SSPC-SP 8-52T	
Structural Steel, Especially Building Frames	Atmospheric, Temporary (6 Mos.)	8 Hr.	L.I.A. 11-2	Solvent Cleaning SSPC-SP 1-52T and Wire Brushing SSPC-SP 2-52T	

(*) (**) See footnotes on page 17.

IF YOU HAVE TO PAINT:	FOR THIS TYPE OF EXPOSURE:	AND THE DRYING TIME RE-QUIRED IS:	THEN THE* RECOMMENDED RED LEAD PRIMER IS:	AND THE** FOLLOWING SURFACE PREPARATION IS RECOM-MENDED:	BUT THESE STEPS MAY ALSO BE REQUIRED:
Railroad Rolling Stock	Atmospheric	18 Hr.	L.L.A. 8-8 or 8-9	Hand Cleaning SSPC-SP 2-52T or Power Tool Cleaning SSPC-SP 3-52T	Solvent Cleaning To Precede Other Cleaning SSPC-SP 1-52T
Hydraulic Structures, e.g. Crest Gates, Sluice Gates, Tainter Gates, Exposed Structural Steel at Pumping Stations	Partial or Continuous Immersion in Fresh Water	6 Hr.	L.L.A. 7-4	Blast Cleaning SSPC-SP 5-52T and Coating Pretreatment MIL-C-15328A	
Hydraulic Structures, e.g. Crest Gates, Sluice Gates Tainter Gates, Exposed Structural Steel at Pumping Stations	Partial Immersion in Fresh Water	1 Hr.	L.L.A. 7-5	Blast Cleaning SSPC-SP 5-52T and Coating Pretreatment MIL-C-15328A	
Ships (Topsides, Interiors, Boot-Topping), Bridges Over Tidewater, Docks	Marine, Intermittent Immersion in Sea Water	6 Hr.	L.L.A. 6-16	Blast Cleaning SSPC-SP 5-52T or Pickling SSPC-SP 8-52T	
Ships (Topsides, Interiors, Boot-Topping), Oil Storage Tanks	Marine, Intermittent Immersion in Sea Water, Chemically Contaminated Atmospheres	1 Hr.	L.L.A. 6-26	Blast Cleaning SSPC-SP 5-52T or Pickling SSPC-SP 8-52T	
Ship Bottoms, Buoys	Immersion in Sea Water	4 Hr.	L.L.A. 6-24	Blast Cleaning SSPC-SP 5-52T or Pickling SSPC-SP 8-52T	

(*) (**) See footnotes page 17.

IF YOU HAVE TO PAINT:	FOR THIS TYPE OF EXPOSURE:	AND THE DRYING TIME RE-QUIRED IS:	THEN THE[b] RECOMMENDED RED LEAD PRIMER IS:	AND THE[cc] FOLLOWING SURFACE PREPARATION IS RECOM-MENDED:	BUT THESE STEPS MAY ALSO BE REQUIRED:
Galvanized Steel, One Coat	Atmospheric	18 Hr. 4 Hr. 18 Hr.	L.I.A. 9-1 9-2 or 9-3	Solvent Cleaning SSPC-SP 1-52T and Phosphate Pre-treatment SSPC-PT 2-53T	
Weathered or Rusted Galvanized Steel, One Coat	Atmospheric	18 Hr. 4 Hr. 18 Hr.	L.I.A. 9-1 9-2 or 9-3	Solvent Cleaning SSPC-SP 1-52T and Wire Brushing SSPC-SP 2-52T	
New Galvanized Steel, Top Coat to be Applied	Atmospheric	18 Hr. 4 Hr.	L.I.A. 9-4 or 9-5	Solvent Cleaning SSPC-SP 1-52T and Phosphate Pre-treatment SSPC-PT 2-53T	
Weathered or Rusted Galvan-ized Steel, Top Coat to be Applied	Atmospheric	18 Hr. 4 Hr.	L.I.A. 9-4 or 9-5	Wire Brushing SSPC-SP 2-52T and Solvent Cleaning SSPC-SP 1-52T	

b The recommended red lead primer formulas may be found in Red Lead Technical Letters of the Lead Industries Association. The first number is the number of the Technical Letter in which that formula appears and the second is the number of the formula in that Technical Letter.

cc All SSPC specifications referred to herein may be found in Volume II of Steel Structures Painting Manual, Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh 13, Pa. MIL specifications may be obtained from any General Services Administration Regional Office.