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SSPC: The Society for Protective Coatings

PAINTING SYSTEM GUIDE NO. 8.00

Guide to Topcoating Zinc-Rich Primers

1. Scope

1.1 This guide covers the selection and application (including surface preparation) of topcoats to surfaces coated with zinc-rich primer. Both organic and inorganic zinc-rich primers are included.

1.2 The guide does not cover the selection and application of the zinc-rich primer.

2. Description

2.1 This guide represents good practice for topcoating zinc-rich primers as determined by industry consensus. It may not be applicable to all materials and conditions encountered.

2.2 Zinc-rich primers are topcoated to provide extended exterior durability in severe exposures; to improve color, gloss, and other appearance properties; and to provide resistance to specific conditions such as highly acidic or highly basic environments.

2.3 Information on the use of one-coat zinc-rich painting systems is provided in SSPC Painting System Specification 12.01.

2.4 DEFINITIONS:

2.4.1 Bubbling: The phenomenon caused by air or solvent vapors rising out of primer pores and being trapped because the topcoat has skinned over.

2.4.2 Burnishing: The polished effect that results from rubbing a zinc-rich primed surface.

2.4.3 Crater: A small bowl-shaped depression in a coating film.

2.4.4 Curing (cure): The process whereby an applied coating film achieves its ultimate physical and chemical properties. Cure time and dry time are generally not identical, as curing may continue after coating is dry to touch.

2.4.5 Dry spray: The condition that results from the paint losing too much solvent before reaching the substrate. Dry overspray is a nonadherent form of dry spray consisting of discontinuous particulate, which occurs when dry paint particles are deposited on an otherwise acceptable surface.

2.4.6 Gassing: See Bubbling.

2.4.7. Mist coats: Very thin spray coats, usually about one-fourth of the required wet film thickness. The application of a mist coat prior to the application of a full topcoat is used to minimize pinholing, bubbling, and cratering of the topcoat system.

2.4.8 Mudcracking: A surface condition characterized by cracks that extend into the body of the zinc-rich primer. The appearance of the surface is that of a dried mud puddle.

2.4.9 Pinhole: A film defect characterized by small porelike flaws in a single coat which extend entirely through that coat and have the general appearance of pin pricks when viewed by reflected light. The term is generally applied to holes caused by solvent bubbling, moisture, other volatile products, or the presence of extraneous particles in the applied film.

2.4.10 Primer: The first complete coat of paint of a painting system applied to a substrate.

2.4.11 Tie coat: An intermediate coat used to bond different types of paint coats.

2.4.12 Topcoat: The coating intended to be the last coat applied in a coating system. The topcoat is usually applied over a primer, under-coats, or surfacers. It is also known as finish coat.

2.4.13 Wash coat: A very thin, semi-transparent coat of paint, applied as a preliminary coating on a surface, which acts as a sealer or tie coat.

2.4.14 Zinc-rich primer: An anti-corrosive primer for steel incorporating zinc dust in a concentration sufficient to give electrical conductivity in the dried film, which enables the zinc metal to corrode preferentially to the substrate, i.e., to give cathodic protection.

2.4.15 Zinc salt formation: A non-uniform white discoloration on the surface of a zincrich paint produced by reaction of zinc dust with atmospheric constituents. It is sometimes referred to as "white rust."

3. Reference Standards

3.1 The standards referenced in this guide are listed in Sections 3.2 through 3.3.

3.2 SSPC STANDARDS AND JOINT STANDARDS:

PA 1	Shop, Field, and Maintenance Painting of Steel
PA 2	Measurement of Dry Coating Thickness With Magnetic Gages
Paint 20	Zinc-Rich Primers (Type I - Inorganic and Type II - Organic)
Paint 27*	Basic Zinc Chromate – Vinyl Butyral Wash Primer
Paint 29	Zinc Dust Sacrificial Primer, Performance-Based
PS Guide 12.00	Guide for Selecting Zinc-Rich Painting Systems
PS 12.01	One-Coat Zinc-Rich Painting System
SP 1	Solvent Cleaning

3.3 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS:

D 3359	Test Methods for Measuring Adhesion by Tape Test
D 4541	Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
D 4752	Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub

4. Selection of Topcoat

4.1 IDENTIFY PRIMER: Proper selection of topcoats requires identification of the generic (chemical) type of primer. Often the specific product name is needed as well. First determine the class of primer in accordance with SSPC-Paint 20, which categorizes zinc-rich primers by the type of vehicle and curing mechanism. If the primer has already been applied, record the date of application, manufacturer's name, product identification, batch number, and manufacturing date. If the primer has been selected but not applied, record the name of the manufacturer and the product designation. It is good painting practice to obtain the primer, intermediate coat (if any), and topcoat from the same manufacturer.

4.2 COMPATIBILITY CONSIDERATIONS: When topcoating zinc-rich primers, consideration must be given to the fact that zinc is being coated, not steel. Coatings based on drying oils, such as most oil and alkyd types, tend to react with the zinc metal to form zinc soaps, resulting in loss of adhesion and peeling of the topcoat. Coatings that have poor alkali resistance should not be applied directly to zinc-rich primers. In general, oil-containing vehicles such as oil paints, alkyd enamels, vinyl alkyds of the oxidizing type, long-oil silicone alkyds, and epoxy esters should not be applied directly to zinc-rich primers.

4.3 SELECT COMPATIBLE TOPCOAT: Table 1 lists commonly used zinc-rich primers and topcoats. For each combination, this table indicates the degree of acceptability, ranging from A (used directly) to E (not recommended). If the primer type has previously been identified, select a topcoat based on the information in 4.1, 4.2, Table 1, and Note 7.1. If the primer has not been identified, select a primer based on the information in 4.2, Table 1, and Note 7.2.

5. Surface Preparation and Repair of Primer

5.1 IDENTIFY AND REPAIR DEFECTS: The zinc-rich primer to be topcoated must be inspected for defects, and the defects must be repaired before the application of a topcoat. These defects include red rust, low dry film thickness (DFT), high DFT, dry overspray, mudcracking, foreign matter, and loose zinc salts. The coating manufacturer should supply recommended procedures for the repair of defects. Some general guidance is provided below.

5.1.1 Red Rust: Red rust resulting from the corrosion of the steel substrate and loose deposits of rust stain must be removed. However, light adherent stain, resulting from rust running from adjacent rusted areas, need not be removed. As there are many different acceptable repair procedures, the manufacturer's recommendations should be considered.

5.1.2 Low Dry Film Thickness: The dry film thickness should be measured in accordance with SSPC-PA 2. Low dry film thickness should be repaired before topcoating, based upon the recommendations of the zinc-rich primer manufacturer.

5.1.3 Excessive Dry Film Thickness: Excessive film thickness above maximum acceptable levels should be repaired by complete removal and reapplication of the primer. The amount of zinc-rich primer that is excessive is highly dependent on the formulation, the environment, the requirements for use, and the curing conditions. The most common value for maximum acceptable DFT is 125 to 150 micrometers (5 to 6 mils), based on a survey of suppliers, specifiers and applicators. For some zinc-rich primers, the maximum DFT may be as low as 90 micrometers (3.5 mils), while for certain organic zinc-rich primers a maximum DFT of 250 micrometers (10 mils) is acceptable.

TABLE 1
Acceptability of Primer/Topcoat Combinations[1]
Generic Type of Pimer

	Inorganic Zinc-Rich Primer			Organic Zinc-Rich Primer	
	Post-Cure Water-Borne Type 1A[2]	Self-Cure Water-Borne Type 1B	Self-Cure Solvent-Borne Type 1C	Thermoplastic (Solvent Evaporation Cure) Type IIA	Thermoset (Chemical Cure) Type IIB
Topcoat					
Vinyl	B	B	B	C	B
Epoxy[3]	A	A	A	E	A
Acrylic Solution	D	D	D	B	A
Chlorinated Rubber	B	B	A	A	A
Polyurethane[4]	B	B	B	B	B
Phenolic	B	B	B	E	A
Silicone	A	B	A	B	B
Alkyd	E	E	E	E	E
Epoxy Ester	D	D	D	D	D
Silicone Alkyd	D	D	D	D	D
Oil Urethane	D	D	D	D	D
Oil Phenolic	D	D	D	D	D
Linseed Oil	D	D	D	D	D
Coal Tar Epoxy	B	B	B	E	A
Vinyl Alkyd	D	D	D	D	D

A Generally used directly on zinc with no difficulties.
B Some formulations can be used directly; others require a tie-coat.
C Lifting of zinc-rich primer is likely to occur unless well aged.
D Not recommended unless tie-coat is added.
E Not recommended.

[1] These are general guidelines, not hard and fast rules. This list is not exhaustive. Always consult the manufacturer's recommendation.
[2] See SSPC-Paint 20.
[3] Chemical cure such as epoxy amine, epoxy polyamide, epoxy polyamine, or epoxy phenolic.
[4] Must be oil-free and alkali resistant.

5.1.4 Dry Overspray: A piece of wadded-up screen wire or screening attached to a wooden block may be used to remove dry overspray (defined in 2.4.5). In the latter case, the wooden block may be shaped to fit the structural members involved. Tightly adhering zinc coats should not be removed.

5.1.5 Mudcracking: This condition (defined in 2.4.8) usually results from excessive dry film thickness in a single coat. Mudcracking that is visible without magnification shall be corrected according to the manufacturer's recommendations This defect can occur anywhere, but it is most likely to occur at inside corners and fillet welds.

5.1.6 Foreign Materials: Dirt, mud, grease, oil, and other foreign materials must be removed prior to topcoating. Usually detergent and solvent cleaning, in accordance with SSPC-SP 1, are sufficient. The manufacturer of the primer and topcoat may be contacted for specific recommendations.

5.1.7 Zinc Salts: Zinc-rich primers may form varying types and amounts of surface salts depending upon exposure. Loose zinc salts must be removed prior to topcoating, as they may have detrimental effects on the coating system. Such salts may be removed by fresh water washing and scrubbing. To achieve satisfactory results when topcoating post-cured inorganic zinc primers, it is important to clean the cure residue from the surface before applying topcoats. Normally, this is done by water washing, using a stiff bristle brush for stubborn residues.

Adherent zinc salts need not be removed for atmospheric exposure service (Note 7.3). Under immersion service, however, water-soluble zinc salts, even if adherent, may cause blistering or other problems when the zinc-rich primer is topcoated (Note 7.4). Such water-soluble

salts should be removed by thorough fresh water washing and scrubbing prior to the application of the topcoat. Wetted surfaces must be dry prior to the application of the topcoat.

5.2 ENSURE ADEQUACY OF CURE: The film formation of most zinc-rich primers includes solvent evaporation (drying) and chemical reaction (curing). To properly receive a topcoat, the primer must be adequately dried and cured. Typically, 90% or more of the solvent will evaporate within the first 15 minutes. Completion of the chemical reaction of curing may require weeks or months; however, the primer can receive a topcoat in a shorter period of time than required for full curing (see Note 7.5).

5.2.1 Factors That Affect Cure:

5.2.1.1 Humidity: Depending on the type of primer, the time to cure can be significantly altered by humidity conditions. Many primers (especially solvent-borne inorganic) do not cure below 40% relative humidity. For some primers in low humidity environments, the application of a thin film of water after the initial drying can be used to promote curing mechanisms. In humidity over 90%, some water-borne inorganic zinc primers do not properly cure.

5.2.1.2. Temperature: The time to cure and the extent of cure for many zinc-rich primers is also affected by temperature. The manufacturer should be contacted for specific recommendations regarding temperature and humidities for curing prior to topcoating.

5.2.1.3 Dry Film Thickness: For almost all zinc-rich primers, thicker films require longer cure times. Solvent-borne inorganic zinc-rich primers, especially the single-component types, are particularly sensitive to this effect. No published data comparing dry film thickness to cure time could be found.

5.2.2 Methods to Assess Adequacy of Cure: The recommendations of the zinc-rich primer manufacturers are the most important factors in determining the adequacy of cure of a zincrich primer. Some general methods for determining zinc-rich primer cure are listed below:

5.2.2.1 Solvent Rub: This method is only applicable to ethyl silicate zinc-rich primers which do not have butyl or other organic modifiers. As described in ASTM D 4752, a clean rag soaked in methyl ethyl ketone (or other suitable solvent) is rubbed over the primer 50 times. No residue, or only traces of residue on the rag, indicates adequate cure.

5.2.2.2 Coin Rub: A quick and easy method to assess adequacy of cure is to rub the primer with the edge of a coin; if the film burnishes, it is acceptable. Some zinc-rich primers which do not burnish may still be acceptable for topcoating, if so indicated by the manufacturer.

5.2.3 Correcting Undercured Inorganic Zinc Primer:

5.2.3.1 If the inorganic zinc-rich primer is undercured due to insufficient humidity, proper curing may be achieved by a longer curing time, or by curing at a high humidity level, achieved through natural weather variations or artificial means, such as spraying the primed surface with water.

5.2.3.2 Undercured water-borne inorganic zinc-rich primers may be corrected by furnishing clean, dry air to aid in water evaporation. In some cases, an acidic post-curing solution may be applied, followed by thorough rinsing.

5.2.3.3 If it is determined that the inorganic zinc-rich primer is not cured and cannot attain a satisfactory condition for topcoating, the zinc-rich primer must be removed, and a new primer must be applied. This condition is generally due to excessive solvent retention or insufficient reaction of the vehicle with oxygen, moisture, or catalyst.

6. Application of Topcoats

6.1 GENERAL:

6.1.1 The surface of the zinc-rich primer to be topcoated should be free of loose zinc salts, dry spray, foreign materials, and other defects described in Section 5.1. The primer should be free of moisture. (See Note 7.6.)

6.1.2 The primer should be adequately cured as described in Section 5.2, based on the requirements of the primer manufacturer.

6.1.3 The topcoat application should be in accordance with SSPC-PA 1.

6.1.4 Factors that affect the acceptability and performance of a topcoated zinc-rich primer include porosity of primer, extent of topcoat bubbling, and adhesion of topcoat. General guidelines are given below.

6.2 POROSITY OF PRIMERS: A zinc-rich primer consists of particles of zinc metal bound to each other by a suitable inorganic or organic binder. The zinc dust content of the dry film may vary from 74 to 95 percent of the total weight. (See Note 7.7.) The small amount of binder results in a very high pigment volume concentration for both organic and inorganic zinc-rich primers, resulting in a porous coating. Porosity becomes more pronounced if the zinc-rich primer is dry sprayed, the weather is hot, the equipment is improperly adjusted, or the applicator fails to apply the zinc-rich primer in a full wet coat. These conditions contribute to pinholing, bubbling, and cratering of the topcoat, the sever-

ity of which may vary with the type of binder used.

6.3 TOPCOAT BUBBLING AND PINHOLING:

6.3.1 Origin of Bubbles and Pinholes: If the topcoat is capable of penetrating the pores and forming a film, this penetration may provide a base for initial adhesion. However, when organic topcoats and their solvents penetrate into the pores of the primer, they may also force air up through the wet film of paint. A bubble or crater results if the surface has "skinned over" or has lost its ability to flow. Pinholes may also occur under these circumstances (see 2.4.1, 2.4.3, and 2.4.9).

6.3.2 Occurrence of Bubbles and Pinholes: Generally, the self-curing inorganic zinc primers have a greater tendency to cause bubbling or pinholing in the topcoat than post-curing inorganic or organic zinc-rich primers. High build coatings especially formulated for application over zinc-rich coatings can reduce bubbling and other application problems. Low build coatings—especially gloss or semi-gloss coatings—have a greater tendency for bubbling or pinholing. Generally, the greater the thickness of the zinc-rich primer, the greater the tendency for bubbles and pinholes to form in the topcoat. Post-cured inorganic zinc primers show less tendency for application bubbling and pinholing in the topcoat as compared to typical solvent-borne self-curing inorganic zinc primers.

6.3.3 Repair of Bubbles and Pinholes: Bubbles, pinholes, or craters are unsightly and should be avoided using the methods in 6.4. They can be repaired by sanding the affected areas, followed by reapplication of the topcoat. When properly repaired, they do not affect the performance of the system. If left unrepaired, the performance may be affected if the environment is characterized by aggressive chemical fumes or chemical contaminants, combined with high humidity and condensed moisture.

6.4 MINIMIZING BUBBLING AND PINHOLING:

6.4.1 Some manufacturers recommend the application of a thin mist coat of the topcoat to reduce bubbles, pinholes, and craters, while others recommend a thinned coat of the topcoat. Both are followed by a full wet coat of the topcoat. The application of the topcoat in two coats (a mid coat/full coat or a thinned coat/full coat) rather than a single heavy coat, will reduce the chance of surface defects, such as pinholes and bubbles.

6.4.2 Other manufacturers recommend using a tie coat, such as vinyl wash primer (SSPCPaint 27) to condition the substrate. The acid component of the wash primer reacts with the zinc and allows the wash primer to bond to the zinc-rich primer. This may be followed by a topcoat of any compatible type. Other specially formulated tie coats may also be used to promote adhesion for topcoats.

6.5 ADHESION OF TOPCOATED SYSTEMS: Three common methods of measuring adhesion of topcoated zinc-rich primer systems have been identified. However, no consensus for minimally acceptable adhesion ratings could be established for any of these methods. The user should consult the coatings manufacturer regarding appropriateness and interpretation of adhesion test results. The three methods for measuring adhesion are:

6.5.1 X-Cut Tape Test (ASTM D 3359 - Method A): An X-cut is made in the film to the substrate, pressure sensitive tape is applied over the cut, and then removed. Adhesion is assessed quantitatively on a scale of 0 to 5 by comparison with descriptions.

6.5.2 Cross Cut Tape Test (ASTM D 3359 - Method B): A lattice pattern with either 6 or 11 cuts in each direction is made in the film to the substrate; pressure sensitive tape is applied over this area and then removed. Adhesion is assessed by comparison with descriptions and illustrations on a scale of 0 to 5. There shall be no separation of the paint film or delamination of an entire square. Spalling, loss of adhesion around the perimeter due to cutting of each square, is acceptable. This method is NOT recommended for film thicknesses greater than 125 micrometers (5 mils).

6.5.3 Portable Adhesion Testers (ASTM D 4541): A dolly is glued to the coating surface, then pulled off. The force required to remove the dolly, as well as the nature of the disbonding, are evaluated. This test provides a quantitative measure of the pull-off strength, but reproducibility of this method and the significance of the adhesion values have yet to be established.

6.6 TOUCH-UP AND REPAIR OF TOPCOATED ZINC-RICH PRIMER: Touch-up and repair of topcoated zinc-rich primers may be required when the topcoat is damaged, when areas intended to be topcoated are missed, or when the total dry film thickness is insufficient. The methods of touch-up and repair depend upon the specific generic type of the topcoat (e.g., epoxy, vinyl, or urethane) and the time interval between the original topcoating and the touch-up and repair operation. The new coating should be applied to provide uniform appearance with the existing coating, including feathering of edges. The surface may require cleaning by solvent, detergent, or pressurized water to remove dirt, grease, and other surface contaminants. Two-component, chemically-curing topcoats may require mechanical abrading to provide adequate surface roughness, even when reapplied over the same generic type of coating. The topcoat manufacturer should be consulted for the procedures for specific coatings.

7. Notes

7.1 Although all of the generic coating types listed in Table 1 have been successfully applied as topcoats over zinc-rich primers, combining different manufacturers' formulations may adversely affect coating performance. No coating should be applied to a zinc-rich primer unless recommended by the manufacturer for that purpose. It is good painting practice to use primer, intermediate coat (if any), and topcoat produced by the same manufacturer.

7.2 Other factors that may influence selection of topcoat and primer-topcoat combinations are: specific durability of topcoats in intended exposure environments, appearance of the finished coat, recoatability, heat resistance, and cost. Information on these factors may be found in SSPC Painting Manual, Volume 1, Good Painting Practice, as well as other technical publications, and from coatings manufacturers. The general appearance of a properly applied zinc-rich topcoated system is acceptable for typical industrial applications; however, an appearance as smooth as an automotive finish coat should not be expected.

7.3 To achieve satisfactory results when topcoating post-cured inorganic zinc primers, it is important that the cure residue be cleaned from the surface before applying topcoats. Normally, this is done by water washing, using a stiff bristle brush for stubborn residues.

7.4 Topcoated zinc-rich primers should not be used for immersion service unless specifically recommended by the manufacturer.

7.5 Because of possible delamination and zinc splitting when topcoating an undercured inorganic zinc, this procedure should only be used in accordance with the manufacturer's recommendations.

7.6 Certain topcoats have a high sensitivity to moisture. For example, amine-cured epoxy coatings may show large blisters if any moisture remains in the pores of the zinc primer at the time of topcoat application.

7.7 SSPC specification (SSPC-Paint 29, "Zinc Dust Sacrificial Primer, Performance-Based") describes a primer with zinc dust loading in the dry film down to 50 percent. SSPC field tests have shown that the practical lower limit for zinc loading is 65 percent. These reduced loading primers may use varying amounts of non-zinc pigment to replace some or all of the zinc dust. These coatings often have topcoating properties comparable to paints meeting the requirements of SSPC-Paint 20, "Zinc-Rich Primers Type I—Inorganic & Type 11—Organic."

8. Disclaimer

8.1 While every precaution is taken to ensure that all information furnished in SSPC standards and specifications is as accurate, complete, and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, coatings, or methods specified herein, or of the specification or standard itself.

8.2 This guide does not attempt to address problems concerning safety associated with its use. The user of this guide, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for insuring compliance with all governmental regulations.

* This paint contains chromate pigments. Users are urged to follow all health, safety, and environmental requirements in applying, handling or disposing of these materials.