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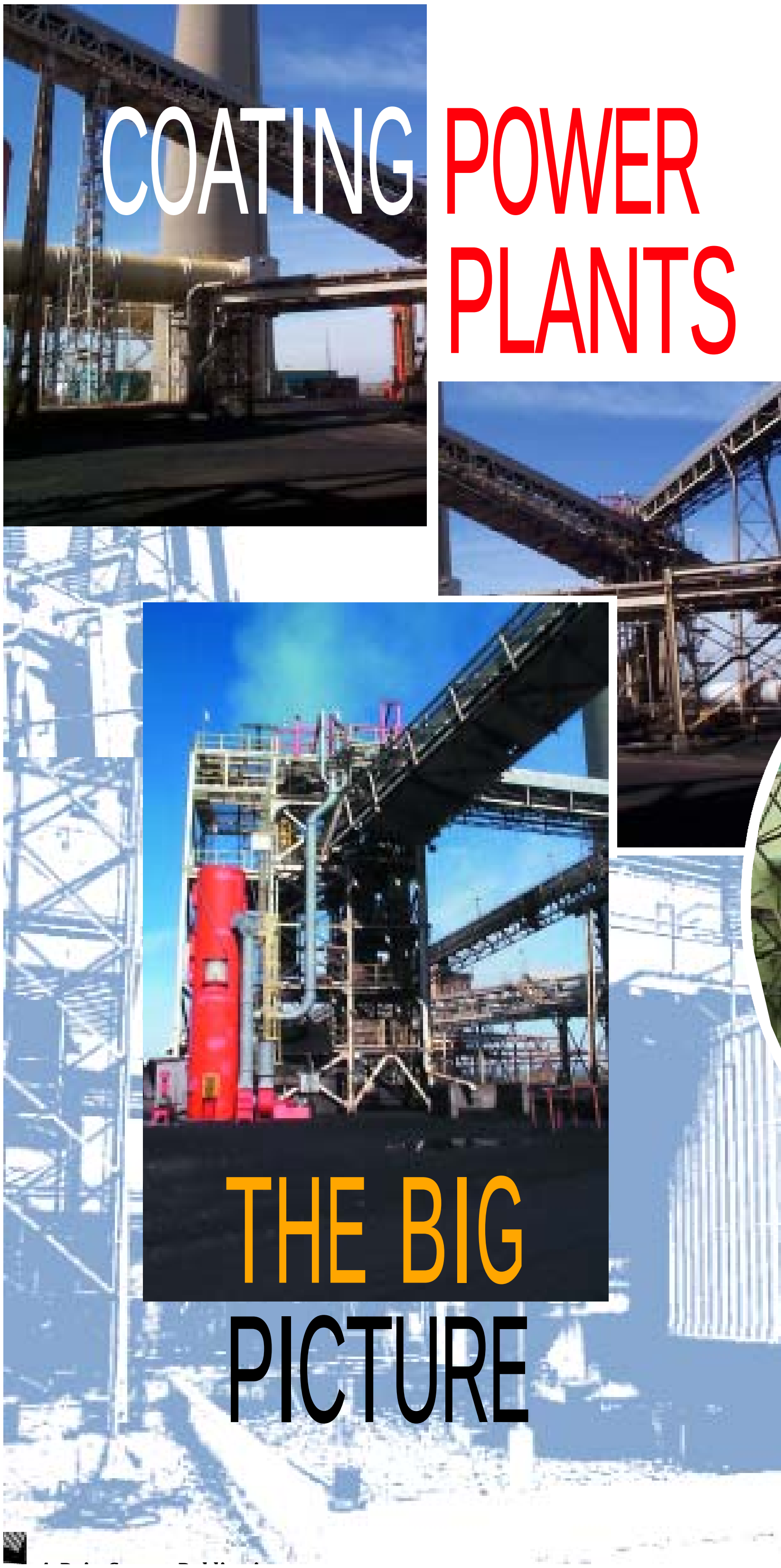

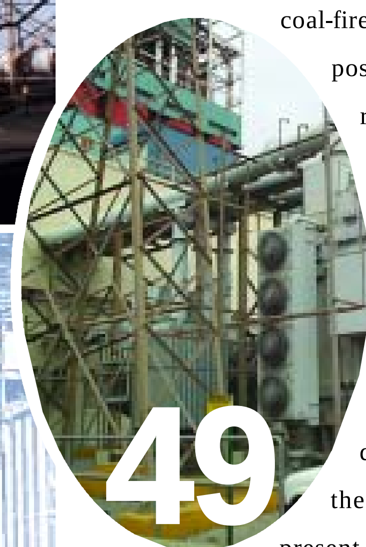

A Guide for Coating Conventional Power Plants

By Curtis Hickcox, Keeler & Long PPG

Of all of the types of power plants, coal-fired plants probably pose the toughest environment for coatings. Surfaces in these plants are exposed to a wide pH spectrum, with each surface requiring coatings specifically designed to handle the unique conditions present. The author discusses coating selection and surface preparation for most of the main areas of a coal-fired plant.

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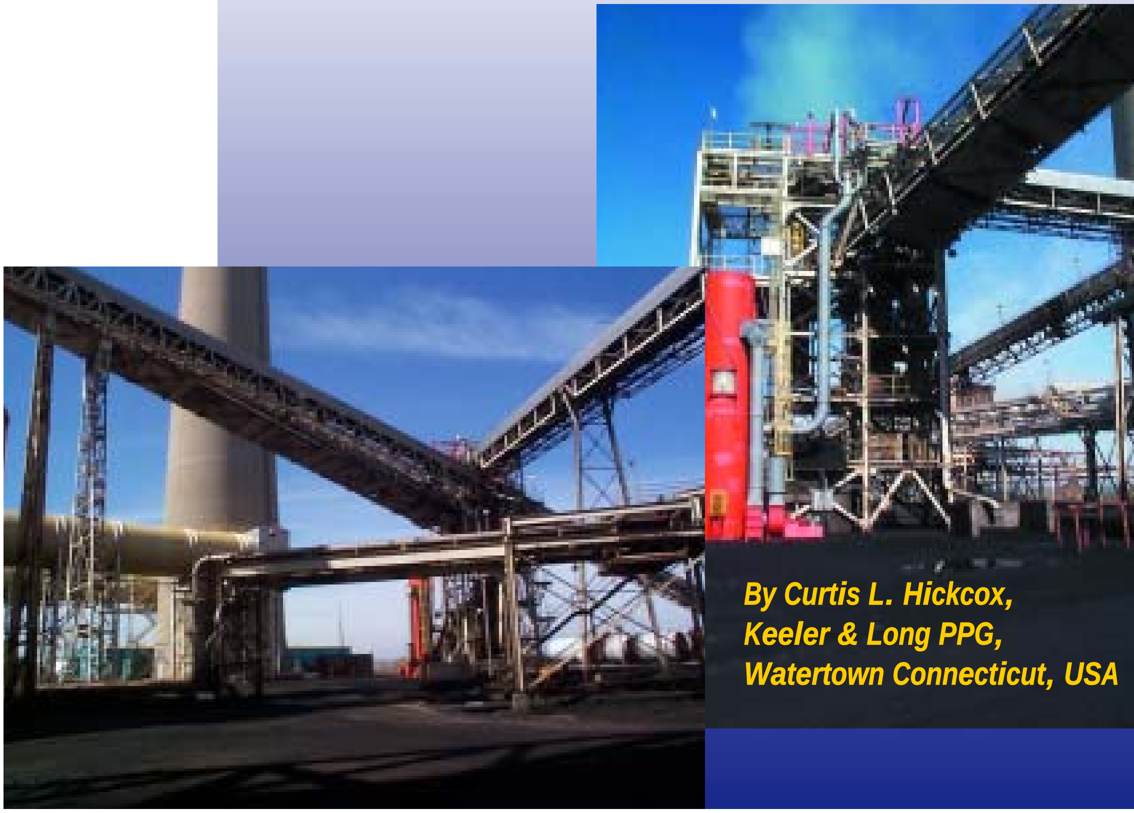

By Curtis L. Hickcox,
Keeler & Long PPG,
Watertown Connecticut, USA

Conveyor (left) and transformer tower (right) at coal-fired power plant.

Photos courtesy of Keeler & Long PPG

There are approximately 2,071 power plants in the USA and Canada each with a generating capacity of at least 50 Megawatts (MW). Along with these plants are 300,000 miles of transmission lines (138 kV and above), and 4,100 substations and line taps over 230 kV. In 2000, power plants in the USA generated 3,807 billion kilowatt hours of electricity. For utilities, generation was split among coal-fired (56%), nuclear (23%), natural gas (10%), hydro-electric (8%), oil (2%), and other sources (1%).[1]

The demand for electricity is expected to rise approximately 2% per year over the next 20 years, well above present capacities. Additional generating capacity, therefore, will be required to handle the demand. Along with construction of new power plants, modification and maintenance of existing plants will be critical. Deregulation of the electric power industry through the U.S. National Energy Policy Act of 1992 has resulted in utilities selling off many plants to reduce costs or concentrate on electricity transmission and distribution. In turn, power plants have become their own profit centers, requiring more attention to plant life extension and efficiency issues.[2]

The wide range of exposure conditions present at each type of plant requires many different types of coatings. Combinations of latexes, alkyds, epoxies, urethanes, and others are used, depending on the type of power plant and the specific location and exposure. The performance of the coating is directly affected by factors such as temperature, humidity and other environmental exposures, airborne contamination from the plant as well as the surrounding atmosphere, and direct mechanical and physical impact. Of all of the types of power plants, coal-fired plants probably pose the toughest environment for coatings because burning coal produces a very corrosive atmosphere. Even with today's advanced air cleaning equipment, surfaces in a coal-fired power plant are exposed to very aggressive conditions. These exposures can run the spectrum of pH, from the very alkaline in limestone handling and water treatment areas of the plant to the extremely acidic in coal handling and ash handling areas. Each location requires coatings specifically designed to handle the unique conditions present. This article discusses coating selection and surface preparation for most of the main areas of a coal-fired plant.

Table 2: Coatings Compatibility Guide

New Topcoat	Primer or Previous Coating: Acrylic	Alkyd	Epoxy Polyamide	Latex	Silicone Alkyd	Urethane	Inorganic Zinc-Rich
Acrylic	R	M	R	R	M	R	R
Alkyd	M	R	R	M	R	R	NR
Epoxy	NR	NR	R	M	NR	R	R
Latex	M	M	M	R	M	M	R
Silicone alkyd	M	R	R	M	R	R	NR
Urethane	NR	M	R	M	M	R	R

R = good, recommended   M = marginal   NR = poor, not recommended

Watering bin

Coating Selection

The correct selection of a coating system is one of the most important steps in a successful corrosion control project.[3] Careful specification of a coating will help ensure excellent long-term, cost-effective substrate protection specifically suited to its environment. The properly selected coating will also minimise maintenance problems and costs.

The coating selection process should take the following into consideration.

• Limitations: Often, there are limitations that will reduce the number of coating options. One important limiting factor is the surface preparation procedures available or practical. Surface location, operating considerations, and other logistical constraints often severely limit the choices for surface preparation methods. Because a coating's performance is heavily dependent on the preparation of its intended surface, limiting the surface preparation options will certainly reduce the coating options. Scheduling, ambient conditions during coating application and curing, practical application methods, location, and regulatory restrictions are other limitations that will have a direct impact on coating selection.

• Exposures: It is imperative to understand the conditions the coating must resist during application and throughout its service life. These conditions include weathering and other environmental factors, chemical exposures, temperatures, moisture, and physical exposure. Table 1 shows relative resistances of some generic coatings based on standard ASTM testing practices. As the table illustrates, coatings are designed to resist specific exposures and will

Table 1: Performance Characteristics of Coatings

Use	Alkyd	Epoxy	Urethane	Acrylic Latex
Adhesion	VG	E	E	VG
Hardness	G	VG	E	G
Flexibility	G	G	G	G
Resistance to:				
Abrasion	G	VG	E	F
Acid	F	G	E	NR
Alkali	F	E	VG	F
Detergent	F	E	E	F
Heat	G	G	G	P
Strong Solvents	F	E	E	P
UV	VG	F	E	F
Water immersion	G	E	F	F
Colour availability	Unlimited	Unlimited	Unlimited	Unlimited

E = excellent VG = very good G = good F = fair P = poor NR = not recommended

Source: David Litter Laboratories

perform much better than others under certain conditions. It is critical to the ultimate success of the painting project that the exposures are determined prior to coating selection to ensure the correct paint type is used. Later in this article, detailed information regarding power plant area specific exposures is presented (Table 3).

• Surface Conditions: The type and condition of the substrate greatly influence coating selection. Certain coatings

Table 3: Power Plant Exposure Chart

Area of Plant	Exposure						
Powerhouse	**Substrate ***	**Interior****	**Exterior**	**Moderate**	**Aggressive**	**High Heat**	**Immersion**
Boiler support/structural steel	S	X	X		X		
Boiler lagging	G/A	X				X	
Walls	C	X		X			
Floors	C	X		X	X		
Grating/handrails	G	X	X	X			
Cranes	S	X	X	X			
Stacks	S		X			X	
Precipitators	S		X		X		
Flue gas desulphurisation area	S/C		X		X		
Fans/blowers	S	X	X		X	X	
Dust collectors	S	X			X		
Ductwork	G	X	X	X			
Piping/conduit	S/C	X	X	X		X	
Pumps/motors	S	X	X	X			
Electrical equipment	S	X		X			
Silos/tanks/vessels	S	X	X		X		X
Pulverisers	S	X			X		
Water Treatment							
Acid/caustic tanks	S	X	X		X		X
Piping/pumps	S	X	X	X			
Floors	C	X		X			
Walls	C	X		X			
Electrical/control equipment	S	X	X	X			
Fuel Yard							
Dumper/unloader	S		X		X		
Floors/walls	C	X		X			
Conveyors/feeders	S		X		X		
Oil storage tanks	S		X		X		X
Handrails/grating	G	X	X	X			
Silos/holding bins	S		X		X		
Miscellaneous Plant Structures							
Building siding	G/A		X	X			
Floors/walls	C	X		X			
Storage tanks	S		X	X			X
Pipe racks/piping	S		X	X	X	X	
Transformers/electrical equipment	S		X	X			
Limestone handling	S		X		X		
Water intake	S	X	X		X		X

*S = Steel C = Concrete (block/poured) G = Galvanizing A = Aluminium ** X = Suitable for

Table 4: Coating System Selection Guide for Steel Surfaces in Power Plants

Surface	Surface Preparation (SSPC)*†	Coating System**	Number of Coats	Dry Film Thickness per Coat mils (microns)
a. Non-Immersion: Exterior Previously Painted—Moderate Exposure Powerhouse structural steel, switchgear, pumps, storage tanks, cranes, piping, electrical equipment, handrails	SSPC-SP 2, Hand Tool Cleaning, or SP 3, Power Tool Cleaning (as required)	Pr: rust-inhibitive oil-alkyd Fn: silicone-alkyd enamel	1 (spot or full, as required) 1	2.0–3.0 (50–75) 1.5–2.5 (37–62)
b. Non-Immersion: Exterior Previously Painted—Aggressive Exposure Precipitators, FGD structural steel, coal/ash handling, conveyors, water treatment	SSPC-SP 11, Power Tool Cleaning to Bare Metal (as required)	Pr: epoxy polyamine mastic Fn: aliphatic polyester or acrylic-urethane enamel	1 1	5.0–8.0 (125–200) 2.0–3.0 (50–75)
c. Non-Immersion: Exterior New or Unprimed—Moderate Exposure Powerhouse structural steel, switchgear, pumps, storage tanks, cranes, piping, electrical equipment, handrails	SSPC-SP 6, Commercial Blast Cleaning, or SP 11, Power Tool Cleaning to Bare Metal, for small areas or those where blasting is not practical	Pr: rust-inhibitive oil-alkyd Fn: silicone-alkyd enamel	2 1	2.0–3.0 (50–75) 1.5–2.5 (37–62)
d. Non-Immersion: Exterior New or Unprimed—Aggressive Exposure Precipitators, FGD structural steel, coal/ash handling conveyors, water treatment	SSPC-SP 10, Near-White Metal Blast Cleaning, or SP 11, Power Tool Cleaning to Bare Metal, for small areas or those where blasting is not practical	Pr: zinc-rich Int: epoxy polyamide Fn: aliphatic polyester or acrylic-urethane enamel	1 1 1	1.5–3.0 (37–75) 4.0–6.0 (100–150) 2.0–3.0 (50–75)
e. Non-Immersion: Interior Previously Painted—Moderate Exposure Structural steel, turbines, pumps, motors, doors, electrical equipment, piping, handrails	SSPC-SP 2, Hand Tool Cleaning, or SP 3, Power Tool Cleaning (as required)	Pr: rust-inhibitive oil-alkyd Fn: alkyd or silicone-alkyd enamel	1 (spot or full, as required) 1	2.0–3.0 (50–75) 1.5–2.5 (37–62)
f. Non-Immersion: Interior Previously Painted—Aggressive Exposure Tanks, vessels, water treatment, FGD areas, fuel handling	SSPC-SP 11, Power Tool Cleaning to Bare Metal (as required)	Pr: epoxy polyamide Fn: aliphatic polyester or acrylic-urethane enamel	1 1	3.0–5.0 (75–125) 1.5–3.0 (37–75)
g. Non-Immersion: Interior New or Unprimed—Moderate Exposure Structural steel, turbines, pumps, motors, doors, electrical equipment, piping, handrails	SSPC-SP 6, Commercial Blast Cleaning, or SP 11, Power Tool Cleaning to Bare Metal, for small areas or those where blasting is not practical	Pr: rust-inhibitive oil-alkyd Fn: alkyd or silicone-alkyd enamel	2 1	2.0–3.0 (50–75) 1.5–2.5 (37–62)
h. Non-Immersion: Interior New or Unprimed— Aggressive Exposure Tanks, vessels, water treatment, FGD areas, fuel handling	SSPC-SP 11, Power Tool Cleaning to Bare Metal, or SP 10, Near-White Metal Blast Cleaning, where blasting is not practical	Pr: epoxy polyamide Fn: aliphatic polyester or acrylic-urethane enamel	2 1	4.0–6.0 (100–150) 1.5–3.0 (37–75)
i. Immersion: Water Tanks	SSPC-SP 10, Near-White Metal Blast Cleaning	Pr/Fn: epoxy polyamide	3	4.0–6.0 (100–150)
j. Immersion: Acids, Caustics Tanks	SP 5, White Metal Blast Cleaning	Pr/Fn: epoxy polyamine or epoxy ester (depending on exposure)	2	10.0–20.0 (250–500)
k. High Temperature Stacks, piping, ductwork	SSPC-SP 5, White Metal Blast Cleaning, or SP 11, Power Tool Cleaning to Bare Metal, for small areas or those where blasting is not practical	Pr: silicone zinc aluminium (750 F [399 C] max.) or silicone (750–1,000 F [399–538 C]) Fn: silicone-aluminium (750 F [399 C] max.) or silicone (750–1,000 F [399–538 C])	1 1	1.0–2.0 (25–50) 1.0–2.0 (25–50)
l. Galvanized Steel: Moderate Exposure Interior/exterior cable tray, ductwork, siding, conduit	SSPC-SP 1, Solvent Cleaning, and SP 2, Hand Tool Cleaning	Pretreat: vinyl butyral wash primer (new steel) Pr: acrylic-latex Fn: acrylic-latex enamel	1 1 1	0.3–0.5 (8–12) 2.0–3.0 (50–75) 2.0–3.0 (50–75)
m. Galvanized Steel: Aggressive Exposure Interior/exterior cable tray, ductwork, siding, conduit	SSPC-SP 1, Solvent Cleaning, and SP 2, Hand Tool Cleaning	Pretreat: vinyl butyral wash primer (new steel) Pr: epoxy polyamide Fn: acrylic-urethane enamel	1 1 1	0.3–0.5 (8–12) 3.0–4.0 (75–100) 2.0–3.0 (50–75)

*NOTE: Washing the surface per SSPC-SP 1 is required prior to all further SSPC preparation procedures and coating application

†Equivalent Standards

SP 1	N/A
SP 2/SP 3	~S+2/S+3
SP 5	~Sa 3
SP 6	~Sa 2
SP 10	~Sa 2½
SP 11	N/A

** Pr = Primer; Int = Intermediate; Fn = Finish Coat

Transformers and related equipment often require protection from moderate exterior exposures.

may perform better on concrete surfaces as opposed to steel, while others might be better for wood. Coatings are also designed for application to surfaces prepared to a particular degree of cleanliness. For example, an epoxy mastic is suited for hand- or power tool-cleaned steel substrates exhibiting tightly adherent rust, while inorganic zinc-rich coatings require abrasive blasting to bare metal. It might be possible to simply power wash a surface for some coatings to perform properly, while others require a greater degree of cleaning. If overcoating existing coating material, then identifying these coatings and carefully examining their condition are important to ensure mechanical and chemical compatibility.

• Existing Coatings: Many newly applied coatings will cause the existing undercoat to delaminate. Other surface defects such as wrinkling might occur when overcoating an incompatible product. Table 2, which is based on the author's experience, provides a general guide to the chemical compatibility of many coating types. Depending on age, some coatings may require procedures such as mechanical abrasion to enhance adhesion of the new paint. This is often the case with many urethane coatings. When the type of existing coating is not known, it is wise to consider applying test patches to evaluate the compatibility of the new and old coatings.

Power Plant Exposures

Because the exposures in a conventional power plant vary from the benign to the extremely aggressive, the exposures must be recognised and understood for the project to succeed in performance and cost. To achieve the longest possible service life from a protective coating system and the cost savings resulting from longer maintenance cycles, shorter downtimes and operational efficiencies, the spectrum of exposures and conditions must be considered.

Table 3 outlines most main power plant areas and the typical exposures associated with each. Of course, each plant is unique and may include additional areas, substrates, and exposures, but I have attempted to provide an overview of the exposures present in a typical conventional power plant.

Surface Preparation

Surface preparation is the foundation of any corrosion control project. Compromising the degree of preparation will always negatively affect coating performance, regardless of the quality of the coating or its application.

The main objectives of surface preparation of any substrate are adequate surface cleanliness and appropriate surface profile. All contaminants that will interfere with coating performance, especially adhesion, are preferably removed before application. Several standards for surface preparation have been published by organisations such as the Society for Protective Coatings (SSPC), NACE International, and the International Organization for Standardization (ISO). The SSPC standards are among the most comprehensive and widely referenced surface preparation standards. They include methods ranging from simple washing of the surface to total removal of corrosion and existing paint by a variety of procedures.

Surface preparation standards must always be included in any power plant coating specification and should be specific to the substrate, exposure, and coating system. A conventional power plant is a dirty environment; therefore, it is almost always required that surfaces be thoroughly washed prior to coating application. Often, surfaces need to be rewashed between coats because the plant normally is operating, and surfaces quickly get recontaminated.

Surface profile—a roughened or increased surface area—improves the mechanical adhesion or bonding of

Table 5: **Coating System Selection Guide for Concrete Surfaces in Power Plants**

Surface	Surface Preparation (SSPC)	Coating System*	Number of Coats	Dry Film Thickness mils (microns)
a. Exterior—Moderate Exposure Floors, walls	SSPC-SP 13/NACE 6, Surface Preparation of Concrete, with a clean, dry profile similar to 60–80 grit sandpaper	Pr: acrylic Fn: latex or silicone-alkyd enamel • epoxy or latex block filler/surfacer/ patching compound applied as required prior to priming	1 1	1.0–3.0 (25–75) 1.0–3.0 (25–75)
b. Exterior—Aggressive Exposure Floors, walls	SSPC-SP 13/NACE 6, Surface Preparation of Concrete, with a clean, dry profile similar to 60–80 grit sandpaper	Pr: epoxy polyamide Fn: acrylic urethane enamel • epoxy or latex block filler/surfacer/ patching compound applied as required prior to priming	1 1	4.0–6.0 (100–150) 2.0–3.0 (50–75)
c. Interior—Moderate Exposure Walls	SSPC-SP 13/NACE 6, Surface Preparation of Concrete, with a clean, dry profile similar to 60–80 grit sandpaper	Pr: acrylic/vinyl acetate latex Fn: acrylic latex or alkyd enamel • epoxy or latex block filler/surfacer/ patching compound applied as required prior to priming	1 1	1.0–3.0 (25–75) 1.0–3.0 (25–75)
d. Interior—Aggressive Exposure Walls	SSPC-SP 13/NACE 6, Surface Preparation of Concrete, with a clean, dry profile similar to 60–80 grit sandpaper	Pr: epoxy polyamide Fn: aliphatic polyester urethane or acrylic urethane enamel • epoxy or latex block filler/surfacer/ patching compound applied as required prior to priming	1 1	5.0–6.0 (125–150) 2.0–3.0 (50–75)
e. Interior Floors, unpainted	SSPC-SP 13/NACE 6, Surface Preparation of Concrete, with a clean, dry profile similar to 60–80 grit sandpaper. Track-blast or similar pattern to provide an etched, sound surface	**Thin Film** Pr/Slr: epoxy amidoamine sealer Fn: epoxy amidoamine enamel **Thick Film** Pr/Slr: epoxy amidoamine sealer Fn: epoxy amine self-levelling enamel • epoxy surfacer/patching compound applied as required prior to priming	 1 1 1 1	 2.0–4.0 (50–100) 6.0–8.0 (150–200) 3.0–4.0 (75–100) 30.0–60.0 (750–1,500)
f. Interior—Moderate Exposure Floors, previously painted	SSPC-SP 13/NACE 6, Surface Preparation of Concrete, with a clean, dry profile similar to 60–80 grit sandpaper	Pr: epoxy polyamide Fn: epoxy amidoamine enamel or epoxy polyamide enamel • epoxy surfacer/patching compound applied as required prior to priming	1 1	4.0–6.0 (100–150) 2.0–6.0 (50–150)
g. Interior—Aggressive Exposure Floors previously painted	SSPC-SP 13/NACE 6, Surface Preparation of Concrete, with a clean, dry profile similar to 60–80 grit sandpaper	Pr: epoxy polyamide Fn: epoxy amine self-leveling enamel • epoxy surfacer/patching compound applied as required prior to priming	1 (spot as required) 1	5.0–6.0 (125–150) 30.0–60.0 (750–1,500)

*Pr = Primer; Fn = Finish coat; Pr/Slr = Primer/Sealer

Conveyors are often subject to aggressive, exterior exposures.

the coating. It is important to be aware of an individual coating's profile requirements to ensure that the correct preparation technique is specified in addition to the degree of cleaning. Certain techniques or tools may provide the incorrect depth or type of profile for a particular coating.

There are many choices available in the quality of cleaning, methods, and equipment used to perform surface preparation. When it is all said and done, the point is that surface preparation is the most important part of an engineered corrosion control project.

System Selection

Proper selection of the coating system, one that is tailored for the specific power plant application, will result in budget money being spent wisely. Just as proper surface preparation is critical to the coating project's success, the appropriate coating system must be specified for the job to result in a cost-effective project with limited maintenance needs.

A typical coating system may include a sealer, primer, intermediate coat, and finish coat. Additional coats of surfacers, patching compounds, or products that combine capabilities may be used. Although there is no such thing as a "canned" coating system schedule for a power plant and each specification must be written around a plant's unique situation, Tables 4 and 5 list many of the most commonly used, proven, and cost-effective coating systems for steel and concrete in power plants. Alternative coating systems are of course available for different situations. The tables are not meant to be comprehensive.

Project Management

As Steve Poncio noted: "The ability to influence final cost over the project life is very high before the project begins, but once the project starts, the ability to control costs is minimised."[4] As this statement aptly summarises, the time to generate true cost savings, both immediate and long term, is at the beginning of the project when the specifications are prepared and the work starts. Competent project management is critical to a successful coatings project. It should start with correct product selection but also include administrative, purchasing, safety, scheduling, operations, and quality assurance. When all is taken as a complete package, success is as close to guaranteed as possible.

Summary

A conventional power plant presents complex coatings situations. These include the wide range of exposures and logistical constraints of an operating plant laden with sensitive equipment, along with tight budgets and other unique conditions. They all support the need to carefully consider corrosion control programmes and procedures. Fortunately, today's coating technology offers solutions for nearly every conceivable application. To be successful, the coating system must resist the intended exposure; be compatible with existing coatings; be tolerant of surface conditions, preparation, and application limitations; and be easily maintained. With careful thought, it is relatively easy to find such a coating system, one that will provide the conventional power plant with long-term, cost-effective protection from corrosion.

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