COATING SYSTEM SELECTION

MATPRO

Selection of Coating Systems by Environmental Zone

General Considerations

The exposure environment is usually the chief concern when selecting a coating system for industrial steel structures. Other factors include government restrictions, ease of application and maintenance, and cost (both initial and long-term).

Locations with Differing Exposure Environments

SSPC, in its Steel Structures Painting Manual, Volume 2, Systems and Specifications, identifies eight different locations with special environments:

1 - Inland, rural regions: Regions remote from coastal and industrial areas and their pollutants. It should be noted that some remote, isolated areas now receive acid rain from wind-borne sulfur dioxide pollution from industrial or power plants.

2 - Heavy industrial regions: Paint life is reduced and corrosion rates are increased.

3 - Marine atmospheric region: Contains salt mist from the ocean.

4 - Fresh and salt water immersion regions: Differences between fresh and salt water immersion occur due to osmotic and electrolytic effects.

5 - Alternative water immersion regions: These regions occur on structures subject to loading and tidal changes, for instance, a ship hull or an offshore oil rig.

6 - Condensation and high humidity regions: This refers to areas that have almost continuous condensation.

7 - Chemical environments: These include contact of high concentrations of corrosive gases, fumes, or chemicals on steel.

8- Underground region: This refers to buried structures, such as piping in direct contact with soil, that may have high salinity (low resistance) or acidity.

Coatings for Atmospheric Zones (Mild and Severe)

Typical structures in atmospheric service include bridges, storage tanks, piping, towers, and industrial plants.

Steel structures in mild atmospheric environments (rural, inland) can be effectively protected with an alkyd (e.g., one coat of primer and two silicone-alkyd topcoats). In severe environments (with salt or industrial pollutants), a high-performance coating (e.g., two coats of epoxy and a finish coat of aliphatic polyurethane) is more appropriate. Obviously, high-performance systems are also appropriate for mild environments and may be economical where coating maintenance and replacement costs are very high.

Steel pipes and other items in atmospheric service that do not require a painted finish can be protected with petrolatum pastes and micro-crystalline waxes. They are usually wrapped with tape impregnated with this material or with a plastic overwrap. The only surface preparation they require is a power tool cleaning (SSPC-SP 3) to remove loose surface contaminants.

Coatings for Atmospheric Zones (Mild and Severe)

Highway and railroad bridges are coated to protect their steel components from corrosion. However, because they are highly visible, an attractive finish is usually also desired. Both needs can be met by proper use of available cleaning methods and coating products.

Bridges in Mild Environments

Bridges in relatively dry locations can be coated with alkyd or waterborne systems applied over a commercial blast finish (SSPC-SP 6). Power tool cleaning (SSPC- SP 3) may be adequate for maintenance work. These systems are easy to repair when they become damaged.

Other coating systems used for maintenance painting ("overcoating") include (1) epoxy mastic systems (a penetrating, 100% solids epoxy primer is sometimes used to improve adhesion, and a polyurethane topcoat applied to improve appearance and protection) and (2) moisture-cured polyurethanes.

Bridges in More Severe Environments

Bridges located in more severe (damp, immersed, or chemical) environments require high-performance systems. Application of road salts and poor bridge design greatly add to the severity of existing climatic environments. One of the more widely recommended high-performance systems include (1) an inorganic or organic zinc-rich primer (2) an epoxy polyamide midcoat, and (3) an aliphatic polyurethane topcoat for improved weathering and appearance.

Many bridges still have lead-containing coatings on them, so that special containment, storage, and disposal procedures must be followed when removing these materials.

Exteriors of Storage Tanks, Piping, and Other Steel Structures

The exteriors of all steel storage tanks, piping, and other industrial structures in atmospheric service may use the same coating systems, regardless of their use or the materials stored in them. They all require corrosion protection and an attractive appearance, since they are quite visible to people in the area.

As with steel bridges, the selection of a coating system is dependent on the severity of the environment. In mild environments, a three-coat alkyd system (preferably with a silicone alkyd finish) or a three-coat water-borne acrylic system will perform well over a commercial blast cleaned (SSPC-SP 6) surface.

In a more severe environment, a high-performance system is necessary. This may be a system with two coats of epoxy and a finish coat of aliphatic polyurethane, or a system of one coat each of zinc-rich epoxy, epoxy- polyamide, and aliphatic polyurethane products.

Towers and Other Tall Structures

There are many towers and other tall metal structures that require coating. These structures are coated for one or more of the following reasons:

- Corrosion protection
- Appearance
- Visibility

Two examples of tower structures are transmission towers for electrical power distribution and communication/ radio towers. The most recognizable tall structure is the elevated water storage tank.

Lining for Immersion Service

Linings for immersion service must be resistant to the stored products and must prevent their contamination.

Linings for Water Tank Interiors

Almost all states require that coating systems used to line potable water tanks conform to ANSI/NSF 61. Most of those approved to date have been epoxies. Approval means that no material leached from the coating system will be in sufficient quantity to cause adverse health effects. The in-service performance of the system is not considered by this standard.

About half of the water tank systems in the United States are cathodically protected. If these interiors are functioning properly, there should be little corrosion in immersed areas except on ladders or other areas not cathodically protected. Blisters may occur in immersed areas from coating solvent retention or excessively high cathodic protection voltages. The top areas of the tank, especially the edges of support beams that are not cathodically protected, are where most of the rusting occurs.

Linings for Interiors of Wastewater Tanks

Almost all states require that coating systems used to line potable water tanks conform to ANSI/NSF Interiors of wastewater tanks must be resistant to the corrosive product contained. They are usually lined with two or more coats of epoxy or two coats of coal tar epoxy (e.g., SSPC-Paint 16). For very severe conditions, composite systems of fiberglass (chopped, mat, or roving) with polyester, vinyl ester, or epoxy resins may be necessary. In all cases, a near-white blast cleaning (SSPC-SP 10) of the steel prior to coating is recommended.

Linings for Chemical Storage Tanks

Obviously, linings for chemical storage tanks must be very resistant to the product stored. Lining manufacturers are best able to provide useful information about their products, but laboratory immersion testing under service conditions may be necessary before a new coating product is used.

For very severe service, fiberglass-reinforced polyester, vinyl ester, or epoxy resins may be appropriate. In all cases, the manufacturer's instructions for surface preparation and application should be followed.

Fuel Tank Linings

Interiors of tanks containing crude oils may be bare or lined with two coats of coal tar epoxy (e.g., SSPC- Paint 16) or two or more coats of epoxy. Many crude oil storage tanks are only part-lined, with coatings on the floor and approximately 3 feet (1 metre) up the walls. The roof may also be coated.

Storage tanks that contain finished products (e.g., gasoline and jet fuels) are best lined with an epoxy system (e.g., three coats of epoxy-polyamide). Coal tar epoxies are generally not used because coal tar may be extracted from linings to discolor the fuel.

Corrosion is usually the most severe on fuel tank floors, because there is always a little water there, despite its periodic removal from sumps. Floors of old, corroded tanks should be checked ultrasonically for adequate thickness before recoating. Pits can be filled with weld metal or epoxy/polyester. If a general loss of thickness occurs, it may be necessary to replace the tank bottom or lay a fiberglass-reinforced bottom over the deteriorated steel bottom and bring it 18 inches up the tank wall. It is desirable to have a white finish on all interior tank linings, so that they can be inspected more easily.

Coatings for Marine Service

Coatings for marine atmospheric service were described at the start of this section. There are, however, some steel structures that have both wet and dry areas. These include marine piling and ships. In such instances, it is a normal practice to use cathodic protection on the immersed portions, in addition to protective coatings on all exposed areas.

Marine Piling

Marine pilings are best protected by abrasive blasting in a shop to a near-white condition (SSPC-SP 10) before coating with one of the two following systems described in MIL-STD-3007: Unified Facilities Criteria and Unified Facilities Guide Specifications.

- Three coats of epoxy-polyamide with at least nine mils (225 μm) total DFT
- Two coats of coal tar epoxy with at least 16 mils (400 μm) DFT

Coating repair and replacement in intertidal or lower areas of steel piling is very difficult. Cofferdams can be used to coat areas normally immersed, and a few commercial products are available that were designed to be applied underwater by divers. Such applied coatings do not perform as well as those applied to dry surfaces.

Ships

Coating systems on immersed or wet areas of ships are usually epoxy-polyamide. Antifouling coats are used over them in continually immersed areas, and nonslip coatings are often used over them on decks. Aluminum oxide grit is used to provide slip resistance to epoxy and other deck coatings. Inorganic zinc or epoxy systems with appropriate topcoats may be used topside.

Offshore Structures

Offshore structure painting differs from onshore painting in that logistics and living, working, and coordinating work with other personnel are especially important. All personnel on offshore structures should attempt to work with others as effectively as possible, because work of different trades must be coordinated during good painting weather. Surface preparation alternatives include contained abrasive blasting, vacuum blasting, and power tool cleaning to bare metal (SSPC-SP 11).

Offshore structures are best initially coated ashore where good surface preparation and coating application can be achieved. A three-coat system of one coat each of inorganic zinc, epoxy, and aliphatic polyurethane is commonly used above water, and a three-coat system of one coat of inorganic zinc and two epoxy topcoats, below water.

Most offshore structures are cathodically protected below water. They may have impressed current, sacrificial anode, or mixed cathodic protection systems.

Coatings for Buried Steel

Coating in Conjunction with Cathodic Protection

A combination of cathodic protection and coatings has long been recognized as the most effective way to protect underground steel piping. The coating isolates the metal from electrolytes in the soil, thus reducing the current requirements for cathodic protection; the cathodic protection protects the metal exposed to the environment at coating holidays. New pipe coatings may initially provide 99 percent of the pipe protection, but as they slowly deteriorate, the cathodic protection system provides more and more of the protection.

Desired Properties for Coatings for Buried Steel

For coatings to perform well in partnership with cathodic protection, they must have the special properties listed below:

- Good electrical resistance
- Good moisture resistance
- Good heat resistance
- Good adhesion to metal
- Resistance to cathodic disbonding
- Resistance to damage during handling
- Ease of application and repair

Application of Coatings

There are a large number of products (both conventional coatings and alternative materials) that have the desired properties for buried steel and are sold for coating piping to be located under-ground. These products are most often applied in a shop under controlled conditions with automated blasting and recycling of abrasive and coating application. Others are designed to be applied in the field over a ditch.

Protective Systems

Bituminous Enamels

Enamels utilizing coal tar pitches or petroleum asphalts have been used successfully for many years on underground piping. Because these products are not resistant to ultraviolet light, when stored in sunlight for lengthy periods, they should be protected by kraft paper or whitewash. The piping is blast-cleaned to an SSPC- SP 6 or 10, followed by hot application and wrapping.

Asphalt Mastics

Asphalt mastics are thick (1/ –5/ in. [12–15 mm]) coatings of sand, fine aggregate, and asphalt. The pipeis blasted by a mixture of shot and grit to an SSPC-SP6 or 10 and primed with an asphalt primer prior to an extrusion of the mastic. Whitewash should be applied to protect the coating during exterior storage.

Today, they are extensively used in a 3-coat system:

- 1 coat of fusion-bonded epoxy (FBE)
- 1 coat FBE polymer with PE or PP
- 1 coat of PE or PP Powder Coatings

Powder coatings are finely divided 100% solids (no VOCs) mixtures containing resins, pigments and curing agents. They are applied to conductive surfaces as a dry powder that is melted, flows together and upon cooling, forms a tough, continuous film.

Surface preparation for industrial or marine use is usually an SSPC-SP 5 or 10, as recommended by the manufacturer.
Fusion-bonded, thermosetting (e.g., epoxy) coatings are usually applied by electrostatic spray to give a one or two-layer film. They have good chemical resistance and are easily inspected for holidays. Pipes exposed to sunlight may be hybrid (epoxy/polyester) for ultraviolet resistance.

Coatings for High-Temperature Surfaces

Most organic coatings do not perform well on hot steel surfaces such as pipes, stacks, and mufflers. There are several products marketed for this purpose, which are aluminium-filled silicone alkyds applied in two coats. As the temperature of the steel is raised, the alkyd resin burns to leave an aluminium-filled silicone film. Because this film is only about one mil thick, it seldom provides long-term protection. An inorganic silicone coating will perform better.
For long-term protection, abrasive blasting the item in a shop to a white metal surface (SSPC-SP 5) and applying one of the following is recommended:

- 3–5 mils inorganic zinc coating (good up to 650°F [330°C])
- 6–8 mils thermal spray zinc (good up to 650°F [330°C])
- 5–7 mils thermal spray aluminium (good up to 1100°F [600°C])
- 3–5 mils of inorganic silicone coating (good up to 1500°F [815°C])

Organic coatings are available that provide resistance to a range of lower temperatures.