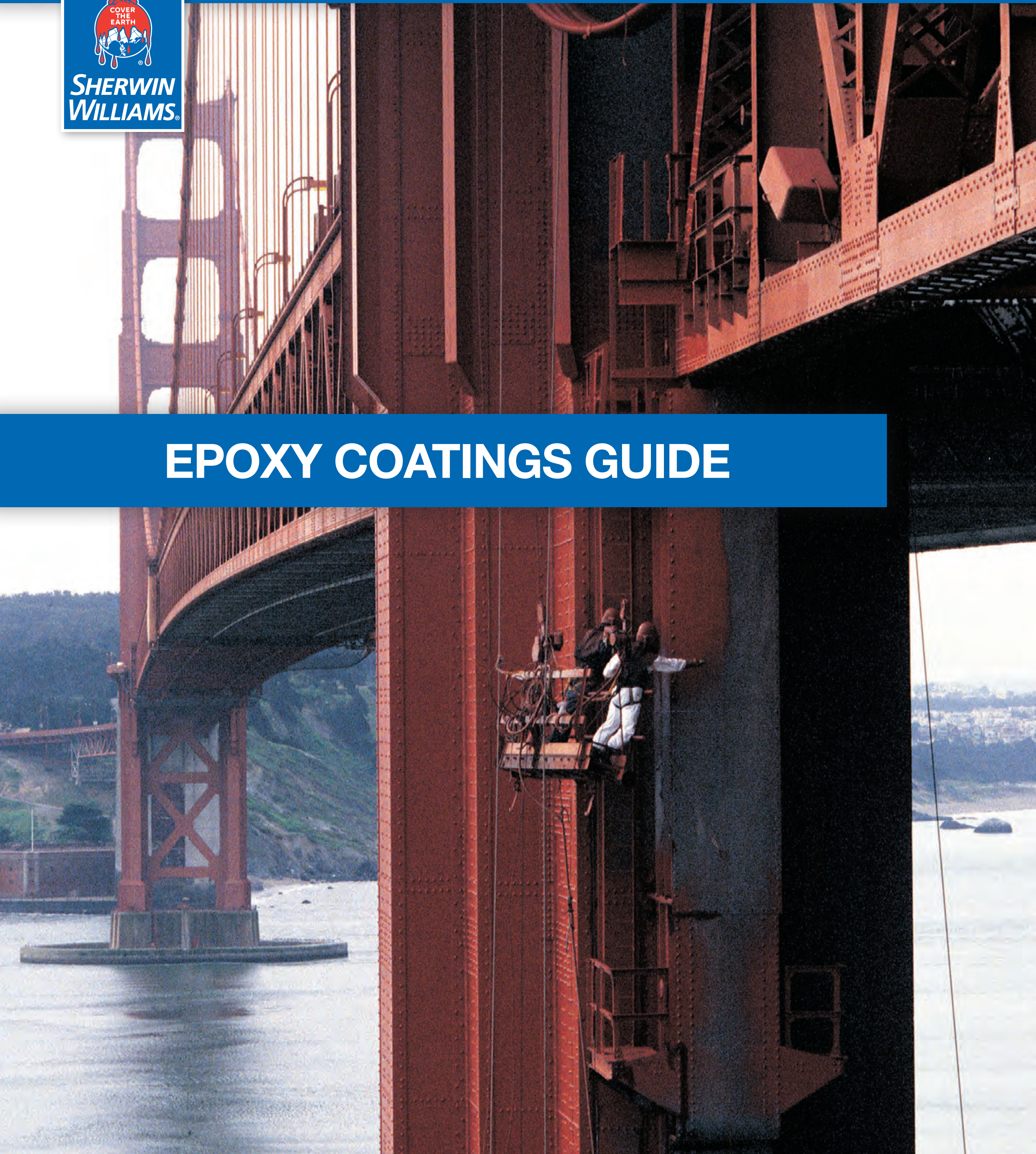
EPOXY COATINGS GUIDE



Epoxy coatings are generally packaged in two parts that are mixed prior to application. The two parts consist of 1) an epoxy resin which is cross-linked with 2) a co-reactant or hardener. Epoxy coatings are formulated based upon the performance requirements for the end product. When properly catalyzed and applied, epoxies produce a hard, chemical and solvent resistant finish. They are typically used on concrete and steel to give resistance to water, alkali and acids.

It is the specific selection and combination of the epoxy component and the hardener component that determines the final characteristics and suitability of the epoxy coating for a given environment.

Epoxy Resins

FEATURES

Common Types	Viscosity	Flexibility	Chemical Resistance
Bisphenol A	Moderate – High	Moderate	Moderate
Bisphenol F	Moderate	Low – Moderate	Moderate
Phenolic Novolac	Moderate – High	Low	High

Co-Reactant or Hardeners

Types: Polyamide, Aromatic Amine, Amidoamine, Aliphatic Amine, Cycloaliphatic Amine, Aliphatic Amine Adduct

FEATURES [co-reactants and hardeners rated top to bottom from best suited to least suited]

		Chemical Resistance		
Film Flexibility	**Adhesion**	**Acids**	**Solvents**	**Water**
Best	**Best**	**Best**	**Best**	**Best**
Polyamide	Polyamide	Aromatic Amine	Aliphatic Amine	Polyamide
Amidoamine	Phenalkamine	Cycloaliphatic Amine	Aliphatic Amine Adducts	Phenalkamine
Phenalkamine	Amidoamine	Aliphatic Amine	Cycloaliphatic Amine	Amidoamine
Cycloaliphatic Amine	Cycloaliphatic Amine	Aliphatic Amine Adducts	Aromatic Amine	Cycloaliphatic Amine
Aromatic Amine	Aliphatic Amine	Amidoamine	Polyamide	Aromatic Amine
Aliphatic Amine Adducts	Aliphatic Amine Adducts	Phenalkamine	Phenalkamine	Aliphatic Amine
Aliphatic Amine	Aromatic Amine	Polyamide	Amidoamine	Aliphatic Amine Adducts

Blush Resistance	Color Stability	Low Temp. Application	Corrosion Resistance	Viscosity
Best	**Best**	**Best**	**Best**	**Best**
Polyamide	Polyamide	Phenalkamine	Polyamide	Cycloaliphatic Amine
Phenalkamine	Amidoamine	Aliphatic Amine	Amidoamine	Aliphatic Amine
Amidoamine	Cycloaliphatic Amine	Aliphatic Amine Adducts	Phenalkamine	Amidoamine
Cycloaliphatic Amine	Aliphatic Amine Adducts	Cycloaliphatic Amine	Cycloaliphatic Amine	Aromatic Amine
Aromatic Amine	Aliphatic Amine	Polyamide	Aliphatic Amine Adducts	Aliphatic Amine Adducts
Aliphatic Amine Adducts	Phenalkamine	Amidoamine	Aromatic Amine	Phenalkamine
Aliphatic Amine	Aromatic Amine	Aromatic Amine	Aliphatic Amine	Polyamide

Common Causes for Irregularities and Finish Defects

Polyamide/Amine Blush or Surface Enrichment

Occurs when the proper cure cycle of catalyzed epoxies is interrupted or slowed. The "lighter" polyamide or amine hardener separates from the epoxy and floats to the surface where it oxidizes and turns yellow or brownish in color.

Check By:

The polyamide/amine blush can be confirmed by rubbing the surface lightly with a clean rag saturated with MEK or Reducer R7K54. The yellow appearance will be removed, but may later return.

Caused By:

Improper Mixing

- Areas rich in polyamide or amine content may exhibit yellowing/blushing and/or an oily exudate
- Areas rich in epoxy content will appear normal in color for a period of time, but may eventually discolor
- May result in color variations along the same coated surface
- Drying and curing times may be affected

Improper Hardener

Epoxy coatings are formulated with optimum levels of a hardener for a given level of epoxy resin. This ratio differs from product to product. The use of an improper hardener may result in an undercatalyzed or overcatalyzed product.

Undercatalyzed Films:

- May appear dry but will not fully cure
- May appear soft and gummy

Overcatalyzed Films:

- May be hard and brittle
- Both will result in discoloration, yellowing, and reduced performance properties

Insufficient Induction (Sweat-In Time)

Many epoxy coatings require a specified induction time in order to fully "compatibilize" the epoxy resin and the hardener. When required, this pre-reaction will reduce the likelihood of poor film appearance and poor coating performance. Lower temperatures and/or high humidity will generally require longer induction periods.

Improperly inducted epoxies will exhibit:

- A lower gloss than expected
- Yellowing becoming progressively worse over time
- Polyamide/amine blushing
- Reduced chemical resistance
- Softer film
- Color float and/or color variation

It is possible that the coating material applied initially may develop low gloss and discolor, while the rest of the surface, painted with the same material, will appear normal as induction time has increased.

Low Temperature

Most epoxies are formulated for application at temperatures above 50–55°F. Temperatures below 50°F will stop the rate of the chemical reaction between the epoxy and the hardener. The evaporation of the solvents in the coating are also inhibited.

- Both of these conditions will increase the likelihood of blushing, discoloration and down-glossing.
- Be aware that surface temperatures may be much lower than the air temperature. Epoxy coatings should never be applied below the recommended temperature range, or when temperatures are expected to fall below the minimum recommended temperature during the first 72 hours of cure.

High Humidity, Moisture Condensation, Stagnant Air

- Most epoxies are designed for application up to a maximum 85% RH.
- High humidity and/or the presence of moisture may cause discoloration or a "greasy" feel and poor uniformity of appearance.
- The polyamide/amine may separate and cause discoloration. Maximum effort should be made to increase fresh air circulation to minimize this effect.

Insufficient Curing of Water-Based Primers or Fillers

If water-based primers are not sufficiently cured prior to topcoating, moisture migrating through the fresh epoxy film will inhibit the drying and curing of the epoxy. This will cause discoloration, low gloss and possibly delamination.

Common Causes for Irregularities and Finish Defects

Discoloration from Exposure UV Light (Sunlight)

- This is a surface phenomenon attributed to the natural darkening of epoxy resin upon exposure to UV or sunlight. This problem occurs most often in areas with intermittent sunlight, creating a “checkerboard” effect.
- The discoloration may be confirmed by scraping away the surface layer with a knife to expose the underlying film which will appear lighter in color.

Discoloration from Chemical Exposure

- Certain chemical compounds, such as carbon monoxide and carbon dioxide, are known to react with freshly applied epoxy films and cause discoloration. This discoloration will be more pronounced in areas of high film build and in areas with little or no air circulation.
- Check area for cleaning agents that may contain these compounds. Animal kennels or shelters are also suspect because of waste byproducts.

Epoxy Finishes: Resistance to Yellowing

PRODUCT [epoxies rated top to bottom from best resistance to least resistance]

Best Resistance

Polysiloxane XLE-80

Pro Industrial Hi-Bild Waterbased Epoxy

Water-Based Catalyzed Epoxy

Tile-Clad HS Epoxy

Water-Based Tile-Clad

Pro Industrial High Performance Epoxy

Epolon II Multi-Mil Epoxy

Macropoxy HS Epoxy

Macropoxy 646 Fast Cure Epoxy

High Solids Catalyzed Epoxy

Macropoxy 846 Winter Grade Epoxy

Sher-Glass FF

Tank Clad HS Epoxy

Duraplate 301

Dura-Plate 235

Least Resistance

Key Issues to Consider During Selection and Use of Epoxies

Substrate Types. Steel, concrete, etc. Is it suitable for the coating and the environmental exposure?

Surface Prep. Are the requirements adequate?

Temperature/Variations. Normally above 55°F for the first 72 hours of drying, and at least 5°F above the dew point.

Humidity. Normally below 85% required.

Environmental Exposure. Is the coating suitable for the conditions it will be exposed to?

Performance Requirements. What performance characteristics will the coating be exposed to? (i.e. abrasion, flexibility, heat resistance, etc.)

Recoatability. Will it be required and within what time frame?

Application Methods. Is the coating designed for the specific method? (i.e. spray, brush, roll, squeegee/trowel)

Cost/Value Considerations. Cost per mil per square foot per year of life expectancy.

Film Build. Is the coating able to comply with the specifications?

Air Movement. It is very important to have fresh air circulating over the surface during drying.

Induction Time. Critical, especially during cold weather and high humidity.

Pot Life. Do not exceed. Coating may appear usable but will exhibit poor performance.

Aesthetics. Be aware that some epoxies yellow more than others. More noticeable in whites and off-whites.

Odor. Will odor be a concern in or around the application area? Solvent-based, water-based, high solids epoxies.

Epoxies: Common Problems and Most Probable Causes

	Most Probable Causes																							
Common Problems	Surface Contamination	Application Method	Exceeded Pot Life	High Humidity	Improper Hardener	Sweat-In Time	Recoat Time	Tint Level	Improper Mix Ratio	UV Light Exposure	Absence of Light	Exposure to Chemicals	Wrong Reducer Solvent	Percent Reduction	Moisture/Condensation	Product Selection	Application Temperature	Surface Temperature	Initial Temperature 72 Hrs.	Film Thickness	Air Movement	Batch Variation	Primer	Surface Preparation
Discoloration/Yellowing			●	●	●	●			●	●	●	●			●	●	●	●	●		●			
Color Variation				●	●	●		●	●	●	●	●			●	●	●	●	●		●	●	●	
Blushing				●	●	●			●			●			●		●	●	●					
Uneven Gloss		●	●	●	●	●			●	●		●	●		●		●	●	●			●		●
Exotherm (Hot Paint)			●		●				●								●							
Poor Intercoat Adhesion	●		●	●	●	●	●		●			●				●	●	●	●	●			●	●
Soft Film				●	●	●		●	●			●	●		●		●	●	●	●	●			
Tacky Film/Slow Dry				●	●	●		●	●				●		●		●	●	●	●	●			
Lifting/Wrinkling	●				●		●						●	●	●					●	●		●	●
Bleeding	●						●	●								●							●	●
Pinholing	●	●			●		●						●		●									●
Cratering	●	●										●	●	●	●								●	●
Low Film Thickness		●							●					●										
Sagging		●	●	●			●		●				●	●		●	●		●		●			
Cracking/Crazing	●				●		●		●	●														
Alligatoring	●																			●			●	●

Epoxy Coating Comparison Chart

	AMINE EPOXIES	POLYAMIDE EPOXIES	AMIDOAMINE EPOXIES	EPOXY PHENOLICS/NOVOLACS
Description	Form very hard, adherent films with excellent chemical and corrosion resistance. Amine cured epoxies are often used as protective coatings and linings in highly corrosive environments. Amine epoxies require care in handling since the amines can be moderately irritating to the skin, and may cause allergic reactions.	Polyamide epoxies generally offer the widest latitude in coating formulation. They are considered more resilient and flexible, and have better weathering resistance and a longer pot life than amine cured epoxies. Polyamide epoxies generally have less solvent and acid resistance than amine cured epoxies.	Amidoamines are reaction products of a polyamine and a fatty acid. Their properties generally fall between those of amines and polyamides. They have good water and corrosion resistance like amines, and good toughness like polyamides. They have relatively small molecular size giving them low viscosities and making them very good surface wetters.	These coatings allow wide range formulating latitude. Novolac epoxy resin increases chemical resistance and solvent resistance. Increasing the level of phenolic increases the chemical and solvent resistance, but the coating loses flexibility. Some phenolics require heat curing.
Advantages	• Excellent alkali and water resistance • Very good acid resistance • Excellent solvent resistance • Hard, abrasion resistant film • Excellent corrosion resistance • Excellent wetting of substrate • Chemical/moisture barrier	• Very good alkali and water resistance • Good acid resistance • Longer pot life than amines • Easy to apply • Cures more quickly than amines • Good weathering characteristics • Good film flexibility • Excellent adhesion	• Excellent surface wetting • Excellent adhesion • Excellent water resistance • Low viscosity • Longer pot life than amines • Good gloss retention	• High heat resistance • Excellent chemical resistance • Excellent solvent resistance • Excellent corrosion resistance • Hard, abrasion resistant film
Disadvantages/Limitations	• Amines can be irritating/toxic • Relatively short recoat time • Relatively short pot life • Slower dry than normal polyamides • Chalks/may discolor	• Faster dry than amines • Chalks • High viscosity • Temperature dependent • Slow cure	• Slow cure • Fair color retention • Temperature dependent	• Some may require heat cure • Relatively slow air cure • Chalks/may discolor • Relatively brittle
Primary Uses • Refer to product data sheets for specific use information	• Severe chemical resistant coating • Barrier coating • Offshore structures • Storage tanks, structural steel • Bridges, power plants • Tank linings • Secondary containment	• Water immersion • General industrial • Offshore structures • Storage tanks, structural steel • Water/wastewater plants • Tank linings • Bridges, power plants • Secondary containment	• Barrier coating • Surface tolerant coating • Where chemical and moisture resistance is required • General industrial • Refineries • Bridges, power plants	• Severe chemical resistance • Tank linings • Secondary containment • General industrial • Refineries • Bridges, power plants
Sherwin-Williams Products	**Amines** Shelcote II Epoxy Shelcote II Flake Filled Dura-Plate UHS Duraplate 301 Tank Clad HS Epoxy Sher-Glass FF **Ketimines** Macropoxy 920 PrePrime **Phenalkamines** Dura-Plate 235 **Water-Based** Water-Based Tile-Clad	Kem Cati-Coat HS Filler/Sealer Tile-Clad High Solids Recoatable Epoxy Primer Copoxy Shop Primer Zinc Clad IV Zinc Clad III HS Hi-Solids Catalyzed Epoxy Macropoxy 646 Fast Cure Macropoxy 846 Winter Grade Epolon II Primer Epolon II Multi-Mil Macropoxy HS Epoxy Pro Industrial High Performance Epoxy	Epoxy Mastic Aluminum II Macropoxy 5500	Phenicon HS Epoxy Phenicon Flake Filled Epo-Phen Nova-Plate UHS Nova-Plate 325 Fast Clad 105ER

Epoxy Coating Comparison Chart

	SILOXANE EPOXIES	COAL TAR EPOXIES	WATER-BASED EPOXIES	EPOXY ESTERS
Description	Siloxane epoxies are relatively fast curing coatings with excellent stain and mar resistance. They have excellent color and gloss stability. Siloxane epoxies are typically used in high performance industrial applications. Also acceptable for architectural applications.	Coal tar epoxies are a combination of a basic epoxy resin and coal tar. The coal tar is in the form of a semi-liquid pitch and blended with the epoxy resin. The curing agents for coal tar epoxies are usually either amines or polyamides. Coal tar epoxies offer excellent resistance to fresh and salt water and are highly resistant to cathodic disbondment.	Generally consist of a non-yellowing acrylic resin disbursed in water mixed with an emulsified epoxy resin. They are relatively hard, durable coatings with moderate chemical resistance. They offer good stain resistance, abrasion resistance and resistance to most commercial cleaning agents and sanitizers. They can be used over previously applied conventional paints to upgrade the surface for better performance without wrinkling, lifting or bleeding.	A combination of epoxy resin and alkyd resin resulting in an air-drying coating. Epoxy esters provide a hard, durable film ideal as a machinery finish. Recommended for general atmospheric use in areas not considered severely corrosive.
Advantages	• Very good weathering resistance • Hard, abrasion resistant film • Very good acid resistance • Excellent color and gloss retention • Relatively fast dry	• High film build with one coat • Excellent salt water resistance • Excellent water resistance • Excellent resistance to cathodic disbondment • Economical	• Good chemical and solvent resistance • Hard, abrasion resistant film • Upgrades conventional systems to high performance • Water clean-up, low-odor • No strong solvents • Good adhesion • Very long pot-life • Good weathering	• Hard, durable film • Easy to apply • One component • Good moisture resistance • Minimal surface preparation • Moderate cost • Low temperature application • Increased alkali resistance over alkyds
Disadvantages/Limitations	• Solvent resistant • Heat resistant	• Not for potable water • Black color • Critical recoat time/ difficult to recoat • Fair solvent resistance • Chalks/browns	• Flash rusting on ferrous metal unless primed	• Fair solvent resistance • Poor weathering characteristics • Poor exterior gloss retention
Primary Uses • Refer to product data sheets for specific use information	• Bridges • Marine • High performance finish coating • Kennels, schools, jails, hospitals • High moisture areas • Stain resistant coating	• Liner for sewage treatment tanks • Not-potable water tanks • Pipe coating • Penstocks, dam gates • Offshore rigs • Paper mills • Chemical plants • Secondary containment	• Light/moderate industrial areas • Tile-like wall coating • Schools • Hospitals • Food plants • Office areas • Kitchens • Hallways • Nursing homes	• Moisture resistance • Where odor or low temperature limitations prevent solvent-based epoxy use • Abrasion resistance
Sherwin-Williams Products	Polysiloxane XLE-80	Hi-Mil Sher-Tar Epoxy TarGuard Coal Tar Epoxy	Water-Based Epoxy Primer Water-Based Epoxy Pro Industrial Hi-Bild Waterbased Epoxy	

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