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CORROSION-RESISTANT COATINGS FOR FAN EQUIPMENT

INTRODUCTION

This Engineering Letter provides basic information regarding the different types of corrosion-resistant coatings readily available for fan equipment. The coatings are described here according to generic classifications having similar characteristics such as curing methods, adhesion qualities, chemical resistance, and temperature limitations. Coating manufacturers offer a variety of brand name coatings which can be categorized by these generic classifications.

The service life of air-moving equipment constructed of carbon steel may be significantly reduced when corrosives are allowed to attack the surface of the metal through chemical or electro-chemical action. One method of inhibiting this corrosive action is by applying a protective coating to the area in contact with the corrosives. Protective coatings act as a barrier between the corrosive and the parent material. A wide range of protective coating systems is available to provide protection from a variety of corrosives including acids, alkalis, solvents, salts, and oils. Although other materials of construction, such as special alloys (see Engineering Letter 14) and fiberglass-reinforced plastic - FRP (see separate Engineering Letters) are available, protective coatings can offer a low-initial-cost solution to the corrosion problem.

The selection of a protective coating is critical in determining the service life of the equipment. The selection process must consider the actual chemical composition of the gas stream. To evaluate the corrosive nature of the gas stream completely, the concentrations and temperatures of the chemicals present must also be considered.

COATING INGREDIENTS

Although protective coatings are differentiated by their specific chemical composition, the most common consist of three basic ingredients; a binder, a flow control agent, and a pigment or filler. When these ingredients are combined, they can range in consistency from thin liquids to semi-solid pastes in a variety of colors.

The binder is the film-forming ingredient in the coating. It consists of either a drying oil or a polymeric substance.

Drying oils form a hard film by reacting with oxygen in the air. Coatings with this type of binder are usually cured by air drying but in some cases may be baked in order to cure more rapidly. Coatings that utilize a polymeric substance as the binder require a “thermoset” cure. Thermosetting can be accomplished by baking the applied coating in some cases or by adding a catalyst in other cases. The type of thermoset is dependent upon the characteristics of the polymeric substance itself.

A flow control agent, or solvent, is combined with the binder to form the liquid portion of the coating. The solvent prevents the binder from solidifying prematurely and ensures uniform dispersion over the surface. This combination of binder and solvent is called the vehicle portion of the coating.

The pigment is any substance, usually a powder, which gives color to the mixture. Most pigments are insoluble in solvents and are not affected by the vehicle portion of the coating.

The generic coating classifications are differentiated by their chemical composition. While the chemical composition alone is not sufficient in determining which protective coating is selected for a specific application, it can be useful in determining the generic group of a particular brand name coating.

COATING TYPES

The following descriptions of generic coatings present curing methods, adhesion qualities, chemical resistance, and temperature limitations. This information can be used as a guide to specifying and selecting corrosion-resistant coatings for fan equipment. For chemical resistance to specific applications refer to the Corrosion-Resistance Table beginning on page 3.

Phenolic - resin systems include any of the several types of thermosetting resins obtained by the condensation of phenol or substituted phenols with aldehydes, such as formaldehyde, acetaldehyde, or furfural. Phenolic resins can be cured by baking, air-drying, or catalyzation. These curing processes remove the solvents and oxidize the oils contained in the resin to produce coatings with an extremely hard finish. Phenolic coatings possess excellent resistance to moisture, solvents, and a wide variety of concentrated acids at temperatures to 150°F. air-dried or 400°F. baked.

Epoxy - coatings are derived from a thermosetting resin based on the reactivity of the epoxide group. The most common form of this resin stems from a reaction between epichlorohydrin and bisphenol A. Another type is formed from the oxidation of polyolefins with peracetic acid. Epoxy resins can be cured by baking or catalyzing. When cured, these coatings have a supple finish and superior adhesion qualities. Epoxy coatings are characterized by their excellent resistance to a variety of corrosive chemicals, including acids, alkalis, and salts with temperature limitations between 200°F. and 300°F.

Epoxy-Phenolic - coatings are modified phenolic coatings created by blending phenolic resins with resins from the epoxide group. Epoxy-phenolics can be cured by baking or by the utilization of a catalyst. Catalyzed epoxy-phenolic coatings require a longer curing time and have lower chemical resistance than the baked epoxy-phenolic coatings. They can be applied in greater thickness to attain virtually the same performance characteristics as the baked epoxy-phenolic coatings. These coatings are used mainly for alkali-resistance in moderate temperatures up to 400°F.

Inorganic Zinc - coatings are formulated by adding zinc dust to inorganic binders. These binders give the zinc coatings their corrosion-resistant qualities, while the zinc adds cathodic protection (alters the rate of electron flow which can produce corrosion) to metals below it in the galvanic series. (However, the zinc-rich coatings are not recommended for use over aluminum substrates.) These coatings, which are cured by air-drying, are not subject to ultraviolet degradation and may be used without a top coat for severe weathering conditions. The inorganic zinc coatings have good solvent-resistant properties, but may require an appropriate protective top coat for acid or alkali-resistant applications. Inorganic zinc coatings are suitable for temperatures to 750°F.

Vinyl - coatings use resins from the vinyl-resin family as the major portion of the binder. These resins are formed by a reaction between acetylene and an acid. They consist largely of vinyl acetate, vinyl chloride, and vinyl copolymer. Vinyl coatings can be cured by baking or air-drying, and have excellent adhesion qualities to steel. As the vinyl dries, the film remains non-brittle and will easily follow the expansion and contraction of the underlying surface. Vinyl coatings are unique in that they possess superior corrosion-resistant performance over a broad range of corrosive combinations. The vinyl coatings will give satisfactory results for most corrosive fume applications below 200°F., but are not recommended for solvent-laden environments.

Coal Tar Epoxy - coatings are formed by combining coal tar, a black liquid obtained from the distillation of coal during the conversion of coke, and a resin from the epoxide group. These coatings, which are cured by air-drying or catalyzing, adhere well to metal surfaces. The blend of coal tar and the epoxy resin forms a coating which has good water-resistance characteristics and is resistant to acids and alkali fumes at temperatures to 250°F.

Alkyds - are actually a type of polyester resin modified by the addition of fatty acids or drying oils. These resins are a product of the thermosetting reaction between polyhydric alcohol and a poly-basic acid. Alkyd resins are cured by catalyzation or air-drying. They have the ability to harden at room temperatures in a very short time. These coatings are not generally selected or specified for corrosion-resistant applications, but are normally required for color-matching purposes.

Silicone - coatings are polymeric silicones formed by heating silicon in methyl chloride to yield methylchlorosilanes which are separated and purified by distillation. The desired compound is then mixed with water. Silicone coatings can be cured by baking or air-drying. Formulated for medium to high temperature service where temperatures seldom fall below 200°F. to 300°F., these coatings normally exhibit good to excellent fume resistance to acids, alkalis, solvents, salts, and water, but are not recommended for areas subjected to acid or alkali splash or spillage. Silicone coatings possess good weathering characteristics, but an inorganic zinc primer will greatly extend the coating's service life when applied to steel, especially if service temperatures fall below 300°F. and moisture is present. The maximum temperature limitation for these coatings varies according to each specific manufacturer's recommendation.

Polyurethane - coatings are derived from prepolymers containing isocyanate groups and hydroxyl containing materials such as polyols and drying oils. Polyurethane coatings, which are cured by air-drying or catalyzing, are frequently applied over zinc and epoxy primers. These coatings produce an extremely hard, yet flexible, high gloss finish that is resistant to weathering, ultraviolet degradation, acids, and alkalis at temperatures to 200°F.

Polyester - resins are thermosetting synthetic resins formed by the polycondensation of dicarboxilic acids and dihydroxy alcohols. Polyester resins are characterized by their ability to cure at room temperatures in a very short time after being catalyzed. They also have excellent adhesion qualities. The polyester coatings are resistant to mild traces of acids, alkalis, and solvents. The maximum temperature limitation for these coatings varies according to each specific manufacturer's recommendation.

Vinyl Ester - resins are combined with a special curing system and inert flake pigment. Vinyl ester coatings, which are cured by air-drying or catalyzing, provide excellent chemical resistance to organic and inorganic acids, oxidizing agents, salts, and a wide range of solvents. Vinyl ester coatings are applied at 35 to 40 mils DFT.

Although these coatings cover a broad range of generic types, they by no means cover them all. Types mentioned here are the most commonly specified and selected generic types offered for use on fan equipment.

Selecting the proper coating system for the application is not enough to ensure its success. Proper surface preparation is essential to the effectiveness of any coating system.

COATING SURFACE PREPARATION

Surface preparation not only ensures that the coating will adhere adequately but also removes contaminants which could be detrimental to the service life of the equipment. The Steel Structures Painting Council further defines various types of surface preparation as shown in Engineering Letter 17. Coating manufacturers then suggest the recommended degree of surface preparation for each of their brand name coatings.

Based on the surface preparation necessary for each coating specification, **nyb** will either apply the coatings in its facilities or have them sent to an outside applicator. Most coatings applied by **nyb** receive a combination of phosphate wash and hand tool cleaning. This procedure removes all oil, dirt, grease, loose rust, and mill scale that hinders the effectiveness of the coating. This method of surface preparation is equivalent to a combination of Solvent Cleaning (SSPC-SP1) and Hand Tool Cleaning (SSPC-SP2). The application of a coating which requires any degree of sandblasting is handled by an outside applicator. Sandblasting is further defined in Engineering Letter 17.

Airstream, exterior, and **all surfaces** are common area requirements for coatings. **Airstream surfaces coated -** includes interior of housing, entire wheel, that portion of the shaft in contact with the airstream, airstream areas of collar, inlet ring and/or inlet plate, and all surfaces of the inlet cone. **Exterior surfaces coated -** includes all outside surfaces, except bearings, motor, and the shaft. **All surfaces coated -** includes all surfaces inside and outside, except bearings, motor, and that portion of the shaft not in contact with the airstream

APPLICATION AND SELECTION GUIDE

The table below provides a condensed guide to the corrosion-resistant properties of generic coatings commonly available on fan equipment. Each coating should be chosen according to the specific corrosive chemical or chemicals involved in the application. The customer is responsible for selecting the coating which will provide proper protection. **nyb** can only warrant that the coating will be applied according to the coating manufacturer's instructions.

Fume-and aerosol-contaminated air has been used as the basis for this guide. The fumes or aerosols of a substance are effectively diluted by air, reducing the chemical concentration to a level significantly lower than the liquid solution. Because this guide is based on dilute concentrations of fumes and aerosols, relatively few chemicals are listed as unsatisfactory for use with these protective coating systems.

Protective coatings play an important role in corrosion-resistant construction. They often have the lowest first cost. Special alloy and fiberglass-reinforced plastic construction are also available for corrosive applications. Special alloy and FRP construction are able to handle a wider range of corrosives, are far superior when it comes to corrosion resistance, and many times result in the lowest life cycle cost.

CORROSION-RESISTANCE GUIDE TO GENERIC COATINGS AND ASSORTED METALS

Corrosive Agent	COATINGS													METALS			
	Baked Phenolic	Air-dried Phenolic	Catalyzed Epoxy	Baked Epoxy-Phenolic	Catalyzed Epoxy-Phenolic	Inorganic Zinc	Air-dried Vinyl	Coal Tar Epoxy	Alkyd	Air-dried Silicone	Polyurethane	Polyester	Vinyl Ester	Carbon Steel	Aluminum	304* Stainless Steel	316 Stainless Steel
Acetic Acid	E	N	N	T	N	N	E	N	N	S	N	E	E	N	S	S	E
Acetic Anhydride	E	N	N	T	N	N	E	S	N	S	N	N	S	N	E	S	E
Acetone	E	N	S	S	S	E	N	N	N	S	E	N	N	E	E	E	E
Acetylene	E	E	S	S	E	E	S	T	N	S	S	T	E	S	E	E	E
Aluminum Acetate	E	E	N	S	N	S	S	T	N	S	S	S	E	T	S	E	E
Aluminum Chloride (dry)	E	S	S	E	S	N	S	S	S	S	S	E	E	N	S	N	S
Ammonia (dry)	E	S	N	E	S	N	N	S	N	S	S	S	E	S	E	E	E
Ammonia (wet)	E	N	N	E	S	N	N	N	N	N	S	N	E	S	E	E	E
Ammonium Sulfite	E	S	S	S	S	N	N	S	N	S	S	S	E	N	N	S	E
Aniline	E	S	N	T	N	E	S	N	N	S	S	S	S	N	N	E	E
Barium Chloride	E	S	S	E	E	S	E	S	N	S	S	S	E	N	N	E	E
Benzene	E	N	S	E	S	E	N	N	N	S	S	S	N	N	S	E	E
Boric Acid	E	E	S	E	E	N	E	S	N	S	S	S	E	N	S	E	E
Bromine Water	N	N	S	N	N	N	N	S	N	N	S	S	S	N	N	N	N
Butane	E	S	N	E	S	S	S	T	S	S	S	T	E	E	S	E	E
Calcium Chloride	E	E	E	E	E	N	E	S	N	S	E	E	E	N	S	S	S
Carbon Tetrachloride (dry)	E	E	N	E	S	S	N	S	N	S	S	S	S	S	N	S	E
Chlorine Gas (dry)	S	S	S	T	S	N	N	S	N	S	S	N	E	S	N	S	S
Chlorobenzene	S	N	N	E	S	S	S	N	N	S	S	S	S	S	S	S	S
Citric Acid	E	E	N	S	E	N	E	S	N	S	S	S	E	N	S	E	E
Copper Sulfate	E	S	S	E	E	S	E	S	N	S	S	S	E	N	N	E	E
Cyclohexanone	E	N	N	S	N	S	S	N	N	S	S	S	S	N	S	S	S
Ethyl Acetate	E	N	S	S	S	S	S	S	N	S	S	N	E	S	S	E	E
Ethyl Alcohol	E	S	S	E	S	E	S	S	N	S	S	S	S	S	S	E	E
Ethylene Dichloride	E	N	N	S	S	S	N	N	N	S	N	S	N	S	S	E	E
Ethylene Oxide	S	N	N	T	N	E	S	N	N	S	N	N	N	S	S	S	S
Ferric Chloride	S	S	E	E	E	S	E	S	N	E	S	S	E	N	N	N	N
Ferric Nitrate	S	S	N	T	S	N	S	T	N	S	S	T	E	N	N	E	E
Fluorine Gas (dry)	N	N	N	T	N	N	S	T	N	S	N	T	E	N	E	E	E
Formaldehyde	E	E	S	E	S	E	E	N	N	S	S	N	S	S	S	E	E

E = Excellent S = Satisfactory N = Not Recommended T = Test data not available

* 347 stainless steel has the same corrosion-resistance characteristics as 304 stainless steel.

The suitability of the coatings found in this table has been based on fume concentration effectively diluted by air at 70°F. High chemical concentra tion and/or elevated temperatures and/or moisture may significantly reduce a coating's suitability.

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Formic Acid	S	N	N	N	N	N	N	N	N	S	S	N	E	N	N	S	E
Gasoline	E	S	S	E	E	E	S	N	S	S	E	S	E	E	E	E	E
Glycerine	E	E	E	E	S	S	S	S	N	S	S	S	E	S	E	E	E
Hydrochloric Acid	E	S	N	S	S	N	S	N	N	S	S	N	E	N	N	N	N
Hydrofluoric Acid	N	N	N	N	N	N	S	N	N	N	N	N	S	N	N	N	N
Hydrogen Peroxide	N	N	S	N	N	N	S	N	N	S	S	S	E	N	E	E	E
Hydrogen Sulfide (dry)	E	S	S	E	S	N	E	S	N	S	S	S	E	S	S	S	E
Hydrogen Sulfide (wet)	S	N	N	S	N	N	N	S	N	N	N	N	E	N	S	N	S
Iodine	E	T	N	T	N	N	N	N	N	S	T	S	E	N	E	N	N
Lactic Acid	E	S	S	S	E	N	E	S	N	S	S	S	E	N	S	S	E
Magnesium Carbonate	E	E	E	E	E	S	E	S	S	S	S	S	E	N	S	E	E
Mercuric Chloride	E	E	E	E	E	S	T	S	N	S	E	S	E	N	N	N	N
Methyl Alcohol	E	S	N	E	S	E	E	N	N	S	E	S	S	S	S	E	E
Methyl Ethyl Ketone	E	N	S	S	N	E	N	N	N	S	E	N	N	S	S	E	E
Mineral Oil	E	E	E	E	E	E	E	E	S	S	E	S	E	S	S	E	E
Moisture	E	E	E	E	E	E	E	E	E	S	E	E	E	S	S	E	E
Naptha	E	E	S	E	S	E	N	S	S	S	S	S	S	S	E	E	E
Nitric Acid	E	N	N	N	N	N	S	N	N	S	N	S	S	N	N	E	E
Ozone	N	N	N	N	N	S	S	N	N	S	N	T	S	N	S	S	S
Perchloric Acid	S	N	N	S	N	N	E	N	N	S	N	S	S	N	N	N	N
Phenol	E	N	S	S	N	S	S	N	N	S	S	S	S	S	E	E	E
Phosphoric Acid	E	S	N	S	S	N	E	N	N	S	E	S	E	N	N	S	E
Polyvinyl Acetate	E	N	E	T	N	N	N	T	N	S	T	N	E	N	T	E	E
Potassium Chloride	E	S	N	E	E	S	S	S	N	S	S	S	E	S	N	S	E
Potassium Cyanide	E	S	N	E	S	N	S	S	N	S	T	S	E	S	N	E	E
Potassium Dichromate	S	S	N	E	S	S	S	S	N	S	S	S	E	S	E	E	E
Potassium Hydroxide	N	N	S	N	S	S	E	S	N	S	S	S	E	S	N	E	E
Pyridine	E	T	N	E	N	S	T	N	N	S	N	N	N	S	S	S	S
Salt Spray	E	S	E	E	S	E	E	E	S	E	E	S	E	N	S	S	S
Silver Nitrate	E	S	N	T	N	N	E	T	N	S	S	T	E	N	N	E	E
Sodium Bicarbonate	E	E	S	E	E	N	E	E	S	S	S	S	E	N	S	E	E
Sodium Chloride	E	S	E	E	E	S	E	E	S	E	S	S	E	N	N	S	E
Sodium Cyanide	N	S	S	S	S	N	S	S	N	S	S	S	E	S	N	E	E
Sodium Dichromate	N	S	S	S	N	S	S	E	N	S	S	S	S	S	S	S	S
Sodium Hydroxide	N	N	S	S	N	S	E	S	N	N	E	S	E	S	N	E	E
Sodium Hypochlorite	N	N	N	N	N	N	N	S	N	N	S	N	E	N	N	N	N
Sodium Sulfate	E	S	S	E	E	N	E	S	N	S	S	S	E	S	E	E	E
Steam Vapor	E	N	S	E	N	N	S	S	S	E	N	S	E	S	S	E	E
Sulfamic Acid	E	S	S	T	S	N	S	S	N	S	S	S	S	N	N	T	S
Sulfur Dioxide (dry)	E	S	S	S	S	N	N	S	N	S	T	S	E	E	S	S	E
Sulfur Dioxide (wet)	E	S	S	S	N	N	N	S	N	N	T	N	S	N	N	N	S
Sulfuric Acid	E	S	N	S	S	N	S	N	N	S	E	N	E	N	N	N	S
Tannic Acid	E	E	S	T	E	N	E	E	N	S	S	T	E	N	N	S	E
Toluene	E	N	E	E	N	E	N	S	N	S	E	S	S	E	E	E	E
Trichloroethylene	E	N	N	E	N	S	N	N	N	S	N	N	N	S	S	S	S
Xylene	E	N	E	E	S	E	N	S	N	S	E	S	E	S	E	E	E
Zinc Chloride	E	S	S	E	E	N	E	S	S	E	S	S	E	N	N	N	S
Zinc Sulfate	E	S	S	E	E	N	E	S	S	S	S	S	E	N	S	E	E

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