Understanding the Basic

By Gary Hall, JPCL Contributing Editor

unsaturated polyester resins based on maleic and fumaric acids have been known since the 1920s. In the late 1930s, the modern form of these resins was introduced when Charleton Ellis combined styrene with unsaturated polyester.

Polyester and vinyl ester resins have been used in severe chemical environments for 50 years in the form of mortars for chemical-resistant brickwork and in fiberglass reinforced plastic (FRP). These successes led to the development of chemical-resistant coatings and linings based upon these resins that offer superior resistance to a broad range of chemicals, especially acids, and to higher temperatures than most other coating types like epoxies and polyurethanes.¹

The terms “coatings” and “linings” are used throughout this article. For the purposes of this article, linings are composed of glass fabric, mat, or woven roving saturated with the chosen resin. They are applied in sheets of fiberglass reinforcement saturated in resin, which are then laid against the substrate and rolled in place using a ribbed roller. Coatings are usually thinner than linings and are applied as a mixture by brush, roller, airless spray, and plural component spray.

This article describes the basic chemistry of polyesters and vinyl esters, properties, concerns with the materials, and application methods.

Editor’s Note: This article is the eighth in JPCL’s 2013 series on generic coating types.
Basic Chemistry
Unsaturated polyesters are formed by the reaction of a dibasic organic acid, such as phthalic or maleic acid, and an alcohol or polyl such as ethylene glycol. Unsaturated polyester resin (usually called a “polyester resin” or “polyester”) is a thermoset that can be cured from a liquid state under the proper conditions. A wide range of polyesters, including partially aromatic and aromatic versions, can be made by using different acids, glycols, alcohols, and monomers, each with different properties (Fig. 1 on p. 36).

Polyester resins used in coatings are typically pale-colored, viscous liquids consisting of the polyester dissolved in a monomer, usually styrene. Styrene reduces the viscosity of the resin, making it easier to handle. Styrene is called a reactive diluent because it is involved in the curing of the polyester resin, as well as in reducing viscosity. They cure through a free radical mechanism. The free radicals are produced by reaction of an organic peroxide, such as methyl ethyl ketone peroxide (MEKP), and a reducing agent, typically a cobalt salt. This type of free radical initiation is known as a redox (reduction-oxidation) reaction. When added to the resin, the MEKP splits into two free radicals (RO* + ROO*), each of which then react with the styrene, causing it to form another free radical.

These styrene radicals then react with the carbon-carbon double bonds (C=C) adjacent to the ester groups along the length of the polyester resin molecules forming crosslinks between adjacent polymer molecules, without creating byproducts. The uncured polyester molecule has multiple reactive sites along the length of the molecule. Multiple cross-link sites ensure that the molecules are tightly bonded to each other. This allows for high mechanical strength and excellent chemical resistance, but it also introduces rigidity to the cross-linked network. This irreversible reaction results in a dense and complex network of intertwined polymers with excellent chemical resistance. Polyester resins and vinyl ester resins are highly reactive, have a short shelf life, and will gel or set on their own upon standing. Warm temperatures hasten this reaction. Inhibitors are often added during manufacture to prolong storage life. Refrigeration is also often recommended. Even with the use of inhibitors and refrigeration, the shelf life of polyester and vinyl ester resins is typically three months or less.

Saturated dicarboxylic acids are used in polyesters to control cross-link density and to optimize the properties of the cured polymer network. The three most commonly used dicarboxylic acids and their contributions to the cured network are shown in the box on p. 36.

To formulate vinyl ester and polyester coatings, the coating manufacturer will add other materials, including initiator; accelerator; and typical coating raw materials such as thixotropes, fillers, and pigments. Flake glass and silane-treated micaceous iron oxide (MIO) are often preferred fillers because they beneficially reduce coating permeability. Fillers are often in the range of 45–50% by weight. There is also some evidence that flake glass will help limit the length of cracks that may form in the coating due to stresses in service.

Vinyl ester resins, a special subclass of polyesters, are similar to polyester resins in that both contain multiple ester groups and are cured in the same way. There are, however, some significant differences in the polyester resins and vinyl ester resins used to
formulate corrosion-resistant coatings. The main difference is that a polyester resin molecule has several reactive ester sites along its length, while a vinyl ester resin has only two ester groups, both in the terminal or vinyl position. This has a significant effect upon the properties of the resulting cured polymer. Since the reactive sites in a vinyl ester resin are only found in the terminal positions of the chain, cross-linking can only occur at these sites, in contrast to several cross-link sites on a polyester chain. Terminal attachment between two polymer chains means that, unlike what occurs in polyester polymers, the entire polymer chain between reactive ester sites is not cross-linked to another polymer chain. The portion of the polymer chain that is not cross-linked is able to absorb shock and impact, making vinyl esters tougher and more resilient than polyesters.

Having only two ester groups per molecule imparts an additional advantage to vinyl esters. In aqueous environments, ester groups are susceptible to hydrolysis, which causes degradation of the polymer; thus, vinyl esters exhibit better resistance to water and many other chemicals than their polyester counterparts. For these reasons, vinyl esters are often used in highly corrosive environments where other resins fail. Vinyl esters will also function at higher temperatures than polyesters and epoxies. The structure of the polymer between the reactive sites has a profound effect upon the chemical and physical properties of the vinyl ester resin.

The vinyl ester resins most often used in chemical-resistant coatings have an epoxy backbone to which terminal ester end groups are attached. These resins are the reaction products of an addition reaction of an epoxy resin with an unsaturated carboxylic acid, which results in terminal double bonds. Several epoxy resins are used in commerce. The bisphenol A diglycidyl ether epoxy, typically called bis A epoxy, and the epoxylated phenol-formaldehyde novolac, typically called novolac epoxy, are the two most commonly used. The epoxy vinyl ester resins produced are frequently referred to as bis A epoxy vinyl ester resins and novolac epoxy vinyl ester resins respectively. Commonly used acids

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**The Three Most Commonly Used Dicarboxylic Acids Used to Control Cross Link Density in Polyesters**

<table>
<thead>
<tr>
<th>Phthalic acid anhydride</th>
<th>Isophthalic acid</th>
<th>Terephthalic</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Phthalic acid anhydride" /></td>
<td><img src="image2.png" alt="Isophthalic acid" /></td>
<td><img src="image3.png" alt="Terephthalic" /></td>
</tr>
</tbody>
</table>

- Most commonly used
- Good overall properties
- General purpose resin
- 1-step condensation

- Chemical resistance
- Best weathering
- More costly than anhyd.
- 2-step condensation
- Increased Tg
- More costly than anhyd.
- 2-step condensation
Fig. 2: The physical and chemical properties of epoxy vinyl ester resins depend on the type of epoxy resin used, its molecular weight, and the acid used.

(Eq) include acrylic acid, methacrylic acid, isophthalic acid, terephthalic acid, maleic anhydride, and fumaric acid. The physical and chemical properties of the resulting vinyl ester resin depend on the type of epoxy resin used, its molecular weight, and the acid used (Fig. 2).

Other modifiers can be used to impart special properties. For example, toughened vinyl esters can be made by incorporating modified liquid rubbers like carboxy-terminated butadiene-acrylonitrile co-polymers (CTBN), epoxy-terminated butadiene-acrylonitrile rubber (ETBN), core shell rubbers, and certain vinyl-modified hybrid urethanes. Toughening vinyl ester resins is usually done to increase properties like temperature resistance, glass transition temperatures (Tg), heat distortion limits (HDT), water resistance, and fracture toughness. Generally, when additives are used to improve elongation and flexibility, chemical resistance will decrease. Flexibilized polyester and vinyl ester resins are typically limited to formulating primers and are rarely used as topcoats.

There is considerable interest in two newer technologies for curing vinyl ester resins. Styrene is a prohibited ingredient in some applications, such as in potable water or in contact with food, and for some customers due to health considerations.

Cobalt carboxylates have already been classified as “CMR2 Reprotoxic” by the European Chemical Agency (ECHA), which means they are carcinogenic, mutagenic reproductive toxins. In Europe, manufacturers must conform to a wide-ranging directive known as REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals). European manufacturers are under pressure to eliminate cobalt (Co+) from coatings and composites. All other cobalt compounds will eventually be evaluated, and those that are capable of forming the Co+2 ion will be prohibited. Cobalt naphthanate and cobalt octoate will both form the Co+2 ion. This means that manufacturers must search for replacements for both cobalt salts and styrene. Other transition group metals such as copper, manganese, and iron have the ability to start the redox reaction needed to initiate the cure, without having carcinogenic or mutagenic characteristics. Other monomers may be used in place of styrene, some of which are neither hazardous air pollutants (HAPs) nor volatile organic compounds (VOCs), resulting in a “styrene-free” vinyl ester. These other monomers include tert-butyl styrene, vinyl toluene, diallyl phthalate, and trimethylolpropane triacrylate. The latter two are neither HAPs nor VOCs and are more expensive.

The use of ultraviolet light (UV) to cure vinyl ester coatings is gaining in interest and in importance. These coatings also use free
radical initiators to initiate cure, but instead of MEKP, a photo initiator is added to the resin. When exposed to UV light, the photo initiators become “excited” and then decompose to generate the free radicals. Radiation-cured resins offer the potential to reduce air pollution and to reduce carcinogens in the environment because they are solvent free. In practice, UV-curable vinyl esters are somewhat limited in their applications because the uncured coating must be exposed to the proper wavelength of UV light at the required intensity. This generally requires placing the UV light source close to the freshly applied coating, while maintaining a uniform distance from the coating. This is not always possible, especially at construction sites.

Various types of fillers are typically added to polyester and vinyl ester coatings to impart distinct characteristics to the coatings and change specific properties of the coating, such as cost, permeation, abrasion resistance, and flexibility (Table 1).

The earliest linings were reinforced with chopped fiberglass or woven roving (woven fiberglass fabric). Later, silica and other mineral fillers were added to improve the release of the heat generated during cure, reduce shrinkage during cure, and reduce the coefficient of thermal expansion (cte) of the coating to better match the cte of the steel or concrete substrate. These earliest linings were either roll-applied or applied by trowel. Later developments included the use of mineral flakes, like mica, and glass flake, which decreased permeation by water vapor and slightly extended the maximum service temperature in wet environments.

**Performance Critical Properties**

Today’s industries present such diverse chemical and thermal environments that no single resin can withstand the many combinations possible. A variety of resin types is required. The resin chemistry will largely determine how a particular resin behaves in any given chemical/thermal environment. Different resins may well yield widely different results in the same environment. The type of resin chosen will be the principal factor in determining whether a coating will perform as expected.

**Flexibility**

As noted earlier, vinyl ester and polyester resins are relatively brittle, especially the polyester resins due to the greater number of cross-link sites along the polymer. Unfilled resins generally have a tensile elongation of about 2 to 5%, although some manufacturers offer modified resins with elongations as high 12%. These flexible resins are not as chemical resistant as the unmodified resins, nor do they have the thermal stability or mechanical properties required to function as a topcoat.

Flexibility and elongation properties of

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**Table 1: Common Fillers and Properties Imparted**

<table>
<thead>
<tr>
<th>Filler</th>
<th>Coating Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graded &amp; cleaned silica</td>
<td>Low cost, good permeation resistance, good abrasion resistance, reduces thermal expansion, most common filler used</td>
</tr>
<tr>
<td>Mineral fillers</td>
<td>Improved abrasion resistance, improved fluoride resistance, non-skid; e.g., garnet, anthracite, granite</td>
</tr>
<tr>
<td>Carbon fillers</td>
<td>Electrical conductivity, fluoride resistance</td>
</tr>
<tr>
<td>Carbon fiber veil &amp; weave</td>
<td>Fluoride resistance, reduces shrinkage, electrical conductivity</td>
</tr>
<tr>
<td>Chopped “C” glass fiber</td>
<td>Improved flexural modulus of elasticity, chemical resistance, shock resistance, reduces thermal expansion</td>
</tr>
<tr>
<td>Chopped fiberglass mat</td>
<td>Improved chemical resistance, decreased shrinkage, reduces thermal expansion</td>
</tr>
<tr>
<td>Woven fiberglass fabric</td>
<td>Bidirectional reinforcement, improved strength, reduces thermal expansion</td>
</tr>
<tr>
<td>“C” glass veil</td>
<td>Excellent chemical resistance, decreased shrinkage, reduces thermal expansion</td>
</tr>
<tr>
<td>Ceramic fillers</td>
<td>Specific properties such as lower thermal conductivity, fluoride and alkali resistance, abrasion resistance depending upon the filler (e.g., alumina, silicon carbide, vitreous silica, hollow ceramic and glass beads, etc.)</td>
</tr>
</tbody>
</table>
These materials are critical to designing a lining system that will not crack in service. It is not as simple as incorporating reinforcement, because reinforcement will reduce elongation capability. Special attention must be paid to areas of high strain, areas where the substrate tends to bend or flex, discontinuities, or localized areas where the temperature on the coating is significantly higher than or lower than the surrounding coating.

The coating manufacturer must be consulted to ensure that the coating has the necessary properties to withstand the intended service conditions.

**Chemical Resistance**

Because chemical resistance is the most important property for these materials to have, manufacturers spend large amounts of time and money evaluating the resistance of their products to an extremely wide range of chemicals and temperatures. A quick look at the chemical resistance charts that the coating and resin manufacturers publish will reveal hundreds of different chemicals and temperatures in which they have tested their products. Each of the different types of resin has a different resistance to a given chemical environment. There are some generalities that can be made, but there are many exceptions. It is imperative that the user consult the coating or resin manufacturer about each application to ensure that the wrong material is not used.

Bisphenol A epoxy vinyl esters are generally not as chemical resistant as novolac epoxy vinyl esters, but, again, exceptions exist. The novolac vinyl esters are not recommended for calcium or sodium hypochlorite exposure, whereas the bis A vinyl ester is recommended. It must be noted, however, that the bis A vinyl ester must use benzoyl peroxide as the initiator for hypochlorite exposures. MEKP-initiated systems will fail after a relatively brief exposure, especially at temperatures above 100°F (~38°C). Due to the improved chemical and thermal stability imparted to the polymer by the epoxy backbone, vinyl esters generally have better chemical resistance and temperature resistance than polyesters; however, there are several environments where the less expensive polyesters are preferred. The bis A fumarate polyesters exhibit resistance to a wide range of chemicals, including strong alkalies that will attack other polyesters and vinyl esters. Another class of polyesters is the chlorendic polyesters. These chlorinated polyesters have excellent resistance to strong mineral and oxidizing acids, for example, chromic acid. Chlorendic polyesters are the best choice for chromic acid exposures.

**Adhesion**

Vinyl ester and polyester coatings have good adhesion to a properly prepared substrate. Both concrete and metallic substrates will require a surface profile to ensure mechanical anchoring so the coating will remain bonded when exposed to the stresses generated during cure and operating conditions. Profile amplitudes, top of peaks to bottom of valleys between peaks, will vary with coating thickness. A minimum profile is about two mils, but can be as high as five mils for very thick liners. Many of these coatings will also use a primer to enhance adhesion.
They are not, however, recommended for alkaline exposures.

Vinyl ester and polyester resins offer resistance to aggressive chemicals at elevated temperatures. In some environments, especially wet ones, these resins can withstand temperatures up to 400°F (204°C), e.g., wet fossil fuel flue gas. As a result, these resins find uses as protective linings for concrete, tanks, secondary containment, flue gas ducts and stacks, floor and wall coatings, structural steel, and process vessels.

Always consult the manufacturer of the coating, because differences in formulations will affect how two coatings made from the same resin will perform. If time permits, ask the manufacturer to prepare cured samples that can be placed in the expected environment for evaluation and testing.

An additional comment is in order regarding chemical resistance charts published by coating and lining manufacturers and resin manufacturers. Most of these tests were conducted according to ASTM test methods, as they should be. However, the ASTM methods are not performance specifications; rather they are detailed instructions on how to conduct the tests. They do not establish pass/fail criteria. The decision as to whether a particular product is recommended for a given environment is left to the individual product manufacturer.

**Areas of Concern**

There are certain characteristics of polyester and vinyl ester based coatings and linings that require the exercise of caution when using them. One of the primary concerns is the high coefficient of thermal expansion (cte) of both types of resin. Unfilled and unreinforced polyester resins have a cte that is approximately 4 to more than 10 times as great as that of carbon steel and concrete. This large difference will cause problems whenever the temperature changes significantly or too rapidly. Problems could include disbondment, cracking, and edge curling. Coating and lining manufacturers are very much aware of this situation and incorporate fillers and reinforcements in their linings and coatings to reduce the cte as much as possible. Fillers like glass fiber, glass flake, and silica have relatively low thermal expansion and are widely used for this purpose, as well as for their reinforcement properties.

Another problem area for these resins is the inherent shrinkage that occurs during cure, which can have undesired effects, such as cracking and disbondment of coatings and delamination in FRP linings shortly after the resin is fully cured.

When curing, these resins are exothermic. The heat developed during cure and the shrinkage occurring at the same time will result in a residual tensile stress that often results in disbondment and cracking. These thermal excursions and volume changes, both from thermal expansion and shrinkage, mandate that linings and coatings be reinforced to prevent premature failure.

When curing these resins, one must be aware of the inhibiting effect of atmospheric oxygen and excessive atmospheric moisture on cure. Both oxygen and moisture inhibit the cure at the surface where the resin makes contact with the environment. Cross-linking is prevented, leaving a surface that is soft and lacking in chemical resistance. The thinner the coating, the more critical this effect becomes. Different resins are affected to different degrees, but all are affected. To overcome this problem, most coating manufacturers supply a "gel" coat or a specially formulated topcoat that has a small amount of paraffin wax dissolved in styrene. As the coating or lining begins to cure, the paraffin migrates towards the air side surface. Since it cannot evaporate at ambient conditions, a thin film of paraffin is distributed over the air-exposed surface. The paraffin wax acts as a physical barrier to both oxygen and moisture, thus preventing cure inhibition. The paraffin will be removed by the chemical and/or thermal conditions once the lining is placed into service, leaving a properly cured and fully resistant lining in place.

Polyester and vinyl ester linings and coatings are more sensitive than some other coatings to application conditions. If temperatures are outside of the specified range, cure problems may arise. If the substrate is not properly cleaned, the contaminants may interfere with cure of material adjacent to the substrate. Atmospheric contaminants, too, can interfere with cure. Installers must ensure that all of these potential problems are accounted for during application and approved by the coating manufacturer.

These potential problems may require heating the application area and the substrate's surface; cooling the application area and the substrate's surface; dehumidifying the application area; or tenting it to protect it from weather, sunlight, and local air pollutants that may otherwise fall onto the substrate and the freshly applied lining/coating.

The user should be aware that there will be a small amount of styrene remaining in the cured resin. This will release from the coating/lining over time and if the cured sys-
and sealed with a gel coat. These systems are typically packaged as three-component units. The resin and initiator (MEKP, etc.) are first mixed together thoroughly. Next, the aggregate is mixed until uniformly dampened, at which point the mix is applied.

These same types of linings can be applied by a method called "pour and spread" or "broadcast." The resin/initiator mixture is spread evenly over the floor with a grooved rake to a uniform thickness. The aggregate is immediately spread, or broad-cast, over the wet resin, either manually or by mechanical device. The aggregate is broadcast until the aggregate can no longer sink into the resin and the resin can no longer wet the aggregate ("broadcast to excess"). After the resin cures, all loose aggregate is removed with brooms or a shop vac. The surface is then sealed with a liberal coat of resin/initiator, pigmented as desired, and followed by a gel coat. This installation method is faster than troweling, but cannot be used on vertical surfaces and floors with a severe slope. These systems can be applied from ⅛-inch (~1.5 mm) to as thick as ⅝-inch (~12.5 mm).

Trowel-applied linings may also be filled with silane-treated micaceous iron oxide (MIO) or silane-treated glass flake. Flake-filled liners offer superior permeation resistance. These are usually three-component systems applied by trowel. Immediately after troweling, the surfaces are compacted by rolling with a short nap paint roller to help remove entrapped air near the surface and to help ensure that the flakes are lying flat. The flakes are typically up to ⅛-inch (~3 mm) in diameter. These flakes overlap each other in layers, creating a tortuous path that makes penetration by liquids much more difficult.

Polyester and vinyl ester coatings for industrial applications may be applied by one of two generally preferred spray methods. Both use airless, high-pressure spray equipment to apply the coatings. In one method, called "hot potting," the resin mixture and initiator are

**Application Methods**

For surface preparation, environmental controls, and worker protection, much of what is needed for polyester and vinyl ester linings is needed for their coatings counterparts. But lining application differs from coating application, and each will be discussed separately.

Several types of linings incorporate combinations of trowel-applied protective barriers and some form of fiber glass reinforcement; stand-alone systems also exist.

These materials are aggregate-filled resins designed to be applied by hand trowel or by power trowel. The aggregate can be just about any of those listed in Table 1, or others. Silica is by far the most common filler, but where fluoride resistance is required or where improved abrasion resistance or some other characteristic is needed, other aggregates are used. These systems typically consist of a primer, followed by a trowel-applied layer that can range from ⅛-inch (~1.5 mm) to as much as ⅝-inch (~12.5 mm). Over this, one or more layers of a fiberglass fabric or veil may be laid to reinforce the lining. (If fluorides or strong alkalies are expected, either synthetic veil or carbon fiber should be substituted for the fiberglass.) These types of linings are generally used to protect concrete floors. They provide both chemical resistance and excellent mechanical properties, including abrasion resistance.

The fiberglass is then saturated with resin and rolled with a ribbed roller to eliminate air pockets and to ensure that the fiberglass is fully wet with the resin. A final top layer of the trowel-applied material is then applied

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**Start of vinyl ester coating on wall above floating roof**

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item is smelled close up, the styrene odor will be noticeable for a brief period after cure.

Some applications will require a forced post cure in order to develop full chemical resistance and maximum mechanical properties. If required, a two-hour post cure at 120°F (49°C) is generally sufficient. Consult the coating/lining manufacturer for recommendations.

Polyester and vinyl ester coatings share concerns with other coatings, as well. For example, it is not advisable to apply any coating or lining on concrete or other porous surfaces in direct sunlight or in the presence of soluble salts on the substrate. UV radiation will damage many organic coatings, including polyesters and vinyl esters, causing photo degradation (e.g., chalking of coatings).
mixed together and then pumped through a material hose to the spray gun. The material is atomized at the spray gun as it is being applied to the substrate. Pressures at the gun tip are typically 5,500 to 6,300 psi.

The second method is plural-component spraying. Plural-component equipment pumps the resin side and the initiator through separate material hoses to the mixing point. Spray-applied coatings will typically use smaller fillers so they can pass through the spray tip, which can have an opening as small as 0.029 inches (0.74 mm). This includes products made with glass or MIO flake. The flakes in spray-applied coatings do not align themselves parallel to the substrate as uniformly as in the trowel-applied systems but still improve permeation resistance and help provide crack resistance.

Other special fillers may be used, such as carbon for fluoride or alkali service, or glass fiber for flexural modulus and tensile strength improvement, or alumina for abrasion resistance.

Application by spray reduces the overall cost of the installation because the time required to apply the material is typically approximately 10% of the time required to hand apply a liner by trowel.

Because polyester and vinyl ester coatings and linings are relatively brittle, they will break if stretched too much. Thus, when placed over substrates that can move significantly, the coatings will crack. Concrete is famous for its tendency to crack with age. If a brittle coating or liner is placed over concrete that develops a crack, the coating above it will crack as well, a phenomenon called “reflection cracking.” To prevent reflection cracking in the coating, first coat the concrete with a highly flexible coating, such as a flexibilized epoxy, urethane, or rubber, called a crack-bridging membrane. The polyester/vinyl ester coating/liner is then placed over this membrane, which can accommodate the high strains generated by the crack opening as it moves and can thus prevent reflection cracking.

Environmental, Safety, and Health Considerations
Both styrene and cobalt have environmental, health, and safety (EHS) concerns. These concerns mandate that workers take precautions, in accordance with OSHA, EPA, and any other relevant federal, state, or local EHS regulations, when handling polyester and vinyl ester resins. For example, first among
these precautions is use of a properly-fitted respirator in compliance with OSHA requirements. OSHA also requires additional protective equipment, including chemical-resistant gloves, face shield or protective goggles, long-sleeved shirt or a full body protective suit, and protective foot gear. If the application is indoors, local ventilation with sufficient capacity to withdraw the styrene vapors is required. All equipment should be electrically grounded to prevent sparking and accidental ignition of the styrene vapors.

The precautions above are not intended to be exhaustive. As with all coatings and linings, always consult the correct Safety Data Sheets (SDS) as well as the appropriate EHS resources (personnel and regulations) before applying polyesters or vinyl esters. Similarly, before you begin the work, take all of the protective measures required. If you become exposed to the product through inhalation, skin contact, or other means, follow all recommended medical procedures.

Summary

Polyester and vinyl ester coatings and linings have a long and successful history of corrosion resistance in a wide range of chemical and thermal environments. They possess high mechanical strength and adhesion as well as low permeation and excellent chemical resistance, even in elevated temperatures. A variety of coatings and linings utilize many different fillers and reinforcements that help impart specific properties. Care must be exercised in using these materials over substrates that move and over concrete that might have, or might develop, cracks. It is strongly recommended that the user consult with the coating/lining manufacturer for each application to ensure that the system will perform as expected and that operating conditions will not result in premature failure. Most important, protection of workers, the public, and the environment must never be ignored.

Reference


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