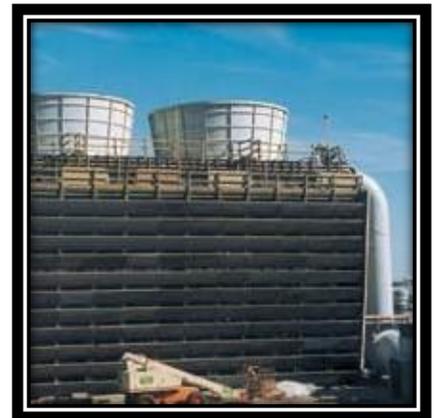
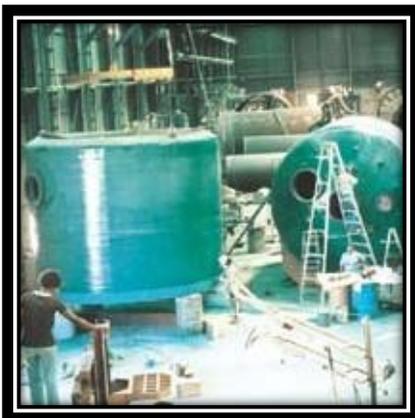
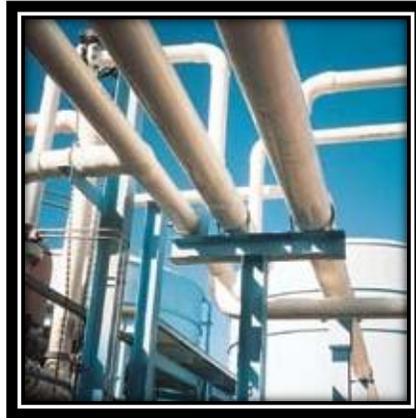


Smoke and Fiberglass Reinforced Plastic Components



■ Piping ■ Tanks ■ Equipment ■ Engineering ■ Services

Where There Is Fire – There Is Smoke

While the fiberglass reinforcements used in corrosion resistant laminates will not burn, most thermoset resins used as the matrix for “FRP” laminates will support combustion. Even the “fire retardant” resins will burn vigorously when fire is supported by an outside source. The rate of flame spread is somewhat lower for these fire retardant resins. Fire retardant thermoset resins typically contain halogens or bromine molecules. When combustion occurs, these additives suppress or smother the flame and the laminate becomes self-extinguishing.

When the more common thermoset resins (polyesters, epoxies, vinyl esters, etc.) used for fiberglass reinforced plastic composites burn, large amounts of heavy, black, dense smoke can be generated. The carbon chains in these resins contribute to that smoke. There is no difference in the density of the smoke generated between a non-fire retardant resin and a fire retardant resin. The only difference is that the amount of smoke may be less when fire retardant resins are used, and the fire is not supported by an external source.

In the past, smoke was not a major consideration for FRP composite pipe and duct. Much of the early corrosion resistant equipment was used in chemical process plants. As one plant engineer of a



major chemical plant told us one time, “When we have a fire in a chemical plant, we are allowed to have smoke.” In those cases of typically wide-open spaces, or facilities with low occupancy, the smoke generated is the least of the problems when a chemical plant or refinery catches on fire.

However, there are a number of facilities using FRP composite pipe and duct where smoke is of major concern. For example, in an electronics plant, the generation of a large amount of smoke can actually cause more damage than the fire itself.

How Much Smoke?

ASTM E-84 test results for polyesters, vinyl esters, and epoxies typically yield smoke generation values in excess of “750”. It can be said unequivocally that if FRP composite pipe and duct is exposed to a “raging fire”, there will be a lot of smoke generated. The ASTM test can only provide a hint of how much smoke.

Inquiries to all of the major manufacturers of resin systems used for corrosion resistant applications have solicited written responses that they have no, and know of no, polyester and vinyl ester thermoset resin systems that will generate, by themselves, smoke generation values under 350. If you are going to be specifying flame spread and smoke generation levels, we recommend that you consult with either a knowledgeable fabricator, or one of the resin manufacturers.

How Important Is Smoke In A Fire?

Before you spend a lot of time trying to develop low smoke alternatives – perhaps you first need to answer the question – “Just how important is low smoke in my service environment?”. If your tank, piping or duct application is mostly outdoors in an industrial location - perhaps smoke is of only minor importance. Again, in these cases, if you are going to have a major plant fire – the smoke generated probably is the least of anyone’s worries. Likewise, in many service installations where there is low “people occupancy”, such as water and waste treatment facilities, composting facilities, warehousing buildings, etc., then again, low smoke is perhaps only of secondary importance.

The Two “Factors” Of Smoke

For those service environments where personnel safety is of primary importance, two distinctly separate aspects of the smoke exposure need to be considered and evaluated.

Heavy dense smoke cannot only make breathing difficult, but can obscure the escape paths when people are trying to escape from a building during a fire.

Smoke toxicity, especially from organic materials, is also a critical safety consideration. Even if the smoke is very light, but is highly toxic, personal injuries can occur. This is one of the reasons that the New York City and New York State Fire Marshals have now added to their code requirement consideration for low smoke toxicity.

The measurement for smoke toxicity that has been accepted by most specifying agencies in the United States is the University of Pittsburgh’s Smoke Toxicity Protocol. This is the test procedure that has been adopted by the New York State and New York City Fire Marshals’ offices.

What are some of the Ways of Achieving Low Smoke Generation and Low Smoke Toxicity?

The ATH Alternate: A filler, such as ATH (aluminum trihydrate), can be added to the resin in very high concentrations. To achieve any meaningful reduction, such filler loadings need to occur up to as high as 50% of the total resin volume. This would also reduce the smoke development. However, unless the filler is also put into the corrosion liner, the duct or pipe still would not meet any reasonable specifications for low smoke generation.

The ATH additive has been primarily used for applications such as subway seating, tunnel liners, and other architectural type applications. By adding the very high levels of ATH filler to polyester and vinyl ester resins necessary to achieve smoke reduction for corrosion resistant equipment, you greatly decrease the structural strength of the pipe and duct laminate. In fact, the fall off of properties with a 50% filler level is great enough that it is not possible to meet most physical properties of present specifications for such corrosion resistant equipment.

Also, high levels of ATH added to the resins significantly down grades the chemical resistance of those laminates. ATH modified resin systems would not be expected to meet most chemical service requirements. In addition, long-term properties of laminates modified with ATH can lead to future laminate cracking and crazing.

It is our opinion that the addition of aluminum trihydrate to the resin, for corrosion resistant equipment, is not an acceptable method of achieving low smoke generation and definitely not low smoke toxicity.

The “Paint” Solution: Another way of obtaining reduced smoke of FRP pipe and duct, during an external fire, is by means of an intumescent paint. This intumescent paint is applied as a thin film coating to the exterior of the pipe or duct. When exposed to a fire, the paint expands to a “char foam” that has 30 to 50 times its normal paint film thickness. This intumescent coating then acts as a protective insulating barrier to the underlying FRP pipe or duct. Intumescent coatings have demonstrated their ability to reduce smoke generation. Smoke generation values of 100 or less may be achieved through the use of intumescent coatings.

The intumescent coatings and paints were originally developed for application to structural steel members. The concept was that they would help keep the steel temperatures below the buckling or collapse temperature preventing catastrophic failures. The intumescent paints that have been used extensively for this type of steel protection service have generally performed as expected.

Little actual experience has been accumulated with intumescent paints and coatings of FRP composites. We do know that the intumescent coatings do not hold up well when exposed to high

moisture, rain, and weathering. Thus, the use of such of such intumescent coatings on FRP would be limited to in-door exposure, and in low humidity environments. The intumescent coatings offer no protection for internal duct fires or where there is a burn through. In these cases, the interior corrosion laminate acts as a tunnel for flame spread.

Little empirical data is available to show how the intumescent coatings applied on FRP laminates would perform in actual fire exposures. Would they keep the underlying laminates below their self ignition point? How well will they bond, and retain the bond, to FRP laminates? Will they really reduce the smoke generation and smoke toxicity in actual field experiences, getting the same results as obtained on small laboratory tests of coupons?

The Phenolic Solution: As a class of resins used for reinforced composites, the phenolics have exceptional fire retardancy, low smoke generation, and low smoke toxicity. The ignition point for phenolics is almost twice that of standard polyesters and vinyl esters. This means that in some cases when not directly exposed to fire, they do not even start to burn.

And, the phenolic resins contribute extremely low smoke generation. It is for this reason that phenolic laminates have been used extensively in subways and underground tunnels. In standards such as the ASTM E-84 tunnel test, the phenolic laminates routinely have a smoke generation of 10 or under. The phenolics generate only 1% to 2% of the total smoke that is typically generated by other laminates, such as the polyesters, vinyl esters, and epoxies.

Besides low smoke generation, the phenolics also have, as an inherent part of their resin molecular structure, low smoke toxicity. It is the only resin system that has consistently passed the very stringent New York Fire Marshall's smoke toxicity tests without heavy filler loading, which compromises corrosion and mechanical properties. If you would like more information on those tests, how they are conducted, and the comparative results, please write us and we will provide that additional input.

The phenolic resin systems are about as close an "answer" as currently exists for low flame spread, low smoke generation, and low smoke toxicity.



A Summary

Step 1: Make your first selection of the best resin system for your service environment based on what it takes to handle the corrosion service environment. FRP composite pipe and duct is typically used because it is the lowest cost (and in some cases, the only) material of construction that will handle the chemicals present in the service environment.

Step 2: Select the type and thickness of corrosion barrier/liner needed to handle the chemical service environment. If it takes a synthetic veil to handle the service environment (for example, sodium hypochlorite or hydrofluoric acid), then be sure to clearly call out that type of reinforcement. If it takes a full 100 mil SPI type liner to handle the service environment, again make sure that the specifications call for that minimum liner.

If a corrosion allowance is desirable to achieve maximum service life, be sure to include that extra thickness. If a conductive liner is required to prevent static build up and discharge, causing an internal explosion and fire, make sure that you work with a knowledgeable fabricator to develop specifications for such a conductive corrosion liner and the “bleed off” of the static charges.

Step 3: Decide whether fire retardancy (low flame spread), smoke generation or smoke toxicity are even important or necessary for your application. These features are going to cost you extra money. If they are not required, do not specify them. Well over 90% of all FRP composite pipe and duct installed to date is not fire retardant and does not provide low smoke generation and low smoke toxicity properties.

When choosing and specifying the materials for your system, consider the cost of the materials, installation and, most importantly, long-term operating costs. Installation of a Factory Mutual approved system may provide lower insurance rates. However, such a system may also cost more in materials and labor, and may require replacement or repairs in half the time when compared to a properly constructed dual laminate system.

Recommendation #1: If fire retardancy is important, but smoke is not a major consideration, then use a premium grade fire retardant vinyl ester resin.

Recommendation #2: If not only fire retardancy (flame spread) is of major concern, but also so is smoke generation and smoke toxicity, then we recommend that you select the internal corrosion barrier/liner of your duct or pipe based upon the best resin matrix for your service environment. If the application is for pressure piping – the resin matrix for the liner need not be fire retardant. However, if the application were for duct, then we would recommend using a fire retardant resin for the corrosion barrier/liner. The probable choice would be one of the premium grade vinyl ester resins.

Recommendation #3: Consult Beetle Plastics LLC for the selection of your optimum piping and duct system.



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