Rigid and Flexible Piping Systems Keep up with Tough Demands: FRP Pipe Goes Coaxial

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Thermosetting and Thermoplastic Technologies
Today's underground piping systems at fueling facilities must hold up under harsh environmental conditions and vigilant testing and monitoring requirements. Yesteryear's single wall metal piping has been replaced by two basic types of double wall, non-metallic piping systems. One type is the well-known fiberglass reinforced plastic (FRP) piping—thermosetting resin reinforced with fiberglass. The other, newer type of piping is made of thermoplastics. Thermosetting piping is rigid and thermoplastic piping is flexible. They both commonly are used in the fueling facility environment, where they must stand up to the rigors of being underground and impermeable to gasoline, alcohol and other product elements. In this article, the technology of FRP piping is presented by Ameron's Joie L. Folkers, while OPW's Mike McCann tells about the technology of flexible piping. Environ's Kevin Struthers pitches in with a sidebar on coaxial fittings.
Fiberglass pipe has been used since the early 1970s for conveying motor fuels at service stations, terminals, marinas and industrial sites. The time-proven technology of FRP piping—thermosetting resin reinforced with fiberglass—has solved the problems of corrosion in piping systems.

The requirement for secondary containment of hazardous fluids when they are conveyed underground has been imposed in many areas since the mid-1980s. The installation of two separate pipe systems—once thought to be unavoidable with rigid piping—has been cumbersome and expensive and has led to searches for alternative methods and materials. Now, the search is over: coaxial fiberglass pipe and fittings solve the cost and installation issues previously associated with installing FRP systems with secondary containment.

Producing the coaxial effect

Coaxial fiberglass pipe is made by successively fabricating the primary pipe, a thin interstitial space and the containment pipe.

The primary pipe is identical to the pipe routinely used in a single-wall system or to the primary pipe in a system that uses “next-size-larger” pipe as the secondary or containment pipe. The interstitial space—the porous layer between the pipe walls—is created by applying a layer of graded, dry sand to the outside of the primary pipe. This sand layer is held in place during the production process by a layer of adhesive-backed tape. Once the containment pipe is made over it, the sand remains firmly in place by the closeness of the pipe walls. The irregularity of the sand particles themselves causes the two pipe walls to remain in a fixed position relative to each other.

Fittings can be made in a very similar manner, with the primary fitting being used as a “mandrel” over which the fittings’ outer layers are formed or the fittings can be made in two separate steps using standard single-wall primary fittings and 2-piece clamshells for the containment.

Coaxial advantages

An obvious advantage of coaxial FRP pipe is its compactness. The coaxial system is installed in virtually the same amount of space that would be taken by a single wall system. The rigid-wall pipe allows a well defined, narrow trench to be made—narrower than other systems. This saves excavation time and cost and reduces the amount of required “haul-off” of left-over soil.

Slope between dispensers is easily achieved with rigid fiberglass pipe, as seen in this large truck-stop series system.
Courtesy of Ameron International.

Also associated with the slim profile of the pipe is the low volume of the interstitial space. In the unlikely event of a primary pipe leak, detection would occur quickly, with only a small amount of fluid in jeopardy. For example, in a 2-inch diameter coaxial FRP, one gallon of fluid will fill 82 feet of interstitial volume.

Since the pipe is rigid, required sloping for control of any leakage is easily accomplished.

The amount of material used to fabricate the pipe is, by definition, less. Winding a pipe wall only slightly larger in diameter than the primary pipe assures a lower cost per foot.

An unanticipated benefit of the coaxial wall is the improved impact resistance. FRP pipe is prone to being struck and damaged by sharp objects. Resistance to this type of damage is dramatically improved (up to four times the energy required) with coaxial pipe. The two walls are “wedged” together by the sand particles but are not physically attached to each other. When an impact occurs, the energy is dissipated at the inner surface of the containment pipe rather than being transmitted radially to the primary pipe. This eliminates the possibility of “hidden damage” to the primary pipe. No damage will be present in the inner pipe that does not show evidence on the outer pipe. When the pipe is “tapped” on an object, the sound made is a dull “thud” rather than a sharp “ring”. This is characteristic of material that is dissipating rather than transmitting impact energy.

Pressure resistance of FRP pipe is maintained in coaxial FRP. This applies not only to the primary pipe but also to the containment pipe. The containment layer is rated above the pressure capability of submersible pumps.

Containment closures can be mechanical or bonded in same FRP system. Note reduction in vapor recovery line. Courtesy of Ameron International

Coaxial construction also allows for 100 percent “inspection” of both layers of the system. The typical method of inspecting the primary system is to pressurize it with air. Pressure gauges are used to view any changes in pressure. Soapy water is used to identify any leak locations (evidenced by visible bubbles). With the coaxial wall, the primary pipe surface is not visible, but any possible leakage would be transmitted to the cut edge of the containment pipe. By soaping this edge, the entire surface of the pipe is effectively inspected.

An event that should never occur—but occasionally does—is water filling the interstitial space. For a next-size-larger containment system (i. e., one not using the coaxial technology) the volume of water is sufficient to collapse the primary pipe if it freezes. As the water expands near its freezing point, external force is applied to the inner wall, causing it to buckle or collapse. With the low volume of the interstitial space in the coaxial pipe, insufficient forces are generated to cause any problems during such a freeze.

Installation issues

Coaxial pipe can be installed in either a series or a parallel layout pattern. Pipe configured in parallel has a branch coming off at a tee to each intermediate dispenser from a line which travels from the tank to the most remote dispenser. Pipe laid out in series goes from the tank into the nearest dispenser sump, then comes out the other side of this first sump to the next one, until the last dispenser is reached. Traditionally, rigid pipe has been run in the parallel configuration and hoses—flexible conduit—run in series (running hose in parallel is not practical). With the possibility of directly linking coaxial pipes inside sumps, either method can be chosen, depending on site layout and flow efficiency.

Through-the-sump FRP piping of clamshell system (series layout). Courtesy of Ameron International.

To install the coaxial pipe, a small portion of the containment “jacket” is stripped away from the end and the primary pipe is prepared for bonding (typically by tapering). After bonding the primary pipe into a fitting and curing the adhesive, a pressure test of the primary pipe is typically run. The containment system is then closed and tested. Unlike the “next-size-larger” double-wall system, no shuttling of the outer pipe is needed to install either the primary or containment pipe, making installation much faster and easier.

Testing of the coaxial pipe can also be done efficiently by pressurizing each portion (primary and containment) to different pressures at the same time. For example, setting the primary at 50 psi and the containment at 30 psi simultaneously will assure total integrity of the whole system in one test.

Should there be a leak in the primary assembly, the pressure in the containment would quickly rise to the higher level. Should the containment leak, pressure would rapidly drop. (Note: with the small volume in the containment portion, very small leaks in either system will show significant changes in pressure.) The likelihood of both systems having a leak of the same rate during a test is minuscule.

Parallel layout of FRP piping. Note the height differences of “jump-over” assemblies. Courtesy of Ameron International

Closure choices

The primary piping is assembled with taper/taper joints and 2-part adhesive. For the containment pipe, mechanically-closing fittings which seal with O-ring gaskets or 2-piece clamshell-type fittings are available. The clamshells are bonded in place with adhesive.

Each closure method for the containment pipe has advantages. The mechanical fittings can be assembled immediately after the primary system has been completed, allowing inspection, if required by the local authorities, to be done on both systems at or close to the same time. Without adhesive bonding, these fittings are less sensitive to weather and temperature conditions. They are fast and easy to install and can be disassembled and reassembled, if needed, for re-inspection or subsequent pressure testing.

The bonded clamshell fittings are also easy to assemble but require time for the adhesive to cure before the system can be pressure tested and inspected. Normally, an inspection of the primary pipe will take place on one day and inspection of the containment pipe the next.

The stable positioning of the primary and containment pipe is especially advantageous when bonding clamshells together. Rather than having containment pipe “loose,” relative to the primary, where it is subject to relative movement, the coaxial walls provide a rigid body over which to bond the clamshells, making assembly easier and more reliable. There need be no further concern that the containment pipe will get “bumped” and move in the fittings. With the solid assembly at the primary fitting, any movement of the containment pipe will be accompanied by the exact movement of the primary pipe, making it unnecessary to tightly “clamp” the fitting onto the pipe in order to stabilize it.

Material properties

Thermosetting resins are less affected by higher and lower temperatures than are thermoplastics, have a lower thermal expansion and contraction coefficient, higher strength, less permeability and better chemical resistance.

A popular analogy to the difference between thermosetting resin and thermoplastic resin is the comparison of eggs and butter. When heated, the egg goes through an irreversible chemical reaction, as does the thermoset resin. Butter can be melted, shaped and re-melted, as is the case for thermoplastics.

Testing

The coaxial pipe and fittings have been tested and listed by Underwriters Laboratories Inc. and

Underwriters Laboratories of Canada. In addition, ERA Technology (UK) has tested and certified the product for the requirements put forth by the Institute of Petroleum. Several state, city and local authorities in the US have also reviewed the data and specifically approved the product for use in their jurisdictions.

Outlook

Coaxial fiberglass pipe is now commercially available, linking the proven performance of FRP pipe with the installation, application and cost advantages of the coaxial design. A new mechanical fitting design is available, along with the extension of the popular, bonded clamshell for containment. Incorporating smooth bore, rigid pipe with its superior flow capacity and low pressure-drop features, coaxial FRP pipe is positioned to provide the optimum product for the long-term with benefits that start when the installation starts.

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