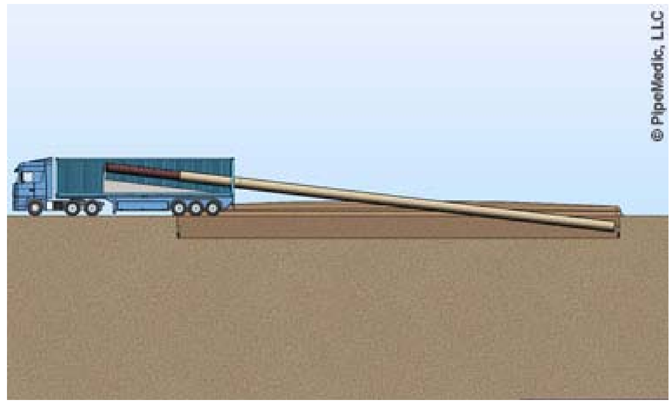
Civil Engineering
THE MAGAZINE OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Layered Pipeline Offers Longer Lengths, Fewer Leaks

By Laurie A. Shuster

A new method of manufacturing pipeline from carbon-fiber fabric layers surrounding a lightweight core offers the promise of longer lengths with fewer joints—which could mean far fewer leaks.



Pipeline of nearly any shape or diameter can be produced at a job site in lengths up to 1,000 ft without joints using a new process that sandwiches a durable but lightweight honeycomb material between two layers of resin-saturated carbon-fiber fabric. © PipeMedic, LLC/Graphic by Reynard Perrin and Joerg Schmit

September 4, 2012—A new type of pipeline that uses essentially the same structural concept as an I-beam enables pipelines to be constructed in almost any length, in nearly any shape or diameter, without the need for an expansion joint, reducing the risk of leakage while maintaining structural integrity. The patent-pending process, called InfinitPipe, uses inner and outer layers of structurally strong carbon-fiber fabrics surrounding a lightweight, inexpensive honeycomb core. The pipeline can be produced in almost any length either in a warehouse or on-site, and can be used for both lining existing pipe or creating entirely new pipeline systems.

The technique builds on a process that has been in use for about 15 years to repair the interiors of deteriorating pipelines, says Mo Ehsani, Ph.D., P.E., S.E., F.ASCE, a professor emeritus of civil engineering at the University of Arizona and the president of the Tucson company, PipeMedic, LLC, that has developed and refined the process. Ehsani says that one current technique for lining existing pipelines is to apply an epoxy-saturated carbon fabric that adheres to the pipe and strengthens it against interior pressures. But Ehsani says clients began to ask for the liner to be strong enough so that if the surrounding pipe structure failed entirely, the new liner could serve as the pipeline, withstanding the exterior pressures of soil and the roadway traffic or structures above it.

“Well, that wouldn’t have worked well, because it would have caused the thin liner that the industry was using to buckle,” Ehsani explains. “One way to solve that problem is to apply many layers of the carbon fabric, to make it perhaps half an inch thick. But the cost of those fabrics is $25 to $30 per square foot, and if you have to put 10 or 12 layers on it, the costs become astronomical.”

Ehsani’s solution is a technique that uses the strong carbon fabric in just two portions of the pipeline, the outer and inner skins. These surround a less expensive and less dense layer, a process very similar to that used to produce airplane fuselages, doors, and floors, for example. “Those curved doors on aircraft are very lightweight, but very stiff and strong,” Ehsani explains. He compares the idea to the structural engineering concept of an I beam replacing a solid steel beam in building construction. “It is more efficient—you only need a lot of material at the top and bottom flange, and in the middle portion you don’t need a lot of material,” he explains. “This is the same concept. On the skin of the pipe we have one or two layers of the expensive carbon fabric and in the middle section, sandwiched between those two layers, we replace that with a lightweight honeycomb core. And that is extremely cost effective." The U.S. and international patents for which the company has applied allow the process to make use of different core materials depending on the application, he says.

Ehsani first developed the process for repairs, using the size and shape of the existing pipeline to create a mandrel, or mold, for the new material. One benefit of using a mandrel is that it can be created in any shape, so if the pipeline being repaired is teardrop-shaped, for example, the lining could be made to fit precisely. "Once you make the mold, you wrap a couple layers of carbon fabric around it, then put on the honeycomb, and then wrap the outside with one or two layers of the fabric, and that becomes the pipe," he explains. "Then once we got into that, I realized that we don't need to stop at 10 or 20 feet," which is the typical length of pipeline sections made from more traditional materials, he says. "We can make it as long as we want."

It is for this reason that he has named the new technique InfinitPipe, although from a practical perspective most applications would require a joint to be used at some point to allow for temperature-induced expansions and contractions. But he points out that this pipeline might only require a joint every 1,000 ft rather than every 10 to 20 ft, and the joints are the weakest links of any pipeline system. "Once the pipe is assembled, that is where the headache begins for the owner, because for decades to come there is the potential of leaking at the joints," Ehsani says. "The main advantage of our pipe is the lack of joints."

Owners concerned about leaks, particularly those in the gas or oil industries, might be more inclined to install leak monitors at the joints if there are fewer of them, Ehsani points out. And some owners may not require joints at all; he says the operator of an offshore energy company has contacted him about its desire for a 2 mi long underwater pipeline, which would not require joints because the temperature under water would be relatively constant. "We could easily make that in one piece, with no joints," Ehsani says.

Currently InfinitPipe can be manufactured in a warehouse or on-site using a truck, though the process is still performed by hand. Even so, Ehsani says that one crew member can produce 10 ft of pipe per hour, so a crew of three to four could potentially produce 1,000 ft in just three to four days. "So even by hand it is a pretty fast process," he says. "And as it comes off the mandrel, it's already assembled and ready to go into service."

One advantage to producing the entire length of pipeline on-site is the elimination of transportation costs, he adds. "With that one truck, depending on the diameter of the pipe, we may be able to build 3,000 to 4,000 feet," he says. In contrast, if that much traditional pipe was built in a factory and shipped in pieces to the site to be assembled, he says, "You could get maybe only five to six pieces of pipe on the back of a truck. And depending on the distance from the manufacturing facility to job site, the cost of transportation is sometimes more than 1/3 or up to ½ of the total project cost."

Ehsani says more research is needed to be sure the resins used in this new process will not corrode in certain circumstances—for example, in the presence of some of the solids that can be found in crude oil. But he points out that natural gas is already piped safely through fiberglass pipeline and the epoxies used in this new process are similar—in fact, in some cases they are superior. "Because they make a solid pipe, they have to use a lower-quality, less expensive polyester or vinyl ester resins," Ehsani explains. "In our case, because we need a smaller quantity, we can go to the most durable and most expensive epoxy resins, and yet the overall price of the pipe remains competitive."

Ehsani says the main focus of his efforts in the coming year will be to develop a more automated, speedy process for production. "Depending on the size of the pipeline and the location of the job, this system can be far less costly than other alternatives, and we have a durable, non-corrodible pipe that is environmentally friendly." Still, Ehsani says, he knows that "it takes time for any new product to be adopted."