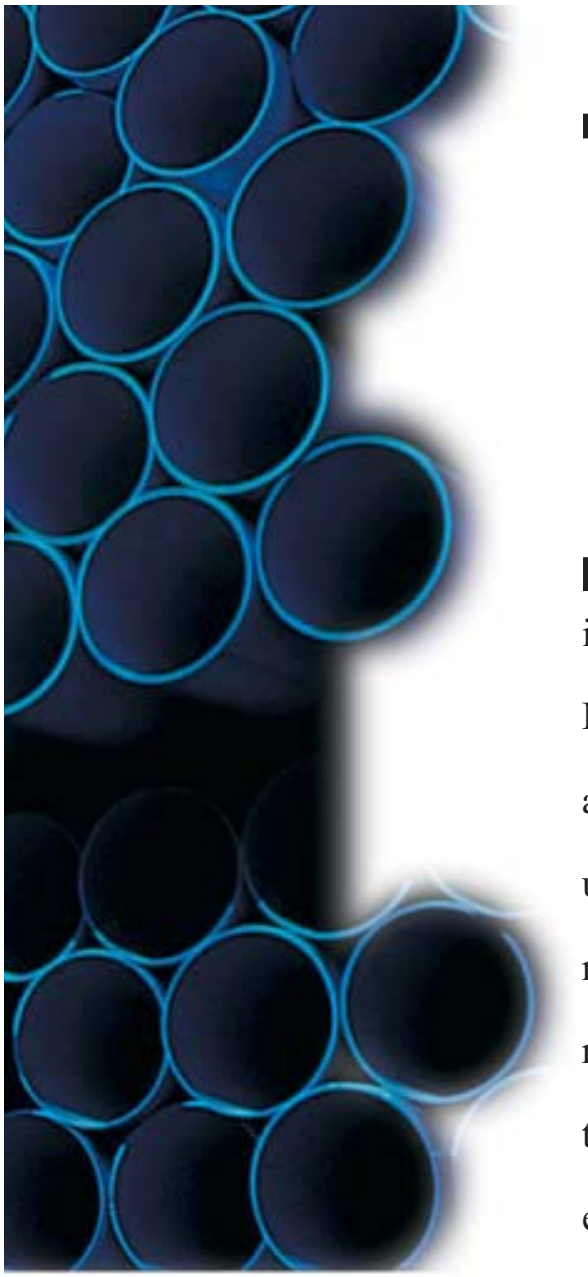
Plastic pipe is less expensive to transport and easier to handle, install, and maintain than pipe made of conventional materials. Pipelife International.

PLASTIC PIPE

Corrosion resistance, ease of installation stimulate demand for plastic pipe

By Richard Stewart



Plastics have been used in the manufacture of pipe for decades, offering significant advantages over traditional piping materials such as cast and ductile iron, steel, and concrete. Extruded pipe is less expensive to transport, handle, install, and maintain than non-plastic pipe. Excellent durability, integrity of joints, and resistance to corrosion and chemicals give these products a longer expected service life—100 years or more—than pipe made of other materials. The rusting, pitting, and scaling that commonly lead to the failure of metal pipeline systems are eliminated with the use of plastics pipe.

Thermoplastics most commonly used in pipe manufacture are polyvinyl chloride (PVC), polyethylene (PE), polypropylene (PP), acrylonitrile-butadiene-styrene (ABS), and polybutylene (PB). Stiffer resin grades have expanded the market for PE. Over the last 40 years, pipe manufactured from PE and PP materials has gained market share in gas and water distribution, sewage systems, and plumbing and heating applications.

Growing Pipe Market

Global demand for plastic pipe is expected to grow more than 4% annually through 2007, the Freedonia Group says in a study titled *World Plastic Pipe.* Infrastructure development in the Asia-Pacific region will stimulate demand there, while growth in developed areas of the U.S., Japan, and Western Europe will be less robust, the study predicts.

PVC is the world's leading plastic-pipe resin, accounting for over two-thirds of global demand (by weight) owing to its low cost, durability, strength, and ease of extrusion, the study notes. Demand for high-density polyethylene (HDPE) pipe is expected to grow, gaining on traditional materials for use in natural gas transmission, water distribution, conduit for electrical and telecommunications applications, and corrugated pipe for drains and sewers.

In the U.S., demand for plastic pipe will grow 2.5% per year from the current 13.7 billion feet to 15.5 billion in 2007, Freedonia forecasts in another study on plastics and competitive pipe. Stimulants to this increased demand include stricter water-management laws, ongoing highway and street construction, and the rehabilitation of aging or obsolete sewer, drainage, and municipal drinking-water systems, the study notes. While PVC will remain the leading pipe resin, the best opportunities are anticipated for HDPE pipe because

of its flexibility, sturdiness, and joint integrity. Growth applications include gas and oil production, corrugated pipe, and potable-water pipe.

Plastic pipe, especially PE, offers natural-gas utilities operational and economic advantages over traditional materials, according to the American Gas Association (AGA). About 90% of the pipe used in natural gas main and service piping installations in the U.S. is made of polyethylene. Some gas utilities are trying polyamide 11, which does not absorb liquid hydrocarbons, in higher-pressure gas applications, the AGA says. Crosslinked polyethylene (PEX) is also being tried in gas applications. PEX has a higher molecular weight than PE, for a higher resistance to slow-crack growth.

Fixing Water Systems

Aging water-supply infrastructures and the need for rehabilitation are a serious concern in many parts of the world. In the U.S., 2.45 billion gallons of treated drinking water are lost or unbilled, mostly because of leaking pipes, according to the American Water Works Association. Leaks in individual main water lines can allow the loss of up to 1000 gallons per minute, reports the AWWA, noting that corrosion is the primary cause of leakage and the most difficult to detect.

New extrusion die produces three-layer PE pipe with a foamed core for reduced weight and wall thickness. Battenfeld Extrusionstechnik.

Extruded plastic pipes offer significant benefits over conventional materials for a broad range of applications. American Maplan.

According to Dow Chemical Company pipe market manager David Fink, an estimated $20–$30 billion per year will be needed in the U.S. over the next 20 years just to rehabilitate all the failing pipes in the ground. He says that after a municipality treats the water, an average of 16% is lost to leakage before it gets to the consumer. Some cities, such as Washington, D.C., lose over 50%, he notes.

"That's a lot of lost revenue, but many municipalities are running on limited budgets and don't have the money to rehab their piping infrastructure. Atlanta and Dallas are raising water rates to afford to rehabilitate their systems," says Fink. He says that the rate hikes will be significant. Atlanta is expected to double its water rate in the next two to three years to pay for the infrastructure that needs to be replaced.

The remedy gaining the most attention in the rehabilitation of leaking water and wastewater systems is trenchless technology, according to Camille Rubeiz, director of engineering of the Plastics Pipe Institute, a trade association representing suppliers and manufacturers of plastic pipe and equipment. Trenchless technology involves the use of non-intrusive construction methods, materials, and equipment for the installation, replacement, or rehabilitation of underground pipe infrastructure (see sidebar, following page).

Fusion-Welded Joints

"Central to trenchless technology is the use of leak-free HDPE pipe," Rubeiz says. HDPE pipe is normally

joined through a process of heat fusion, which produces fully sealed connections that have proven stronger than the pipe itself, he explains. "Fusion produces one continuous pipeline that can be easily bent into place and pulled through existing pipes."

Dow recommends the use of HDPE with trenchless methods both for new installations and rehabilitation. "Trenchless methods are about 25%–30% more cost-effective than dig-and-replace installations, mainly due to the elimination of soil removal and resurfacing costs," Rubeiz says. "But there are still a lot of engineers in municipalities who believe that metal pipes are the only way to go. They haven't been educated about the advantages, plus they are generally reluctant to change."

HDPE pipe for water main rehabilitation in Louisville, Ky., is heat-fused on location using equipment from McElroy Manufacturing Inc. ISCO Industries.

Educating engineers in utilities and municipalities about the benefits of PE piping is a top priority at PPI, Rubeiz says. "It's not enough to tell a water utility that the gas company down the street has been using plastic pipe for years. A big part of our education effort focuses on spreading the word about successful water projects and the experiences of other engineers who have used HDPE in their water systems," he says.

But changing old habits has been a challenge. Rubeiz explains that public agencies typically bid projects based on initial cost per foot of pipe. "PE is normally higher in initial cost than other materials. However, it is less expensive in overall life-cycle costs, which include maintenance," he adds. "Product performance and lower maintenance costs are what gets them into PE."

Rubeiz cites a case history in which the city of Flower Mound, Texas, replaced about 2.5 miles of 6-inch and 9-inch ductile iron mains with HDPE using horizontal directional drilling, a trenchless method. The original plans for the estimated $1,325,000 project were for copper and PVC to be laid in open trenches. By switching to trenchless technology, the city was able to save an estimated $455,000, Rubeiz reports.

PPI is working with the AWWA to develop a manual

Abandoning the Trenches

Trenchless processes, commonly used to install HDPE pipe underground without digging an open trench, are especially useful for installations under roadways, driveways, and waterways. Methods include directional drilling of horizontal holes into which pipe is inserted. Pipe jacking behind a micro-tunnel-boring machine is also commonly used. Sliplining, another method, involves insertion of pipe inside an existing line to rehabilitate the system. Pipe-bursting tools are used to open up the host pipe to accept larger-diameter plastic pipe.

Trenchless techniques are quicker than open-trench construction, and they minimize the disruption and economic impact caused by excavation projects in populated or environmentally sensitive areas. Engineering drawings can be used in rehabilitation projects that go through existing pipe, avoiding the need to secure a right of way or determine where other utility lines are located to avoid damaging them.

on PE pipe for water applications; publication is expected by June. PPI offers a seminar on designing and installing HDPE piping systems to raise awareness of the material and the benefits it offers. The seminar will be held in Orlando, Fla., in April and in Charleston, S.C., in May. Check the PPI website (www.plasticpipe.org) for additional sites and dates. PPI is also developing a tool to help engineers compare life-cycle costs of PE vs. traditional materials.

ISCO Industries, a U.S. distributor of PE pipe, expects demand for HDPE in water applications to continue growing. "We think it's the pipe of the future. It's a superior product, but one with weak market share in the U.S.—leaving lots of room to grow," says company president Jimmy Kirchdorfer. "Once utilities try it, they like it and start using it more and more. We get them to use HDPE for a very difficult application—a trenchless project that requires a lot of flexibility such as going under a road or a waterway," he says.

Fast Fusion™ MobileFusion Trac 20 is a self-propelled machine designed to facilitate the heat fusion of HDPE pipe. ISCO Industries.

ISCO distributes Fast Fusion™ MobileFusion Trac 20, a self-propelled machine that facilitates the handling and heat fusion of HDPE pipe. Moving along the pipe, it can increase the production capacity and number of fusion welds per hour by up to 50% over conventional fusion methods, says ISCO. Depending on the fusion equipment mounted in the unit, the machine can butt-fuse HDPE pipe up to 20 inches OD.

Demand for Polyolefins

The penetration of polyolefin materials into the pipe market continues to be strong, both in exterior and interior applications, according to Netherlands-based Basell, the world's largest producer of PP and a leading supplier of PE and advanced polyolefin products.

Basell has introduced two PP copolymers for use in non-pressurized sewer pipes, offering compression resistance to withstand road traffic loads. Hostalen PP H 2464 is a high-modulus grade with a stiffness/rigidity balance that makes it suitable for corrugated pipes, says Basell. Hostalen PP H 2483 has a flexural modulus above 1900 MPa and good impact performance, making it appropriate for use in smooth-bore pipes, where the intrinsically high modulus is a critical factor.

For interior heating and plumbing applications, Basell has developed the Lupolen line of crosslinkable HDPE resins for crosslinked PEX pipes. The crosslinked products offer enhanced performance, including higher service temperatures and resistance to scratches and stress-cracking, says Basell. Typical applications are hot-water supply, underfloor heating, and radiator connections. The company also offers cost-effective, three-layer PE systems for coating steel pipe in pipeline applications and a new Lupolen bimodal HDPE pipe topcoat for use in extreme temperatures.

Stiffer Pipe Grades

Sweden-based Borealis, a leading supplier of polyolefins for pipe applications, recently introduced the BorEco™ line of PP for sewer and waste applications. It was designed to provide increased stiffness with high impact resistance for extrusion of smooth solid-wall pipes, production of corrugated and double-wall pipes, injection molded fittings, and spiral-wound structured wall pipes.

Another innovation from Borealis is Beta-PPR™ for hot and cold water pressure-pipe systems. Compared with polypropylene random copolymer (PP-R) materials, it offers improved long-term strength and enables the use of thinner and smaller pipes for a given building project. This allows higher extrusion speeds and improved utilization of existing extrusion lines, while making plastic pipe systems even more competitive vs. copper and steel, according to Borealis.

Borealis Borcoat™, a bimodal PE pipe-coating material, was recently selected to provide corrosion protection for a steel pipeline that carries crude oil across Turkey. The material is applied with PE adhesive and epoxy primer, providing a high-performance, three-layer system.

Dow Chemical Company, the world's largest manufacturer of PE and PS, offers Dowlex PE resins for pipe applications in plumbing and other hot and cold water systems such as drinking water distribution and heating and cooling systems. Dowlex 2388 is a new grade said to be suited for composite pipes and plumb-

ing applications because of its excellent processability and long-term hydrostatic strength. Classified as a PE-RT (polyethylene of Raised Temperature Resistance) resin, it is an ethylene-octene copolymer, featuring a unique molecular structure with a controlled side-chain distribution, says Dow.

Another recent introduction from Dow is the Continuum line of bimodal PE resins, which meet ISO PE100 standards for pipe-grade materials. These resins are appropriate for pressure pipe applications, including natural gas distribution, potable water and irrigation applications, oil and gas production, industrial and chemical processing, and mining, Dow says.

The new engineered polyethylene features an advanced molecular architecture, providing enhanced performance characteristics such as long-term hydrostatic strength combined with outstanding resistance to slow crack growth along with excellent high-temperature/pressure performance, and increased toughness, tensile strength, and modulus.

Ion Beam Applications has introduced a family of preprocessed PE resins called Raprex™, formulated to provide improved physical properties without using chemical crosslinking agents. The crosslinking effect is achieved prior to forming the finished parts through radiation processing of the base PE resin. This results in parts that are higher in mechanical properties than their unmodified versions and are recyclable, the company says. An extrusion grade of the resin is available for pipe manufacturing.

QuickSwitch pipe extrusion system enables the diameter and wall thickness to be changed "on the fly." Krauss-Maffei.

FRP Pipe Applications

Fiberglass-reinforced thermosetting plastic (FRP) pipe and tanks are used in many industrial product applications, including storage and transfer of corrosive materials and handling of other materials in corrosive environments. FRP pipe, typically manufactured using winding processes with epoxy resins and continuous glass filaments, offers excellent corrosion resistance, high strength-to-weight ratio, and low maintenance and life-cycle costs.

From its principal original use in oilfield gathering lines, FRP

pipe has grown into applications ranging from handling flammable and combustible liquids at retail consumer facilities to sewer and water mains in the municipal and industrial markets, according to the Fiberglass Tank & Pipe Institute (FTPI).

In the oil and gas production industry, high-pressure FRP pipe applications include 4000-psi, 4-inch lines in oilfield service, 2-inch to 16-inch pipes for water filtration projects in extreme-temperature environments, and a salt water/crude oil 12-inch pipeline operating at 290 psi at temperatures up to 120°F, FTPI says.

FRP pipe has also been used as a liner in large (48- to 60-inch) concrete pipe in sewer applications to protect the concrete from deterioration resulting from hydrogen sulfide attack. It is well suited to trenchless processes such as micro-tunneling and sliplining to rehabilitate existing pipelines.

Borcoat bimodal PE pipe coating provides a three-layer system for steel pipeline. Borealis.

Multilayer Pipe Extrusion

Krauss-Maffei has introduced a pipe die-head to simplify the coextrusion of multilayered pipes. The KM-3L RKW 54 QS is capable of producing single-, double-, or triple-layer pipes. It features three concentrically intermeshing spirals for uniform melt distribution across the die orifice section. Flow channels for the external and internal layers are supplied with melt through a ring-shaped distributor system.

The die-head enables the external layer to be independently centered, reducing material consumption. A typical application would be PE sewer pipe coextruded with an internal white liner to facilitate the optical inspection of pipelines with a camera. For PE pipelines installed above ground, a wear-resistant PP layer can be coextruded to protect the pipe surface.

Battenfeld Extrusionstechnik has developed an extrusion die for the production of three-layer PP pipes with a foamed core. The WPO 124-3 die enables pipe-weight reduction of up to 20% and reduced wall thickness, the company says. The die was demonstrated recently using three single-screw extruders to produce sewage pipe.

A PP block copolymer was used for the outer layers; a chemical blowing agent was added to the PP to produce the foamed inner layer. Cost savings could be achieved by producing the inner layer from recycled materials with high filler content. An adapter is available for the die that enables the extrusion line to operate with two extruders.

At K2004, Battenfeld displayed a line for polyolefin pipe production, using the new BEX 1-90-30 D single-screw extruder. More powerful motors, drives with higher torques, and new barrier-screw geometries are said to produce an increase in throughput of up to 25% with polyolefins. The extruder was coupled with a

Large-diameter, long-length plastics pipe is a specialty of Pipelife International, a global manufacturer and distributor of plastic pipe, fittings, and pipe systems. Pipelife Norway supplied 3000 m of PE pipe, 1600 mm (5.2 ft) in diameter, in 500-m lengths, for a desalination plant project in Israel. The pipe was extruded directly into the water in Norway and towed by tugboats through the Mediterranean to its destination. Pipelife International.

Battenfeld PO 250/900 VSI lattice basket die for pipes up to 250-mm diameter and a maximum throughput of 900 kg/hr. The die features a two-stage distributor, consisting of a threaded preliminary distributor followed by a compact lattice basket for final melt dispersion.

The Quick-Switch pipe extrusion system introduced by Krauss-Maffei in 2003 has been well received by manufacturers running mass-production operations. The system allows the diameter and the wall thickness of pipe to be changed with high precision during running production—without stopping the line—for increased productivity and reduced waste.

An adjustable die gap can be enlarged or reduced by changing the axial position of a cone-shaped mandrel relative to the pipehead. The calibrating basket consists of movable segments whose inner surfaces form a smooth circular inner wall. The inner radius of the basket can be changed at the push of a button and with great precision, says Krauss-Maffei. Versions of the system are available for pipe diameters of 32–63 mm, 75–160 mm, and 160–250 mm.

Plastic-Metal Composite

Krauss-Maffei and pipe manufacturer Plastream are cooperating to build production systems for continuous steel-reinforced HDPE pipe for wastewater and drainage applications from 200 to 2250 mm (8 inches to 7.4 feet) in diameter. The pipe is made from a continuous steel-ribbed extruded plastic profile that is spirally wound on a winding machine.

Pipe diameters are quickly changed by changing the pipe-forming cage on the winding machine. Pipe-ring stiffness can be varied for different requirements by using profiles reinforced with steel bands of different dimensions. Krauss-Maffei will be the exclusive supplier of the complete extrusion line to produce the profile.

In another development, Krauss-Maffei has signed an agreement with Thomas Machines to build complete production systems for plastic-metal composite pipe that can be made with an aluminum or steel layer up to 110 mm in diameter. Applications include water pipe, radiator connections, and underfloor heating.

The inner pipe is typically crosslinked PEX, PP-R or HDPE, which is coated with an adhesion promoter. The metal layer is shaped around the inner pipe, and the longitudinal seam is continuously welded. It acts as a diffusion barrier and reduces the thermal longitudinal expansion of the pipe, Krauss-Maffei says. In the final step, an adhesion promoter and the outer plastic layer are applied together over the metal layer in a one-step process using a two-layer transverse spray head.

Cincinnati Extrusion has teamed with Nexans, a supplier of pipe-forming and welding equipment, to produce turnkey systems for manufacturing plastic-metal composite pipe for natural gas and water applications. An inner plastic pipe and exterior plastic sheathing are extruded in-line and combined to form the composite pipe.

All components in the lines, including the material feed and the take-up device, are designed to ensure continuous production. The systems offer an automatic high-precision process for the inner pipe and a fully continuous TwinTorch® WIG welding system as an alternative to laser welding to produce composite pipe with an excellent price/performance ratio, says the company.

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