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# working pressure

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## PIPE JOINING, ANYONE?

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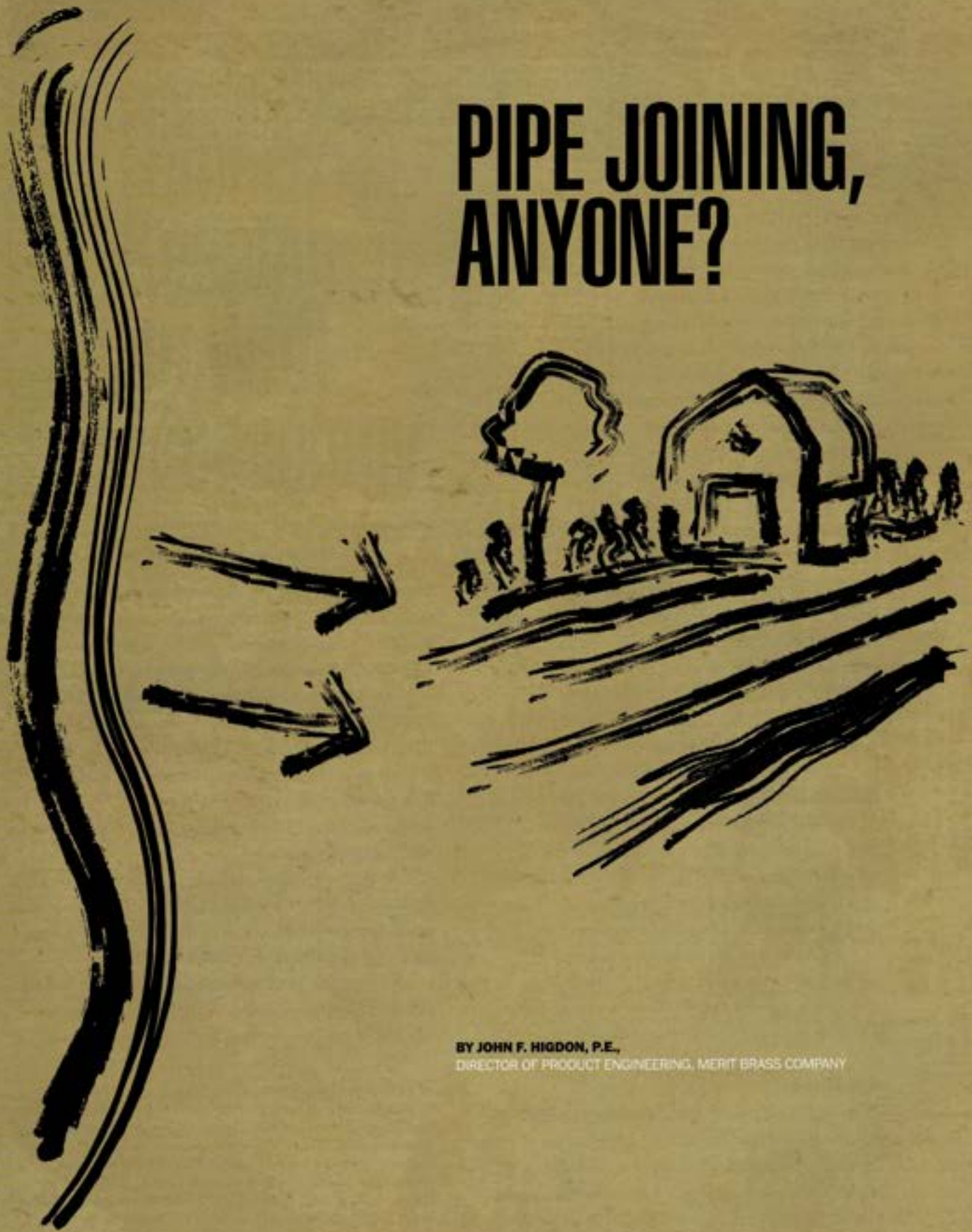
# PIPE JOINING, ANYONE?



**BY JOHN F. HIGDON, P.E.,**
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One day, a few millennia ago somewhere in the far East, a village leader called his brightest engineer to his residence. Standing on his impressive porch, the leader said, "Pft, you are a socially awkward loner with a very difficult-to-pronounce name, but I am told you are very intelligent — so, today I ask for your assistance with a problem we're currently experiencing. You have no doubt heard the men complaining about all the noise the women and children are making when they gather water for our community farm from the river … you know the clanging of pots and such. This disturbs the men's afternoon naps and makes them cranky during supper. Do you think you could design some sound proofing for the pots so they won't make so much noise?"

Pft withdrew one of five marking sticks from a leather holder in his shirt pocket and walked down from the porch to a stretch of dirt. He squatted down and began sketching his solution. "Here is the river," he said, making a line in the dirt. "And over here is the farm," he continued. Scratching some perpendicular lines between the two he said, "What we need to do is bring the river to the farm." Pft had invented irrigation channels through which flow could be controlled by opening and closing wooden water gates. He was celebrated across the land for his invention. One day, a nearby village asked for Pft's help. Their farm was located some 20 feet above the river and, despite using the latest Archimedes model screw pump, the water rushed over the top of the open channel and back to the river before reaching the crops. Pft scratched his head and said, "What we need is an enclosed flow path." With some clay, sand, straw, and curing sunshine, he then built the world's first hardened pipe. "If you need to make it longer, or have it make a turn or two, just add on to the end!"

In the generations that followed, it became apparent that manufacturing pipe where it was installed was not always ideal. Having one long pipe made maintenance difficult and layout reorganization nearly impossible. Pipe began to be made at off site locations in segments to facilitate ease of handling and delivery. An obvious consequence of this mode of manufacturing was the need to join the pipe at the installation site. As plumbing became a universal necessity wherever people congregated to live, work, or recreate, pipe joining methods continued to be improved and refined, as well as tailored for specific applications.

**HERE ARE A FEW OF THE MORE NOTABLE METHODS OF PIPE JOINING, FROM THE EARLIEST THROUGH THE MOST RECENT:**

Ancient Egyptians are usually credited with making the first metal pipes. The pipes were made of copper lengths, held together by hammered lap joints. One can only imagine the difficulty of making leak tight connections with this method — but today, nearly 5,000 years after their initial construction, several examples still exist and a few, remarkably, are still in use!

The Romans were next on the scene with metal piping. Initially, they used molten lead — a much-revered material at the time — to seal the joints of their terra cotta piping. Later, they made extensive use of irrigation and drinking water pipes constructed fully of lead, even inspiring the word plumbing from plumbum, the Latin word for the metal. The pipes were typically made in 3-meter lengths and fused together at the installation site. Considering Flint, Michigan and other recent lead-related water crises, it is interesting to note that an engineer named Vitruvius, employed by Julius Caesar, warned of lead's adverse effects on human health. Well over 2,000 years ago, he wrote in his book De Architectura, "Lead receives the

current of air, the fumes from it occupy the members of the body, and burning them thereupon, rob the limbs of the virtues of the blood. Therefore, it seems that water should not be brought in lead pipes if we desire it to be wholesome." Vitruvius was indeed a man ahead of his time.

After the fall of the Roman empire, an event sometimes attributed to widespread lead poisoning, vitrified clay piping became the fluid conveyance method of choice throughout much of the world. After a realization that field-applied mortar sometimes made the pipe joints too rigid and subject to cracking, tars and mastics were employed to provide joint flexibility. Modern clay and concrete piping installations typically utilize elastomeric couplings to join pipe sections.

When North America was colonized, the settlers had to use construction materials that were readily available. Consequently, much of the early plumbing systems in the United States were made of hollow wooden logs joined together with metal straps. Sometimes firefighters would drill holes in the pipes for emergency access to water, which they would later seal with conical-shaped pieces of wood, inspiring the term "fire plug." In what has become a somewhat commonplace occurrence during excavations, water purveyors still discover remote sections of their piping distribution systems are made of wooden logs — some over a century old and still functioning; others abandoned but still intact.

At the advent of the 19th century, Philadelphia became the first U.S. city to switch from wooden log piping to cast iron. The cast iron pipes provided more reliable water pressure because the flow paths were smoother and leaked less readily than their wooden counterparts. With Vitruvius' centuries old warning unheeded, the cast iron pipes were typically joined together using bell and spigot connections, packed with wool and sealed with lead. In the following decades, flanged connections also gained in popularity.

As plumbing applications became more complex, a need arose to join steel piping inexpensively and quickly. Pipe ends were fabricated with tapered threaded ends that could be screwed together until the metal yielded, producing a leak tight seal. Alternatives to tapered threads were also specified when the sealing surface was something other than the threads themselves. For applications where periodic dismantling was anticipated, unions were used. Threading remains a very popular pipe joining method and is typically used in pipe diameters from 1/16" to 24".

By the early 1900s, the limitations of threaded and flanged connections accelerated the need for other pipe joining methods. Tapered threads are easily overtightened during installation, leading to stress fractures with catastrophic failure — sometimes only seen after some period of use. Threaded pipe also must be thicker than otherwise necessary to accommodate the threads. Threaded joints are also prone to leakage, particularly when exposed to wide temperature fluctuations. Flanged joints are expensive to manufacture and add considerable weight.

Welding, a process where the joined base metals are melted and fused together with a filler metal, had its rudimentary origins in antiquity, but only became a viable on-site pipe joining method after the industrial revolution. The "Roaring Twenties" introduced Americans to an exciting new art form called jazz, and also proved to be somewhat of a renaissance time for pipe joining. It was then that portable welding machines utilizing shielding gases first made in-the-field pipe welding a possibility. Welding yields stronger joints than threaded or flanged connections, and the weight added to the piping system is inconsequential. Pipe 2" in diameter and smaller is typically fillet welded, with larger pipes butt welded. Welding's drawbacks — it requires skilled labor and is relatively expensive.

The 1920s also saw the introduction of grooved pipe couplings. In this method, the pipe ends are grooved and a mechanical coupling with an interior gasket is fitted over the ends and tightened with

ANCIENT ROMAN SEWER PIPES. PHOTO VIA ISIDHE / ISTOCK / GETTY IMAGES PLUS.

nuts and bolts. Grooved couplings are available in flexible or rigid configurations and can be used on any type of pipe that can be cut or roll grooved. Pipes up to 42" in diameter can be joined with this method.

Although there is evidence of soldering being used as early as 4,000 BC for some types of metal working, it wasn't until Ernst Sachs introduced a mass-produced electric soldering iron in 1921 that the plumbing trade took notice and made soldering the joining method of choice for copper pipe. Soldering, also referred to as sweating in the U.S., produces a pressure-type joint made with a filler metal that, when heated to its melting point, is drawn into the annular space between the pipe and fitting by capillary action. Brazing is a similar process but utilizes a filler metal with a higher melting point, yielding a stronger joint. Due to the difficulty in evenly distributing heat, soldering and brazing are generally limited to pipe no larger than 8" in diameter.

As the do-it-yourself market exploded after World War II, homeowners found themselves without the skill required for soldering and brazing, and also uncomfortable with the heat these joining methods required. The industry responded with the compression fitting — a joint made by tightening a nut that yields an internal ferrule and thereby creates a leak tight seal. Compression seals are still widely used in bathroom and kitchen installations.

The 1970s saw the introduction of PEX (cross-linked polyethylene) piping offered in diameters 3/8" to 1". PEX piping can be joined in several ways — using a copper crimping ring, stainless steel clamp, or an expansion tool to stretch the tubing over an inserted fitting, then allowing the tubing to shrink tightly over the fitting end. As a nod to an ever-surging home improvement center market searching for ease of installation, push fittings were also introduced during this time as a fourth method to join PEX. Push fittings utilize an internal ring with engineered metal teeth that tightly grip a pipe when inserted in the fitting ends. Push fittings can be used to join copper and PVC pipes as well.

By the 1980s, cast iron piping in the U.S. began to be replaced with polyvinyl chloride (PVC) for water and sanitary sewer applications. While most of this piping greater than 4" in diameter is joined with a metal reinforced elastomeric gasket, solvent joining is also sometimes used. Some other plastics, including polyolefin, can be heat fused together.

The start of the 21st century witnessed the most recent significant breakthrough in pipe joining technology with the introduction of the press fitting. Produced in stainless and carbon steel, and copper, press fittings have an internal sealing element that, when crimped with a battery powered mechanical tool, impinges on the outside diameter of a pipe, creating a leak tight seal. Press fittings are available in sizes up to 4" in diameter, with sizes greater than 2" typically containing a grip ring that deforms upon crimping, and grips the outside diameter of the pipe and further prevents axial movement. Press fittings offer a pipe joining method requiring no heat or open flames or the associated safety permits, and a process that produces very little variation from joint to joint. Press fittings include a mechanical leak before press feature so that unpressed connections can be identified prior to the "go live" date of the system. Some manufacturers also include a redundant visual leak before press feature, such as a sticker, breakaway end clip, or plastic band that is color coded to identify the sealing element material.

While it is not an easy task to predict the next big thing when it comes to pipe joining, the trends throughout time do give us some clues. The oft repeated saying, "Work smarter, not harder," comes to mind. There has been a clear desire since time immemorial to install piping systems in a consistent, high-quality manner as quickly and safely as possible. Whatever new pipe joining designs the future holds, you can bet they will need to address these core concerns to be successful.

**PHOTOS VIA MERIT BRASS COMPANY.**
(FROM TOM TO BOTTOM) MERIT SS PRESS 45 DEGREE FF ELBOW, 3/4";
MERIT COPPERPRESS COUPLING (NO STOP), 3/4";
MERIT COPPERPRESS XL COUPLING (WITH STOP), 4";
MERIT SS PRESS COUPLING, 1/2"

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