Don't Make Your Piggable Pipeline Unpiggable

Jeffery Knighton[1], Ken Maxfield[2], Phil Tisovec[1]
[1]ExxonMobil, [2]KMAX Inspection

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Abstract

Recent updates to 49 CFR Parts 192 & 195 call for pipeline operators in the USA to comply with regulations covering the construction and operation of their pipelines. These codes require that when a new line is constructed or when an existing pipeline is modified, it must be designed and built to accommodate the passage of ILI tools.

Besides the typical challenges of designing a new pipeline or modifying an existing one to ensure it meets the code requirements for ILI tool passage, some unexpected issues can occur when operators attempt to construct new lines or modify them to be piggable. In particular, selection of small-diameter piping (14" and below) and fittings can meet design standards, but still be completely unpiggable resulting in new pipeline construction that is less or not piggable at all. Several real-world situations are discussed where good intentions to increase piggability have backfired, including pipelines that are designed with restricted bores, pipelines that are constructed of materials that due to the manufacturing process have unexpected bore restrictions, and pipelines that have bore restrictions due to the construction process.

Review of US regulations for passage of internal inspection devices

In the US, many gas pipelines are regulated by 49 CFR Part 192 and many liquid pipelines are regulated by 49 CFR Part 195. Both regulations have sections that deal with the "Passage of internal inspection devices" (1,2). There are some subtle differences in each section, but they essentially say that new pipelines and replacement of pipe, valves, fittings, or other line components "must be designed and constructed to accommodate the passage of instrumented internal inspection devices in accordance with NACE SP0102".

In reviewing NACE SP0102 (3), pipeline operators are required to accommodate ILI tools, or "make piggable" pipe segments when it comes to new pipeline construction or modification of existing segments. The version of NACE SP0102 currently referenced in Parts 192 and 195 is NACE SP0102-2010. Since PHMSA recommends NACE SP0102-2017 be incorporated into part 192 and 195 (4), the 2017 version of the standard will be reviewed in anticipation of future incorporation.

Section 7 of SP0102 is titled "New Construction—Planning for ILI Surveys". If you are a pipeline operator and haven't read section 7 lately it is worth reading again, especially if you are involved in building new pipelines or modifying existing pipelines. The pertinent sections of section 7 are 7.2.4 "High-yield strength bends and fittings" and section 7.2.5 "Bends and bend radius".

Section 7.2.4 "High-yield strength bends and fittings" cautions pipeline operators that bends, tees, reducers, and other fittings made from high strength steel may not be so "readily" available. The lead time for these fittings can often be long, so projects should be planned with adequate lead time

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to procure such fittings. The choice of fittings with a lower strength steel that has heavier wall thickness might be the obvious compromise if high strength fittings are not readily available. The section further discusses the balance between using heavy-wall fittings and the choice of ILI tools that can pass through those fittings. The section uses the word "should" when evaluating wall thickness of fittings vs ILI tool passage. So, a pipeline operator needs to evaluate the thickness of the fittings installed in a new or modified pipeline versus ILI passage. Installing readily available heavy-wall fittings instead of thinner, higher strength fittings might limit the choice of ILI tools currently available, translating to potentially higher cost or inability to run a preferred tool. A final thought on this section in SP0102 is the advice given about speed excursions that can occur when running ILI tools in gas through heavy wall fittings and how this is especially applicable to small diameter pipelines.

In section 7.2.4 "Bends and bend radius", there is a discussion about the proper bend radius and wall thickness to select when evaluating passage of an ILI tool. There is a "must" clause in 7.2.5.2 where it states that "Prior to placing an order for bends, the compatibility of those bends for ILI must be verified." When designing new or modified pipe for successful ILI, it is recommended that bend radii of less than 3D is not used on small diameter pipelines, and preferably 5D or greater if possible. One related issue KMAX experiences in small diameter 1.5D bends is sometimes heavy weld penetration exists where the bend is welded to the adjacent pipe. This heavy weld penetration creates a potential piggability issue and is often not considered when the pipeline is designed or constructed with 1.5D bends.

Codes for fitting manufacturers and why fittings are manufactured with heavy wall

Engineers in the pipeline industry frequently face the challenge of ensuring their designs meet the requirements of 49 CFR 192.120 and 49 CFR 195.150, both titled "Passage of internal inspection devices", which mandate that pipelines accommodate ILI tools. Compliance requires understanding and applying interrelated standards for fittings, which can sometimes create uncertainty or confusion leading to undesirable wall thicknesses and problems with ILI tool passage. Some of the related standards are:

- ASME B31.4 - *Pipeline Transportation Systems for Liquids and Slurries* (5) and ASME B31.8 *Gas Transmission & Distribution Piping Systems* (6) provide overarching guidance for liquid and gas pipeline design, materials, construction, assembly, inspection, testing, operation and maintenance. These standards further reference others such as:

- ASME B16.9 - *Factory-Made Wrought Steel Buttwelding Fittings* (7) focuses on the dimensions and tolerances of wrought fittings for piping components.

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- MSS SP-75 - *High-Strength, Wrought, Butt-Welding Fittings* (8) covers manufacturing properties of fittings and emphasizes bore diameter tolerances to ensure piggability in pipelines with nominal diameters greater than NPS 14.

- ASME B16.49 - *Factory-Made Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems* (9) details requirements for induction bends, including ovality limits.

MSS SP-75 explicitly states in its scope section that for pipelines with nominal diameters of 14 inches and below, the requirements are stewarded by ASME B16.9. Engineers may initially rely on MSS SP-75, which specifies a minimum bore diameter of 93% of the nominal pipe inside diameter for sizes above 14 inches. However, for smaller sizes, it is important to note the standard defaults back to ASME B16.9, which specifies an OD dimension and has no minimum bore requirement unless specified by the purchaser. Fitting manufacturers can add as much wall thickness as necessary to meet strength requirements. This fallback to ASME B16.9 creates situations where fittings comply with the standard for pressure containment but may leave the line unpiggable, leaving engineers with unanticipated design conflicts.

This issue has arisen in many pipelines with nominal diameters of 14 inches and below, where the reliance on MSS SP-75 to ensure piggability clashes with the fallback to ASME B16.9 tolerances. Manufacturers, aiming to prevent containment failures, often produce fittings with heavier walls for additional safety buffer. While this ensures structural integrity, the added thickness can encroach on the bore space, reducing the internal diameter (ID) or bore of the pipe. The inherent trade-off between safety, functionality, availability and cost should be balanced by engineers to also anticipate potential piggability issues and therefore specify fittings with custom tolerances during the design phase. However, without a full understanding of how standards interact, even experienced engineers might inadvertently approve fittings that hinder ILI tool passage.

Why heavy wall fittings are being installed and the lack of inspection of fittings to be used

Real-world operational scenarios further illustrate the complexities of heavy wall fittings and the potential pitfalls of insufficient inspection of the fitting prior to installation. Engineers responsible for pipeline maintenance, including emergency repairs, often prioritize speed to restore flow, which may involve using off-the-shelf fittings without thorough verification of the fitting.

For instance, a heavy-wall fitting might be installed in a pipeline without confirming its bore diameter with a gauge tool. While this expedites a repair, it risks creating obstructions for ILI tools, leading to operational disruptions and costly rectifications further down the road. Such risks underscore the importance of proper planning and inspection of fittings, even under time constraints. This issue is particularly common in pipelines with nominal diameters of 14 inches and below, where off-the-shelf fittings may technically meet the code standards, but fail to ensure piggability.

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Induction bends, regulated by ASME B16.49, add another layer of complexity. These bends are gauged based on the pipe's original wall thickness. For example, an 8-inch pipe with schedule 100 (≤0.594" wall) accommodates a 7.251-inch gauge tool. The same 8-inch pipe with schedule 60 (≤0.406" wall) accommodates a 7.618-inch gauge tool. This variation means that a heavier wall, chosen for its pressure containment benefits, may inadvertently limit piggability by reducing compatibility with standard ILI tools. Without a thorough understanding of these implications, an engineer might unintentionally compromise the pipeline's ability to be inspected with ILI.

Additionally, standards like NACE SP0102, which is widely used to guide ILI tool implementation, assume engineers have a nuanced understanding of how other standards, such as MSS-SP-75 and ASME B16.9, influence each other. Without this knowledge, an engineer might make decisions that align with one standard but fall short of ensuring overall piggability and compliance. See Figure 1 for an example.

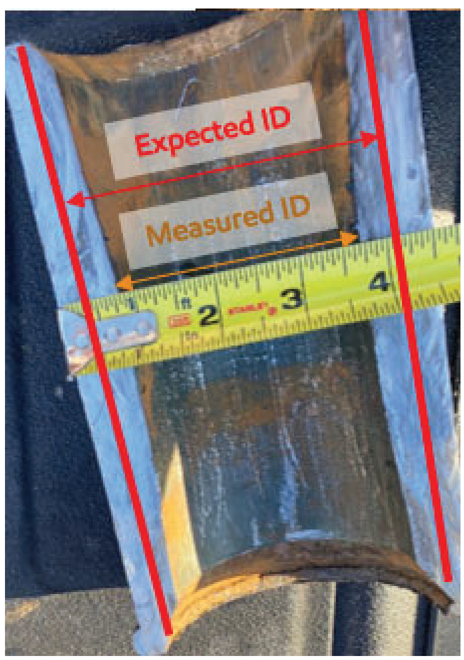

Figure 1. Cross section of typical heavy wall tee comparing expected vs actual ID.

The lack of comprehensive inspection or understanding of the interplay between standards can lead to significant issues during both design and operation of a pipeline segment. Engineers can better align their decisions with industry regulations and operational needs by addressing these challenges with a proactive approach, such as: specifying fittings with precise tolerances, verifying bore diameters before installation, and anticipating the impact of wall thickness on ILI tool passage.

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Case Studies

Case Study #1, 4-inch Line with Heavy Wall Tee

In 2023, KMAX was contracted to inspect a 4" pipeline. The operator built a new launcher for the inspection (Figure 2). Since the pipeline had a previous ILI inspection prior to the change, no gauge pig was run in the line before the currently planned ILI.

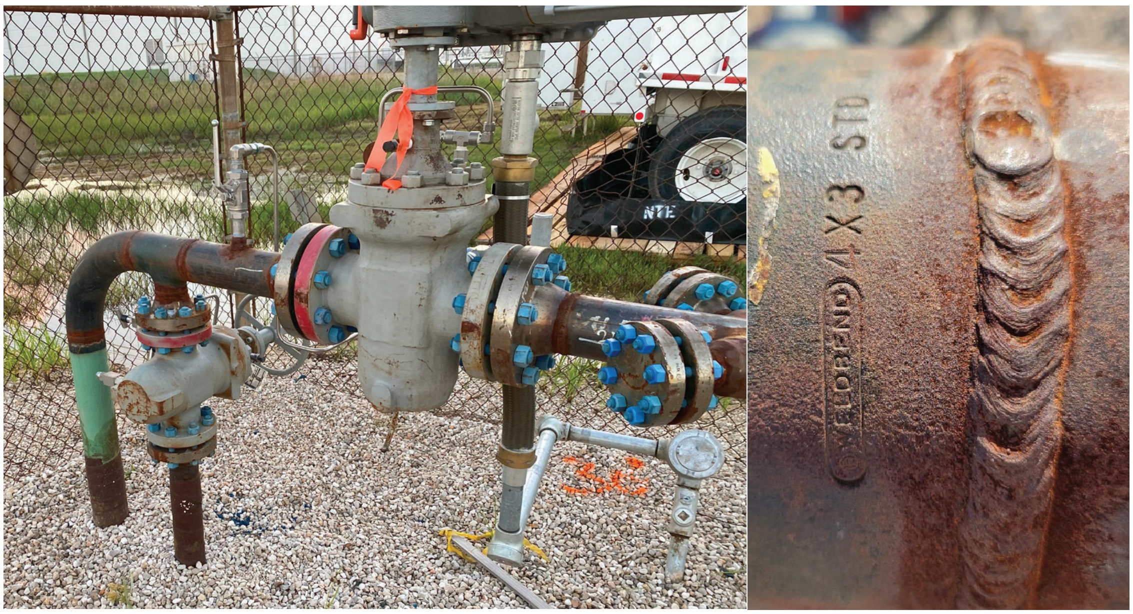

Figure 2. New 4" launcher constructed for an ILI, with a standard wall tee.

The KMAX MFL/DEF/IMU combo tool was launched, but immediately the tool became lodged in the tee at the launcher. Attempts were made to get the tool dislodged, but eventually the combo tool had to be cut out of the line. See Figures 3 and 4 for pictures of the tee where the tool stuck.

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Figure 3-. Cross section of schedule 40 tee showing heavy wall thickness.

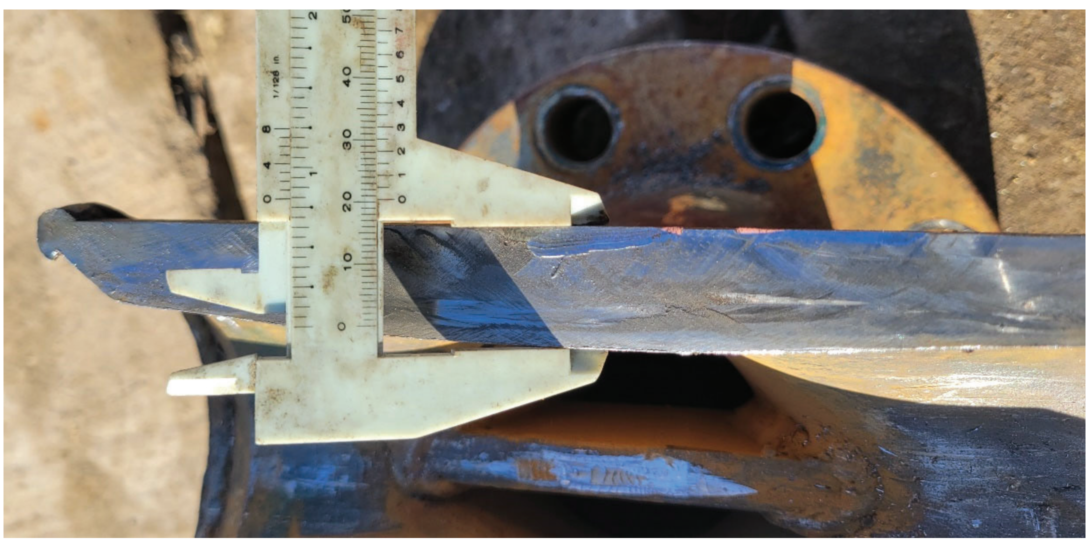

Figure 4-. Cross section of the standard wall tee. Notice the bevels on each end of the tee to meet the requirements of ASME B16.9.

After the tee was removed and cut in half, the cross section of the tee was measured. The bore of the tee measured 73mm (2.875") or a bore reduction of 26%. The maximum wall thickness was 20mm (0.787"). Figure 4 shows the profile of the tee including the bevelled ends of the tee. This bevel is necessary to comply with ASME B16.9 to get the wall thickness down to Schedule 40 or standard wall thickness in 4" pipe at the end of the tee to aid with welding to adjacent piping.

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So why was this tee installed in this launcher? The welder surely noticed the wall thickness of the tee as it was welded into the launcher. Should there have been an onsite inspector who looked at the fitting and confirmed ILI-friendly bore before it was welded into the pipeline? The tee was stamped as a standard wall tee, so it certainly met the requirements of the engineering drawings. In choosing this fitting, engineering codes and standards were followed, but were the requirements of NACE SP0102 considered? The pipeline operator who installed this tee is one of the largest oil and gas companies in the world highlighting the issue can occur in any operating environment.

Case Study #2, 4-inch Line with Bore Restrictions

KMAX was contacted by a pipeline operator to inspect a 4" butane pipeline that is 10 miles long. The pipeline had never been inspected by a metal loss ILI tool. The operator wanted to run an ILI tool through the line to better determine the line condition.

The pipeline was built in the 1960's with schedule 40 pipe. Later the pipeline was modified with the installation of two above ground valves. The above ground valves were designed and installed with schedule 80 pipe and fittings to meet or exceed code. Forty-five (45) degree, schedule 80 3D bends were used to bring the pipe out of the ground and turn the pipe horizontal above ground.

The pipeline operator contracted another ILI company to run a calliper tool through the pipeline to determine the minimum bore of the pipe. The company reported several locations that had bore restrictions down to 3.60" (Figure 5) and therefore could not inspect the pipeline with their MFL tool due to the bore restriction limit of their tool.

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Figure 5-. Location of 3.6” restriction in -schedule 80 bend and tee. Also note the high/low weld.

The pipeline operator reached out to six different ILI vendors to see if they could inspect the pipeline. All six vendors declined to inspect the pipeline due to the bore restrictions compounded with it being a butane line. This highlights the limitation the operator now had in selecting ILI tools even with new piping installed that met or exceeded code and standards. KMAX successfully inspected the pipeline with an MFL tool, after much testing in a controlled environment, that was able to pass through this restriction.

Case Study #3, 4-inch Line with Heavy Wall Tees

KMAX was contacted about inspecting a 4”, 16-mile, Natural Gas Liquid (NGL) pipeline. The line had never been successfully inspected by an ILI tool. An attempt to inspect the line in the past had resulted in a stuck inspection tool by another ILI vendor. The nominal wall thickness was standard .237”, with potentially thicker wall thicknesses in the pipeline.

The inspection was planned in stages. The first stage would be running a cleaning/gauge pig through the line. If there was no damage to the gauge plate, the second stage would be running the KMAX MFL/DEF combo tool through the line. If there was damage to the gauge plate, then KMAX would run the stand-alone DEF (deformation) tool to locate areas in the pipeline that were a concern.

The KMAX cleaning/gauge tool was run through the line and the gauge plate came back with bent tabs as shown in Figure 6. The diameter of the gauge tool was 3.25” and the damage was full circumferential.

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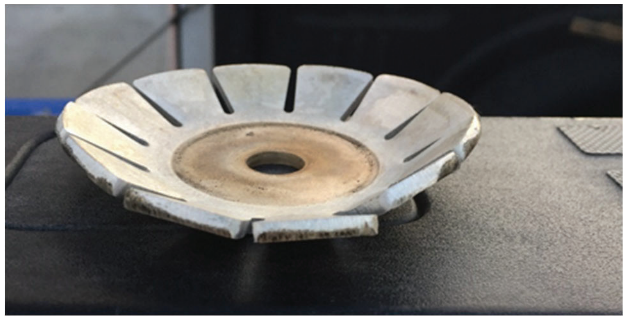

Figure 6. The gauge plate showing damage around the full circumference of the plate

KMAX then decided to run the KMAX DEF tool to locate the restrictions in the pipeline and made it through the pipeline with no issues.

Once the data from the DEF tool was evaluated it showed that the pipeline had extra heavy fittings at the launcher, at the three above ground valve settings (Figure 7), and at the receiver.

Table 1. Results of DEF run showing location and measurements of potentially restrictive bores

Location	Minimum Bore
Launcher	87.63mm (3.45”) in Tee
Above Ground Valve Setting	87.12mm (3.43”) in Tee
Above Ground Valve Setting	82.04mm (3.23”) in Tee
Above Ground Valve Setting	88.39mm (3.48”) in Tee
Receiver	88.34mm (3.36”) in Tee

The restricted bore in these tees precluded the ability to run the MFL tool through the pipeline, so the operator opted to hydrotest the pipeline instead. Again, this highlights that even though the piping met design codes, piggability issues may not have been considered and the operator lost options to run ILI in the line.

Figure 7. Above ground valve setting with heavy wall tees

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Case Study #4, 3-inch Line with Heavy Wall Tees.

An operator of a 3-inch pipeline built in the 1960's wanted to inspect the pipeline with a metal loss ILI tool for the first time. The operator modified the launcher and receiver traps to accommodate ILI tools. KMAX provided the operator a 3-inch gauge pig that included magnets, brushes, a gauge plate and a 22Hz transmitter. The pipeline contained propylene. The operator chose to remove the propylene from the pipeline and propel the gauge pig with nitrogen.

The gauge pig was run through the pipeline and became stuck in the pipeline. The operator started to investigate the location and cause of the stuck gauge pig. During that investigation, it was determined that there was a very heavy tee near the receiver (Figure 8), which upon inspection using UT had a wall thickness of 22.3 mm or 0.878". This section of the receiver was recently rebuilt to get the line ready for an ILI metal loss inspection and this new, heavy wall tee was used as part of this modification. Clearly, no one considered obstructions that might hang up inspection tools when this tee was installed into the new receiver configuration, even though the tee met engineering standards.

Figure 8. 3" Heavy wall tee with wall thickness up to 22.3mm (0.878"). Bore was 60.3mm (2.375"), a 20% restriction.

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Case Study #5, 4-inch Line with Heavy Wall.

KMAX was contacted by a pipeline operator that was constructing a new 4" pipeline. The line was being built with schedule 80 wall pipe. The operator wanted the ability to be able to inspect the pipeline with an MFL tool. Once the pipeline was constructed, the operator wanted to run a baseline survey of the pipeline before it was put into service. KMAX worked with the operator to make sure that the KMAX 4" heavy wall MFL tool could inspect the pipeline segment.

Figure 9. After construction, a KMAX gauge plate pig was run through the new pipeline.

After construction, a KMAX gauge pig was run through the new pipeline segment. The pipeline operator had a hard time launching the gauge pig, but the pig successfully travelled through the pipeline. Figure 9 shows the shape of the gauge plate with all the tabs of the plate bent back. The minimum bore in the pipeline segment, based on the deflection of the gauge plate, was 70.6mm (2.78"). The pipeline operator started investigating the piping at the launcher and receiver and discovered that the reducers used at both the launcher and receiver had heavy wall causing the bore restrictions.

In this case, a brand-new pipeline built in 2023, which was designed to meet the regulations to be piggable. The operator even proactively coordinated with an ILI company to make sure an ILI tool could be run through the system. However, when the pipeline was built, fittings were installed that met engineering codes, but also made the pipeline unpiggable with an MFL tool.

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Conclusions and Recommendations

Several case studies have been presented illustrating that pipeline operators are constructing or modifying pipelines regulated by 49 CFR Parts 192 or 195 where the requirements and guidance of NACE SP0102 are inadvertently not being followed. Pipeline operators should evaluate or modify their procedures to ensure that fittings installed into a pipeline are inspected prior to installation so they meet code requirements including minimum bore for ILI tool passage.

It is further recommended that ASME revisit the B16.9 code and make changes to require that a fitting's bore matches the specified wall schedule thickness. If additional wall thickness is needed in the fitting to meet specifications or strength requirements, the additional material should be added to the OD of the fitting and not the ID. If this is not possible or feasible to modify this code, then perhaps a new class of fittings could be developed that is ILI friendly, for example stating there is a minimum bore requirement for all fittings. Additionally, if fittings can be specified by code which are more ILI compatible, it could be required that all nominal tees have pig bars installed across the outlet which also improves piggability.

References

(1) **CFR Title 49, Subtitle B, Chapter I, Subchapter D, Part 192.150**

(2) **CFR Title 49, Subtitle B, Chapter I, Subchapter D, Part 195.120**

(3) **NACE International.** *NACE SP0102-2010 & 2017 - In-Line Inspection of Pipelines.* NACE, 2010 & 2017

(4) **Federal Register**: Pipeline Safety: Periodic Standards Update II. *A Proposed Rule by the Pipeline and Hazardous Materials Safety Administration on 08/29/2022*

(5) **Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.** *MSS SP-75: High-Strength, Wrought, Butt-Welding Fittings*. MSS, 2019.

(6) **American Society of Mechanical Engineers.** *ASME B31.4: Pipeline Transportation Systems for Liquids and Slurries*. ASME, 2022.

(7) **American Society of Mechanical Engineers.** *ASME B31.8: Gas Transmission and Distribution Piping Systems*. ASME, 2022.

(8) **American Society of Mechanical Engineers.** *ASME B16.9: Factory-Made Wrought Buttwelding Fittings*. ASME, 2018.

(9) **American Society of Mechanical Engineers.** *ASME B16.49: Factory-Made, Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems*. ASME, 2023

https://doi.org/10.52202/078572-0034