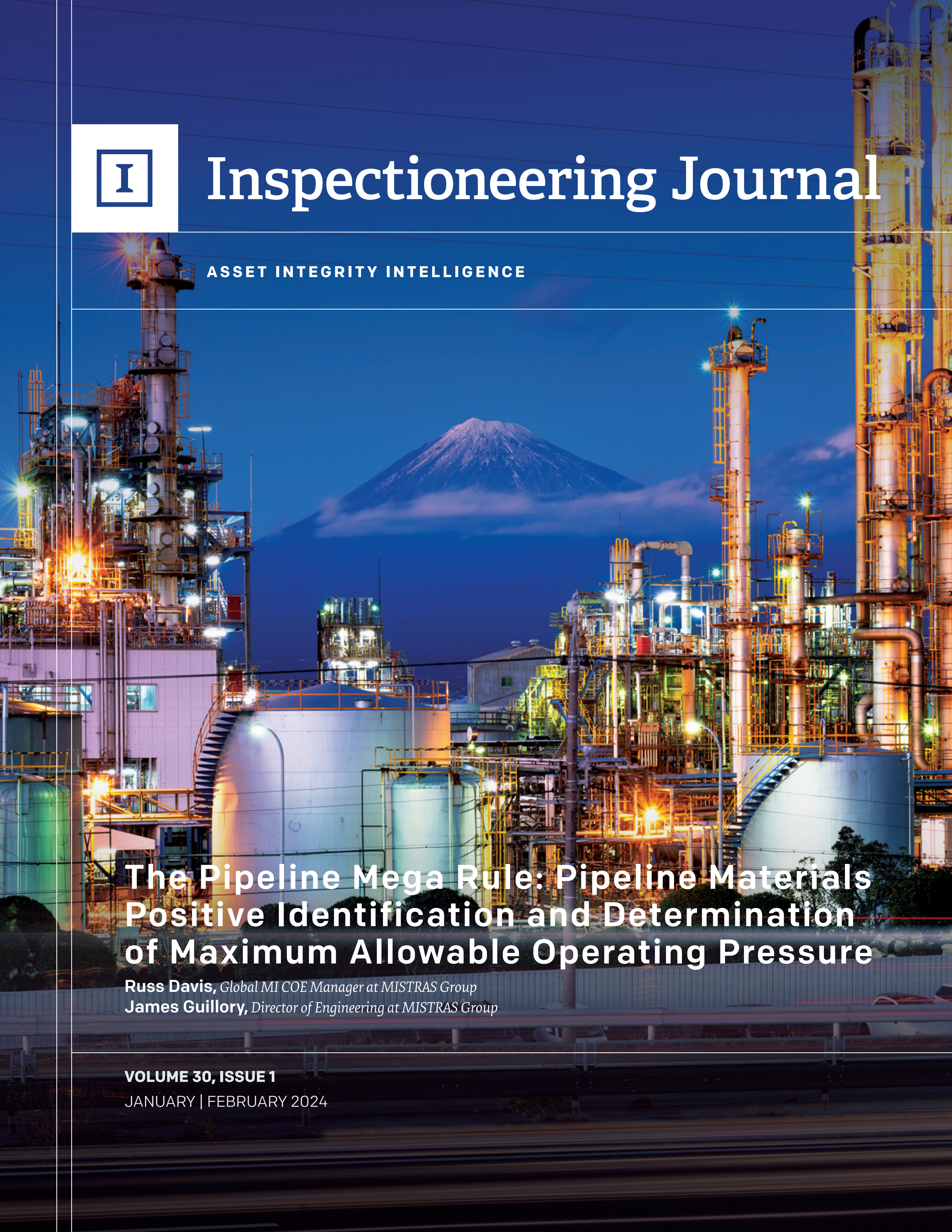

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Introduction

In 2020, the Pipeline and Hazardous Materials Safety Administration's (PHMSA) revisions to 49 CFR 192 Part 1, the "Mega Rule," went into effect. Part 1 includes pipeline material verification and maximum allowable operating pressure (MAOP) reconfirmation, and the records required to reconfirm MAOP must be traceable, verifiable, and complete (TVC). Although the rule has material verification requirements for components other than line pipe, the scope of this publication only includes line pipe material. Where records are not TVC for the pipeline materials of construction, the owner must perform material identification. An owner must verify, at minimum ultimate, tensile strength and yield. As an example, if an owner is using an ultimate tensile strength of 52,000 in the 5L-X52 piping for MAOP calculations, piping must be verified as 52,000. Subpart 192.607, "Verification of Pipeline Material Properties and Attributes: Onshore steel transmission pipelines," provides the records required to be verified include:

- Diameter
- Wall thickness
- Seam type
- Pipe Material Grade
  - Yield strength (YS)
  - Ultimate tensile strength (UTS)
  - Pressure rating of valves & flanges
- Toughness values

There are multiple methods for gathering the data required to confirm MAOP, but the preferred method is to utilize in-situ non-destructive methods. This methodology can be performed at opportunity digs by qualified technicians utilizing approved tools or by a prescriptive approach (scheduled repairs, excavations, etc.).

The prescriptive approach consists of:

- 1 excavation per mile, or
- 150 excavations if a comparable population is more than 150 miles

Operators must define separate populations of similar segments of pipe for each combination of the following material properties and attributes: nominal wall thicknesses, grade, manufacturing process, pipe manufacturing dates, and construction dates. If the dates between the manufacture or construction of the pipeline segments exceed 2 years, those segments cannot be considered as the same vintage for the purpose of defining a population. The prescribed excavation frequency is applicable to each different population.

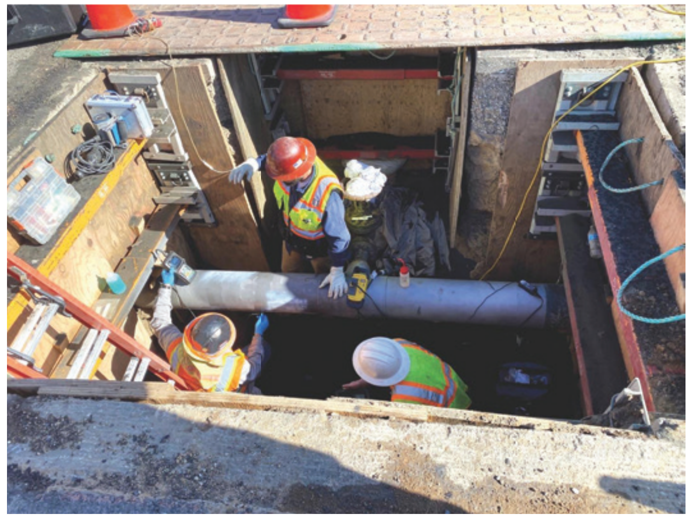

Figure 1. In-situ non-destructive testing is the preferred method for gathering the data required to reconfirm maximum allowable operating pressure (MAOP).

It is critical that companies utilize qualified technicians to perform testing with PHMSA-approved tools for data collection. Operators must develop a procedure for performing the testing necessary to collect the material properties data required to confirm MAOP and suitability for reliable service.

Options for Determining Pipeline Material in the Field

The Pipeline Research Council International (PRCI) evaluated certain tools and methodologies for determining material properties in the field in a project titled "Validation of In Situ Methods for Material Property Determination." The project involved validating, testing, and ranking various tools and methods and their ability to properly identify pipeline materials.

A determination of ultimate tensile strength (UTS) methodology was compared by PRCI. A material verification tool, which measures hardness, strength, and ductility (HSD), was found to have the lowest mean absolute percentage error (MAPE) of the tools with which it was compared. Surface preparation is critical so that any external oxidation is removed. By proper surface preparation, surface hardness and yield readings are comparable to destructive transverse hardness readings throughout the material thickness. Hardness testing was performed using the Krautkramer MIC 20 with correlation of hardness to UTS. As always, training and qualification of field personnel were critical to the quality of data

Figure 2. Advanced hardness, strength, and ductility (HSD) services can provide TVC records for missing integrity data to allow full utilization of the maximum allowable operating pressure (MAOP).

being collected. These training and certification requirements are much more rigid than the training requirements for NDE personnel to perform hardness testing. The MAPE for various MIC 20 testing resulted in almost double the MAPE for the HSD tester. Generally speaking, the validity of field data is heavily dependent on the quality of the personnel performing the testing and the understanding of the engineer's evaluation of the data.

Conducting Positive Material Identification and Composition Analysis

Positive material identification (PMI) is particularly useful for determining the chemistry of piping materials. PMI tools are widely available, and many have proven effective while meeting quality expectations.

The material comparison to known pipe material and grade must be evaluated based on the chemistry requirements of the code and intended design service. Data from PMI tools, hardness testing, and any records of material and grades typically purchased by owner-operators at the time of the piping installation are utilized for this purpose.

An effective PMI testing methodology requires good substrate preparation and equipment calibration based on the design requirements and anticipated material. Technicians must be professionally trained for their equipment and an experienced corrosion and materials SME should review the test results to ensure accuracy and quality. Buffing the test areas to a near-white finish with equipment that will not introduce contaminants, including carbon, to an SP 10 finish will remove the external oxidation layer and not skew the carbon content reading. Multiple readings must be taken and an average of the readings should give the best results. No material is perfectly homogeneous, so the test procedure should recommend testing various locations on the same pipe.

Collecting a good sample of metal shavings for analysis is another acceptable method for determining chemical composition. Be aware that grinding tools can sometimes contaminate the sample and can significantly skew results.

The use of digital field tools allows for data to be instantly logged using a tablet/phone, and hardness readings can quickly be converted to UTS and transferred to project engineers for quality control. This information can then quickly be sent to the owner-operator to validate that the TVC documentation has been collected and digs can be covered.

Weld Location and Joint Type Verification

Joint type must also be verified by owner-operators before calculating MAOP. Electric resistance welding (ERW) is currently the most common joining process for manufacturing line pipe. PHMSA requires that joint types must be documented. Until 1962, all ERW welds were performed using low-frequency ERW. Since that time, high-frequency ERW has generally replaced low frequency, as it has resulted in fewer discontinuities than is typically seen in low frequency. Additionally, the heat-affected zone (HAZ) is smaller for high frequency. PHMSA now requires that owners-operators determine and document whether low frequency or high frequency ERW was used during pipe fabrication, which has led to the development of a methodology for locating and evaluating the welds.

As weld seams are often flush with the base materials, automated ultrasonic testing (AUT) is proving to be a good method for locating ERW welds in the field. The weld seam can be located

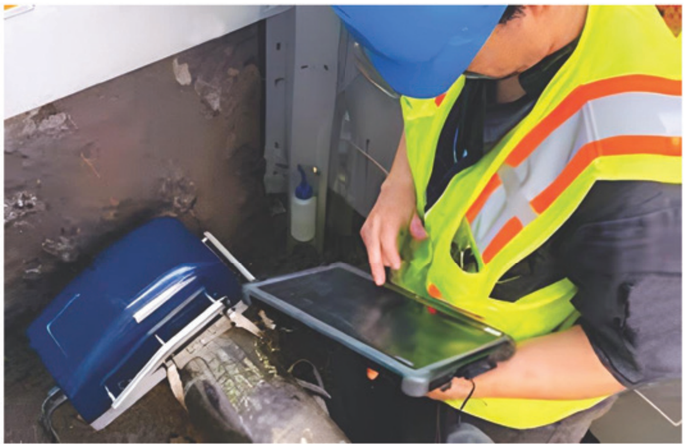

Figure 3. Utilizing the right technology is a crucial factor in effective material property determination.

by performing a 360-degree scan at multiple locations and then extrapolating connecting weld locations, linearly. A small linear reduction in wall thickness can verify ERW seams. Low vs. high-frequency welds can typically be determined using the field metallographic replication (FMR) technique, which can be performed and reviewed in the field by qualified technicians with a high familiarity in differentiating between HAZs of low and high-frequency ERW welding.

PHMSA rules include specific requirements for non-destructive evaluation (NDE) methods vs. destructive testing in 49 CFR § 192.607. Per § 192.607(d), procedures must comply with the following for NDE tools and equipment:

1) Utilize methods, tools, procedures, and techniques that have been validated by a subject matter expert based on comparisons with destructive test results on material of comparable grade and vintage;

2) Conservatively account for measurement inaccuracy and uncertainty using reliable engineering tests and analyses;

3) Utilize test equipment properly calibrated for comparable test materials before usage.

Conclusion

Sample cutting and piping replacement is a very expensive approach for pipeline material verification. In-situ testing is a much more economical option, but it must meet the requirements of 49 CFR § 192 subpart L. Inspection procedures must be documented in accordance with good engineering practices. Unknown materials can be verified with proper testing, and traceable, verifiable, and complete (TVC) documentation can be obtained. From the data gathered, the MAOP can then be recalculated, helping operators achieve compliance with regulatory guidelines. ■

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For nearly 30 years, Russ has worked in asset integrity program development and implementation. His experience includes pressure vessels, aboveground storage tanks (AST), piping inspection, testing and evaluation, and process safety management (PSM). He has developed and directed asset integrity programs for a global chemical company with facilities in North America, South America, Europe, and Asia Pacific regions. Russ has served as an owner-operator and external consultant for the implementation of asset integrity programs. He has knowledge of NDE, damage mechanisms, and the various materials of construction for equipment in the refining, chemical, and energy industries.

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James has over 30 years of experience in engineering, including pipe extrusion and metal forming of carbon alloy, stainless steel, titanium, and nickel-based alloys. He has experience in clamp evaluation, large storage tank evaluation and repair, fitness for service (FFS) and suitability for service (SFS), and design evaluations. James also has experience in piping, pressure vessels, and storage tanks. He is a registered Professional Engineer in the State of Texas.