



INSPECTION TRENDS

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THE MAGAZINE FOR MATERIALS INSPECTION AND TESTING PERSONNEL



**Offshore Marine Riser
Ultrasonic Inspection**

**The Role of Human Judgment
in AI-Augmented Inspection**

**Building a Compliant AWS QC47
Quality Assurance System**

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Cover Photo: An offshore oil rig's riser. (Credit: iStock.)

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What You Do Matters

As Certified Welding Inspectors (CWIs), we show up, look at welds, write a report, and repeat. That routine can feel humdrum, but the work is important. I travel across the country investigating failures, and I have seen both competent welders and CWIs miss consequential conditions.

On one project, concrete fractured around shear studs welded to the back of a large steel embed supporting a roof beam. Seasonal temperature movement, combined with an overly stiff connection, resulted in more load than the designer assumed. During the repair, a welder installed new welds, and I was asked to assess the welds. For the first time as a CWI, I found a cracked weld. Had that crack gone unnoticed, the connection could have failed again. It felt satisfying to catch something consequential.

I also routinely inspect welds in parking structures, where flange-to-flange connections are especially vulnerable to fatigue from vehicle traffic. In some cases, after a garage has been welded out and given the OK by a CWI, I still find poor fit-up, welds in the wrong locations, welds that fail to meet visual acceptance criteria, and inspection reports that flag none of it. These joints support vehicles and help provide diaphragm action for lateral stability. One broken weld may seem manageable, but once one fails, the joint can unzip. Over time, the double tee can rock on its bearings, creating unsafe conditions. Again, improperly installed welds and the absence of a discerning CWI can pose a serious life-safety issue.

I once inspected welds on a fall-arrest system and found downhill welds, missing welds, and poor workmanship. By chance, I put a wrench on one anchor-rod nut, and it turned freely. The others were loose, too. When I pulled on the rods, all four came out of the holes; the part had been installed without nuts on the bolts. This device was intended to support personnel descending the facade of a 30-plus-story building. If someone had trusted it, the result could have been serious. Both installers and inspectors missed basic opportunities to verify that the work matched the specification.

I have also seen the opposite. On many projects, welders and attentive inspectors identify and correct issues long before they become problems. Most of that work never makes headlines, but it helps keep structures safe and serviceable every day.

America is being built one weld at a time. Welding takes skill. Inspection takes skill. Let's do both as well as we can. The work we do helps keep ordinary people safe as they move through the built world. What we do matters. Make it count. 



BY JEREMY O. WHEELLESS

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ASNT and Sigma Enterprises Collaborate to Increase NDE Training in the Gulf Region

The American Society for Nondestructive Testing (ASNT), Columbus, Ohio, has partnered with Sigma Enterprises LLC, a provider of engineering solutions, technical support, and after-sales services based in Dubai, United Arab Emirates, to expand access to advanced nondestructive examination (NDE) training programs and technical workshops throughout the Gulf region of the Middle East. Through Sigma's Training & Innovation Centre, the collaboration will provide NDE professionals with access to globally recognized NDE knowledge, emerging technologies, best practices, and professional development opportunities.

By leveraging ASNT's international leadership in NDE standards, certification, and technical education, along with Sigma's regional expertise and industry presence, the partnership aims to address the demand for skilled NDE

professionals across key industries, including oil and gas, petrochemicals, power generation, manufacturing, and infrastructure.

The first phase of the partnership will focus on a new workshop series featuring hands-on instruction, practical applications, and opportunities for participants to gain experience applicable to certification and recertification requirements. Additional details regarding workshop topics, schedules, and registration will be announced in the coming months.

Certerra Expands Southwest NDE Capabilities with Addition of Code NDT

Certerra, Rancho Cucamonga, Calif., a provider of technology-enabled testing, inspection, and certification services, has added Code NDT to its platform, strengthening the company's nondestructive examination (NDE) capabilities across its Southwest division.

Code NDT, Anaheim, Calif., utilizes modern inspection technologies and certified personnel to perform ultrasonic testing, radiographic testing, magnetic particle testing, visual testing, and liquid penetrant testing, as well as advanced NDE methods such as computed and digital radiography and phased-array ultrasonic testing/time-of-flight diffraction.

Following the transaction, Jonathan Felts will continue to lead Certerra's Southwest Division as Code NDT integrates into the division's existing operations and growth strategy. Niko Svimonoff, former president of Code NDT, has been appointed regional vice president of the Southwest division.

Texas Steel Conversion Adds Phased-Array FLUT Inspection Line

Texas Steel Conversion Inc. (TSC), Houston, Tex., has launched a phased-array full-length ultrasonic testing (FLUT) inspection line for steel tubular products, expanding its non-destructive examination (NDE) capabilities. The system is designed to inspect drill pipe, oil country tubular goods, and subsea components.

The phased-array technology uses multiple coordinated transducers to detect discontinuities and measure wall thickness throughout the length of a tube. The system identifies longitudinal, transverse, and oblique indications at multiple angles on internal, midwall, and external surfaces.

The inspection line accommodates steel tubulars from 3.5 to 10.625 in. O.D. and lengths from 12 to 48 ft. According to TSC, the system incorporates automated handling, adaptive centering, and rotational scanning to provide consistent inspection coverage across a range of product sizes.

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Texas Steel Conversion's new phased-array FLUT inspection line expands the company's NDE capabilities for steel tubular products.

VOGT Ultrasonics Adopts New Name

VOGT Ultrasonics GmbH, Hanover, Germany, has rebranded as VSM Technologies – a ScanMaster company. The name change reflects the continued integration of VOGT Ultrasonics and ScanMaster Systems following ScanMaster's acquisition of VOGT in 2026. VSM Technologies combines expertise in ultrasonic inspection systems with capabilities in phased-array spot weld inspection, robotic inspection, and AI-assisted analysis.

The combined organization will continue developing automated inspection technologies for automotive manufacturers and suppliers, as well as other industrial markets.

Motive Conducts TIC Campaign in Asia-Pacific Region

Motive, a Scotland-based manufacturer of marine and lifting equipment for the oil and gas industry, completed a month-long testing, inspection, and certification (TIC) campaign across three major projects in the Asia-Pacific (APAC) region. The company used local inspection personnel and in-country assets to support safety compliance and asset integrity requirements.

Over the course of the month, the APAC team completed a range of specialized TIC services across the three projects, including eddy current testing of critical weldments on an umbilical reel.

The projects were completed under compressed schedules to accommodate vessel schedules. The company's engineering and project management teams planned the inspection and umbilical spooling activities based on project requirements, environmental conditions, and available resources. 



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FORGED THROUGH COMMUNITY

Discover how one CWI has helped shape decades of welders and journeymen



A young Wisehart competing in the union's inaugural welding competition in 1991.

Robert “Bob” Wisehart had just graduated from the local community college when an ironworker introduced him to the apprenticeship program he now directs.

Wisehart's acceptance into Iron Workers Local Union 272's apprenticeship program in Fort Lauderdale, Fla., has shaped his life immensely and has reinforced what everyone who knows him can agree on: community and quality are at the heart of everything he does. A hard worker, he takes advantage of every opportunity presented, which is why, after his acceptance into the apprenticeship program, he set his sights on earning a welding certification, which he achieved in 1989. He then worked



Wisehart (left) poses with a colleague at a charity event.

his way up from a welder to a weld foreman.

However, he has always had a passion for teaching. This passion led him to start teaching in the apprenticeship program nearly ten years after earning certification. He continued to grow in his role and responsibilities, and 15 years later, he became the apprentice director, a role he's held since.

“One of the important things for an apprentice director is to be a CWI. It really just ups the game. As a CWI, I can certify the students and help them complete their training as welders,” Wisehart said.

He recalls preparing to become a CWI with support from peers and the apprenticeship program, while teaching journeymen and apprentices in the program. The same support he can now provide to his students working toward their certifications.

Mentorship

Wisehart credits those who came before him in the union with helping shape the ironworker and instructor he is today.

His mentor was an iconic member of the local union who served as an advisor and teacher to everyone who came through the doors. It was his encouragement that shaped Wisehart's trajectory. He was notorious for being tough on apprentices who passed through the program while simultaneously pushing them to put their best foot forward, which helped



Wisehart standing on a beam 400 ft in the air while preparing a weld.



Over 100 of Wisehart's welders worked to help build the Hard Rock Stadium in Miami Gardens, Fla.

mold Wisehart into the ironworker he is today.

Wisehart has similar policies in his own teaching. He spoke of a welder in desperate need of renewing his certification. He brought the welder into the weld shop and administered a test, working with him to ensure that the welder had all the resources and support necessary to pass.

"I have a responsibility to the union and the students to turn out quality welders," he shared.

For Wisehart, it is more than just a certificate. It's a pathway to making a living and having a career.

Beyond the Classroom

Wisehart's philosophy carries over beyond the classroom. He recalls a large project in Miami where a team of 50 welders was working with him to expand and build an airport terminal. While he believes in the necessity of certifications, he wants to make sure that welders have the skill to accompany the knowledge.

He has all welders show him their work, making sure they know how to fit up and weld. He gives pointers as needed, guiding and imparting knowledge to both novice and seasoned welders.

Because of this, he does not believe in failing inspections. He is big on quality control: keeping an eye on the weld, giving advice, having welders grind out any issues, making sure procedures are right, and ensuring the process is flawless before another inspector makes the final call.

Wisehart wants to ensure that his hallmark quality is present, a trait he held before he became a CWI.

Community

Outside of the weld shop, Wisehart, a fifth-generation South Floridian, is an active member of his community. From church handrails to art displays, community members and institutions know they can rely on Wisehart and the union for any of their technical needs. He is also involved with the Freemasons, where his community work goes beyond welding. "Whatever anybody needs, we're going to help them out," he reaffirmed.

Still, Wisehart's passion for education bleeds through. He regularly attends local high school events and career fairs, emphasizing the future life in the trades could provide for young minds.

He advises all students to consider any trade, not just welding, though he is favorable toward it. He emphasizes the need for tradespeople in all fields and highlights the benefits the career can offer those interested, noting that completing an apprenticeship program similar to the one he directs puts students a handful of courses away from an associate's degree.

"My advice to up-and-coming students is that they can always get a head start in high school," he said.

He believes that they can always go back to school, but having a necessary foundation is vital. 

RACHEL BHEECHAM

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Students in the apprenticeship program show off their skills.



Video Borescope Supports Accurate 3D Inspections

The 3D measurement VJ-4 video borescope captures precise dimensional measurements during inspections. Combining high-definition imaging with intuitive measurement technology, the borescope enables users to evaluate defects without disassembly. The tool is available in 3.9-mm, 6.0-mm, front-view, and side-view configurations. It can adapt to a wide variety of inspection applications across aerospace, aviation, power generation, manufacturing, automotive, oil and gas, and industrial maintenance environments. The borescope allows maintenance teams to accurately characterize corrosion, cracks, erosion, weld defects, foreign object damage, coating loss, and other anomalies. Additional features include onboard file management, optional Wi-Fi connectivity, and a 5.5-in. OLED touchscreen that supports navigation and on-screen annotation. Mini joystick controls and full HD camera resolution support detailed inspections, while software enables efficient creation of professional inspection reports.

Viewtech Borescopes
viewtech.com



AWS Issues Third Edition of B5.2

AWS B5.2:2026, *Specification for Establishing a Company Program for Qualification and Certification of Welding Inspection Specialists*, provides a framework for companies to develop in-house programs for qualifying and certifying personnel who perform visual welding inspections in accordance with contract or industry-specific requirements. This third edition is a complete revision of the standard, with updates to its content and organization. It establishes minimum qualification requirements for welding inspection specialists based on a combination of education, experience, and examination and includes guidance for documenting training, qualification, and certification activities. The revision also adds company-specific references and updates terminology and body-of-knowledge requirements to reflect current industry practices.

AWS
aws.org

System Performance Verification Capability Verifies Daily Equipment Readiness

The System Performance Verification (SPV) capability for the Cypher phased-array ultrasonic testing instrument helps inspection teams confirm equipment readiness between scheduled calibration intervals. Designed for point-of-use verification, it uses an automated test procedure to evaluate system performance parameters before inspections begin. The SPV plug connects through an IPEX interface and checks pulser/receiver health, firmware integrity, and system monitoring functions, providing a pass/fail result within minutes. Verification reports can be saved in HTML or PDF format to support quality documentation, traceability, and auditing requirements. The tool complements accredited calibration by providing additional verification between formal calibration events. Regular SPV testing can help identify changes in instrument performance over time



and provide documented records to support the reliability of inspection results.

Eddyfi Technologies
eddyfi.com

Global Non-Destructive Testing Equipment Market Size Forecast to Cross \$20.36 Billion by 2030

The *Non-Destructive Testing Equipment Market* report predicts the market will grow from \$13.47 billion in 2026 to \$20.36 billion by 2030, representing a compound annual growth rate of 10.9%. According to the report, expansion during this period is largely due to increased oil and gas infrastructure development, stricter industrial safety regulations, increased manufacturing

quality assurance, widespread use of traditional ultrasonic and radiographic testing, and a surge in construction and heavy engineering projects. The report also cites continued adoption of advanced inspection technologies in oil and gas, manufacturing, and other industrial markets. Additional factors supporting growth include the increasing use of asset integrity management programs and testing-as-a-service business models. North America accounted for the largest share of the market in 2025, while the Asia-Pacific region is expected to see the fastest growth through 2030.

The Business Research Co.
thebusinessresearchcompany.com

AWS Publishes B5.31 for B31 Owner's Inspectors

AWS B5.31:2026, *Specification for the Qualification of B31 Owner's Inspectors*, establishes qualification requirements for personnel serving as Owner's Inspectors under ASME B31 piping codes. The standard outlines education, experience, and examination requirements and defines the duties and tasks a qualified Owner's Inspector should be able to perform. This first edition addresses responsibilities associated with fabrication, examination, testing, repair, and quality-assurance oversight of piping systems governed by ASME B31 codes. It covers areas including design review, fabrication and welding, examinations, assembly, erection, nonmetallic materials, and recordkeeping. The standard also describes requirements for qualification maintenance and includes examinations covering piping system fundamentals and the application of ASME B31.1, *Power Piping*, and B31.3, *Process Piping*. The document was developed to provide guidance for a role referenced throughout ASME B31 codes but not previously defined through a dedicated qualification standard. It emphasizes the Owner's Inspector's responsibility to ensure required inspections are performed and to verify compliance with applicable codes and contractual requirements.

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Advancing Offshore Marine Riser Inspection

Automated ultrasonic scanners improve corrosion mapping, weld assessment, and inspection repeatability

Marine risers are among the most critical components in offshore oil and gas infrastructure, providing the essential connection between subsea production systems and surface facilities. Operating in some of the harshest industrial environments, these structures are exposed to continuous mechanical loading, fluctuating pressures, corrosive fluids, and aggressive marine conditions. Over time, these factors can lead to wall thinning, pitting corrosion, fatigue cracking, and weld defects that threaten both operational reliability and safety.

As offshore assets age and operators seek to extend service life while reducing operational downtime, the demand for more advanced inspection methodologies has grown significantly. Traditional inspection techniques, such as manual ultrasonic testing (UT) and conventional visual inspection, often struggle to deliver the coverage, repeatability, and efficiency required for modern offshore integrity management programs. Access limitations, confined geometries, and the sheer scale of marine riser systems can make manual inspection both time-consuming and inconsistent.

To address these challenges, inspectors can use manual and automated ultrasonic inspection

scanners that are designed specifically for marine riser applications. Rather than relying on a single inspection tool, the approach uses multiple specialized scanners that can be deployed individually or in combination, depending on the inspection requirement. Together, these systems provide high-resolution inspection capability for corrosion mapping, weld assessment, flange inspection, and auxiliary line evaluation.

As shown in Fig. 1, the inspection strategy integrates several complementary scanners with automated deployment systems, encoded positional tracking, and advanced data acquisition technology. Each scanner has been engineered for a specific inspection task, allowing the overall system to achieve greater flexibility and inspection coverage while maintaining highly repeatable results.

Mapping Corrosion in Main Bores and Auxiliary Lines

One of the key inspection requirements for marine risers is accurate internal corrosion mapping. Corrosion within the main bore can occur gradually over time and may

remain undetected until significant wall loss has developed. To address this, specialized immersion ultrasonic testing scanners equipped with high-channel probe arrays can generate detailed wall-thickness measurements along extended pipe lengths — Fig. 2.

The main bore scanners are deployed using pneumatically driven winch systems that provide controlled traversal through the riser. Integrated encoders continuously monitor scanner position, ensuring accurate spatial correlation between the inspection data and the physical location within the riser. By creating a controlled flooded inspection zone, the scanners maintain stable acoustic coupling and consistent signal transmission throughout the inspection process.

The baseline inspection configuration incorporates 56 immersion probes, while advanced versions can accommodate up to 84, enabling greater circumferential coverage within the bore. This significantly increases data density and improves the probability of detecting localized corrosion or wall thinning.

Auxiliary lines present an additional inspection challenge due to their smaller diameters and more restricted geometries. To overcome this, dedicated auxiliary line scanners



Fig. 1 — A Phoenix Inspection Systems Ltd. (Phoenix ISL) system for marine riser inspection.

have been developed using smaller immersion UT probes configured specifically for narrow bore inspection. Standard systems utilize four probes for continuous thickness monitoring, while more advanced scanners employ a spiral arrangement of 24 probes.

This helical probe configuration is particularly significant because it allows circumferential coverage during axial movement of the scanner. By effectively sweeping around the pipe circumference as the tool travels longitudinally, the design reduces inspection gaps and minimizes the likelihood of missing isolated corrosion features.

Further technological development will introduce convex phased array probes into the auxiliary line scanners. Unlike conventional

fixed-beam probes, phased array technology allows electronic beam steering and dynamic focusing. This improves inspection sensitivity and provides greater flexibility when evaluating complex corrosion profiles or irregular geometries.

Assessing Welds and Flanges with Advanced Ultrasonic Methods

In addition to corrosion mapping, weld integrity remains a major focus in marine riser inspection. Weld defects such as incomplete fusion, incomplete penetration, and fatigue cracking can compromise structural performance if not accurately identified and characterized. To address this, dedicated weld

inspection scanners that use both phased-array ultrasonic testing (PAUT) and time-of-flight diffraction (TOFD) are employed.

PAUT scanners enable electronic beam steering and sectorial scanning without requiring mechanical movement of the probe itself. This allows inspectors to rapidly and efficiently interrogate weld volumes from multiple angles, improving the detection and characterization of planar defects. The resulting data provides detailed imaging of weld conditions and supports more accurate defect assessment.

TOFD technology complements PAUT by providing highly accurate sizing of crack-like defects. By analyzing diffracted signals generated at defect tips, TOFD enables



Fig. 2 — A Phoenix Inspection Systems Ltd. (Phoenix ISL) main bore winch assembly.

precise measurement of defect depth and through-wall extent.

The combination of PAUT and TOFD provides a robust inspection methodology that enhances reliability while reducing uncertainty in defect evaluation.

To further support inspection accuracy, visual inspection systems are integrated alongside the ultrasonic scanners. Onboard camera systems confirm weld locations and enable operators to correlate ultrasonic indications with visible

physical features. This combination of visual and ultrasonic data improves interpretation confidence and assists with inspection reporting.

Flange inspection represents another critical aspect of marine riser integrity management. Flanges are subjected to high loading and sealing stresses and can be vulnerable to cracking or corrosion, particularly around sealing surfaces and weld interfaces. To inspect these areas effectively, external and internal flange scanners tailored to the

specific geometries involved are used.

External flange inspection is performed using magnetic scanning buggies equipped with dual phased array probes and positional encoding systems. These scanners can traverse flange surfaces while maintaining stable probe contact and precise positional tracking. Internal flange inspection, meanwhile, is achieved using compact probe carriers and specifically designed for confined access conditions — Fig. 3.

Improving Repeatability through Automation and Validation

An advantage of the overall inspection strategy is its emphasis on automation and semiautomation, as well as repeatability. Manual inspection techniques can be heavily dependent on operator skill and consistency, potentially leading to variability in inspection quality. Automated and semiautomated scanners reduce this dependency by controlling probe positioning, scan speed, and data acquisition parameters throughout the inspection process.

Calibration procedures are performed using reference standards with known reflectors to verify sensitivity, time-base accuracy, and overall probe performance before deployment. During operation, continuous acquisition of encoded data ensures that all measurements are accurately linked to their physical locations, enabling detailed corrosion maps and inspection reports to be generated during postprocessing.

Field trials and laboratory validation programs have demonstrated the effectiveness of the automated scanner suite across a range of

offshore inspection scenarios. High-resolution corrosion mapping results have shown improved detection capability compared with conventional UT methods, particularly in identifying localized wall loss and pitting corrosion.

Similarly, weld inspection trials using combined PAUT and TOFD techniques have demonstrated strong performance in detecting and sizing defects with high accuracy and repeatability. The spiral probe configuration being developed for auxiliary line inspection will show significant improvements in circumferential coverage, reducing the risk of missed indications and enhancing the overall probability of detection.

The ability to deploy multiple specialized scanners also provides greater operational flexibility offshore. Inspection programs can be tailored to the specific condition-monitoring requirements of a riser system, allowing operators to focus on areas of greatest concern while minimizing inspection time and associated operational disruption.

Conclusion

As offshore infrastructure continues to age, the importance

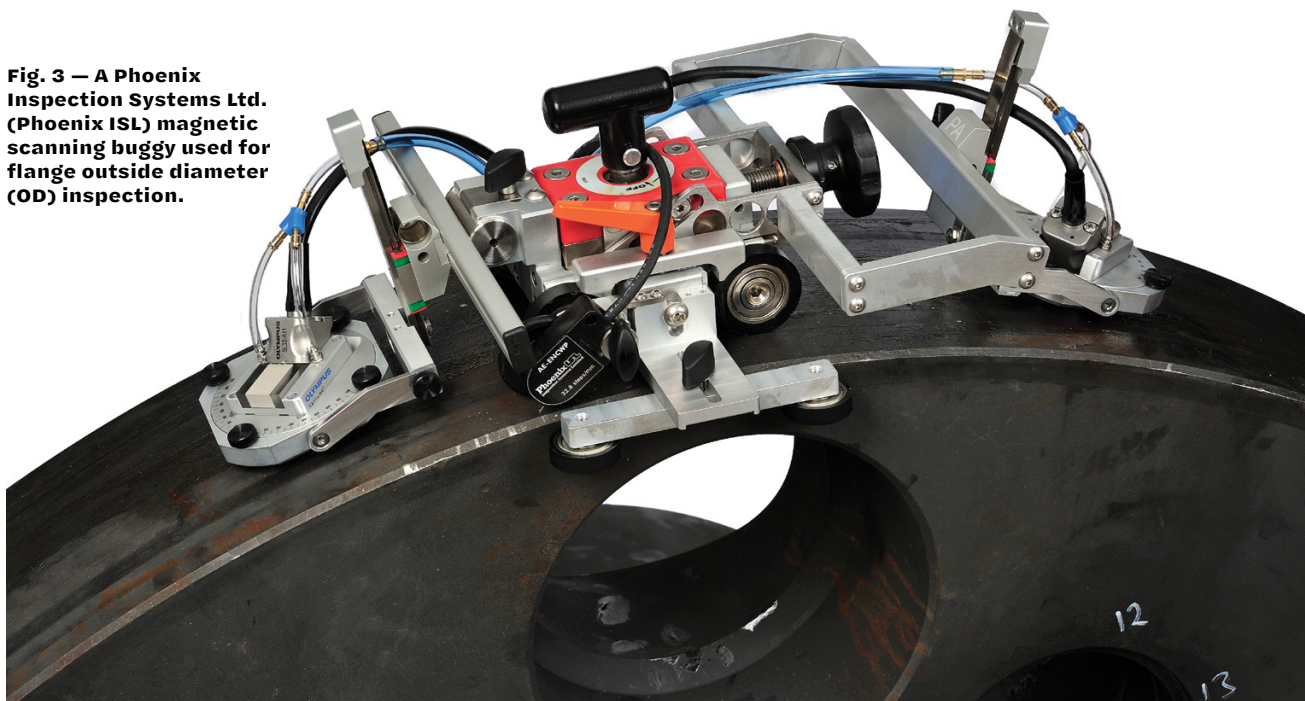
of advanced integrity assessment technologies will only increase. Operators are under growing pressure to extend asset life safely while controlling maintenance costs and reducing downtime. Automated ultrasonic inspection systems offer a practical pathway to achieving these objectives by delivering more comprehensive inspection data with greater efficiency and reliability.

By combining high-resolution ultrasonic technologies, advanced probe configurations, automated deployment systems, and encoded positional tracking, these specialized scanners represent an advancement in marine riser inspection capability. Their successful application in corrosion mapping, weld assessment, auxiliary line inspection, and flange evaluation demonstrates how automated and semiautomated non-destructive examination systems are helping to establish a new benchmark for offshore integrity management and long-term asset assurance. 

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Fig. 3 — A Phoenix Inspection Systems Ltd. (Phoenix ISL) magnetic scanning buggy used for flange outside diameter (OD) inspection.





The Role of Human Judgment in AI-Augmented Welding Inspection

How artificial intelligence is reshaping welding inspection while keeping human expertise at the center

Walk through any modern factory, hospital, or office, and you are sitting, standing, or moving surrounded by welds. Chairs, vehicles, structural beams, pressure vessels, and the electrical systems powering daily life all rely on welds whose integrity depends on inspectors trained to see what most people cannot. Artificial intelligence (AI) is now demonstrating capabilities that, in many controlled conditions, can match or exceed those of even seasoned AWS Certified Welding Inspectors (CWIs). That fact has prompted welding professionals, manufacturers, and the broader industry to ask a question with no simple answer: As AI matures, what becomes of the human inspector?

This article explores that question by drawing on a presentation delivered at a recent AWS Professional Program session and on broader research into AI adoption across knowledge professions.

The following two goals shape the discussion:

1. To describe what AI can and cannot do in welding inspection today.
2. To examine the human and organizational factors that determine whether the technology delivers on its promise or quietly fails.

Welding inspection serves as a useful test case because the stakes are high, the technology is progressing rapidly, and the people doing the work have invested years in

developing their expertise. The lessons learned here apply far beyond the trade.

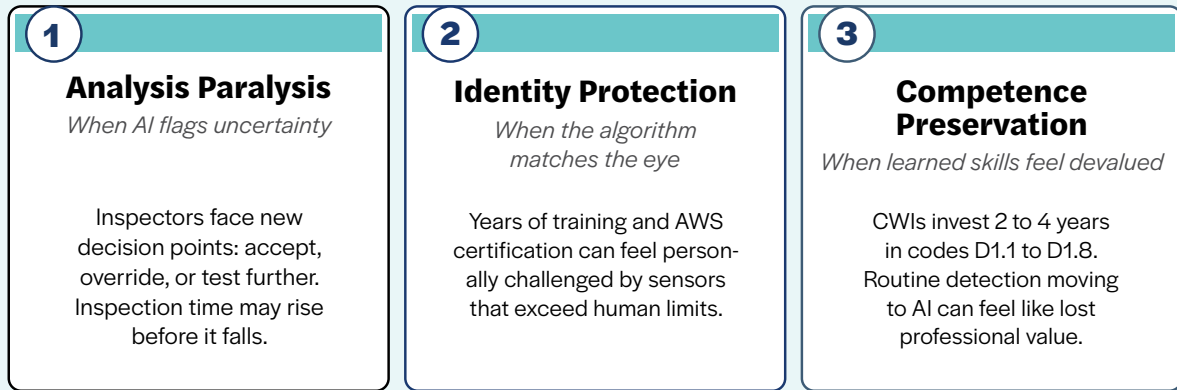
The Hidden Cost of Imperfection

The economic case for improvement is well documented. Welding defects, including porosity, cracking, incomplete fusion, and distortion, contribute to the broader automotive warranty challenge that industry analysts estimate exceeds \$50 billion annually across all categories of defects (Ref. 1). Add aerospace, pipeline construction, shipbuilding, and infrastructure, and the total quality cost across welded products climbs higher still. Each dollar lost represents not only inefficiency but also a quality risk that can affect public safety.

AI inspection systems address part of that problem. Machine vision platforms now combine high-resolution cameras, acoustic sensors, and thermal imaging to evaluate welds during production rather than only afterward. Industry research indicates that the machine vision welding inspection services market was valued at approximately \$1.2 billion in 2024 and is projected to reach \$2.5 billion by 2033, a compound annual growth rate of 9.5% (Ref. 2). Vendor demonstrations show inspection speeds of 300 mm/second and defect detection as small as 0.5

Three Psychological Barriers to AI Adoption

Observed across welding inspection and other knowledge professions



Source: Synthesis of presentation research, cited during the AWS Professional Program.

Fig. 1 – Three psychological barriers that influence AI adoption in welding inspection and other knowledge fields.

mm, compared with a typical 1-mm threshold for human visual inspection. Yet the technology remains imperfect. Surface oxidation, unusual lighting, and material variations can cause AI systems to flag results as uncertain, transferring the burden of judgment back to the inspector.

Three Barriers Technology Alone Can't Solve

A consistent finding across research on AI adoption is that human factors, not technical capability, decide whether implementations succeed. Three barriers appear repeatedly in welding inspection and across other knowledge fields — Fig. 1.

The first is analysis paralysis. When AI flags a weld as uncertain, an inspector with years of experience must decide whether to accept that classification, override it based on professional judgment, or halt production for additional testing. Each option carries weight in a safety-critical environment. The result is often more decision points, not fewer, and inspection time can rise rather than fall in the early phases of adoption.

The second barrier is professional identity protection. CWIs complete rigorous AWS training, accumulate years of field experience, and develop what veterans call an eye for perfection. When a sensor and an algorithm match or exceed that ability under controlled conditions, the challenge feels personal rather than procedural. The dis-

comfort is a normal human response, and ignoring it has real consequences for adoption.

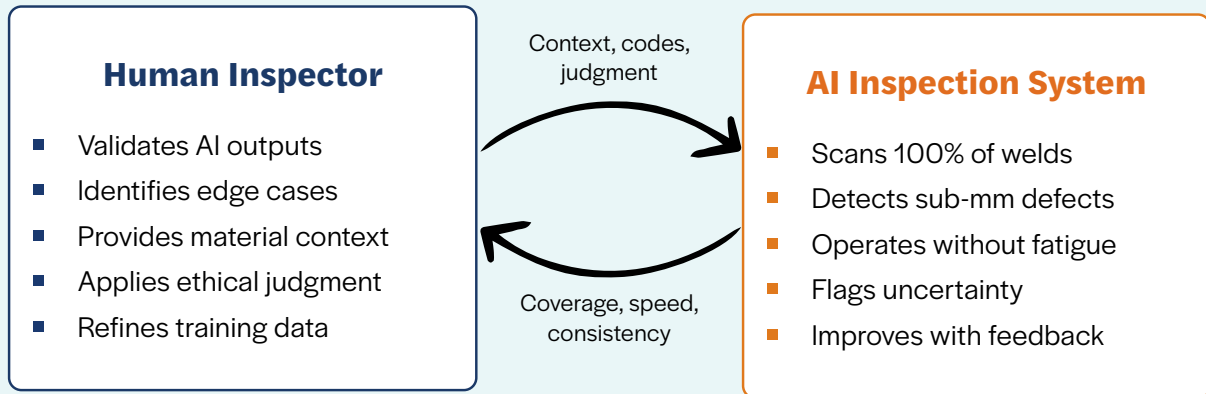
The third barrier is competence preservation. CWIs typically invest two to four years in mastering AWS welding codes from D1.1, *Structural Welding Code — Steel*, through D1.8, *Structural Welding Code — Seismic Supplement*, along with documentation and visual inspection standards. As AI takes over routine detection, that hard-won knowledge can feel devalued even though the underlying skills remain essential. The U.S. Bureau of Labor Statistics projects that welding employment will grow about 2% from 2023 to 2033, slower than the average across all occupations (Ref. 3). The trajectory points toward fewer purely manual inspectors and greater demand for those who can supervise automated systems.

From Inspector to Intelligent Oversight Specialist

The most useful response to these barriers is to redefine the role rather than defend or replace it. Research from the McKinsey Global Institute estimates that approximately 60% of occupations have at least one-third of their constituent activities that could be automated with currently demonstrated technologies, which calls for substantial workforce transformation rather than wholesale displacement (Ref. 4). The data do not call for fewer welding inspectors so much as a different kind of welding inspector.

The Intelligent Oversight Model

Human expertise and AI capability operate in continuous loop



Outcome: higher coverage, preserved judgment, accountable decisions

Fig. 2 – The intelligent oversight model shows how human expertise and AI capability operate in a continuous feedback loop.

In what can be called an intelligent oversight model, the certified inspector validates AI outputs, identifies edge cases, provides context for unusual material conditions, and refines algorithms with field knowledge that no training dataset can fully capture — Fig. 2. The inspector becomes the source of ground truth that the AI relies on to improve. Research by MIT economists Daron Acemoglu and Pascual Restrepo (Ref. 5) finds that for every additional industrial robot per 1000 workers, employment falls by about 0.2% points and wages by approximately 0.42% points in affected regions. Those findings underscore the urgency of preparing the workforce in advance rather than after disruption.

A Human-Centered Future for Welding

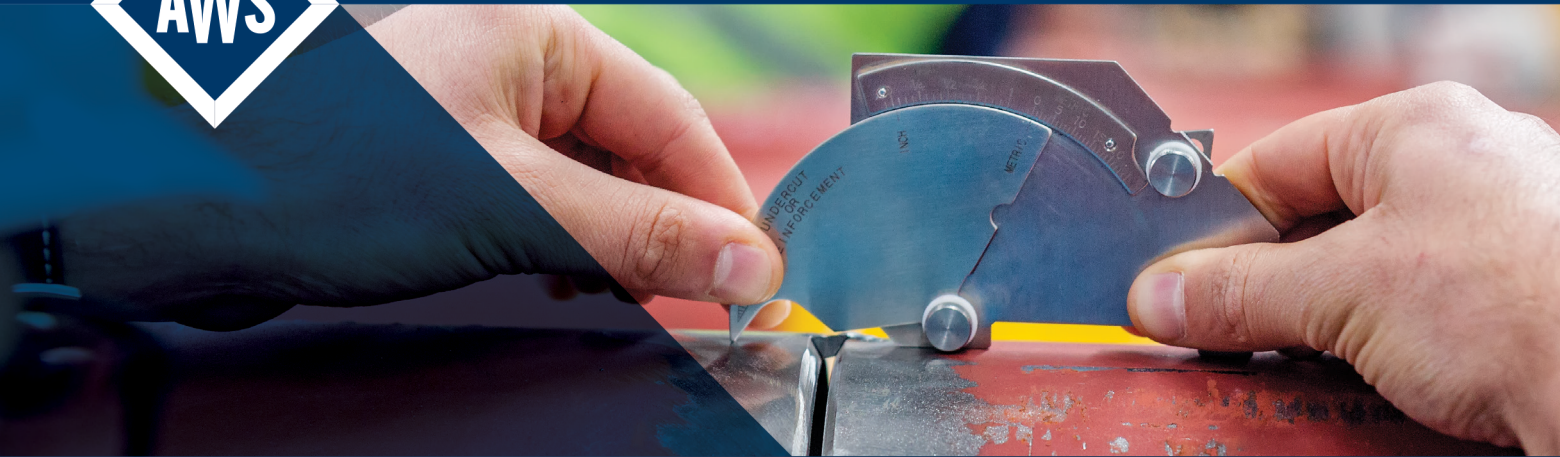
AI will not eliminate welding inspection, but it will reshape the work. The inspectors and organizations that lead through this transition are those who treat the technology as a tool that amplifies professional judgment rather than as a replacement for it. Welding has always demanded human attention to detail, ethics, and consequence. That standard should remain the measure by which any new tool, including AI, is judged. When the

technology serves the inspector and the public who depend on their work, it earns its place. When it does not, no efficiency gain is worth the risk. 

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Building a Compliant and Functional AWS QC47 Quality Assurance System

A practical approach for Accredited Test Facilities



The AWS Accredited Test Facility (ATF) program has undergone significant modernization. With the retirement of AWS QC4, *Standard for Accreditation of Test Facilities for AWS Certified Welder Program*, and QC7, *Standard for AWS Certified Welders*, along with the introduction of AWS QC47, *Specification for AWS Certification of Welders and Accreditation of Test Facilities*, ATFs are now required to meet a unified, more rigorous standard for welder performance qualification. While AWS provides formal documentation and guidance, many facilities struggle with a practical challenge: How do you build a quality assurance (QA) system that satisfies QC47 and performs reliably during an audit?

Having authored one of the earliest AWS QC47 quality manuals (May 2025) — and subsequently developed three additional QC47-compliant programs that have all passed AWS audits — I offer the following insight into the practical “how” behind creating a robust, audit-ready QA system.

Understanding the Foundation

The first step in developing a QC47-compliant system is a disciplined review of the governing

documents. Three resources form the backbone of the ATF QA system:

- AWS QC47 — the primary specification governing welder performance qualification under the ATF program.
- AWS B5.4, *Specification for the Qualification of Welder Test Facilities* — defines facility-level requirements.
- AWS Quality Assurance System Audit Checklist — the tool AWS auditors use to evaluate compliance.

To build a compliant and functional system, each of these documents must be studied carefully. In my process, I first highlight all QC47 requirements in yellow, then highlight all B5.4 requirements (also in yellow). Next, I review the AWS audit checklist and highlight each checklist question in blue, cross referencing it to the relevant QC47 and B5.4 clauses.

This color-coded mapping ensures that every requirement and audit question is accounted for before a single page of the quality manual is written.

Structuring the Quality Manual: Aligning with QC47 Clause 10

AWS provides a QC47 *Quality Manual Guide*, but I found that a more effective approach is to structure the manual to mirror Clause 10 of QC47 directly. This creates a one-to-one relationship between the manual and the specification, making navigation intuitive for internal users and AWS auditors.

Example Table of Contents Structure

Clause 1 – Welder Performance Qualification Quality Manual

- 1.1 Scope and Policy – Corresponds to QC47 10.1
- 1.1.1 References – Corresponds to QC47 10.1.1
- 1.1.2 Quality Manual and Related Documents – Corresponds to QC47 10.1.2
- 1.1.3 Quality Policy Statement – Corresponds to QC47 10.1.3

This structure allows any clause in the manual — such as 1.1.2 — to be instantly cross referenced to the corresponding QC47 requirement by replacing the leading “1” with “10,” resulting in 10.1.2. This method creates clarity, consistency, and traceability throughout the system.

Note that there are a few audit questions that come from other clauses. For example, Clause 11.4.2.1 contains a requirement to address audit nonconformance reports (NCRs) within 30 days. I added this requirement to my manual under clause 1.1.11, which corresponds to QC47 Clause 10.1.11 – Nonconformance and Corrective Actions.

Integrating the Audit Checklist into System Development

One of the most common pitfalls in developing an ATF quality manual is treating the audit checklist as an afterthought. In reality, the checklist should be integrated into the system from the beginning.

By cross referencing checklist questions to QC47 and B5.4 during the initial review, the quality manual can be written in a way that directly answers each audit question. This prevents the need for later revisions and ensures that the system is complete, defensible, and aligned with AWS expectations.

This approach also simplifies internal audits. When the manual is built around the checklist, auditing the system becomes a matter of verifying that each documented process is implemented exactly as written.

Conducting Internal Audits

Before AWS assigns an auditor, the facility must conduct its own internal audit. This includes the following:

- Auditing the quality manual
- Auditing the quality assurance system
- Verifying compliance with QC47, B5.4, and the audit checklist

Because the manual is already structured around the checklist and specification, the internal audit becomes straightforward. Any gaps can be identified and corrected before AWS conducts its formal review.

This proactive approach is one of the key reasons the programs I developed have consistently passed audits with outstanding results.

Designing a System That Works for You

While compliance is essential, the quality manual and quality assurance system must also be practical. They should support the daily operations of the ATF — not hinder them. AWS audit questions may evolve over time, but a well-designed system remains stable because it is built on clear requirements, documented processes, logical structure, and practical workflows.

The goal is not simply to pass an audit. The goal is to build a system that ensures consistent, repeatable, and defensible welder performance qualification testing.

Conclusion

Developing a QC47-compliant quality assurance system is not merely a matter of filling out forms or copying templates. It requires a structured, methodical approach grounded in the governing documents and aligned with the AWS audit process. By cross referencing QC47, B5.4, and the audit checklist; structuring the manual around Clause 10; and conducting thorough internal audits, ATFs can build systems that are compliant and operationally effective.

This approach has been proven through multiple successful audits and provides a clear, practical pathway for any facility seeking ATF accreditation under AWS QC47. 

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Why Conflict of Interest Matters in Welding Inspection

How the appearance of a conflict can be just as damaging as an actual ethical violation



Integrity is one of the most valuable assets a welding inspector possesses. Technical knowledge, certifications, and experience are essential, but they carry little weight if clients' confidence in an inspector's objectivity is compromised. For that reason, conflicts of interest remain among the most important ethical challenges welding inspectors face, particularly those working in small markets where professional roles often overlap.

This article explores how conflicts of interest emerge in everyday situations and why inspectors must be vigilant not only about actual conflicts but also about the appearance of impropriety.

Why Perception Matters

A conflict of interest occurs when an individual has competing interests or responsibilities that could influence professional judgment. While many inspectors immediately think of financial gain, conflicts can arise from personal relationships, business interests, educational roles, or organizational affiliations.

The larger issue is perception. Even when an inspector acts fairly and objectively, circumstances that appear questionable can lead others to question the inspector's integrity. Once credibility is challenged, professionals often find themselves defending decisions that were otherwise technically sound.

For inspectors, maintaining trust requires evaluating not only whether an action is ethical, but also whether

it could reasonably be perceived as unethical by clients, employers, coworkers, or regulators.

Common Forms of Conflict

Conflicts of interest can take many forms, ranging from obvious ethical violations to more subtle situations that develop over time. Examples include self-dealing, nepotism, preferential treatment, and the misuse of insider information.

In each case, an individual's personal interests compete with professional obligations. Whether the benefit takes the form of financial gain, favoritism toward family members, special opportunities for selected individuals, or access to nonpublic information, objectivity is called into question.

For inspectors, these situations often arise in less obvious ways than the examples commonly depicted in ethics training. A recommendation for employment, a training assignment, a qualification test, or a long-standing personal relationship can all create situations that require careful consideration.

The Challenges of Wearing Multiple Hats

Many welding professionals routinely serve in multiple capacities. They may own businesses, teach classes,

conduct inspections, volunteer with industry organizations, mentor students, or participate in competitions and workforce development programs. Each role carries responsibilities that can sometimes overlap.

The challenge is not necessarily avoiding multiple roles altogether. Instead, it is identifying potential conflicts early and disclosing them openly.

Transparency plays a critical role in maintaining trust. When inspectors disclose affiliations and potential conflicts before questions arise, they demonstrate professionalism and protect both themselves and the organizations they represent.

Failing to disclose a relevant relationship may create the impression that information was intentionally concealed, even when no unethical conduct occurred.

Separating Instruction from Evaluation

One of the most common ethical challenges in welding education involves maintaining separation between teaching and testing.

Although regulations may not always prohibit an individual from serving as both an instructor and an evaluator, doing so can raise concerns about impartiality. Students, employers, and customers may question whether qualifications were earned objectively or influenced by the instructor's personal relationship with the candidate.

A best practice is to separate those responsibilities whenever possible. By ensuring that training and evaluation are performed by different individuals, organizations reduce the likelihood of perceived favoritism and strengthen confidence in qualification results.

Even in communities with limited personnel resources, inspectors can take steps to maintain clear boundaries and document decisions carefully.

Small-Town Inspection Challenges

Inspectors working in large metropolitan areas often have access to extensive professional networks. Those working in smaller communities face different realities.

In some regions, a welding inspector may be the only available Certified Welding Inspector (CWI) within several hours. As a result, inspectors frequently encounter situations involving friends, former students, customers, family connections, or professional contacts.

These relationships do not automatically create ethical violations, but they increase the importance of maintaining professional boundaries. Treating every client consistently, following established procedures, and applying the same technical standards to everyone are essential practices.

Professionalism serves as the safeguard for objectivity when personal relationships cannot realistically be avoided.

Documentation Is the Best Defense

When inspectors face situations that could be perceived as conflicts of interest, thorough documentation provides evidence that decisions were based on objective criteria rather than personal preference. Test samples, photographs, inspection records, qualification results, reports, and supporting documentation all contribute to a defensible process.

Documentation creates transparency. It demonstrates consistency. Most importantly, it allows inspectors to show exactly how conclusions were reached if questions arise later.

In many cases, strong documentation can eliminate doubts before they become formal disputes.

Questions Every Inspector Should Ask

Before accepting an assignment or making a decision, inspectors should pause and evaluate the situation objectively by asking key questions, including:

- Can I remain unbiased?
- Do I have a relationship that could influence my judgment?
- Could someone reasonably perceive a conflict?
- Have I disclosed all relevant affiliations?
- Should another inspector perform this work?
- Is my documentation sufficient to support my decisions?

If the answer to any of these questions raises concerns, additional safeguards may be necessary. In some cases, the most ethical decision may be to decline the assignment altogether.

Integrity above All

Technical expertise is the foundation of welding inspection, but integrity is what gives that expertise value. Clients hire inspectors because they trust independent judgment. Employers rely on inspectors to provide unbiased assessments. The public depends on inspectors to help ensure safety and quality.

Conflicts of interest are not limited to corporate scandals or high-profile ethical failures. They occur in everyday decisions, especially when inspectors hold multiple roles and operate in close-knit professional communities.

By recognizing potential conflicts early, maintaining professional boundaries, disclosing relevant relationships, and documenting decisions thoroughly, inspectors can protect their credibility, the one asset most difficult to regain once lost. 

Based on a session presented at the Upholding Integrity: Legal and Ethical Standards in the Welding Industry Conference, Austin, Tex., February 2, 2026, by **SHANEN ARANMÓR** (shanen@weldlikeagirl.us), founder of Weld Like A Girl™, Yuma, Ariz., and an AWS director-at-large.



The Geometry of Failure: How Internal Weld Profiles Drive Corrosion-Erosion

A closer look at the service conditions that can turn acceptable weld profiles into corrosion-erosion hot spots

There is a moment, right after a weld passes inspection, when everyone involved feels a quiet sense of closure. The joint meets the requirements, the reports are signed, the coating is applied, and the system moves forward. On paper, the weld is sound. In service, however, especially inside a pipeline, a weld becomes something very different: a geometric and metallurgical disturbance in a moving environment.

Fluids do not read codes; they respond to shape, velocity, and surface condition. And when those factors align in the wrong way, a mechanism emerges that is subtle and aggressive: corrosion-erosion.

Corrosion-erosion is not simply corrosion that happens faster, nor is it purely mechanical wear. It is a coupled degradation process driven by the interaction between

electrochemical attack and fluid dynamics. Corrosion weakens the material at the surface, often through the formation and removal of protective films such as oxides. Flow then removes this weakened layer, exposing fresh, more reactive metal beneath. That newly exposed surface corrodes again, and the cycle repeats. Over time, this produces localized material loss that is far more severe than either mechanism acting alone. The presence of a weld amplifies this effect.

When Weld Geometry Disrupts Flow

From a fabrication perspective, small internal features, minor reinforcement at the root, slight high-low misalignment, subtle

undercut, or irregular penetration are often within acceptable limits. From a flow perspective, these same features can be critical. They disturb the pipe's internal profile, altering the flow regime. What may have been predominantly laminar becomes locally turbulent. Velocity gradients increase, and shear stress at the wall intensifies. In systems carrying solids, particles begin to impact preferentially at these disturbed regions, concentrating mechanical damage.

Even in clean systems, the disruption of flow is enough to continuously strip away protective films. In water or wet gas service, this can lead to flow-accelerated corrosion. In multiphase systems, the situation becomes more complex, with liquid droplets, gas phases, and entrained solids interacting dynamically with the weld surface. The weld, in effect,

becomes a focal point where hydrodynamics and chemistry converge.

Geometry is only part of the story; a welded joint is inherently heterogeneous. The base metal, weld metal, and heat-affected zone (HAZ) differ in microstructure, composition, and often in hardness. These differences translate into variations in electrochemical potential. Under certain conditions, localized galvanic cells can form across the weld region. One area, often the weld metal or a portion of the HAZ, acts as an anode and corrodes preferentially.

Under static conditions, this may result in relatively slow, localized attack. Under flowing conditions, the situation changes dramatically. Corrosion initiates in the more susceptible region, and erosion prevents the corrosion products from accumulating and forming a protective barrier. Instead, they are continuously removed, keeping the surface active and exposed. The result is accelerated, localized wall loss, often manifesting as grooving along the weld line or preferential thinning at the toe or root.

Beyond Code Compliance

What makes corrosion-erosion particularly challenging is that it develops in areas that are not easily assessed during conventional inspection. Traditional methods, including visual testing, radiography, and standard ultrasonics, are designed to detect discontinuities such as cracks, incomplete fusion, or volumetric defects. They are not intended to evaluate how an internal surface profile will interact with fluid flow over time. A weld can be free of rejectable indications and still present a profile that promotes aggressive degradation in service.

This reveals a critical gap, not in the standards themselves, but in how they are applied. Codes such as AWS D1.1/D1.1M:2025, *Structural Welding Code — Steel*, establish essential acceptance criteria for fabrication quality. They are not designed to account for every possible service

condition, particularly those involving complex flow dynamics and corrosion mechanisms. When compliance with code is treated as a complete measure of fitness for service, important variables can be overlooked.

Field observations repeatedly confirm this. Pipelines with fully compliant welds begin to show localized thinning, pitting, or grooving after relatively short periods in operation. In some cases, failure occurs not in the base material but along the weld region itself. The weld did not fail because it was improperly made; it failed because its geometry and metallurgy interacted unfavorably with the service environment.

Addressing corrosion-erosion in welded pipelines requires a broader perspective. Internal weld profile should be considered a functional characteristic, not merely a dimensional one. In systems with high flow velocities, entrained solids, or corrosive media, tighter control of alignment and root geometry may be necessary. In critical applications, postweld internal finishing or design modifications to reduce flow disturbance may be justified.

Equally important is the integration of inspection, corrosion engineering, and flow analysis. Advanced ultrasonic techniques, in-line inspection tools, and targeted monitoring can provide insight into how degradation is developing in service. More importantly, communication between disciplines must improve. Corrosion-erosion is not the responsibility of a single function; it is the result of their interaction.

Conclusion

A weld can satisfy every requirement during inspection and still fail under real operating conditions. Not because the code is inadequate, but because the environment introduces variables that extend beyond its scope. Understanding this distinction is not a matter of interpretation; it is a matter of recognizing that a weld's true performance is defined not only at the moment of acceptance but continuously by the conditions it must endure. **IT**



Internal weld geometry can accelerate corrosion-erosion even when a weld meets inspection requirements.

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INSPECTION INSIGHTS

A summary of selected AWS Weld Wednesday podcast episodes hosted by Jason Becker. Visit weld.ng/podcasts for more episodes.



Built from the Bottom Up

Why welding codes need the experience, judgment, and commitment of industry volunteers

Welding codes and standards may appear to be finished authorities, assembled by institutions and delivered to the industry as definitive books. However, every clause, requirement, revision, and commentary is the result of a continuing process driven largely by volunteers.

These contributors come from fabrication shops, inspection firms, engineering offices, equipment manufacturers, transportation projects, aerospace operations, and many other corners of the welding industry. They bring different technical backgrounds and sometimes conflicting priorities, but they share a responsibility to improve the documents that guide the work.

During a discussion at the latest Inspection Expo and Conference (IEC) in Austin, Tex., host Jason Becker and Bill Komlos, a Senior Certified Welding Inspector (SCWI), AWS Counselor, and AWS Life Member, explored how that process works. Their message was straightforward:

Welding codes cannot be developed effectively in isolation. They must be built from the bottom up by people who understand how requirements perform in the field.

A Responsibility to the Craft

Komlos's path into volunteer leadership began when he started his business in 1999. Seeking stronger connections within Utah's welding community, he became more active in his local AWS Section. His initial motivation was practical. As secretary, he managed a mailing list of hundreds of members and distributed newsletters during the era of printed mailings and postage.

That responsibility introduced him to fabricators, welding supply houses, and other industry professionals across the state. What began as a way to build his business gradually became something larger.

"As you get into it, you find that you've got responsibilities to the craft and to our industry," Komlos said.

He later served as chair. To qualify for a district director position, he needed experience with an activity that had national impact. As a lifelong welding inspector, he found a natural opportunity in a technical committee focused on inspection methods.

That committee represented only one part of a much broader system. Technical activities include the development of welding codes and documents covering inspection, hydrogen studies, stainless steels, postweld heat treatment, metric conversion, heat input calculations, brazing, soldering, and nondestructive examination.

The range of work means volunteers do not need to fit a single professional profile. A person can find an area connected to an existing specialty or enter a subject area that offers room to learn.

Consensus Strengthened by Evidence

The code development process is consensus-based. Participants discuss technical questions, evaluate competing perspectives, and work toward agreement. Consensus enables specialists from different sectors to shape requirements collectively, but it also carries an important limitation: Agreement among experts is not automatically the same as experimental proof.

Komlos recalled a professor comparing consensus development to a group of great artists discussing



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what makes good art. The knowledge in the room may be exceptional, but discussions must still be supported by evidence.

Committees receive data from industries and organizations that perform testing and technical investigations. Volunteers bring that information into the standards process.

The process is demanding, but the results can have lasting value.

"These are lifetime achievements that you're going to make," Komlos said. "If you're making a difference at AWS, you're making a difference in the craft."

The impact also extends beyond the United States. Industries in Asia, Europe, South America, and other regions reference AWS codes and standards. A volunteer participating in their development may, therefore, influence welding practices far beyond a local shop or project.

Entering the Room

Becker initially hesitated to join a code committee because he expected the commitment to require more time than he could provide. His view changed after attending an AWS B1 Committee on Methods of Inspection meeting that was open to the public.

The room included several highly experienced industry figures who agreed, disagreed, and considered how to improve welding practices. Becker recognized immediately that he had entered a place where he could learn.

"If you're the smartest guy in the room, you need to find another room," he recalled being told.

Rather than arriving with an immediate desire to influence decisions, he listened. After the meeting, he asked how he could become involved and, upon returning home, submitted an application.

Committee participation proved more manageable than he had expected. Potential meeting dates were distributed in advance, and members worked collectively to select practical times. Virtual participation also made it possible to attend meetings without traveling.

The environment was welcoming, but Becker did not feel compelled to speak before understanding the committee's history and current work. He approached his first meetings as opportunities to absorb information and determine where his experience could add value.

For younger welders, inspectors, educators, and fabricators, that access can become an important form of professional development. Committee rooms bring emerging professionals into contact with people who know the codes deeply and understand the reasoning behind them.

Komlos emphasized that participation does not require someone to arrive as the most knowledgeable person in the room.

"You don't have to be smart enough," he said. "You just have to be committed to the craft."

The Value of Different Perspectives

Committees work best when they include people from a wide range of technical environments. Bridge professionals, structural fabricators, engineers, inspectors, equipment manufacturers, amusement ride specialists, and others may all interpret the same requirement through different experiences.

No individual can fully understand the demands of every sector. Someone working primarily with structural steel may not be familiar with the concerns surrounding pressure vessels. A designer may not see the problems an inspector encounters while crawling around a completed structure. A specialist in one process may not recognize how another shop must interpret the same language.

This diversity helps keep requirements practical. It can also make technical language more understandable to the people expected to use it.

Komlos offered deposition rate as an example. The term may be clear within engineering calculations and filler metal documentation, but it is less useful as a direct instruction to a welder. Committee participation can help translate the concept into actionable limits, such as amperage or wire feed speed.

The goal is not to dilute technical accuracy. It is to make the requirements usable throughout the industry.

Fresh participants are especially valuable because they may notice weaknesses that longtime contributors have stopped seeing. Experience deserves respect, but it can also create familiarity with assumptions. New voices can ask why a requirement exists, whether it addresses current practice, and how it affects people performing the work.

Codes Must Continue to Change

New materials, equipment, and inspection methods require the standards governing them to evolve. A code written around older technology cannot fully address every development appearing in fabrication and construction.

The 2025 edition of AWS D1.1, *Structural Welding Code — Steel*, provided Komlos with a clear example. He described provisions involving ASTM A913 Grade 65 steel, a high-strength material that does not require the same preheat approach as some conventional steels. Its incorporation into the code followed the material's development and formal ASTM designation.

The change has practical consequences. Reduced preheating can save substantial production time, particularly when shops are working with thick material. Yet the benefit can only be realized when designers, fabricators, inspectors, and welders understand the applicable requirements.

Code revisions may also force companies to update established procedures. Komlos noted that he had to revise his prequalified welding procedures after changes appeared in the 2025 edition. Whether an individual prefers a change is secondary to understanding the current requirement and performing the work accordingly.

This is one reason committee participation can be valuable. Volunteers gain insight into developing issues and hear perspectives they might not encounter within their own workplaces.

Key Takeaways

- Welding codes and standards are not created in isolation. They are developed through the ongoing work of industry volunteers representing fabrication, inspection, engineering, manufacturing, and education.
- Effective code development depends on real-world experience. Requirements are strengthened when professionals bring field knowledge, testing data, and practical lessons to committee discussions.
- Consensus is essential, but evidence matters. Committees evaluate technical data and industry research to ensure revisions are supported by more than opinion.
- Diverse perspectives help keep codes practical, understandable, and applicable across different welding sectors and environments.
- New participants play a critical role by challenging assumptions, asking important questions, and contributing fresh perspectives.
- Codes must evolve alongside new materials, technologies, and manufacturing practices to remain relevant and effective.
- Volunteer service offers significant professional benefits, including technical growth, leadership development, networking opportunities, and a deeper understanding of the reasoning behind requirements.
- The industry's greatest need is not expertise alone but committed professionals willing to learn, participate, and contribute to the craft.

Judgment Grounded in Real Work

Field experience gives codes much of their practical strength. Komlos described investigations in which an apparent welding problem originated outside the weld itself.

At an Air Force facility, welders were having difficulty passing specialized tests. Examination of the work revealed issues involving low-amperage equipment performance and incorrect amperage information in a procedure. An aluminum porosity problem was also connected to a large evaporative cooling system that introduced high humidity into the welding area.

The lesson was broader than any single defect. Technical problems require investigators to look beyond the most obvious explanation. Equipment, environment, procedures, materials, scheduling, and manufacturing steps can influence results.

In another manufacturing example, welded components were placed in front of cooling fans immediately after welding. Komlos's test pieces performed differently because he allowed them to cool naturally before placing them near the fan. The difference showed how a manufacturing step outside the defined welding operation could affect performance.

Experiences like these can lead to code revisions, commentary,

cautions, or simply better committee questions. They reinforce the need for critical thinking rather than automatic acceptance of established assumptions.

Responsible Use of Emerging Technology

Artificial intelligence (AI) adds another emerging consideration. Committee members must protect copyrighted, proprietary, and unreleased information. Becker explained that participants agree not to upload committee materials, preliminary documents, or standards to public AI systems.

The discussion also highlighted the potential of closed systems developed around authorized information and customer knowledge. Such tools may help preserve the experience of inspectors and engineers without exposing protected codes or proprietary data.

In life-safety work, however, experimentation must be approached carefully. Incorrect guidance can have serious consequences. Any system used for technical decision-making must recognize its limits, protect the information it contains, and remain grounded in qualified experience.

The objective is not to label AI entirely good or bad. It is to determine where the technology can provide value while maintaining accountability.

An Invitation to Contribute

Volunteer committee work benefits both the industry and the individual. Participation strengthens technical knowledge, professional confidence, leadership skills, and connections across the welding community.

Contributors may go on to chair subcommittees, earn recommendations from respected professionals, or see their names included in published standards. More importantly, they develop a deeper understanding of why requirements exist. Code language explains what must be done; committee discussions, supporting commentary, and members' experiences explain why. That insight helps professionals apply requirements more effectively and avoid mistakes others have encountered elsewhere.

The industry also needs welders, inspectors, fabricators, educators, business owners, and technical specialists who are willing to listen, study, question, and contribute. Codes are strongest when they reflect the full range of people they serve, combining the knowledge of experienced leaders with the fresh perspectives of newcomers. The essential qualification is not status but commitment to the craft. 



Q I passed my Certified Welding Inspector exam recently, but I'm having a difficult time understanding exactly how alloying elements interact with iron and how they influence the properties of metal. Can you provide an overview of the basics of alloying steels?

A The last installment of this article (see the August 2026 *The Answer Is* column) addressed some basic concepts of alloying. We will continue our discussion of steels because ferrous metals represent a significant segment of the metals used by industry.

Part Two

In the first installment, we devoted most of our discussion to how carbon influences the properties of steel. This installment will consider the influence of other alloying elements on steel properties.

Carbon is considered by many people to be the most influential alloying element added to iron in terms of its ability to increase hardness and strength. Other alloying elements act like carbon, but not to the same extent. In terms of hardening, the hierarchy from most influential to least influential is $C > Mo > Cr > Mn > Si > Cu > Ni$. The list doesn't include boron because its solubility in iron is so limited.

Alloying elements can also affect other properties such as corrosion resistance, low-temperature toughness, and hardenability. The metallurgist can enhance specific properties of steel with the judicious addition of specific alloying elements. The amount of an alloying element that can be added to iron is not unlimited. Many alloying elements have solubility limits; any excess may be rejected or result in unacceptable conditions, such as segregation or possible cracking. This is the case

with aluminum. Aluminum added in small amounts to iron is an effective deoxidizer that helps prevent porosity in the steel and, in the case of filler metals such as flux-cored electrodes, serves a similar purpose. Porosity, if left unchecked, can result in laminations in rolled steel shapes and plate. Aluminum has a higher affinity for oxygen, so it combines with oxygen to form aluminum oxide inclusions. Those inclusions act as nuclei during solidification and serve to reduce grain size. However, too much aluminum can result in a loss of low-temperature toughness in the steel or weld. Low-temperature toughness is an important property for a structure such as a bridge in northern latitudes. Another alloying addition is boron, which has a very strong influence on the hardness and strength of steel, but due to its very limited solubility in iron, only about 20 to 30 parts per million can be added. When an alloying element is added to iron in very small quantities, the alloy steel is categorized as microalloyed steel. Then there is nickel, which is fully soluble in iron. We can add as little as 1% nickel or as much as 99% and still form a viable solution with iron.

Alloying constituents can form solid solutions with iron, or they can form chemical compounds. Alloy additions and their solubility are strongly influenced by temperature. Larger amounts of an alloy will dissolve in iron when the temperature is high, but the solubility of the alloying element is reduced as the temperature reduces.

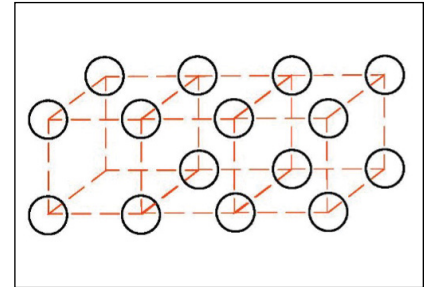


Fig. 1 — Unalloyed iron has a body-centered cubic structure. The atoms along the edges of the lattice are aligned.

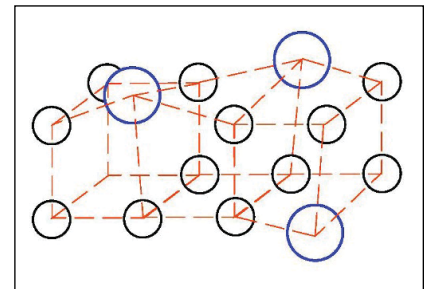


Fig. 2 — The alignment of the lattice is distorted when the alloying constituent has roughly the same atomic number and atomic radius as iron. A substitutional solid solution is formed.

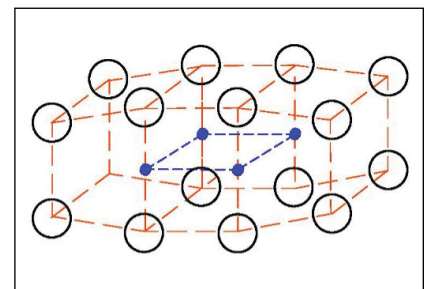


Fig. 3 — When the alloying constituent has a smaller atomic number and a smaller atomic radius than iron, an interstitial solid solution is likely to form. The atoms of the alloying constituent will “squeeze” in between the atoms of the base metal lattice. In doing so, the lattice is distorted and strengthened.

Table 2 — Properties of Typical Alloying Elements

Element	Atomic Number	Atomic Radii	Crystalline Structure	Temperature Range
Fe	26	126 pm*	BCC	→ 1674°F
			FCC	> 1674°F → 2541°F
			BCC	> 2541°F → (MP) 2800°F
V	23	134 pm	BCC	→ (MP) 3452°F
Cr	24	139 pm	BCC	→ (MP) 3407°F
Mn	25	127 pm	α BCC	→ 1290°F
			β BCC	> 1290°F → 2010°F
			γ FCC	> 2010°F → 2070°F
			δ BCC	> 2070°F
Ni	28	135 pm	FCC	→ (MP) 2647°F
Cu	29	128 pm	FCC	→ (MP) 1984°F
Mo	42	139 pm	BCC	→ (MP) 4753°F
Pb	82	175/180 pm	FCC	→ (MP) 621°F
B	5	84 pm	Complex	→ (MP) 3992°F
C	6	67 pm		Nonmetal
N	7	75 pm		Nonmetal
Al	13	143 pm	FCC	→ (MP) 1220°F
Si	14	111 pm	FCC	→ (MP) 2577°F
P	15	106 pm	Nonmetal	
S	16	100/105 pm	Nonmetal (MP) 235°F	

*pm = pico meter and 1 mm = 1 mm × 10⁹ pm

Metals are unique compared with other materials that form solutions such as sugar dissolved in water or oil mixed with gasoline. Metals can dissolve into each other; that is, one metal can dissolve into another metal. Figure 1 shows a pure metal with a basic cubic structure, either face-centered cubic (FCC) or body-centered cubic (BCC). The solid solutions may form either a substitutional solid solution or an interstitial solid solution, as illustrated in Figs. 2 and 3. In general, if the alloying constituent has nearly the same atomic number and nearly the same atomic radius as iron, it will most likely form a substitutional solid solution. If both

iron and the alloying constituent have the same crystalline structure, the probability of forming a substitutional solid solution is enhanced. In a substitutional solid solution, an alloying atom simply replaces an atom of the base metal in the crystalline lattice. On the other hand, if the alloying constituent has a much lower atomic number and a much smaller atomic radius, an interstitial solid solution will most likely form. In an interstitial solid solution, the “smaller” atom of the alloying constituent squeezes in between the atoms of the base metal, and in doing so, the lattice is distorted by a slight elongation. Whenever the lattice is distorted,

whether by forming a substitutional solid solution or an interstitial solid solution, the hardness and strength of the alloy increase. If the solubility limit is exceeded, the excess alloying element can form a chemical compound. Fe₃C (cementite) is an example. The excess alloying element can also be rejected to the grain boundary, as in the case of solute rejection experienced by a low-melting-point constituent (LMPC), e.g., sulfur. The LMPC is still in the liquid state while the iron solidifies at a much higher temperature. The LMPC, still in the liquid state, is rejected to the grain boundaries by a mechanism called solute rejection. Solidification

cracking often results from solute rejection. We experience solidification cracking when attempting to weld free-machining steels due to solute rejection.

Table 2 tabulates information that is helpful in predicting whether a substitutional solid solution will form or an interstitial solid solution will form. What the table doesn't include is the solubility limit of the elements listed because solubility is dependent on temperature.

Some metals are allotropic; that is, the crystalline structure within the lattice is dependent on temperature. The crystalline structures and the temperatures at which allotropic transformations occur are included in Table 2. Iron is well known for being allotropic. It can be FCC at high temperatures or BCC at low temperatures. Nickel is not allotropic; it is FCC at both high and low temperatures. The solubility of alloying elements, e.g., the solute, is influenced by the crystalline structure of the solvent and the temperature. Carbon, the solute, is more soluble in iron, the solvent, at high temperatures, i.e., in FCC austenite, while the solubility of carbon drops as the crystalline structure undergoes an allotropic transformation and becomes BCC ferrite.

The metals vanadium, chromium, manganese, and nickel listed in Table 2 have nearly the same atomic number and similar atomic radii as iron, so they will form substitutional solid solutions when added to iron. Copper will also form a substitutional solid solution, but it is an LMPC with very limited solubility when the iron is BCC. As the solidified iron cools and undergoes an allotropic transformation from FCC to BCC, the solubility of copper is reduced, and it is rejected by BCC ferrite. Once the temperature has cooled below the solidus temperature of copper, cracks in the copper or along the edges of the solidified copper may appear. This type of crack is categorized as a solidification crack.

Let's look at the effects of several metals that are alloyed with iron.

Vanadium will form a substitutional solid solution with iron. It increases the hardenability of steel, i.e., the

depth of high hardness increases when the steel is quenched from austenitizing temperatures. However, steels containing vanadium do not respond favorably to thermal stress relief because of vanadium's strong tendency to form carbides.

Chromium will form a substitutional solid solution when added to iron and will increase both strength and hardness. Depending on the percentage of chromium added to the steel, it may be categorized as low-alloy steel, high-alloy steel, or stainless steel. The more chromium in the steel, the higher the resistance to atmospheric corrosion. In stainless steel, chromium is a ferrite (BCC) former, which is more resistant to solidification cracking when welding austenitic stainless steel. When the chromium content is in excess of 11%, it is categorized as stainless steel. Ferritic stainless steel is iron alloyed with chromium and small amounts of carbon. Martensitic stainless steel is iron alloyed with chromium and sufficient carbon so that it responds to quenching. Austenitic stainless steel is iron alloyed with chromium, nickel, and a little carbon. It is called austenitic stainless steel because the crystalline structure at room temperature is primarily FCC. There must be a correct balance between the ferrite formers and austenite formers when welding dissimilar metals and stainless steels. The WRC diagram is a tool that can be used to predict whether the combination of ferrite formers and austenite formers provides sufficient ferrite to prevent solidification cracking.

Manganese is allotropic and serves several purposes when added to steel. Initially, it serves as a deoxidizer and prevents the formation of CO, which is a root cause of porosity in raw steel and welds. If there is sufficient manganese present, it combines with sulfur to form solid, "spherical" manganese sulfide inclusions that reduce solute rejection and help prevent solidification cracking. If more manganese is present, it will replace some of the iron atoms in the atomic lattice by forming a substitutional solid solution, thereby distorting the atomic lattice. That

distortion increases the hardness and strength of the steel.

Nickel will form a substitutional solid solution when added to iron. It is fully soluble in iron, so it can be added to iron in any proportion. Nickel, in small percentages, will improve low-temperature toughness. It has a small hardening effect on steel when compared to carbon, molybdenum, chromium, vanadium, or silicon. In stainless steel, nickel is an austenite former. Austenitic stainless steel is an alloy of iron, chromium, and nickel. The amount of nickel must be sufficient to retain the austenitic microstructure once solidification is complete and the BCC structure undergoes a transformation to FCC. When the stainless steel contains at least 20% nickel, it is categorized as a subcategory of austenitic stainless steel: super-austenitic stainless steel. The chromium content of super-austenitic stainless steel is typically between 19 and 25%, with about 6% molybdenum added to improve high-temperature performance and pitting resistance. It is more resistant to pitting and crevice corrosion than austenitic stainless steel when exposed to chloride-rich and acidic environments. Generally, nickel does not reduce the ease of welding, i.e., the weldability remains "good."

Copper has very low solubility in solidified iron. It is used in small quantities in weathering steels. When exposed to atmospheric conditions, the weathering steel forms a patina when it corrodes. Once the patina attains a certain thickness, it inhibits further corrosion. Exposure to sodium chloride negates the protection provided by the patina. The patina protects the underlying steel from further corrosion under normal atmospheric conditions. Recently, steelmakers have reduced the amount of copper in weathering steels to reduce the weld cracking problems associated with copper.

Molybdenum is a large atom compared to iron. It is more effective as a hardening agent than chromium and improves high-temperature creep properties. It does little to diminish the weldability of steel. It is used in austenitic stainless steel to improve resistance to pitting corrosion when

subjected to sulfuric acid. In limited amounts, molybdenum forms a substitutional solid solution with iron.

Lead used to be added to steel to make it “free-machining.” Due to its toxicity, lead has largely been replaced by less toxic sulfur or selenium. Lead, sulfur, and selenium are all categorized as LMPCs. All have low solubility in iron, and each of them can undergo solute rejection and suffer solidification cracking when welded.

Boron is very effective as a hardening agent. It is more effective than carbon, but it has very low solubility in iron. The amount that can be added to iron is typically between 20 and 30 ppm. In terms of percentage, this is on the order of 0.002 to 0.003%. Steels containing boron are typically called microalloyed steels. Boron is used to control grain size, and it reduces the need for chromium, manganese, nickel, and molybdenum, thus reducing the cost of the steel.

Carbon is an alloying element we’ve already discussed, so there’s no need to address it again.

Nitrogen isn’t a typical alloying addition to carbon steels, but it is an austenite former in stainless steel, and it is used in certain aluminum alloys. It will form an interstitial solid solution.

Aluminum is used as a deoxidizer in steel. It prevents the formation of carbon monoxide by combining with oxygen to form aluminum oxide. Aluminum oxide is a grain refiner, but too much aluminum oxide results in poor low-temperature toughness.

Silicon is also an effective deoxidizer due to its high affinity for oxygen. Silicon in excess of that needed for deoxidation will act as a strengthening agent.

Table 2 provides helpful information for determining if an alloying element will likely form a substitutional solid solution or an interstitial solid solution. The table also includes the solidus temperature, which is helpful for determining if the alloy can potentially contribute to solute rejection and result in solidification cracking during welding.

If all this sounds complicated, don’t fret. It is not unusual for the newly minted CWI to be a bit frazzled by the subject of metallurgy. You are just starting your career as an inspector, so reach out to more seasoned people who have more experience when you encounter something new. No one is born knowing everything. We all learn as we pursue our careers as inspectors. Metallurgy is just one of the subjects you will learn about. The more you learn about

metallurgy, the less overwhelming it will become. That’s why our work as CWIs can be so interesting. By the time we are comfortable with all that we’ve learned, it is time to hang up our spurs and live a life of comfort and ease. But the more you learn, the more in demand your experience and knowledge become. If you do retire, it is only because you want to. Good luck with your new lifetime of learning.

I hope this article is helpful in your quest for more information and a better understanding of metallurgy. **IT**

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