INSPECTION TRENDS

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NDE School Profiles

Weld Joint Design and Process Practice Improvements

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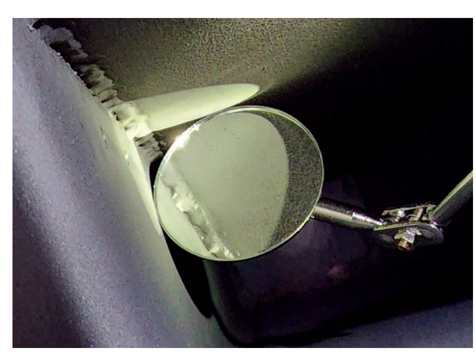
COVER PHOTO:
Sidewall incomplete fusion on the root side of a CJP, cover plate, single-bevel corner joint weld along the beam flange as the result of utilizing rectangular, ceramic weld backing and poor process practices. Credit: William C. LaPlante.



Patience Is an Essential Variable

BY JAMIE HUNTER

There are many different career avenues a welder or welding inspector can take: aerospace, food, sanitation, water treatment, oil and gas, automotive, bridges, skyscrapers . . . the list is endless. However, no matter which path an individual chooses, I have found there is one trait that should not be ignored: patience.

There will always be those who cannot wait to be recognized as competent: the welder with the ink still wet on their pressure ticket or the inspector who just got their certification. I've never seen the point in rushing to get crow's feet around your eyes and gray hairs, which seem to be the industry standard for gaining competence and experience.

As a welding apprentice, I was embarrassed to admit to my first journeyman that I didn't know what I was doing. He took it as blessing and taught me the patience I needed to hone my welding skills. He was a great mentor, seeing me as an open book waiting for the pages to be written. He taught me not only about welding but also invaluable life lessons.

In my first quality-control (QC) job, I was supplied with a banker's box filled with unorganized material test reports (MTRs). I was overwhelmed and in way over my head. I reached out for advice to the gentleman who got me started inspecting. He simply said, "If you don't feel like you're in over your head for at least the first three years, then you're not learning enough." So I dumped out the box of MTRs and got to work organizing things.

I was QC at an oil sands extraction plant where an imposing and angry superintendent unloaded his stress on me verbally. He was sure that I had caused delays, but he had been fed inaccurate information. Somehow, I stayed calm. I explained the truth of the situation without matching his elevated temper. It was like watching a full balloon slowly deflate. Mutual respect was achieved. Patience, again, for the win.

Recently, I was an owner's inspector on an upgrader turnaround. One of the contractor QC personnel was disorganized and bereft of relevant knowledge. After this individual left our field office, one of the other people in the office commented, "I would have yelled at him by now. Why weren't you harder on him?" I explained how I required this person to maintain communication with me. I did not need him to be hesitant to speak with me or feel like I was acting superior. Basically, you catch more flies with honey than vinegar. Patience, again, made sure that this individual was comfortable working with me and supplying the information how I required it for successful system turnover.

Patience isn't something we're all born with. It is a skill that is learned over the years. Whether you're dealing with a heavy workload, learning new subjects or skills, or speaking with coworkers, it all comes down to patience. Without patience, you can be prone to making snap decisions without knowing all the facts. Without patience, you will push away the very people who are your most valuable resources. Without patience, you could miss that part in the code that would've stopped you from making a terrible call. Patience is very much an essential variable. IT

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ASME BPVC Meetings Held at AWS Headquarters

During the week of February 6, hybrid ASME *Boiler and Pressure Vessel Code* (BPVC) Section VIII and Section IX Subgroup and Committee meetings were held at AWS Headquarters in Doral, Fla. Longstanding AWS instructor and volunteer Lynn Sturgill, who also serves as an officer and member of numerous ASME committees, was inducted as an ASME Fellow during the ASME Section IX Committee meeting.

Lynn Sturgill (left) was presented the ASME Fellow induction certificate by John Swezy, ASME Fellow, during the ASME Section IX Committee meeting.

Acquisition of NDT Classroom Bolsters ASNT's Training Portfolio

The American Society for Nondestructive Testing (ASNT), Columbus, Ohio, a technical society for nondestructive examination (NDE) professionals, has acquired NDT Classroom, a provider of online NDE training programs. This acquisition will increase the learning opportunities for NDE professionals through an extensive library of curated and convenient online training courses.

Founded in 2012 by NDE professionals Chuck Hellier and Jim Treat, NDT Classroom delivers engaging and interactive video-based training designed to meet the NDE industry's professional development needs from the seasoned practitioner to the newcomer.

"Learning opportunities are the number one reason NDT professionals look to ASNT," said Neal J. Couture, certified association executive, ASNT executive director. "The acquisition of NDT Classroom allows ASNT to continue to fulfill its purpose and deliver immediate, accessible, and relevant NDT training solutions."

Hellier and Treat plan to continue providing support to ASNT through the transition period to assure the continuation of quality service for NDT Classroom's current clients and ASNT's members.

Elliott Services Opens Louisiana Onshore and Offshore Service Center

Elliott Services Inc. (ESI), Humble, Tex., an inspection company specializing in quality assurance and quality control for the energy, chemical, and refining industries, has opened a Louisiana service center.

"We are happy to announce the opening of our Louisiana site for the regional delivery of inspection, NDE, and NDT services for both onshore and offshore," said the spokesperson for Elliott Services Inc. "Our new facility in Broussard will provide ESI the capability to deliver our inspection services on customer assets in our yard for eventual delivery to the installation sites."

ESI provides all nondestructive examination services, including API 510, 570, 653 internal and external inspections; magnetic particle testing, penetrant testing, and ultrasonic thickness testing utilizing Level II and III technicians; advanced ultrasonics (phased array ultrasonic testing and ultrasonic shear wave testing); and more.

Baron NDT Expands to Gulf Coast Region with New Office in Beaumont

Baron NDT, Jacksonville, Fla., a provider of nondestructive examination (NDE) services, has opened an office in Beaumont, Tex. The company, which has a focus on advanced ultrasonics, will be able to support the industrial NDE needs of Southeast Texas and South Louisiana with its expanded presence on the Gulf Coast.

"We are thrilled to bring our expertise and experience to the Gulf Coast region," said Garrett Thompson, manager of the Beaumont office. "We are committed to providing top-quality NDT services to our clients and supporting the growth and success of the region." IT

Baron NDT's new office in Beaumont, Tex., will allow the company to support the industrial NDE needs of Southeast Texas and South Louisiana as well as the rest of the Gulf Coast region.

EDDY CURRENT FOCUS

Eddy Current Flaw Detector Adds RFA Technology

The Ectane® 3 eddy current flaw detector for nondestructive examination of surfaces and tubing utilizes remote field array technology for advanced carbon steel heat exchanger inspections. Offering a 5 to 10 MHz frequency range, eight channel inputs, and up to 32 time slots, the instrument can tackle a broad spectrum of applications. Modular by design, the 11 models of the flaw detector can be upgraded and retrofitted to meet the user's inspection needs. The unit is available in three different array configurations: 64, 128, or 256 elements with support for ten technologies, including remote-field array, eddy current testing, eddy current array (ECA), and more. The IP65-certified device can be used for semiautomatic inspections involving ECA probes manipulated by a robotic arm or crawler.

Eddyfi Technologies

eddyfi.com

Portable System Enables Bolt Hole Inspections of Complex Layers

The EV[i] eddy current testing/eddy current array (ECA) system performs nondestructive detection of cracks and indications in conductive materials to facilitate bolt hole inspections of complex layers. Capable of storing instrument setups, reports, screen shots, and data files for later recall, the system works directly with the EddyView family of probes and accessories as well as ECA probes up to 64 elements (128 elements with external multiplexer). Key to the instrument's performance is the display of a visual image of the surface area under inspection alongside the customary and selectable eddy current signal displays (impedance plane, A-scan, or strip charts). The system provides a high-precision, easily readable display of surface conditions to enable improved interpretation of data while giving more accurate discernment of cracks, pits, gouges, and fretting. The portable package measures 13.8 × 8.75 × 2.58 in.; weighs slightly more than 9 lb with batteries; and provides numerous inputs and outputs, such as multiple encoder connections, Ethernet, USB 1 and 2, and more.

UniWest

uniwest.com

Compact Instrument Produces Signals in All Lighting Conditions

The Nortec® 600 eddy current flaw detector generates highly visible and contrasting eddy current signals in any lighting conditions on a 5.7-in. video graphics adapter screen. The compact unit is designed for endurance in harsh field conditions and features a full-screen mode that can be activated at the touch of a key. The redesigned interface borrows the intuitive, knob-operated navigation of its predecessors combined with a simple menu structure and direct-access keys. Available in four models, the flaw detector offers a wide range of functionalities, including an application selection menu, an all-in-one display, real-time readings, and signal calibration in freeze mode, to ensure quick and easy inspections for any level of operator. Its other features include battery life of up to ten hours, on-board file preview, and storage capacity of up to 500 files. The flaw detector weighs 3.5 lb (1.6 kg) and comes with a factory-installed hand strap that provides direct thumb access to the key controls for increased handheld versatility.

Evident

olympus-ims.com

BY ROLINE PASCAL

Reporting for Duty: A Marine Corps Welder Finds a New Career in the Classroom

Blaine C. Lowry

Blaine C. Lowry had never showed an interest in welding. But he knew from a very young age that he wanted to join the military. He had several relatives who'd served, and they would recount their experiences to him. In fact, his grandfather, an Air Force flight navigator during the Cold War, was primarily responsible for his decision to join the armed forces. After speaking to several recruiters from various service branches, Lowry opted for the U.S. Marine Corps. It wasn't until he joined the Marines that his passion for welding emerged.

In 2006, Lowry signed his enlistment contract. At the time he joined, he was required to choose a military occupational specialty (MOS), and he chose Engineer, Construction, Facilities & Equipment and Ground Ordnance Maintenance, which included ordnance tech, small arms repair, engineer mechanic, and metal worker. He hoped to receive small arms repair as he had been shooting since a very young age, and firearms were one of his hobbies. Due to the Marines' MOS quotas, he was given metal worker (welder).

He attended welding school at Aberdeen Proving Ground in Maryland. However, welding was not something that came easily for Lowry. He struggled through school. But he wanted to make the best of it, so he stuck with it and completed the program. After, he was stationed at Marine Corps Base Camp Lejeune in North Carolina and was assigned to Bridge Co.'s 8th Engineer Support Battalion. Lowry was one of two welders assigned to maintenance. It was at the maintenance shop where he learned to love welding.

Every day was a new experience, and he began to perfect his craft. In 2012, he was released from active duty.

After his service, Lowry worked a couple of welding jobs. He was a welder/fabricator at Carpenter Welding, Beavercreek, Ohio, for about six months then joined the Army Corps of Engineers for a short period as a deck hand/welder on a barge. At Endolite, Miamisburg, Ohio, he worked as a machinist and worked part time in the deburring department. He was also attending Sinclair Community College, Dayton, Ohio, at the same time and obtained a certificate in CNC machining. He enrolled at Hobart Institute of Welding Technology (HIWT), Troy, Ohio, in 2012 and graduated with high honors the following year. At the end of 2014, he joined the school as a skills instructor.

Lowry held several positions at the institute, including second shift supervisor and skills supervisor. Most recently, his primary focus has been curriculum development. In 2018, he became an AWS Certified Welding Inspector (CWI).

1. Why did you decide to become an AWS CWI?

When I hired on [to HIWT], the career path for a skill instructor was to cross-train in all skill classes, and then you could put in to take the CWI test. It was a natural career progression.

2. What inspection processes do you use at HIWT? What welding/inspection processes do you teach at HIWT?

Visual testing is the only nondestructive inspection process I utilize on a regular basis. We also use leak testing

and penetrant testing for specific classes. Other nondestructive examination methods are carried out by other employees. For destructive — bend test, nick break, peel, etc. — I have conducted tensile pulls when needed. We teach all of the commonly used inspection methods.

3. How has being an AWS CWI been beneficial to your professional career?

Being a CWI gives me more opportunities to look at welding through a different set of lenses. The more information I can gather, the more I can relay to our students and improve their education while at the school. I can also ensure that they are held to a nationally recognized standard.

4. What words of encouragement do you have for individuals thinking about becoming an AWS CWI?

I always tell my students if there is an opportunity to advance your career and better yourself, you should take it. Even if you do not use the knowledge on a regular basis, there is always something to be gained by learning something new. If anything, it can put you ahead of your peers and make you stand out as an employee. IT

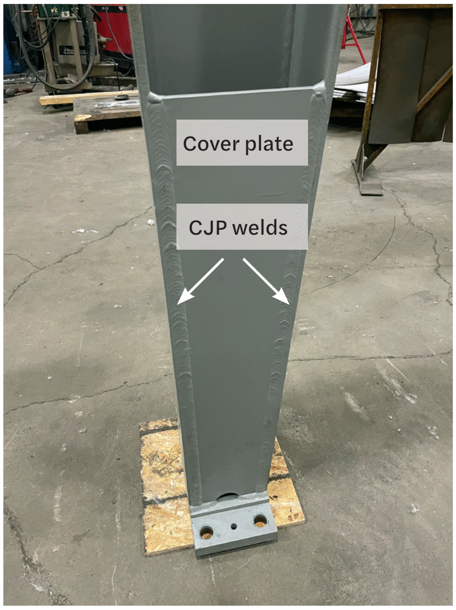
BY WILLIAM C. LAPLANTE

The Importance of WELD JOINT DESIGN AND PROCESS PRACTICE IMPROVEMENTS

Continuous improvement initiatives were implemented to resolve chronic weld and weldment quality problems

Continuous improvement initiatives make a difference in driving the changes necessary to improve status quo processes and practices while increasing quality, enhancing production efficiency, and lowering costs. Figure 1 illustrates a vertical support beam consisting of a stiffening cover plate manually welded between two beam flanges that required nondestructive examination (NDE), which included visual testing (VT), magnetic particle testing (MT), and ultrasonic testing (UT). These processes are hereafter referred to as *NDE*. Based on previous weld joint design and process practices, achieving NDE-acceptable welds with 100% root weld penetration and beam flange sidewall fusion proved challenging.

Also, in the rewelding of the cutoff beam flange to the tapered beam web, it was difficult to achieve weld joint offset within the maximum permissible limits as specified within Naval Sea Systems Command (NAVSEA), MIL-STD-2035A (SH), *Nondestructive Testing Acceptance Criteria*.



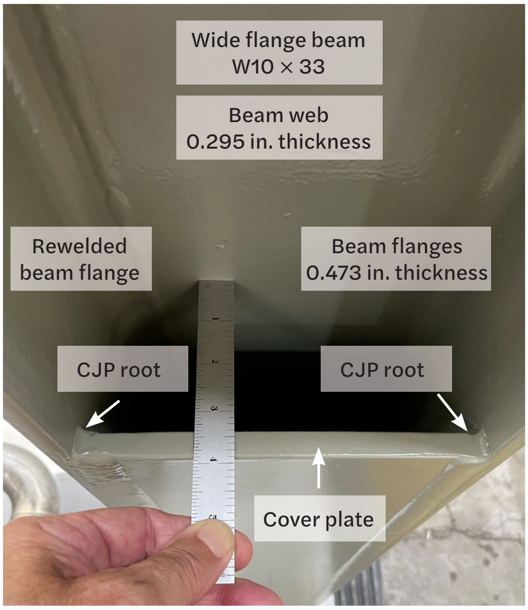


Fig. 1 — One of four vertical support beams employed in a marine gas turbine power-generation module.

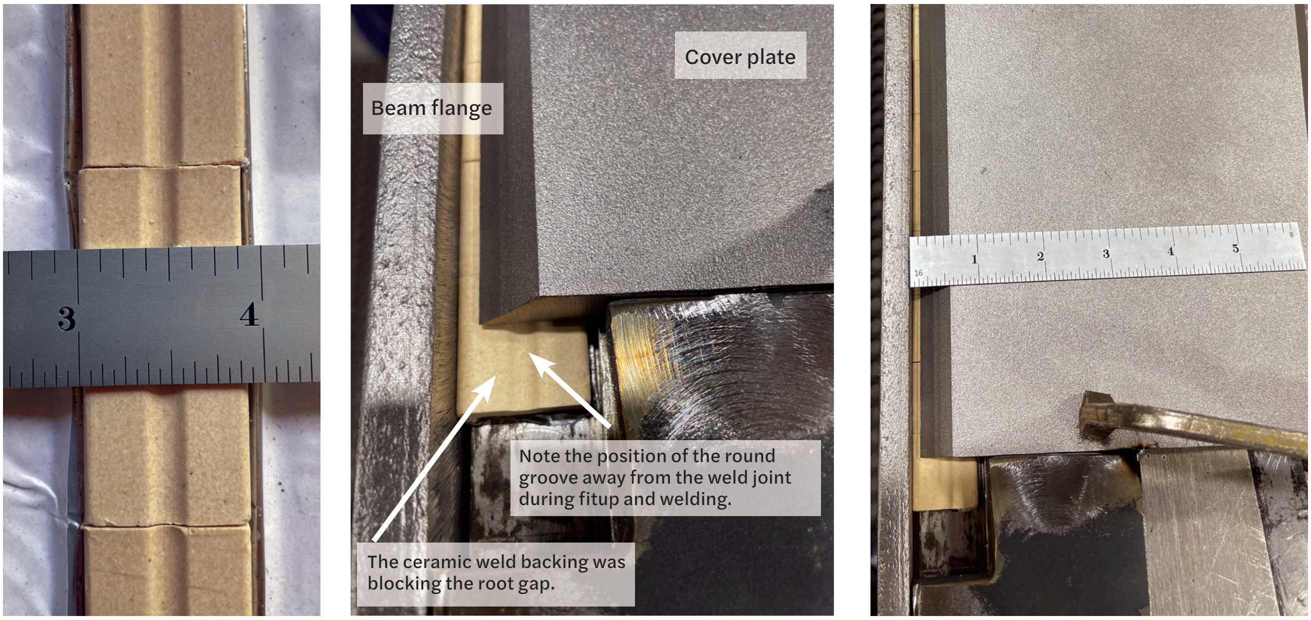


Fig. 2 — For previous CJP cover plate to beam flange welding, a temporary, rectangular, ceramic weld backing was used in the single-bevel corner joint design, which proved detrimental in achieving complete weld joint penetration and sidewall fusion. (See also Fig. 3.)

The process used for welding was manual pulsed gas metal arc welding (GMAW-P) spray transfer mode. Fabrication documents encompassed the client's project weld specification, with NDE acceptance criteria in accordance with MIL-STD-2035A (SH). These included MIL-STD-22D, *Department of Defense Design Criteria: Welded Joint Design*; and NAVSEA S9074-AR-GIB-010/278, *Requirements for Fabrication Welding and Inspection, and Casting Inspection and Repair for Machinery, Piping, and Pressure Vessels*.

WELDMENT BACKGROUND

As specified by ASTM International A36, *Standard Specification for Carbon Structural Steel*, vertical support beams are used for marine gas turbine power-generation modules. Weld joint members were comprised of the vertical support beam, which was a modified, commercial wide flange beam (W10 × 33) in accordance with ASTM A6, *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*. One beam flange was removed so the web width of the beam could be cut at a taper, and the flange was then rewelded back onto the web. Additionally, an A36, 0.500 in. thick × 29 in. long, tapered cover plate was fit up and welded between the beam flanges. The cover plate served as a structural stiffener plate.

The cover plate weld joint geometry was a complete joint penetration (CJP), single-bevel (45 deg) corner joint with a 0.0 in. root face. Seawater has the potential to enter the backside of the weld joint — Fig. 1. Consequently, a permanent weld backing could not be employed because seawater could get underneath the backing, resulting in corrosion of the root side of the weld.

Previous welding engineers employed a temporary, rectangular, ceramic weld backing that was removed after welding — Fig. 2. However, this proved to be detrimental in attaining acceptable NDE quality welds. As Fig. 1 illustrates, there is a nominal 3.375 in. between the beam web and the backside of the cover plate. The preceding welding engineers did not consider how root penetration would be achieved with the rectangular weld backing effectively blocking the root gap nor how root-pass and sidewall fusion would be attained (i.e., the depth of fusion into the beam flange).

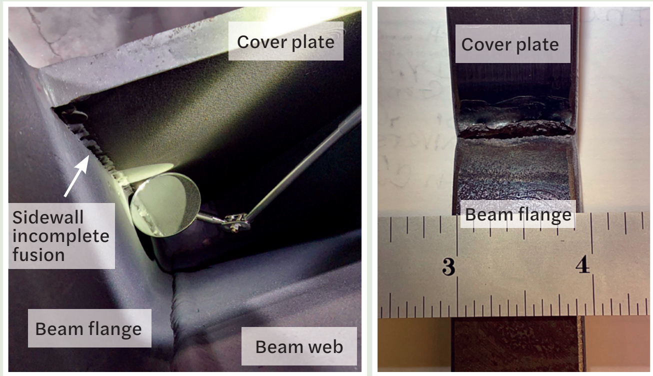


Fig. 3 — Left — Sidewall incomplete fusion on the root side of the CJP, cover plate, single-bevel corner joint weld along the beam flange as the result of utilizing rectangular, ceramic weld backing and poor process practices. Right — Weld joint fracture during a root weld bend test.

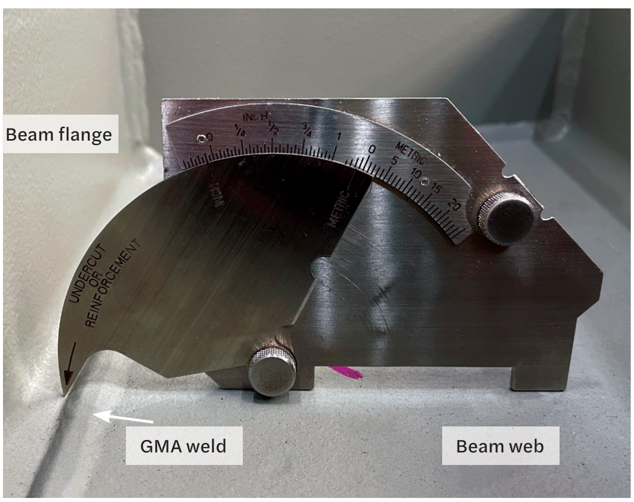


Fig. 4 — Top — Weld joint fitup of the beam flange and the beam web after tapering for GMAW rewelding utilizing old tooling. Poor tooling and personnel training resulted in a high degree of weld joint mismatch prior to welding. Bottom — Measuring weld joint offset between the beam web and the rewelded beam flange using a bridge cam gauge.

PROCESS PRACTICE IMPROVEMENTS

In analyzing weld joint inspection failures, the two major weld discontinuities and defects were as follows: 1) achieving 100% root weld penetration and beam flange sidewall fusion during cover plate welding, and 2) achieving beam web and rewelded beam flange offset within the maximum permissible limits. The following process improvement initiatives were implemented:

1. Utilizing rectangular, ceramic weld backing needed to be corrected. The rectangular geometry did not facilitate achieving NDE-quality corner joint welds with 100% root weld penetration and sidewall fusion. Thus, the rectangular, ceramic weld backing was replaced with a ceramic cylindrical backing at 0.375 in. diameter to facilitate the formation of a root penetration fillet contour and sidewall fusion — Fig. 5. The diameter of the ceramic cylindrical backing controls the amount of root sidewall fusion and the formation of a root penetration fillet contour (i.e., concave/miter). That is, as the cylindrical radius increases, the root penetration fillet contour increases and vice versa. Destructive weld tests of corner joint mockups and NDE provided engineering evidence that root side penetration and sidewall fusion could be attained consistently by employing ceramic cylindrical weld backing — Fig. 6.
2. Employing the previous root gap of 0.125 in. was insufficient where a new, expanded root gap of 0.190 in. was established. The expanded root gap increased the root penetration weld pool flow and the depth of fusion into the beam flange.
3. Grinding the weld joint to a bright, shiny metal finish to remove mill scale prior to welding was introduced. Mill scale inhibits weld pool fusion (i.e., washing) characteristics.
4. Increasing weld metal soundness via the use of killed steels (a completely deoxidized steel) as opposed to the continued use of semikilled steels (a partially deoxidized steel). Weld metal porosity was observed during welding and NDE inspections. Also, because the manual GMAW-P spray process was used, an ER70S-6 at 0.035-in.-diameter weld filler metal was specified with a 95% Ar/5% CO_2 shielding gas. The chemical composition of the ER70S-6 welding wire includes higher levels of silicon (Si) and manganese (Mn) as opposed to ER70S-2, which serves as effective weld metal deoxidizers.
5. Welding was also performed slightly uphill at 15 deg in the 1G position within a fixture. Uphill welding increases penetration and weld pool fusion characteristics.
6. Mitigating beam web and rewelded beam flange weld joint mismatch/offset by employing tooling

to adjust the beam web height to better align the beam web to the beam flange during weld joint fitup. Based on the tooling design, the goal was to mitigate mismatch/offset to < 0.063 in. Welders and fitters were further trained on fitup techniques and practices. In addition, prior to welding, the weld joint fitup was inspected for mismatch. Emphasis was placed on the weld joint fitup and alignment to mitigate mismatch prior to welding and eliminate nonacceptable post-weld offset.

7. Preheating the weld joint area with an oxyfuel torch to a minimum of 100°F prior to imminent welding was introduced to drive out and remove moisture. Also, preheating facilitated weld pool fusion characteristics.
8. Providing additional training to the welders relative to the welding technique involved repositioning the GMAW gun angle directly toward the beam flange such that arc energy was concentrated on the beam flange to achieve depth of fusion into the flange and sidewall fusion.
9. Performing postweld NDE inspections while the weldment was still sitting within the production fixture and repairing/reworking welds as required.
10. Note: The next scheduled process improvement includes the implementation of a mechanized GMAW system with a 75% Ar/25% CO_2 shielding gas mixture as well as the utilization of two new specially designed ceramic weld backing geometries that facilitate achieving highly favorable root penetration fillet contours (i.e., a flat/mitered fillet contour, a convex radiused fillet contour).

FABRICATION PROBLEMS

Based on the previous weld joint design and welding practices, there were two major recurring problems:

- The cover plate, CJP, and single-bevel corner joint welds were regularly failing NDE because of incomplete root penetration and beam flange sidewall fusion. Welds were performed in the 1G position utilizing the manual GMAW-P process (95% Ar/5% CO_2, ER70S-2 weld filler metal at 0.035 in. diameter). Incomplete penetration and sidewall incomplete fusion were occurring along each of the two 29-in.-long cover plate single-bevel corner joints. For VT inspection, a mirror was employed to examine the root side of the cover plate weld for penetration and sidewall fusion — Fig. 3.

- The beam web to the rewelded beam flange was failing weld joint offset inspections — Fig. 4. As noted within MIL-STD-2035A (SH), paragraph 4.2.3, the maximum permissible offset for a base metal thickness over 0.250 to 0.750 in. equals 25% of the weld joint thickness where the beam web thickness equaled 0.295 in. This translates to a maximum permissible weld joint offset of 0.074 in. Utilizing a combination of bridge cam gauges or Reprorubber® metrology casting material, some postweld joint offsets were measured up to 0.236 in. Poor inspection results signified that decisive action was required to correct fabrication problems, increase weld and weldment quality and NDE, and improve first-time quality yields.

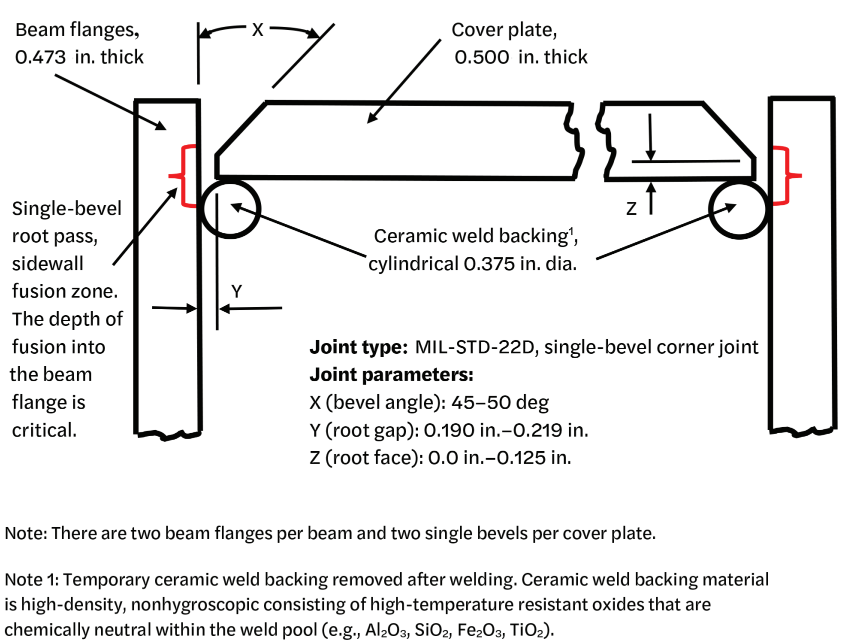


Fig. 5 — New corner weld joint design comprising a 0.375-in.-diameter ceramic cylindrical weld backing and a 0.190-in. root gap to facilitate complete root penetration and root pass, sidewall fusion.

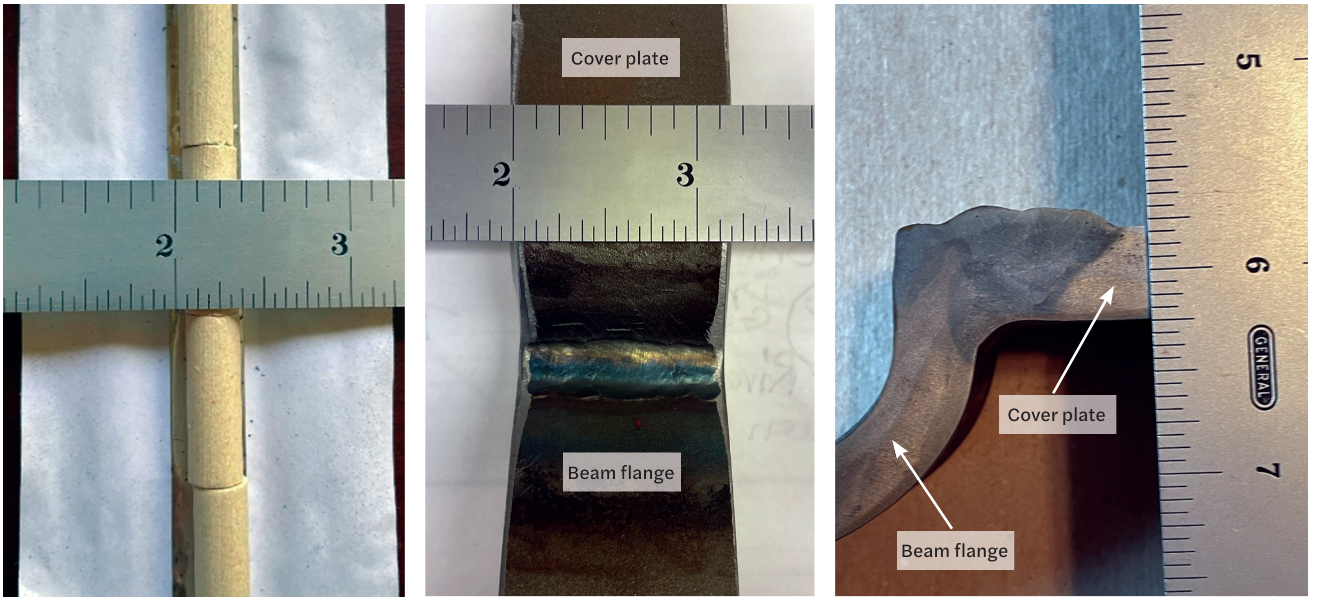


Fig. 6 — Left — 0.375-in.-diameter ceramic cylindrical weld backing to facilitate penetration and root pass, sidewall fusion using a CJP, single-bevel, corner weld-joint design. Center — An illustration of the mechanical soundness of the weld joint during a root weld bend test. Right — The etched area illustrates the root side penetration fillet contour (i.e., concave/miter) and the depth of fusion into the beam flange and cover plate.

THE IMPORTANCE OF WELD BACKING

More emphasis must be placed on employing the correct weld backing geometry to achieve NDE structural quality welds. To facilitate CJP, single-bevel corner joint welds, the use of cylindrical backing supports the weld pool during welding, enabling welding to be carried out from a single side. With only 3.375 in. to the backside of the cover plate, root-side weld joint accessibility is not attainable, so properly using a ceramic weld backing geometry is required. For CJP, single-bevel corner joint welds, consideration must be given to the weld pool flow during root pass welding. That is, to achieve a high-integrity corner joint weld with complete root weld-bead penetration and sidewall fusion, the weld pool must be able to form a root penetration fillet contour and penetrate the beam flange to attain sidewall fusion. There are a multitude of ceramic weld backing geometries available, as well as backing tapes, depending on the weld joint design and application. Utilizing ceramic, cylindrical weld backing (e.g., 0.250–0.750 in. diameter) greatly facilitates sidewall fusion. Permanent and nonpermanent weld backing is an integral part of structural steel welding in facilitating fabrication and weld joint efficiency and in achieving mechanically sound, CJP, NDE quality welds.

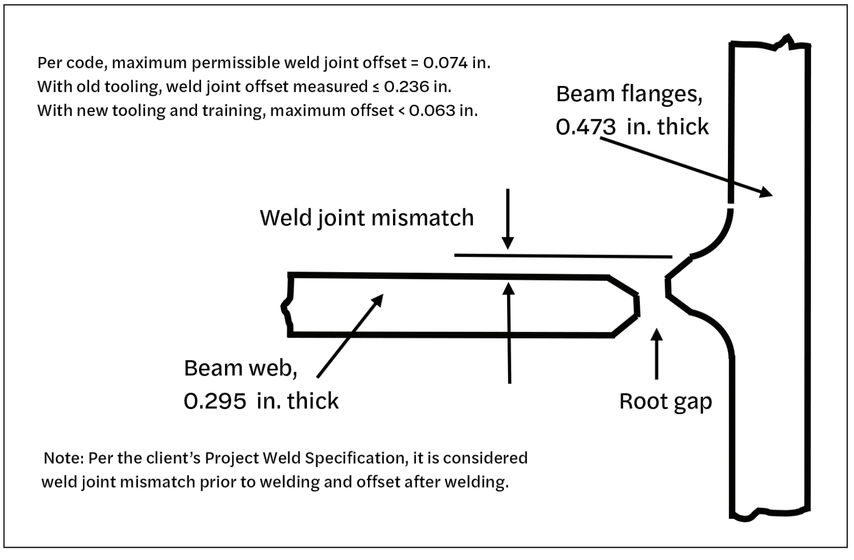
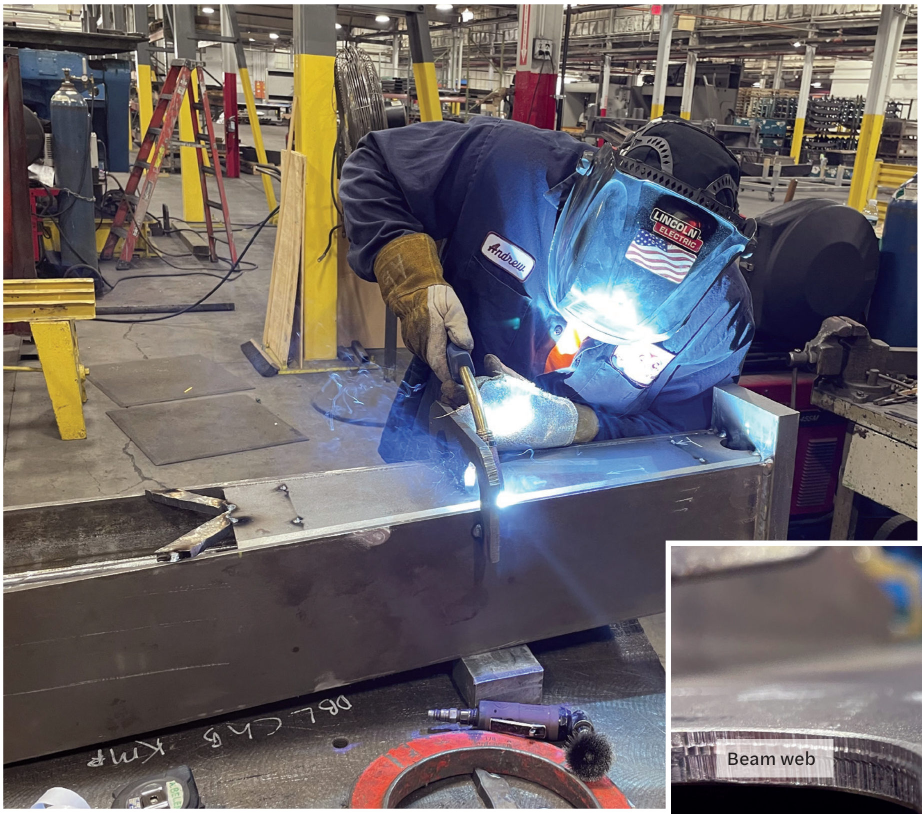


Fig. 7 — Beam web to beam flange weld joint mismatch/offset. Weld joint fitup, alignment, and tooling are important in rewelding the beam flange to the beam web. Process improvements included new tooling installed to facilitate fitup, alignment, and the height of the beam web to more accurately match the beam flange to mitigate weld joint mismatch during fitup and postweld offset to < 0.063 in. Also, welders and fitters were provided additional training in fitup techniques and practices.



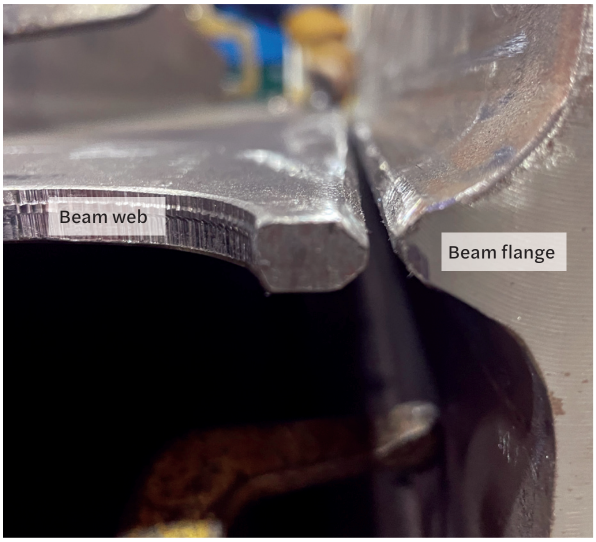


Fig. 8 — Left — With implementing process practice improvements, increased weldment quality, first-time NDE quality yields, and increased productivity were realized. Below — A close-up illustrating the mitigation of weld joint mismatch between the beam web and the beam flange as the result of process improvements.

PROCESS PRACTICE IMPROVEMENT RESULTS

As illustrated in Figs. 5–8, the work performed under the paragraph Process Practice Improvements resulted in resolving the two foremost production problems:

- Achieving complete weld joint penetration and sidewall fusion on the beam flange; and

- Attaining weld joint offset within the maximum permissible limits between the beam web and the rewelded beam flange. Welders were responsive and receptive to changes due to increased weld quality, as noted in Fig. 6. First-time NDE quality weld yields drastically improved and were achieved consistently.

It is important to initiate continuous improvement projects to improve and resolve ongoing production problems, increase first-time quality yields and production efficiency, and lower production costs. Welders were receptive to continuous improvement initiatives because these initiatives provided an opportunity for them to demonstrate their process improvement ideas, workmanship pride, and commitment to the quality of workmanship of the weldment. Welders wanted to contribute, and their input mattered.

To mitigate beam web and flange mismatch/offset, new tooling was designed and installed to support, align, and adjust the beam web height to the beam flange during fitup operations — Figs. 7, 8. Welders and fitters were also further trained in fitup techniques and practices. The aforementioned actions reduced weld joint mismatch/offset to < 0.063 in. The production process required attention to rectify prolonged weldment and weld quality problems.

CONCLUSION

Continuous improvement initiatives make a difference and drive change to improve from status quo processes and practices. Enough emphasis cannot be placed on devoting the time, energy, and resources to analyze the weld joint design and process practices, ensuring optimization in achieving weldment quality and first-time NDE quality welds consistently.

WILLIAM C. LAPLANTE (*wlaplante.scwi@gmail.com*) **is a welding engineer as well as an AWS CWI, SCWI, and CWE in Anchorage, Alaska.**

NDE SCHOOL PROFILES

Attention Schools in Training and Testing for Materials Evaluation, Weld Inspection, and Quality Assurance:

Included in this section are welding schools across the country that have taken this advertising opportunity to promote their resources, both to industry in need of welders and to those searching for a solid career path to employment and growth. Reach 65,000 readers, many of whose livelihoods depend on quality assurance, materials testing, or weld inspection, with your school profile.

The **National Center for Welding Education and Training** (dba Weld-Ed) is a partnership of community colleges, universities, business and industry, and the American Welding Society. It is funded by the National Science Foundation. The Center's primary mission is to increase the quantity and quality of welding and materials joining technicians to meet industry demand through curriculum reform and educator professional development. Additional information is available at *weld-ed.org*. Participating schools display the Weld-Ed logo below next to their names.

Weld-Ed
National Center for Welding Education and Training

Austin Community College

The Welding Technology Program at Austin Community College offers seven certificates and four Associate of Applied Science degrees. Areas of specialty include welding inspection, ultrasonic testing, structural welding, and inert gas welding. Additional topics include orbital tube welding, metallurgy, and pipe welding. Our architectural and ornamental metal programs include blacksmithing, power hammer, and metal sculpture. Classes totaling over 600 seats are offered at two campuses.

(512) 223-6220
austincc.edu/welding

Central Carolina Technical College Sumter, South Carolina

Central Carolina Technical College's welding program is one of the leading pipe and structural welding programs on the east coast. CCTC offers a two-year program where students can earn a Basic Welding Certificate, an Advanced Pipe Welding Certificate, or a General Technology Associate degree in Applied Science. CCTC's welding programs are in accordance with AWS, ASME, and API codes. The program's current job placement rate is 100%. CCTC is accredited by SACSCOC.

Axel Reis, Welding Department Chair
506 N. Guignard Dr.
Sumter, SC 29150
(803) 778-7863
reisah@cctech.edu
cctech.edu

Cuesta College Welding Technology

Cuesta College is highly regarded for its excellent education programs and exceptional faculty and staff. The Welding Technology program offers a well-rounded curriculum that has a strong history of teaching diverse populations ranging from beginners to students preparing to work in industry. Candidates are provided the opportunity to obtain a Certificate of Achievement, two Certificates of Specialization, and an associate degree in Welding Technology as they reach the ultimate goal of becoming a certified welder. Our three CWI instructors qualify our students in structural steel and pipe welding to AWS D1.1, ASME Section IX, and API 1104 standards. Additionally, six part-time instructors add their vast industry experience teaching additional elective courses that set our students apart upon graduation.

Mike Fontes, mfontes@cuesta.edu
San Luis Obispo, CA 93403
(805) 546-3100, ext. 2737
cuesta.edu

Cal-Trade Welding School of Modesto

Cal-Trade Welding School of Modesto has been operating since 1975. Using the industry employers as a guide, we teach SMAW, GMAW, GTAW, FCAW, and pipeline welding. Welding technique training is primary, and students are given one-on-one instruction. In the 18-week Combination Welding Course, students have the opportunity to earn multiple certifications. Welding theory, mathematics for welders, and blueprint reading are also offered. Lifetime job placement assistance is available to students after graduation.

424 Kansas Ave.
Modesto, CA 95351
(209) 523-0753
caltradeweldingschool.com

Columbus State Community College

Columbus State Community College, located in Columbus, Ohio, offers individuals an opportunity to learn welding and complete a Welding Associate degree or an Intermediate Welder certificate. The certificate provides the necessary credentials for entering the workforce as an intermediate-level welder. Our Skilled Trades program proudly participates as a Level II SENSE school, teaching SMAW, GMAW, FCAW, GTAW, PAC, and oxyfuel processes. Certificate studies can be completed in one year. Financial aid and veteran's benefits are available.

Scott Laslo, Program Coordinator
(614) 287-2653
slaslo1@cscc.edu
550 E. Spring St.
Columbus, OH 43215
cscc.edu

Earlbeck Technical Center

The Earlbeck Technical Center started in 1988 and offers a complete curriculum of welding classes that can be completed in as little as six weeks. Our Fundamentals course instructs in the basics of oxyfuel welding, GTAW, GMAW, and SMAW. Students may then progress through intermediate-level classes, offering certification testing in plate, and advanced level classes, offering certification testing in pipe. Customized and mobile training are also available. We also provide custom visual inspection training to codes and specifications for customers. The Earlbeck Technical Center, Winner of the AWS and WEMCO Excellence in Welding award in the Educational Facility Category, is an AWS Accredited Test Facility.

8204 Pulaski Highway
Baltimore, MD 21237
York, PA / Scranton, PA
(410) 687-8400
tsmith@earlbeck.com
earlbeck.com/weldertraining

Fortis College Birmingham, AL

Small class sizes, experienced instructors, and lots of opportunities to develop your hands-on skills are only part of what makes Fortis special. Our comprehensive welding program is designed to prepare you with the knowledge and real-world skills you need to pursue entry-level employment as a welder. Call today to learn how to get started training for a career in welding at Fortis.

100 London Pkwy., Ste. 150
Birmingham, AL 35211
(205) 940-7800
fortis.edu

Fortis College Cincinnati, OH

Enjoy using your hands and finding practical solutions to complex problems? If so, a career in welding could be for you! The first step is to gain the essential training to be successful in the field. At Fortis, we have the training, guidance, and resources to help you succeed. Our Welding Technology program offers instruction in fundamental math applications, introduction to oxyfuel cutting, and experience in various welding processes to make you skillful in this skilled trade with a future. Give Fortis a call today to learn more and to schedule a campus visit.

11499 Chester Rd., Ste. 200
Cincinnati, OH 45246
(513) 771-2795
fortis.edu

Fortis College Houston South, TX

Train to become a welding technician at Fortis College — Houston South. The ideal blend of art and science, welding is integral to many industries, including construction, manufacturing, and aerospace. At Fortis College, you will learn from experienced professionals as they guide you through a comprehensive curriculum. Our small class sizes and skilled faculty are committed to helping you gain the knowledge and hands-on skills you need to achieve your goals.

1201 West Oaks Mall
Houston, TX 77082
(713) 266-6594
fortis.edu

FORTIS COLLEGE

FORTIS COLLEGE

FORTIS COLLEGE

Fortis College Smyrna, GA

Kick-start your welding career with a Fortis College education. In our Welding Technology program, you can get the training and hands-on expertise needed to enter the growing welding industry in various careers, including industrial welders, check welders, welding apprentices, and more. Our courses offer instruction on the intricacies of welding and all its phases, including the use of destructive and nondestructive testing, to ensure our students have a thorough understanding of quality welding. Contact us today to learn more about our program and schedule a campus visit.

2140 South Cobb Dr.
Smyrna, GA 30080
(770) 980-0002
fortis.edu

Fortis College Cuyahoga Falls, OH

Fortis College Cuyahoga Falls, formerly known as National Institute of Technology, was founded in Cuyahoga Falls, Ohio, in 1966. The Welding Technician program teaches students the principles of welding technology. In the program, students are introduced to basic air carbon arc, oxyfuel, and plasma arc cutting processes. The fundamental concepts of shielded metal arc welding and gas metal arc welding as well as flux core arc welding are taught. Pipe welding and gas tungsten arc welding applications are also included in the curriculum.

2545 Bailey Rd.
Cuyahoga Falls, OH 44221
(330) 923-9959
fortis.edu

Georgia Trade School

Family owned and operated, Georgia Trade School stands as one of the nation's elite boutique welding schools. Named a Cobb Chamber Top 25 Small Business of the Year seven consecutive times, our efforts to rebuild America have led to critical acclaim and commercial viability. With 1200 graduates representing 20 states in a range of industries, including energy, construction, manufacturing, shipbuilding, film, and television, this program changes lives and leads to middle-class security.

Joanna Vinson, President
jvinson@georgiatradeschool.com
4231 Southside Dr.
Acworth, GA 30101
(770) 590-9353
georgiatradeschool.com

FORTIS COLLEGE

FORTIS COLLEGE

GEORGIA TRADE SCHOOL
REBUILDING AMERICA

Hill College

Hill College's welding program offers comprehensive training in a high-demand job market and is available on both Hillsboro and Cleburne campuses. Choose from several program options, including a certificate in basic welding up to an Associate of Applied Science in Welding Technology. Hill College is equipped with state-of-the-art technology to help you get a jump start on your career. With hands-on curriculum, you are given an experience that exceeds what a classroom can teach.

Hill County Campus
Hillsboro, TX 7664
Cleburne Technical Center
Cleburne, TX 76031
Joe Price, JPrice@hillcollege.edu
(254) 659-7984
hillcollege.edu

Lakeshore Technical College

Located between Milwaukee and Green Bay, Wisconsin, on the eastern shore of Lake Michigan, Lakeshore Technical College (LTC) is a nationally recognized college that can have you work ready in 27 weeks. From our innovative programs and experienced faculty to our high-tech classrooms and labs, affordability, and graduate placement rates, LTC ranks among the best. Our state-of-the-art KOHLER Center for Manufacturing Excellence serves as the only AWS Accredited Test Facility in the area; it's also where we offer multiple entry points for our welding fabrication and welding industrial programs.

1290 North Ave.
Cleveland, WI 53015
(888) GO TO LTC
gotoltc.edu

Modern Welding School

Modern Welding School is an ACCSC School of Excellence award recipient. Students receive training in OAW, SMAW, pipe, GTAW, and GMAW/FCAW. The school's fulltime program is 900 hours and the evening part time program is 665 hours. Job placement assistance is available for students of the career programs. Training is also available to companies looking for specialized welding training, welding certification testing, or consulting for their personnel.

Schenectady, NY 12304
(800) 396-6810
(518) 374-1216
Andrew Daubert
adaubert@modernwelding.com
learn2weld@modernwelding.com
modernwelding.com

Hobart Institute of Welding Technology

Hobart Institute of Welding Technology (HIWT) offers a wide range of welding skill and technical training classes and certifications. The catalog lists the skill training programs, over 25 individual courses, corporate training, and a listing of the AWS-certified testing services provided. Corporate training may be done at our facility or yours. The HIWT bookstore offers a complete training curriculum that includes DVDs, instructor guides, and student workbooks along with other welding-education-related items.

400 Trade Square E.
Troy, OH 45363
(937) 332-9500
welding.org

Mitchell Technical College

Mitchell Technical College offers an industry-driven Welding and Manufacturing Technology program providing skills for graduates to excel in welding, machining, drafting, laser/plasma cutting systems, robotics, and lean manufacturing techniques. Instruction is AWS-code based during the second year. Students learn clearly defined and communicated welding quality standards. They also learn to test welds by various methods, including dye penetrant, radiographic, visual, and tensile load testing as well as bend-and-break testing conducted by a CW within an ATF.

Mitchell Technical College
1800 E. Spruce St.
Mitchell, SD 57301
(800) 684-1969
mitchelltech.edu

Monroe County Community College

MCCC's Welding Technology Education includes training in SMAW, GMAW, FCAW, and GTAW of ferrous and nonferrous materials. Our state-of-the-art, hands-on training facility emphasizes mechanical and manual thermal cutting processes and techniques. AWS SENSE certification may also be attained through our ten-week QC-10 (entry level) and QC-11 (advanced level) offerings. MCCC proudly offers multiple certificate pathways, including a Basic Welding Certificate, Advanced Welding Certificate, and a Nondestructive Testing Certificate program in addition to the Associates in Applied Science Degree in Welding Technology that will transfer to both Ferris State University and Wayne State University. Apprentice training is available to companies with registered apprenticeship programs.

Steve Hasselbach-CWI, (734) 384-4118
shasselbach@monroeccc.edu
Jennifer St. Charles, (734) 384-4112
jstcharles@monroeccc.edu

Odessa College

Nationally recognized as one of the leading colleges in the country, the award-winning Odessa College Welding Technology program provides the educational training for tomorrow's welding technicians. The four specialized lab areas are equipped with 75 welding stations for instruction on SMAW, GMAW, FCAW, GTAW, SAW, and robotic welding procedures. Learn the cutting process in oxyfuel, plasma, and CAC-A in both manual and mechanized methods. The modern classrooms utilize Smartwall technology with Lincoln Electric virtual welding training systems to enhance the learning experience. Students have the opportunity to earn a one-year certificate or a two-year AAS degree in Welding Technology. The program is an AWS Educational Institution Member and an active NC3 member with several trained instructors. Our AWS Student Chapter is active on the OC campus and in our community.

Syed Muhammad Naqvi, CWI/CWE
snaqvi@odessa.edu
(432) 335-6306
odessa.edu

Ridgewater College

Ridgewater College offers welding excellence with state-of-the-art labs that include CNC plasma and laser cutting along with robotic welding. Students learn TIG/GTAW and MIG/GMAW. We are proud to be an AWS Accredited Test Facility. Our students excel in SkillsUSA and Behind the Mask competitions and benefit from a partnership with our Nondestructive Testing program that offers weld quality evaluation. Welding options include an AAS degree, diploma, or certificate.

Hutchinson and Willmar, MN
(320) 234-8500
admissions@ridgewater.edu
ridgewater.edu/welding-aws

St. Charles Community College

St. Charles Community College (SCC) is a two-year community college offering three certificates and a two-year AAS degree, all stackable credentials. This semester-based AWS SENSE program teaches SMAW, GTAW, GMAW, FCAW, and oxyfuel in order to provide graduates with the skills they need to go to work immediately. Students receive hands-on instruction from industry professionals. SCC has industry partners willing to hire graduates immediately for this rewarding career.

Roxanne Finneran
Welding Program Coordinator
4601 Mid Rivers Mall Dr.
Cottleville, MO 63376
(636) 922-8513
welding@stchas.edu

PIT Instruction & Training LLC Pit Weld U

Located in Mooresville, N.C., Pit Weld U, an Accredited Testing Facility, offers a host of industry specific welding and fabrication classes. The certificate-based program allows students to be selective in the courses they take, providing a more direct, cost-effective path towards the industry segment of their choice. Tuition includes AWS certification testing and OSHA-10 certification, providing graduates with the foundation to a successful career.

156 Byers Creek Rd.
Mooresville, NC 28117
(704) 799-3869
visitPIT.com

Schoolcraft College

Located in one of the largest manufacturing areas of the USA, Schoolcraft College offers certificates and associates degrees in an AWS Accredited Test Facility. The college provides state of the art welding and fabrication equipment in an innovative, dynamic, and productive environment. Small class sizes give easy access for students to knowledgeable industry trained experts and CWI instructors who strive to educate students for real-life on the job scenarios. Schoolcraft College offers classes in all major welding processes as well as specialized classes in blueprint reading, inspection, metallurgy, OSHA 30, CAD, robotics, mechatronics, and CNC manufacturing. Schoolcraft College also offers courses for AWS certifications in aerospace, ASME, D1.1, B2.1, and several other codes and standards to enrolled students as well as local skilled tradesmen and tradeswomen.

Coley McLean
cmclean@schoolcraft.edu
Livonia, MI 48150
(734) 462-7020 | schoolcraft.edu

Tyler Junior College

Tyler Junior College (TJC) is a comprehensive community college in Tyler, Texas, recognized as one of the top colleges in Texas. Its one-year certificate and two-year associate degree pathways in welding technology prepare students for entry-level code welding for industry. Training is provided in blueprint reading and layout as well as SMAW, GMAW, FCAW, GTAW, and pipe welding. In addition, the welding program follows the AWS SENSE entry level guidelines for welder training. Many TJC welding graduates secure a great job before graduation. Let us help you prepare for a rewarding career in a high-demand field. Call or visit our website.

P.O. Box 9020
Tyler, TX 75711
(903) 510-2390
(800) 687-5680
tjc.edu

United Technical Inc.

Train, test, and certify as an AWS Certified Welding Inspector at our facility in southeast Michigan. The ability to train all common NDE methods (RT, UT, PT, MT, and VT) makes United Technical your answer for any welding inspection need. Our classes emphasize hands-on training, so students spend most of their time actually performing inspections. With years of experience focused on corporate training, we know what it takes to create a successful welding inspection professional. Our in-house CWIs and CWEs enable United Technical to support manufacturing companies of any size.

1081 E. North Territorial Road
Whitmore Lake, MI 48189
(248) 667-9185
Robert Dines
info@unitedtech1.com
unitedtech1.com

Waubonsee Community College

The Welding Technology program at Waubonsee Community College offers students options of two certificates, as well as an Associate in Applied Science Degree. Class sizes are small to ensure students get focused and individualized attention. Waubonsee's welding program includes classes in each of the basic processes including: OFW, TB, OFC-A, PAC, SMAW, GMAW, FCAW, and GTAW. Additionally, the curriculum includes two courses specifically devoted to pipe welding with GTAW and SMAW in all positions.

Rt. 47 at Waubonsee Dr.
Sugar Grove, IL 60554
(630) 466-7900, ext. 2263
waubonsee.edu

4C Welding and Industrial Center Inc.

4C Welding and Industrial Center Inc. is a private owned construction trade school. We are an accredited NCCER training sponsor and assessment center. We are a state of Oklahoma weld testing laboratory; an AWS Educational Institute, AWS SENSE Level I and II site; and an NCCER endorsed crane and rigging site. Courses are offered welding, rigging, safety, ironworking, boilermaking core, and project supervision. We are a one-stop shop for the petrochemical industry in that we are a satellite site for the Oklahoma Safety Council and also OSCA out of the state of California. We have a drug testing business in the same facility.

Lena Kopp
Hugo, OK 74743
(580) 326-9417
4cwelding.com

UNITED TECHNICAL

WAUBONSEE COMMUNITY COLLEGE

Where futures take shape

COURAGE · CONFIDENCE · CERTIFICATION · CAREER
4C WELDING AND INDUSTRIAL CENTER

Washtenaw Community College

WCC's Welding & Fabrication program offers certificates and an Associate of Applied Science degree. Courses focus on welding and fabrication but also introduce students to industry trends such as weld quality testing (visual, physical, and nondestructive) and automated welding and cutting. The faculty at WCC are AWS CWIs with more than 40 years of combined industry experience. WCC also offers a preapprenticeship certificate program connecting students to the Local 25 Ironworkers Union. WCC's program combines classroom learning with practical hands-on learning that arms students with the skills they need to thrive in the welding workforce. WCC is an AWS Accredited Test Facility so students can achieve AWS welding certifications.

Alex Pazkowski
Bradley Clink
Ann Arbor, MI
(734) 973-3628

Welder Training and Testing Institute

Welder Training and Testing Institute (WTTI) maintains a freestanding campus in Pennsylvania, housing a weld lab equipped with 65 work stations. Training is provided in all major welding processes. Classrooms are fully equipped to support lessons in theory, blueprint reading, and fitting. Specialized on-site training is available to industry. WTTI also offers CWI and NDE training and certification as well as welder certification through our AWS Accredited Test Facility and ISO 17025 Accredited Laboratory.

729 E. Highland St.
Allentown, PA 18109
(800) 223-WTTI
info@wtti.edu

Wilson Community College Welding Technology Diploma and Certificate Program

Established in 1958, Wilson Community College is one of the system's oldest institutions. The college offers associate degrees, diplomas, and certificates. The Welding Technology curriculum provides students with an understanding of the science, technology, and applications essential for successful employment in the industry. Instruction includes electrode welding and cutting processes, blueprint reading, metallurgy, welding inspection, and destructive and nondestructive testing to provide the student with industry-standard skills. Enrollment is approximately 17 to 25 students.

Travis Flewelling,
Dean of Industrial Technologies
tflewelling@wilsoncc.edu
(252) 246-1210
902 Herring Ave., Wilson, NC 27893
(252) 291-1195 | wilsoncc.edu

Washtenaw Community College

WELDER TRAINING & TESTING INSTITUTE

WILSON COMMUNITY COLLEGE

From Warrior to Inspector

How one school is transitioning military veterans to the nondestructive examination industry

Jarret Herbel, an advanced senior nondestructive examination technician, prepares to inspect wind turbine hubs in Schönewalde, Germany.

Warrior-to-Inspector (War2In) is a nondestructive examination (NDE) trade school and apprenticeship program in Bellemont, Ariz. It offers a three-semester program open to civilian and transitioning military students. The courses include book learning, hands-on learning, and on-the-job training for students seeking an inspection trade specialty. War2In aims to prepare graduates for the employment marketplace and offers robust job opportunities, scholarships resulting in little to no debt upon completion, and competitive wages that typically match the industry's national average in the first year of employment. Students can also enroll through Coconino Community College in Flagstaff, Ariz., to receive 45 college-transferable credit units for the three-semester program.

Although the school doesn't offer training directly related to the AWS Certified Welding Inspector (CWI) program, many of the courses are complementary to a CWI's career, and a large number of CWIs hold these certifications together with their CWI credentials.

Origins

War2In was started in 2015 by Kenny Greene, who has been an American Society for Nondestructive Testing (ASNT) NDT Level II in ultrasonic testing (UT), penetrant testing (PT), and magnetic particle testing (MT) since 1989; an ASNT NDT Level III in UT and MT since 1999; and a CWI since 2009. Over the last 34 years, his ASNT, AWS, and International Code Council (ICC) certifications have provided opportunities to work on projects such as the Los Angeles 73-story First Interstate World Center (1989); the 5888-ton Mammoet crane (2008), which is the world's largest mobile crane; the Port Authority of New York and New Jersey's 105-story World Trade Center Tower 1 (2010); and the development of a pipeline material verification process that was patented by the U.S. Department of Transportation (DOT) and the U.S. Pipeline and Hazardous Materials Safety Administration (PHMSA).

As president and lead instructor of War2In, Greene dedicates the remainder of his career to fostering the next generation of expert inspectors and NDE practitioners.

Kenny Greene, president and lead instructor of War2In, inspects a component.

Appreciation

War2In graduates and instructors as well as industry professionals are enthusiastic about sharing their experiences with the school.

Graduate **Nathan Frady** expressed, "War2In isn't just a training program; it allows individuals to excel and grow as far as they desire. It's a family for warriors and brothers alike with a new purpose and task as they did in their military careers. This program develops an individual's character, mind, and body for the better. The owner/lead instructor won't give up on you, and the staff believes in the principles of honor, courage, commitment, integrity, accountability, and, above all else, standing and helping others."

Graduate and instructor **Angel Alvarez** shared, "As I began my journey in 2016 with War2In, it allowed me to become a well-rounded and proficient inspector. Seeing our impact on our students' lives is the most rewarding part for me as an instructor. War2In allows inspectors to bring students into the field, giving them hands-on work experience and making great students into great inspectors. Accessing a job site and navigating through the different situations unique to each site builds the students' confidence. They develop the ability to adapt and overcome situations they might face once in the field on the job."

Industry professional **Emilie Peloquin**, director of global advanced product support at EVIDENT, said, "It is inspiring to see people like Kenny Greene in our industry, someone who sees an obvious need and rallies to make a change. Kenny noticed that, for a student, it is challenging to gather

COURSES OFFERED

General Industry

- Introduction to NDT: 40 hours
- Material Sciences – Metallurgy, Welding, and Corrosion: 40 hours
- Shutdown/Turn Around Job Readiness: 40 hours

NDE Methods

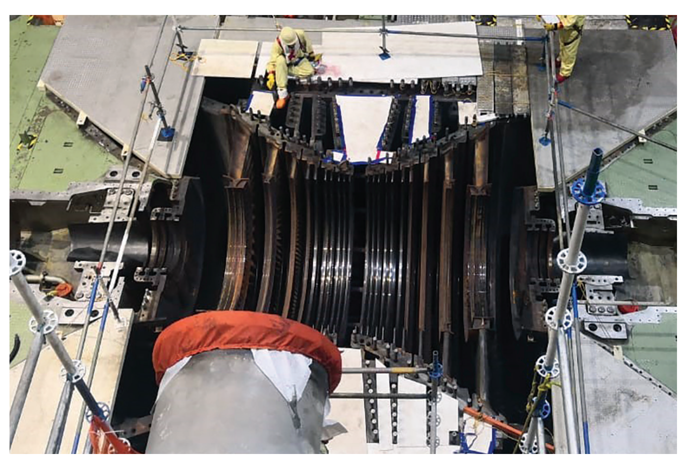
- Magnetic Particle Testing (MT) – Level 2: 310 hours
- Ultrasonic Thickness Testing (UTT) – Level 1: 250 hours
- Ultrasonic Shear Wave (UTSW) – Level 2: 670 hours
- Phased Array Ultrasonic (PAUT) – Level 2: 240 hours

Pipeline Integrity Courses

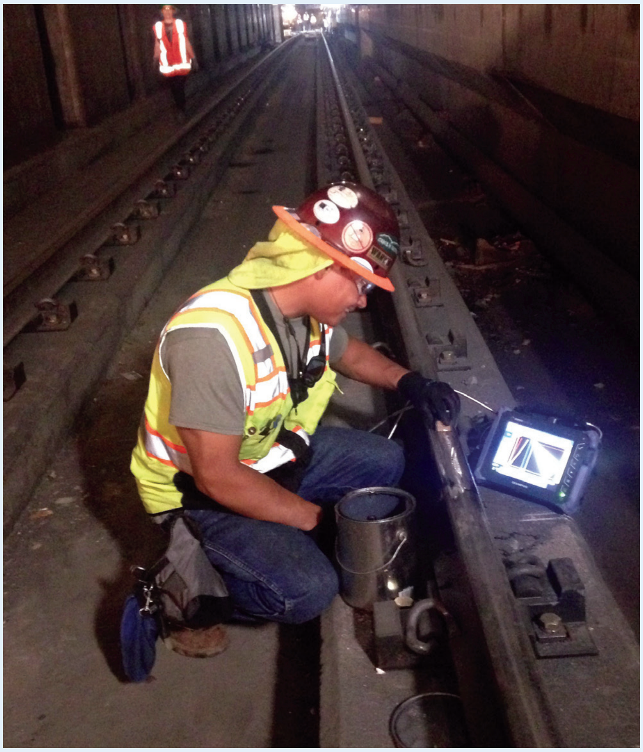
- In-Line Inspection (ILI)/NDE Correlation
- In-Ditch Technician
- Manual External Corrosion Direct Assessment (ECDA)
- Manual Internal Corrosion Direct Assessment (ICDA)
- Creaform Pipecheck Laser Corrosion Mapping
- AUT Automated Ultrasonic Corrosion Mapping
- Long-Seam Identification
- Stress Corrosion Cracking and Critical Crack Sizing

National Certification Exam Prep Courses

- API-QUTE – Qualification of Ultrasonic Testing Examiners (Detection)



Angel Alvarez, a War2In instructor and senior inspector, conducts NDE on the turbine rotor of the Laguna Verde Nuclear Power Plant in Mexico.



Top — War2In Instructor, CWI, and Advanced Senior NDE Technician Mark Lewis works at Flint Hills Chemical Plant in Houston, Tex., using dual-matrix array refracted L-wave PAUT to examine 316 Stainless Steel weld splices on 66-in.-diameter reactor piping. Bottom — Lewis performs PAUT on replacement rail thermite weld splices on the METRO Blue Line light rail project running between downtown Long Beach to downtown Los Angeles, Calif.

War2In graduate William Golliher performs UT to detect fluid-actuated corrosion on 20-in. main-steam piping at the Byron Nuclear Power Facility in Byron, Ill.

those precious on-the-job training hours required to progress in their career. He also noticed that many military veterans had perfect profiles for being an NDE inspector: integrity, passion for making the world safer, and a desire to continue contributing to society when returning from their deployments. His love for the NDE industry and his passion for sharing his knowledge culminated in creating a training center that truly cares about the expertise that students gather before heading out into the world."

William Golliher, a retired U.S. Army combat medic, Purple Heart recipient for combat tours in Iraq and Afghanistan, and graduate of the school, shared, "I have a traumatic brain injury and post-traumatic stress disorder. I was told by the military and the VA [Veteran Affairs] doctors that I could never go to work or attend school again. I proved them wrong, graduating top of my class and now work for Sonic Systems International doing NDE for the nuclear power industry. Going to War2In helped me, and we had camaraderie and friendships that would last a lifetime. The knowledge and expertise I was provided at the school put me at least ten to 15 years ahead of my peers in the industry with the hours and certifications. It also helped me make it to the Electrical Power Research Institute (EPRI) and receive my Performance Demonstration Initiative (PDI) certification quickly. We owe so much to War2In for helping me be a functional person in society."

This article was submitted by **War2In** (*war2in.org*), Bellemont, Ariz.

BY ALBERT J. MOORE JR.

Q Why are nickel alloys so expensive? I've heard them referred to as exotic metals or superalloys. Why?

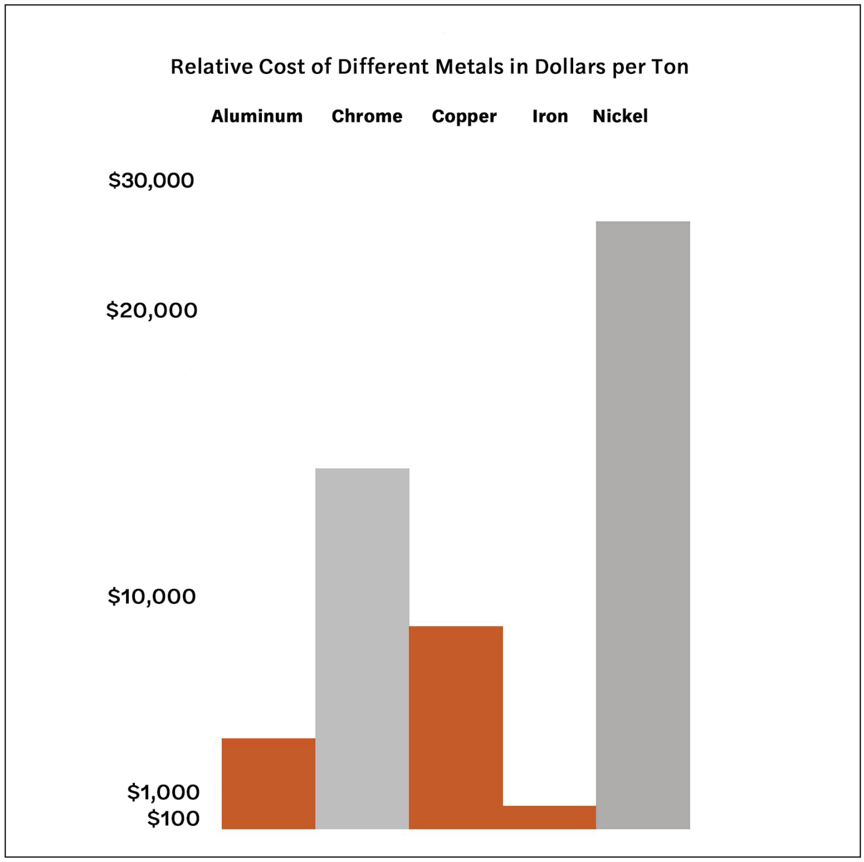
A That's a good question. An inspector should have an appreciation for the cost of the materials being joined, how the alloy content affects how the materials are welded, and the level of quality control exercised by the manufacturer to ensure the product delivered meets the intended service requirements and contract specifications. If the materials being used are relatively inexpensive, and if the cost of labor involved is relatively low, the level of nondestructive examination (NDE) may be somewhat limited because the cost of scrapping unacceptable material or parts is less than the cost of NDE. On the other hand, if the materials of construction are high and if the amount of labor involved is high, the cost of added NDE can be easily justified by eliminating bad material or work as soon as that's practical. So, you asked, "Why is nickel so expensive?" That's a fair question to ask.

If you want to get rich quick, trade nickel on the commodities market. Then again, you can go broke just as fast. The following are spot prices for nickel:

- March 2022: $34,000/ton
- July 2022: $18,000/ton
- February 2023: $26,000/ton

Let's compare the price of nickel to the price of a few other metals:

- Iron Ore: $80/ton (November 2022) $129/ton (Current)
- Aluminum: $2165/ton
- Chrome Ore (65%): $14,700/ton
- Copper: $8157/ton



Relative cost of several metals in dollars per ton. The cost may be in raw metal or cost per ton for the ore.

Figuring the prices can be interesting because in some cases, the price is for the ore and depends on the percentage of the element in the ore. In other cases, the price is for the semirefined metal that is used for feedstock. I looked at several websites and averaged prices to get these numbers. The point of the exercise is the cost of nickel is high relative to other metallic materials.

Now, let's look at the way high-quality nickel is made. I am referring to nickel alloys used by the aerospace industry and sold under various trade names, such as Waspaloy®, Hastelloy® C276, etc. These alloys are highly refined by multistep melting performed under a vacuum. The first step is to load the raw materials into a bucket in the right proportions to make the specific alloy. The bucket holding 10,000 lb (or more) is placed into a chamber that is evacuated and then lowered into a vacuum induction melting (VIM) furnace, where it is melted in a vacuum. The molten metal is poured into electrode molds that are about 10 to 12 in. in diameter and 10 ft long, where it cools and solidifies, still under a vacuum. From there, the cast electrode is pulled from the mold and ground to remove any surface contaminates from the outside diameter. The cast electrode is placed in a vacuum arc remelting (VAR) furnace, which is similar to a giant gas metal arc welding process without the shielding gas. The electrode is once again remelted under a vacuum using an electric arc established between the end of the nickel electrode and the copper crucible that also acts as a mold. The melt is allowed to cool and solidify while under a vacuum, and then ground once again to remove any surface contaminants from the outside diameter of the nickel casting. For the final remelt, the nickel casting is placed in another remelt furnace. The cast nickel rod is the electrode, and it is remelted in an electroslag remelting (ESR) furnace, which is a giant electroslag welding machine. The melting takes place in

The feedstock for VIM: (from left) chromium, cobalt, nickel, and molybdenum.

another copper crucible. Each step is used to remove some of the undesirable elements to obtain a better distribution of chemistry and control grain size. This is called triple vacuum remelting. In some cases, between the VAR and ESR furnaces, the manufacturer will perform a forging operation to control grain size before going into final remelt in the ESR furnace. All the metal removed by grinding metal chips from turning on a lathe are remelted. Nothing is wasted. It's too valuable.

Some people call nickel alloys exotic because of their cost. They are also called superalloys because they can be used for high-temperature or low-temperature applications. Nickel alloys resist oxidation at high temperatures and retain their ductility and toughness at low temperatures. Nickel is not allotropic; therefore, it retains its face-centered cubic crystalline structure at all temperatures.

Compare this to the typical way steel used in buildings, bridges, or ships is manufactured. The steel is melted in a furnace, open to the air, poured into a ladle in the air, then transferred to a continuous casting machine or, occasionally, into an ingot mold. The oxygen from the air is very soluble in the molten steel, where it has an opportunity to form small oxide inclusions and small carbon monoxide bubbles in the molten steel. Those bubbles rise through the molten metal as it cools and finally escapes into the atmosphere. In the case of the continuous casting machine, most all the bubbles (porosity) escape to the top of the tundish, where it escapes into the atmosphere. That isn't the case with an ingot. Less carbon monoxide escapes; therefore, the ingot tends to have more porosity that must be removed by cutting off a portion of the ingot and tossing it back into the scrap pile for remelting. The cost of producing steel in the manner described is inexpensive in comparison to the triple vacuum remelting process. Additionally, the feedstock being melted (i.e., scrap steel) is relatively inexpensive: less than $200/ton.

Stainless steel can be melted like steel (i.e., in the air in an induction furnace or electric arc furnace) to keep costs competitive. However, if the stainless steel is going to be used for an aerospace application where the properties must be optimized, it can be produced in a manner similar to the nickel. The added cost of melting the stainless steel under a vacuum drives up the price, but the end product will have superior mechanical properties.

Whether you are dealing with nickel alloy, stainless steel alloys, or carbon and low-alloy steels, they must be shaped by forging, rolling, or casting into the required shape. Each manufacturing process adds cost to the raw material. The more sophisticated the manufacturing process, the more expensive the product. The low-cost material produced for the mass market will involve a minimum amount of NDE. The quality control implemented by the manufacturer may be limited to a sampling of the finished product. The entire lot is accepted or rejected based on the test performed on a few finished pieces. A high-value product that is constructed using high-cost materials will see a higher level of NDE performed during the manufacturing process. The raw material will be tested by the manufacturer responsible for producing the raw material. In the case of carbon steels, high-alloy steels, nickel alloys, etc., each ladle is tested to ensure the right chemical composition is being poured. The high-nickel alloys that are triple vacuum melted will be tested for composition, grain size, and more, between each melt.

In the case of structural steel fabricated for a small building, the level of inspection is minimal. A high-rise building or a bridge requires more extensive inspection and volumetric examination of complete joint penetration groove welds by radiographic or ultrasonic test methods. A high-value part or assembly for the aerospace industry made from a high-cost base metal, like a nickel alloy, will more likely see very stringent quality control measures, including complete material traceability, dimensional checks, and penetrant testing as well as volumetric testing at several stages of manufacturing.

The inspector should have an appreciation for how the product is used, the materials of construction, and the manufacturing processes used to produce the product. That helps the inspector appreciate the importance of inspection and the role the inspector plays in protecting the public and people using the product from injury or worse. IT

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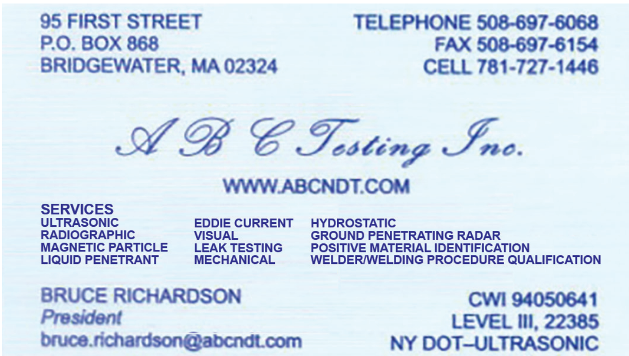

Certification Quikcheck

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- The text of the articles should be about 1000 words and provided in a Word document.
- Line drawings, graphs, and photos should be high-resolution JPG or TIFF files with a resolution of 300 or more dots per inch.
- Plan on about one figure for every 500 words and provide captions for every image. Also, if a nice lead photo is available, please include it for review.
- The authors' names, along with the companies they work for and their positions, should be listed.

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