FEBRUARY 2019 / VOL. 22 / NO. 1

Inspection Trends

THE MAGAZINE FOR MATERIALS INSPECTION AND TESTING PERSONNEL

AWS
American Welding Society®
CELEBRATING 100 YEARS
SINCE 1919

- **Pipeline Hot Tapping and CWIs**
- **Applications of Symbols for NDE**
- **SOPs for Workforce Development and Quality Control**

PUBLISHED BY THE AMERICAN WELDING SOCIETY TO ADVANCE THE SCIENCE, TECHNOLOGY, AND APPLICATION OF WELDING AND ALLIED JOINING AND CUTTING PROCESSES WORLDWIDE, INCLUDING BRAZING, SOLDERING, AND THERMAL SPRAYING

American Welding Society®

CELEBRATING 100 YEARS SINCE 1919

Prepare for Your CWI Exam with the Organization that Set the Standard

AWS Offers FOUR Convenient Study Options

For the past century, AWS has been the worldwide authority in welding standards development and compliance. AWS CWI seminars cover key concepts and principles and include the most current and accurate information available. As a bonus, **all of your books and printed materials will be shipped to you upon registration*** so you can make the most of your AWS training.

Week-Long Seminar Followed by the CWI Exam.

- Shortest, most comprehensive in the industry
- Only 40 hours of intensive classroom instruction *(not 80!)*
- Seminar occurs the week before the exam

Location	Seminar Date	Exam Date	Register By
Las Vegas, NV	Apr 7–12	Apr 13	Feb 24
Dallas, TX	Apr 7–12	Apr 13	Feb 24
Bakersfield, CA	Apr 28–May 3	May 4	Mar 17
Miami, FL	Apr 28–May 3	May 4	Mar 17
St. Louis, MO	Apr 28–May 3	May 4	Mar 17
Tulsa, OK	Apr 28–May 3	May 4	Mar 17
Baton Rouge, LA	May 5–10	May 11	Mar 24
Detroit, MI	May 5–10	May 11	Mar 24
Denver, CO	May 19–24	May 25	Apr 7
Nashville, TN	May 19–24	May 25	Apr 7
Birmingham, AL	June 2–7	Jun 8	Apr 21
Kansas City, MO	June 2–7	Jun 8	Apr 21
Indianapolis, IN	June 9–14	June 15	Apr 28
Pittsburgh, PA	June 9–14	June 15	Apr 28
Spokane, WA	June 9–14	June 15	Apr 28
Hartford, CT	June 16–21	June 22	May 5
Beaumont, TX	June 16–21	June 22	May 5
Omaha, NE	June 23–28	June 29	May 12
Newark, NJ	June 23–28	June 29	May 12
Louisville, KY	July 7–12	July 13	May 26
Phoenix, AZ	July 7–12	July 13	May 26

To view the entire 2019 schedule, visit *aws.org/it-cwi-seminar*.

***API1104 Codebook must be purchased separately.*

8-Week Online Seminar

Limit 25 students per seminar

- Instructor-led, twice-weekly, 2-hour sessions
- Take from the comfort of your home or office
- Provides ample time to review and retain concepts between class times

	Start	End
1st Quarter	3/18/19	5/10/19
2nd Quarter	6/3/19	7/26/19
3rd Quarter	9/2/19	10/25/19
4th Quarter	11/25/19	1/31/20

For more information and to register, visit *aws.org/it-week-cwi*.

CWI Part B Training and Exam

- Instructor-led 3-day workshop
- Focused only on Part B

Location	Seminar Date	Exam Date
San Diego, CA	April 3-5	April 6
Philadelphia, PA	April 3-5	April 6
Los Angeles, CA	May 22-24	May 25
Las Vegas, NV	June 19-21	June 22
Minneapolis, MN	July 17-19	July 20

For more information and to register, visit *aws.org/cwi-viw*.

Custom On-Site Seminar

Let AWS bring the classroom to you!

- At your location or a site of your choosing
- Scheduled at your convenience
- Minimizes travel time and expense

For more information, visit *aws.org/custom-cwi*.

February 2019 / Vol. 22 / No. 1

Inspection Trends

THE MAGAZINE FOR MATERIALS INSPECTIONS AND TESTING PERSONNEL

Cover photo: Welder and CWI Jeff Strahan performs an API 1104 branch test for qualification on pipeline welding. (Photo by Sam Sievert.)

INSPECTION TRENDS (ISSN 1523-7168) is published quarterly by the American Welding Society. Editorial and advertising offices are located at 8669 NW 36 St., #130, Miami, FL 33166; telephone (305) 443-9353. Printed by R. R. Donnelley & Sons Co., Senatobia, Miss. Subscriptions $30.00 per year for noncertified, nonmembers in the United States and its possessions; $50.00 per year in foreign countries; $20.00 per year for noncertified members and students; $10.00 single issue for nonmembers; and $7.00 single issue for members. American Welding Society is located at 8669 NW 36 St., #130, Miami, FL 33166; telephone (305) 443-9353. Periodicals postage paid in Miami, Fla., and additional mailing offices.

POSTMASTER: Send address changes to Inspection Trends c/o American Welding Society, 8669 NW 36 St., #130, Miami, FL 33166.

AWS MISSION STATEMENT

The mission of the American Welding Society is to advance the science, technology, and application of welding and allied joining processes worldwide, including brazing, soldering, and thermal spraying.

AWS DIVERSITY AND INCLUSION STATEMENT

AWS values diversity, advocates equitable and inclusive practices, and engages its members and stakeholders in establishing a culture in the welding community that welcomes, learns from, and celebrates differences among people.

AWS recognizes that a commitment to diversity, equity, and inclusion is essential to achieving excellence for the Association, its members, and employees.

Features

Departments

Editorial

Carlos Guzman
Editor of *Inspection Trends*

Celebrate 100 Years with Us

As some of you may know, the American Welding Society (AWS) commemorates its 100th anniversary this year. Our industry and the Society have come a long way since 1919, from the evolution of the welding processes and the development of welding standards, to the creation of the Certified Welding Inspector (CWI) program in 1976 and the publication of the first *Inspection Trends* in 1998.

Today, AWS serves more than 70,000 members, has 22 Districts and 250 Sections, publishes more than 300 technical books, has certified more than 97,000 welding inspectors, and offers 8 welding-related certifications and 12 endorsements. In continuing with the modernization of our certification program, 2019 will see a further transition toward computer-based testing by our partner, Prometric. Although many of the CWI endorsements are already offered using this testing method, this will be the first year a portion of the CWI exam will be conducted using computer-based testing. Please visit *aws.org/certification* for updated information.

This year, we will bring you four issues filled with welding inspection articles we hope you find informative and interesting. Authors J. P. Christein and Richard Campbell will continue to produce their series on applications of welding symbols, including topics such as symbols for nondestructive examination (NDE), brazing, and a comparison between AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*, and ISO 2553, *Welding and allied processes — Symbolic representation on drawings — Welded joints*.

Other topics that will be covered throughout the year are NDE education and training, software for NDE projects management, radiographic examination, metallurgy for CWIs, demagnetization, eddy current testing, magnetic particle testing (MT), and code interpretation and acceptance criteria. As always, please don't hesitate to contact me at *cguzman@aws.org* and let me know what topics you would like to see covered in the future. *Inspection Trends* indeed is written by welding inspectors for welding inspectors.

Beside the continuation of the series on the application of welding symbols, this issue brings two attention-grabbing topics: the roles of CWIs in pipeline hot tapping, and using standard operating procedures as a single mechanism for workforce development programs and quality control programs. Hot tapping is a demanding pipeline modification and repair method that requires the expertise of an experienced CWI; this article will give inspectors unfamiliar with the process a detailed look of what it entails. Last but not least, our third feature explains how standard operating procedures (SOPs) can provide a basis for training while creating standards for quality control.

In case your AWS membership has expired, or if you are not yet a member, I would like to invite you to renew or become an AWS member and celebrate this 100th anniversary with us. With your membership, you will receive the *Welding Journal*, our monthly publication, which will be packed with special content, from the historical milestones of the Society to its myriad expanding activities, and a look into the future of the welding industry.

Publisher
Mary Ruth Johnsen, *mjohnsen@aws.org*

Editorial

Editor
Carlos Guzman, *cguzman@aws.org*

Senior Editor
Cindy Weihl, *cweihl@aws.org*

Features Editor
Kristin Campbell, *kcampbell@aws.org*

Design and Production

Production Editor
Zaida Chavez, *zaida@aws.org*

Senior Production Coordinator
Brenda Flores, *bflores@aws.org*

Manager of International Periodicals and Electronic Media
Carlos Guzman, *cguzman@aws.org*

Advertising

Media Sales Executives
Jeff Rhodes, *jeff.rhodes@mci-group.com*
Kim Daniele, *kim.daniele@mci-group*

Subscriptions Representative
Sonia Aleman, *saleman@aws.org*

American Welding Society
8669 NW 36th St., #130
Miami, FL 33166-6672
(800/305) 443-9353

American Welding Society®
CELEBRATING 100 YEARS
SINCE 1919

American Welding Society®
MEMBERSHIP
aws.org

Our Corporate Members Get MORE

Whether your organization has joined American Welding Society as a Supporting, Sustaining or Affiliate member, as a Distributor or Educational Institution, we are proud to support the companies and organizations that support us. Here are just some of the ways our AWS Corporate members experience **MORE**:

MORE ACCESS

- Membership for up to twenty (20) people (depending on membership level)
- Complimentary VIP passes to FABTECH for staff incentives or customer relations
- Exclusive usage of the AWS Corporate Member logo on your business and promotional materials
- Annual subscription for each member to the award-winning *Welding Journal* and *American Welder* (a special section of the *Welding Journal*)
- Company Listing on *AWS.org*

MORE PROFESSIONAL GROWTH

- Customized seminars and workshops for your organization
- Member-only networking opportunities at AWS-sponsored events
- Online AWS Standards eLibrary Access for your employees (depending on membership level)

MORE DISCOUNTS

- 25% off over 300 technical standards and publications offered at the AWS Bookstore
- Additional 5% discount off the already-reduced member registration price of any AWS conference
- Savings on certification programs and seminars offered through AWS
- Get discounted rates on insurance, travel, shipping, AWS logo merchandise and more

To review, renew or increase your membership benefits, contact American Welding Society

T: 800-443-9353, ext. 480. | info@aws.org | *aws.org/membership*

American Institute of Nondestructive Testing Expands CWI Exam Prep Course to Houston, Texas

The American Institute of Nondestructive Testing (AINDT) now offers its Certified Welding Inspector (CWI) exam prep courses in Houston, Tex.

"Our instructors have decades of welding inspection experience and are deftly involved with the American Welding Society (AWS), providing the most up-to-date training for the ever-evolving CWI exam," said AINDT CEO Don Booth. "We not only prepare our students for taking the CWI exam but also provide them with real-life experiences from industry experts."

The AINDT CWI exam prep course begins with a 40-h online course that students can move through at their own pace. Part A, the online portion, covers the fundamentals of welding technology as established by AWS; part B consists of extensive practical hands-on techniques and will be held at the Houston Marriott North in Houston, Tex.; and part C provides in-depth training to the welding code portion of the exam.

According to Booth, AINDT will be adding additional locations across the country for the CWI exam prep course in the third quarter of 2019 and early 2020.

For more information about available training courses, contact Jeff LeTourneau at *instructor@trainingndt.com*, visit *trainingndt.com*, or call (855) 313-0325.

War2In Inspection Training Program Relocates to Bellemont

Warrior to Inspector (War2In), Flagstaff, Ariz., a training program that certifies veterans and others in the field of nondestructive examination (NDE), is relocating from the moonshot at NACET facility to its own facility in nearby Bellemont.

War2In was the first moonshot client to occupy its business accelerator at the Northern Arizona Center for Entrepreneurship and Technology (NACET) when it opened in October 2015.

"In about three years, we outgrew our space in the accelerator," said Kenny Greene, War2In's founder and one of its two instructors. "It's perfect evidence of how well NACET is working; it's a good program and a good process."

The school's new 6000-sq-ft Bellemont facility will quadruple the indoor space War2In currently uses. The additional space will help accommodate an anticipated increase in students.

Premium Inspection & Testing Group Appoints Vice President of Operations

Premium Inspection & Testing Group, Houston, Tex., a provider of industrial nondestructive examination (NDE), inspection, and calibration services, has appointed Stephone Elam to vice president, operations.

Elam is a 20-plus year NDE veteran. Most recently, he was in a management role in business development for team industrial services. Prior to that, he was director of operations for Acuren Inspection for 15 years.

"Mr. Elam has built a decades-long leadership career in our industry and understands the unique needs and requirements of asset owners for top quality [NDE], as well as the challenges and opportunities on the service provider side...," said Rodney Bonvillain, CEO of Premium Inspection & Testing Group.

Elam also serves as a regional director for the American Society for Nondestructive Testing in Region 8 and founded the Society's Acadiana Section, La.

— continued on page 33

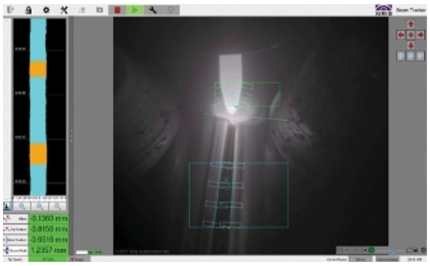
XRF Analyzer Provides Low Detection Limits

The Niton™ XL2 Plus handheld XRF analyzer provides operators the ability to scan a broad range of materials for diverse applications. It also identifies pure metals and alloys in manufacturing operations, detects tramp elements, and obtains geochemical data. Additional benefits include a 2W x-ray tube, silicon drift detector for light element detection (Mg, Al, Si, P, and S), detector ProGuard protection, micro camera, hot-swap battery, touch

screen and directional keys, password-protected security, and nose cone alignment guides. It is IP54 certified (splash/dust proof).

Thermo Fisher Scientific
thermofisher.com

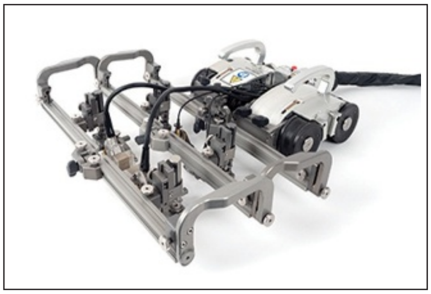
System Tracks and Inspects Joints in Tube Mills



The SeamMonitor™ tracking and inspection system for tube mills and weld seamers allows operators to measure the alignment of the weld joint relative to the torch tip and the width of the weld joint, as well as monitor the torch tip condition. The system includes an open-arc weld camera, industrial HMI controller, software, and optional optics, and interfaces to integrate with other automation devices. The software offers multiple recipe setups and user-level control features, along with a view of the welding process in real time. Parameters and images can be recorded for process monitoring and quality assurance based on the setup parameters and defined warning limits.

Xiris Automation Inc.
xiris.com

Motorized Scanner Features Steering Capabilities



The field-tested, remote-controlled SteerROVER™ scanner performs circumferential weld inspection and corrosion mapping. It inspects at heights without expensive scaffolding, is easy to control and versatile, and performs longitudinal inspection of welds on pipes as small as 12-in. outer diameter. The steerable scanner is comprised of two pods with independent motors and four magnetic wheels, touch screen handheld remote control with two joysticks, two automatic raster scan patterns, and emergency-stop buttons. The product can be ordered with two choices of motorized raster arms for corrosion inspection or a probe holder rack for weld inspection with four probes (users can increase to six probes with optional probe holders). A divisible cable conduit umbilical offers cable protection and flexible configurations. Ultrasonic data can be acquired and collected using a compatible instrument, such as the OmniScan® MX2 flaw detector or the FOCUS PX™ phased array data acquisition unit.

Olympus®
olympus-ims.com

Overhead Lamp Meant for Wash Station Work

The EDGE™ 4 overhead lamp is designed with long-lasting LEDs for wash station applications. It provides a wide area of coverage without a high intensity. Its large beam profile allows the lamp to light the entire sample or booth, while also minimizing UV exposure with its movable beam path. The IP65 rating enables this unit to withstand water and dust, a necessity in harsh wash station conditions. Heat sinks keep the lamp cool without the need for a fan, so no dust or water can enter. Four UV-A LEDs provide a wide, uniform beam that is consistent and reliable.

Spectroline®
spectroline.com

By A. Moore

Q: I have a problem with welding in the field. We are welding with flux core on a high-rise, steel-framed building. The welders are having problems maintaining the arc when the wire feeder and welding are located at a distance from the welding machines. The welding machines are located in the basement of the building. We had no difficulty welding on the first few floors, but now that we're several stories above the basement, the welders are complaining, and the rejection rate has increased to an unacceptable level. The welders were qualified using the same welding procedure specification (WPS) they are using to weld the field connections. I've checked the welding parameters, for example, voltage and amperage, shown by the meters on the welding machines, and they are within the limits of the WPS. Do you have any suggestions or recommendations?

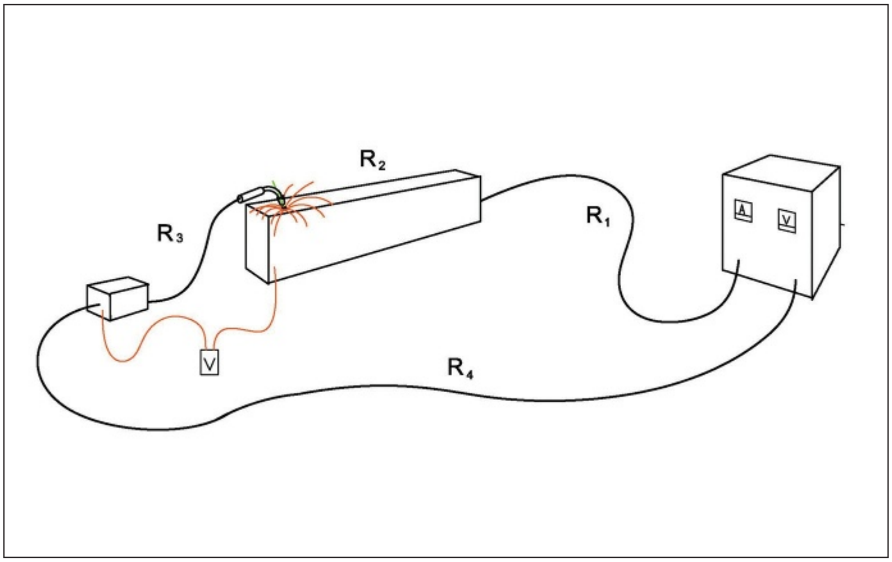


Fig. 1 — The total resistance in the welding circuit is the sum of the resistance, i.e., R_1, R_2, R_3, and R_4.

A: You didn't provide any information regarding the type of defects being observed. However, you included a couple of clues that point in the direction of possible causes of your problems.

Clue 1: Monitoring the welding parameters using the meters on the power supply. The meters on the welding machines are reasonably accurate if the welding leads are short (20 ft or less). However, as the welding leads get longer, the voltage meter is no longer an accurate means of checking the voltage drop across the arc.

Clue 2: The welders were producing acceptable welds when the connections were located near the power supplies. The quality degraded when the distance increased between the connections and the power supplies.

There is a reasonable explanation for the cause of your problems. The power supply is a constant-voltage power supply. The welding machine self-regulates to maintain the voltage set by the welder regardless of the resistance offered by the welding circuit. When the welding machine is located close to the wire feeder, the resistance of the welding circuit is relatively low, and the welding current and voltage as indicated by the meters on the welding machine are "accurate enough" for setting and monitoring the welding operations. As welding leads are added to the circuit and as more structural steel is added to the circuit, the resistance of the circuit increases. Ohm's law predicts the amperage decreases in inverse proportion to the increase in resistance in the circuit. The formula for Ohm's law is as follows :

$$\text{Amperage} = \frac{\text{Voltage}}{\text{Resistance}}$$

The circuit is in series, so the resistance is simply the sum of the individual components. Figure 1 shows the components that have to be considered. They include the welding leads and the structural steel framing that are part of the circuit. The equation shows that as resistance increases, amperage decreases.

Assuming the voltage provided by the welding machine is constant (it is a constant-voltage power supply), the voltage drop in each component is inversely proportional to the resistance of the component. The sum of the voltage drop in each component is equal to the voltage indicated by the voltmeter on the welding machine.

Per Ohm's law

$$\text{Amperage} = \frac{\text{Voltage}}{\text{R1} + \text{R2} + \text{R3} + \text{R4}}$$

As the sum of the resistance increases, the amperage decreases, unless the voltage increases. Thus, there is an additional consideration: the voltage drop across each component in the welding circuit. The voltage drop across the arc must fall within a small range as specified by the manufacturer, so it is "fixed." The greater the resistance of the other components, the larger the voltage drop. Therefore, as more welding lead is added, the resistance increases, and the voltage drop increases. The welding machine must be capable of supplying sufficient voltage to accommodate the total voltage drop in the welding circuit. The welding machine voltage output is limited to about 80 V to mitigate the possibility of electrocuting the welder, but that is static voltage. We need to know the dynamic voltage (voltage while under load, i.e., while welding) of the power supply. The dynamic voltage must be greater than the sum of the voltage drops of each component in the circuit.

The formula for the approximate dynamic voltage is

Voltage = 20 + (0.04 × Amperage)

where the amperage is the rated amperage listed by the nameplate on the welding machine.

The values shown in the following example are not actual values. They are intended to illustrate the principles at work:

- Voltage drop in the work lead equals 4 V
- Voltage drop through the structural steel frame equals 3 V due to the resistance of the structural steel that is part of the circuit
- Arc voltage equals 29 V based on the electrode requirements
- Voltage drop in the electrode lead equals 6 V due to the resistance of the welding lead
- Welding amperage equals 375 A based on the electrode requirements

The minimum required amperage of the power supply is the greater of 375 A or:

39 = 20 + (0.04 × Amperage)

Amperage = (39 – 20) ÷ 0.04 = 475

Therefore, we need to have a power supply rated to provide 475 A to provide a dynamic voltage of 39 V.

The amperage is the same regardless of where in the circuit it is measured. That isn't the case for voltage because there is a voltage drop across each component. Since the welder is only concerned with the voltage drop across the arc, it is best to measure the voltage close to the arc. The voltmeter on the welding machine may be adequate when the welding leads are short; however, the voltmeter on the machine is not adequate if the welding leads are "long." It is best to use a multimeter located close to the welding arc. Typical practice is to locate the multimeter between the wire feeder and the member being welded as shown in Fig. 1 when measuring the arc voltage. The voltage reading taken when the multimeter is positioned as shown by Fig. 1 is accurate enough for most work.

Assume the welding circuit includes the cable between the wire feeder and the gun, electrode lead, the structural steel framing and work lead. In Fig. 1, these components each have resistance value indicated by R_1, R_2, R_3, and R_4. The resistance of each is a variable that depends on the length, and in the case of the welding leads, the diameter and material (aluminum or copper). If the length of the welding lead is increased and if linear distance of the structural steel framing is increased, the resistance increases. An increase in the distance between the welding machine increases the resistance in the circuit and results in more voltage drop. To maintain the required arc voltage and welding current, the welder must increase the voltage at the welding machine. The value of R_3 is not a variable because it doesn't change. The voltage measured at the welding machine represents the voltage drop of the work lead, the structural steel frame, the welding arc, the lead

— continued on page 33

By J. P. Christein and Richard D. Campbell

Applications of Symbols for Nondestructive Examination

Their use and proper applications are described

This is the ninth in a series of articles about improving the communication of welding symbols. The previous eight issues of *Inspection Trends* have addressed groove weld symbols; fillet weld symbols; spot, seam, and projection weld symbols; plug and slot weld symbols; edge weld symbols; stud, back, backing, and surfacing weld symbols; supplementary welding symbols; and welding symbols to support T- and corner joints as well as seal welds. This article addresses applications of symbols for nondestructive examination (NDE).

Welding symbols provide a system for placing welding information on drawings, procedures, and data sheets for the purpose of relaying information to fitters, welders, fabricators, and inspectors. Welding symbols quickly indicate the type of weld joint needed to satisfy the requirements for the intended service conditions.

There are a number of standards throughout the world that relate to welding symbols; however, AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*, is the standard most widely used. The data and definitions in this article are referenced from AWS A2.4:2012 and AWS A3.0M/A3.0:2010, *Standard Welding Terms and Definitions*.

While welding symbols are widely applied on structural, civil, and architectural drawings and blueprints, symbols for NDE are not utilized to the same extent. However, they are powerful and have great potential for users.

Basics of Symbols for NDE

In the AWS system, the same basic principles of welding symbols apply to symbols for NDE applications. Some elements, however, have slightly different meanings. Even though a symbol for NDE may consist of several elements, only the reference line and an arrow are required elements — Fig. 1. The reference line is always drawn horizontally. The arrow connects the reference line to the weld, surface, part, or component to be examined (noting that NDE may be performed on more than just the weld). The side of the member to which the arrow points is considered the *arrow side* and the side opposite the arrow side of the part is considered the *other side*.

In the next edition of AWS A2.4, the planned direction for NDE symbols is to refer to them as *symbols for nondestructive examination* rather than *nondestructive examination symbols*;

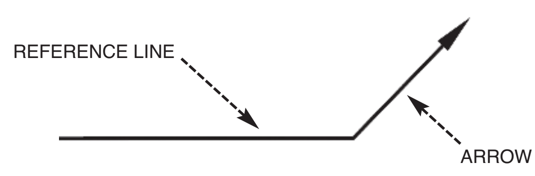


Fig. 1 — Reference line and arrow.

Examination Method	Letter Designation
Acoustic emission	AET
Electromagnetic	ET
Leak	LT
Magnetic particle	MT
Neutron radiographic	NRT
Penetrant	PT
Proof	PRT
Radiographic	RT
Ultrasonic	UT
Visual	VT

Table 1 — NDE method letter designations.

however, since the 2012 Edition still uses *NDE symbols*, that is used throughout this article.

Unique to NDE symbols, the method of NDE is used on the symbol to identify the operation, which is different than the welding symbol that may contain a weld symbol, which is a depiction of the specific type of weld (for example, fillet, groove, plug, or slot).

Symbols for NDE

Symbols for NDE were established in 1950 with the release of MIL-STD-23, *Nondestructive Testing Symbols* by the Munitions Board Standards Agency of the Department of Defense. MIL-STD-23 was later adopted by AWS, producing AWS A2.2:1958, *Nondestructive Testing Symbols*. AWS A2.2:1969 was later incorporated into Part B of A2.4:1976, *Symbols for Welding and Nondestructive Testing*. These symbols for NDE have been a part of AWS A2.4 ever since.

Elements

The NDE symbol consists of several elements:
1. Reference line
2. Arrow
3. Examination method (i.e., letter designations)
4. Extent and number of examinations
5. Supplementary symbols
6. Tail (specifications, codes, notes, or other references).

Examination Method Letter Designations

NDE methods are specified on the symbol by use of the letter designations shown in Table 1. These standard NDE methods are explained in significant detail in AWS B1.10M/B1.10: 2016, *Guide for the Nondestructive Examination of Welds*.

AWS B1.10M/B1.10:2016 describes the term nondestructive examination (abbreviated NDE) as a general term used to identify the common examination methods used for evaluation of welds and related materials without destroying their usefulness. AWS has chosen nondestructive examination (NDE) as the preferred terminology for these inspection methods. In other standards, literature, and industry usage, different expressions are commonly used, including nondestructive evaluation, nondestructive inspection (NDI), and nondestructive testing (NDT). The term most commonly used in AWS D1 structural welding codes is nondestructive testing (NDT) (Ref. AWS D1.1/D1.1M:2015, *Structural Welding Code — Steel*, paragraph 6.11). It must be emphasized that all of these expressions are commonly used and may be considered equivalent. (Ref. AWS A3.0M/A3.0:2010, paragraph 3.)

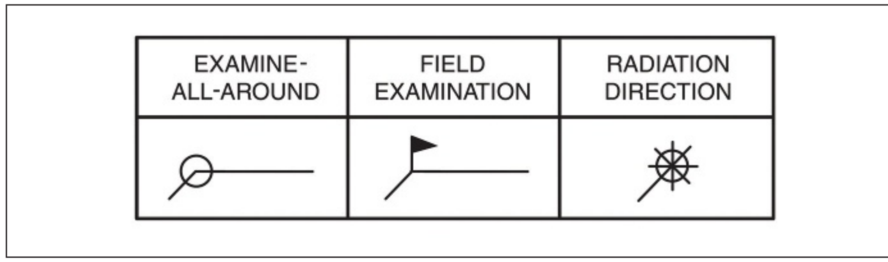


Fig. 2 — Supplementary nondestructive examination symbols.

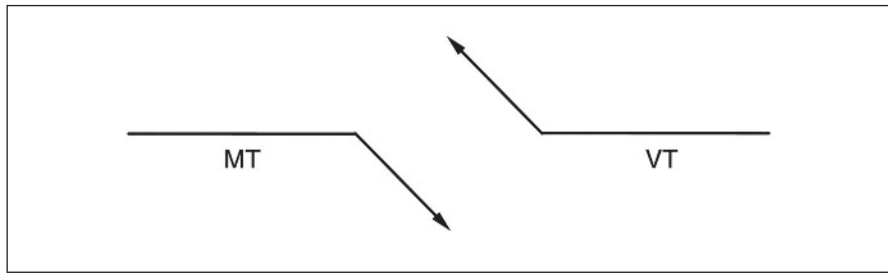


Fig. 3 — NDE on the arrow side of the member.

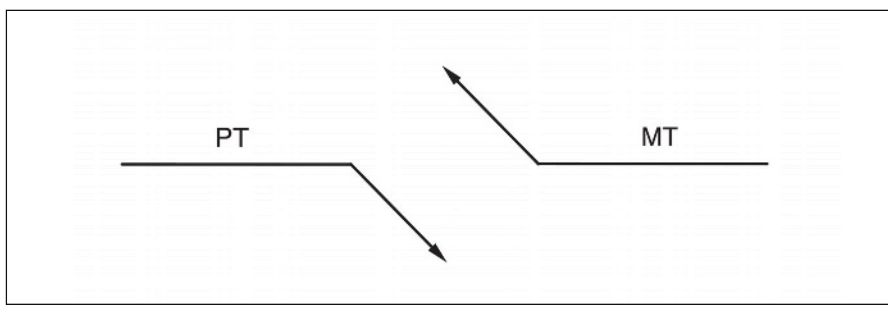


Fig. 4 — NDE on the other side of the member.

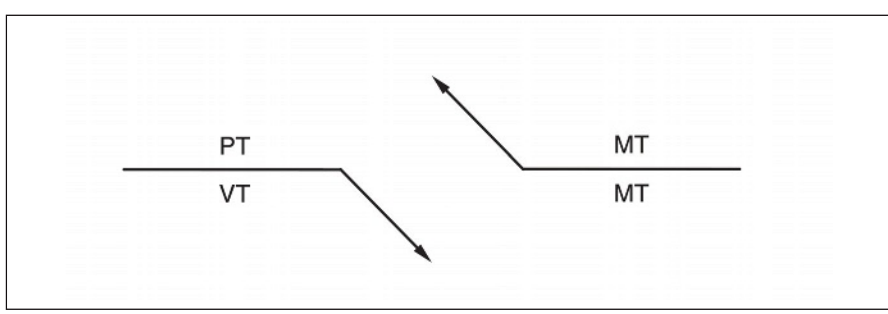


Fig. 5 — NDE on both sides of the member.

Supplementary Symbols

Where supplementary symbols are to be used in symbols for nondestructive examination, they are as shown in Fig. 2.

Location Significance of the Elements

The elements of a nondestructive

examination symbol have standard locations with respect to each other, similar to welding symbols. These are described in the following paragraphs.

Placement of the Arrow

The arrow shall connect the reference line to the part to be examined. The side of the part to which the arrow points shall be considered the arrow side. The side opposite the arrow side of the part shall be considered the other side.

Location on the Arrow Side

Examinations to be made on the arrow side of the part are specified by placing the letter designation for the selected examination method below the reference line, as shown in Fig. 3.

Location on the Other Side

Examinations to be made on the other side of the part are specified by placing the letter designation for the selected examination method above the reference line, as illustrated in Fig. 4.

Location on Both Sides

Examinations to be made on both sides of the part are specified by placing the letter designation for the selected examination method on each side of the reference line, as shown in Fig. 5 and applied in Fig. 6.

Location Centered on the Reference Line

When the letter designation has no arrow- or other-side significance, or there is no preference from which side the examination is to be made, the letter designation is centered on the reference line, as shown in Fig. 7. This is typically utilized for those NDE methods that are considered volumetric or can detect subsurface discontinuities (e.g., RT, UT, ET).

Combinations of NDE Methods

More than one nondestructive examination method may be specified for the same part by placing the combined letter designations of the selected examination methods in the appropriate positions relative to the reference line — Fig. 8. Letter designations for two or more examination methods, to be placed on the same side of the reference line or centered on the reference line, shall be separated by a plus sign.

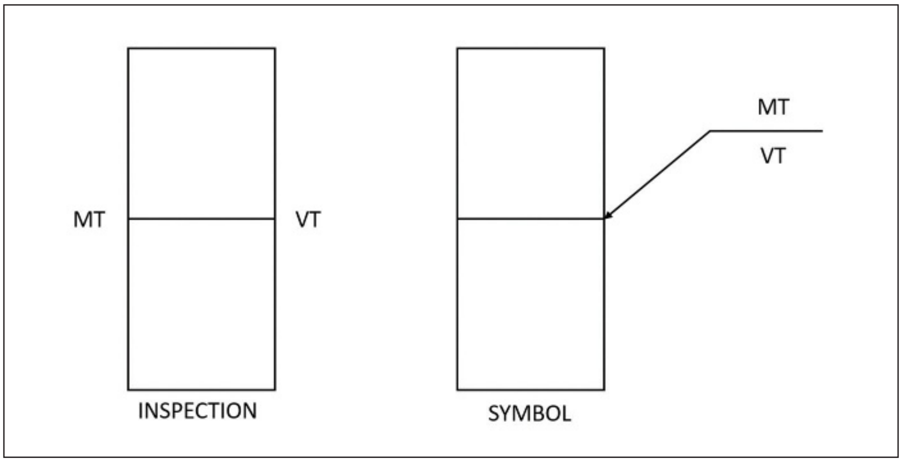


Fig. 6 — Application of NDE symbol to indicate both sides of the member.

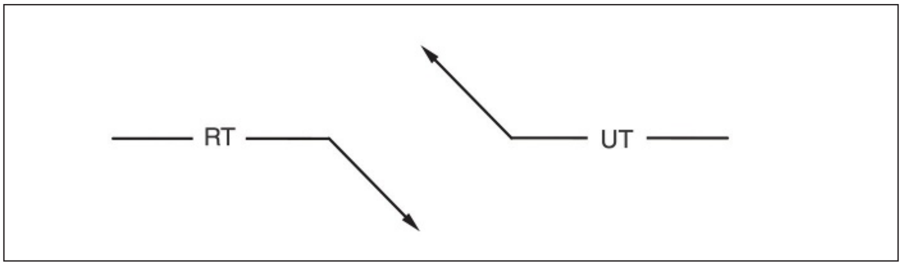


Fig. 7 — NDE methods for which there is no side significance.

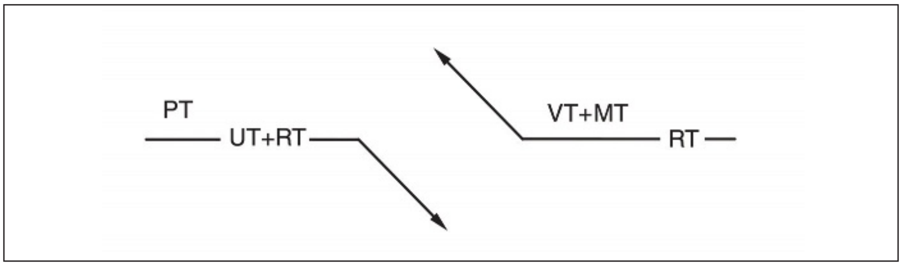


Fig. 8 — Combinations of NDE methods.

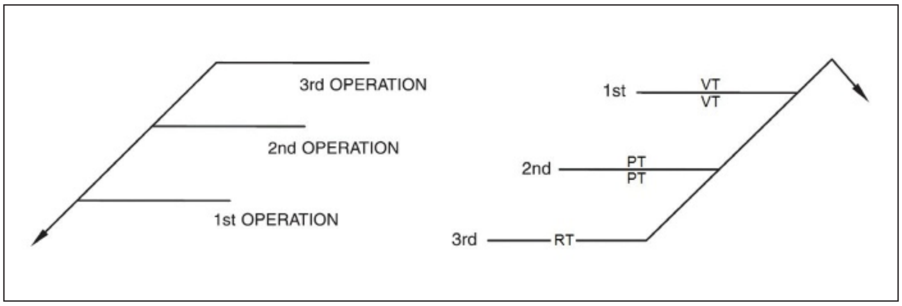


Fig. 9 — Multiple reference lines.

Multiple Reference Lines to Show a Sequence of Operations

Two or more reference lines may be used to indicate a sequence of operations in a manner similar to welding symbols. The first operation is specified on the reference line nearest the arrow, with subsequent operations specified sequentially on additional reference lines — Fig. 9.

Welding and NDE Symbols

Nondestructive examination symbols and welding symbols may be combined to provide clear instructions for all operations, as illustrated in Fig. 10.

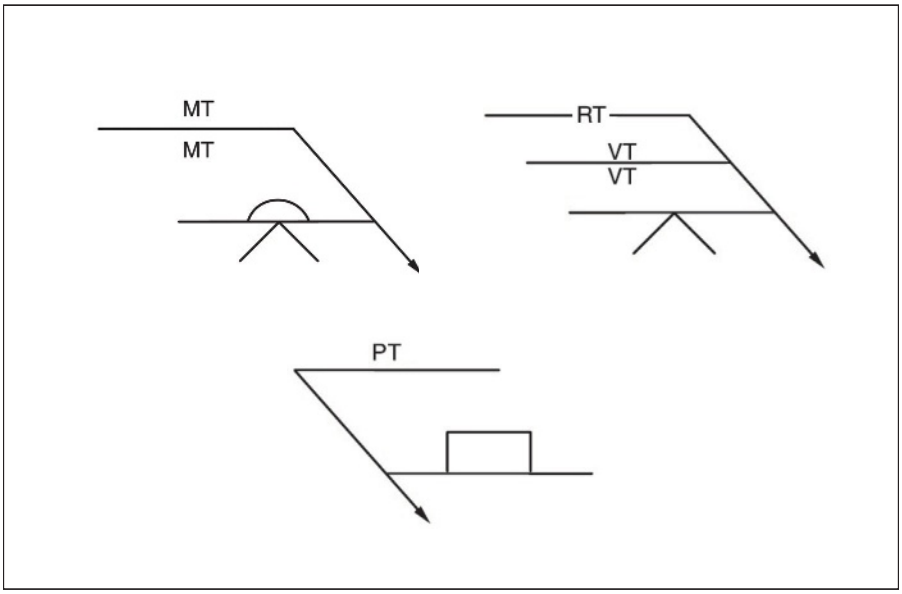


Fig. 10 — Welding and nondestructive examination symbols.

Supplementary NDE Symbols

Examine-All-Around Symbol

Examinations required all around a weld, joint, or part are specified by placing the examine-all-around symbol at the junction of the arrow and reference line, such as in Fig. 11.

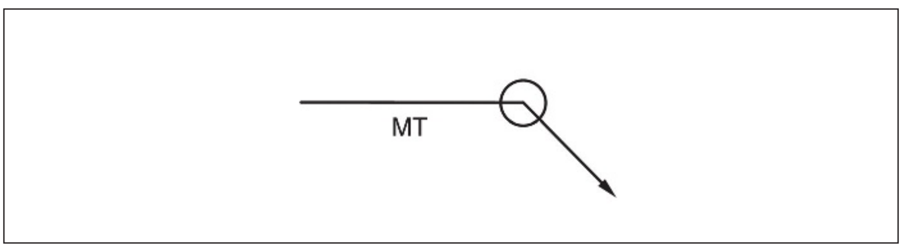


Fig. 11 — Examine-all-around with magnetic particle examination from the arrow side.

Field Examination Symbol

Examinations required to be conducted in the field (not in a shop or at the place of initial construction) are specified by placing the field examination symbol at the junction of the arrow and reference line, as illustrated in Fig. 12.

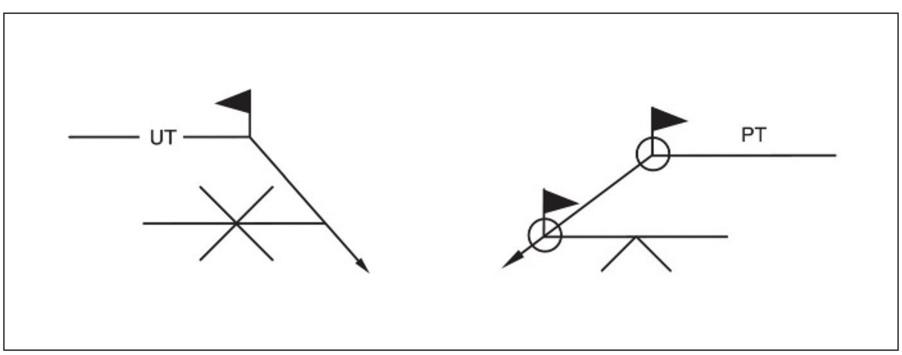


Fig. 12 — Field examine symbols in combination with weld symbols.

Radiation Direction Symbol

The direction of penetrating radiation may be specified by use of the radiation direction symbol drawn at the required angle on the drawing, and the angle indicated, in degrees, to ensure no misunderstanding, as shown in Fig. 13. This could be applied on a drawing when a double-wall-exposure for double-wall-viewing RT shot is to be made, such as an elliptical shot on a pipe circumferential groove weld, as shown in Fig. 14.

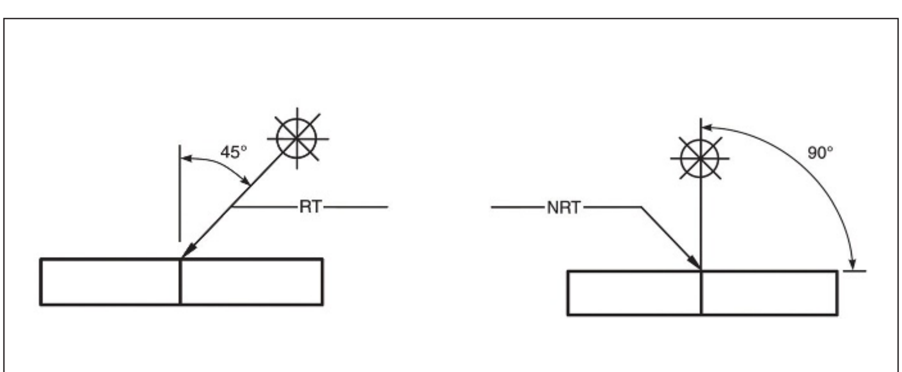


Fig. 13 — Radiation direction.

Specifications, Codes, and References

In a manner similar to welding symbols, information applicable to the examination specified, such as identification of an NDE procedure, and that is not otherwise provided, may be placed in the tail of the symbol for nondestructive examination — Fig. 15.

Extent, Location, and Orientation of NDE Symbols

Specifying the Length of the Weld or Section to be Examined

To specify the examination of welds or parts where only a portion of the length of the weld or section is to be considered, the length dimension is placed to the right of the letter designation, as illustrated in Fig. 16. Dimensions on symbols do not include the unit (U.S. Customary or SI). Dimensions utilize the same primary system of measurement that is standard for the drawing, similar to units on welding symbols.

Location Shown

To specify the exact location of a section to be examined as well as the length, dimension lines are used, as shown in Fig. 17. While the symbols shown are perfectly acceptable symbols for nondestructive examination, they defy a logic about their application. These symbols for NDE identify the exact location where magnetic particle examinations are to be performed; thus the welder is aware of this prior to welding.

Codes such as ASME B31.3, *Process Piping Code,* specify minimum requirements for random or spot examination. For Normal Fluid Service piping systems, this code requires a minimum of 5% of circumferential groove welds are to be examined fully by random radiographic or ultrasonic examination (Ref. ASME B31.3-2016, paragraph 341.4.1(b)(1)). One of the purposes in this requirement is to inform welders that a percentage of their welds will be examined, but the welder is not aware of which welds (or portions of welds) will be examined.

Full-Length Examination

When the full length of a part is to be examined, no length dimension or percentage dimension needs to be included in the nondestructive examination symbol, such as shown in Fig. 18.

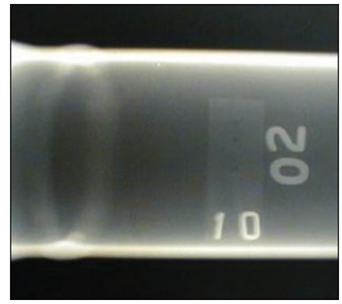


Fig. 14 — Elliptical radiographic image of a circumferential groove weld on a pipe.

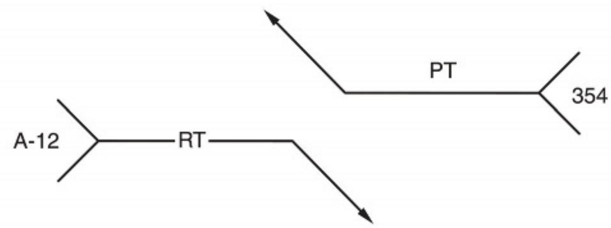


Fig. 15 — Use of the tail to identify additional information.

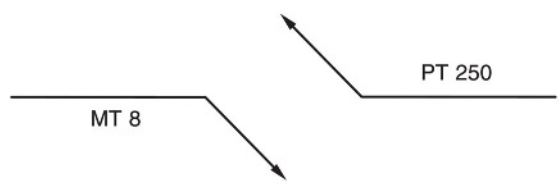


Fig. 16 — Length of section to be examined.

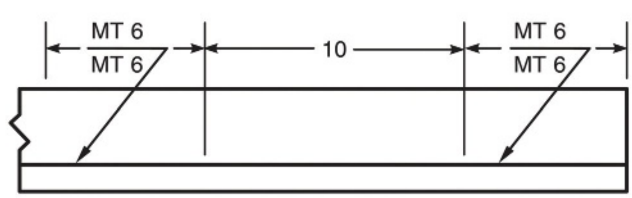


Fig. 17 — Exact location to be examined.

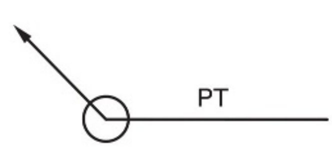


Fig. 18 — Full-length penetrant examination required.

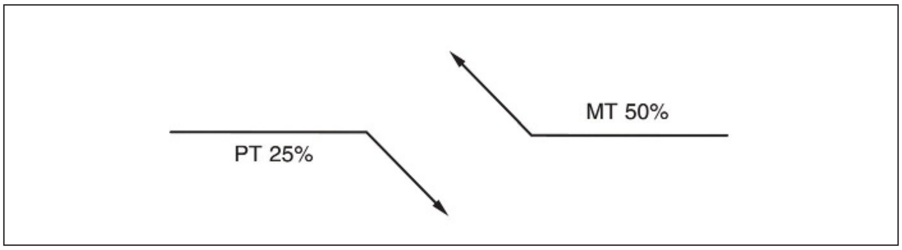


Fig. 19 — Partial examination.

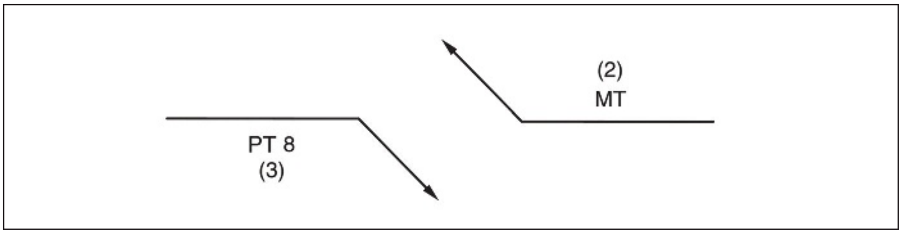


Fig. 20 — Number of examinations.

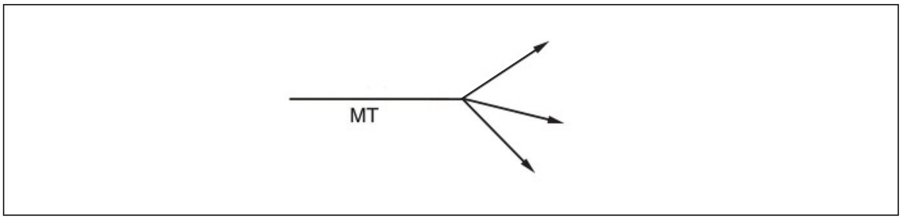


Fig. 21 — Specific locations using multiple arrows.

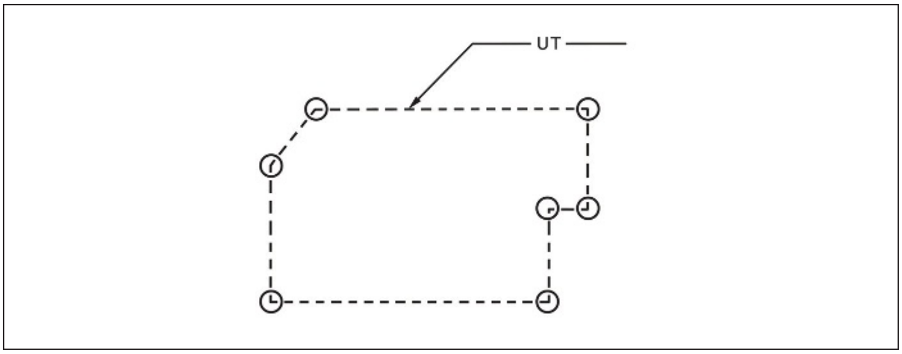


Fig. 22 — NDE of plane areas.

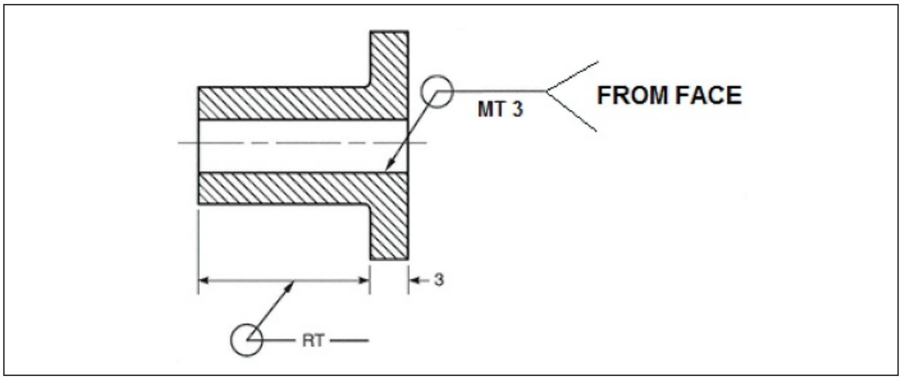


Fig. 23 —NDE of areas of revolution.

Partial Examination

When less than 100% of the length of a weld or part is to be examined, the length to be examined is specified by placing the appropriate percentage to the right of the letter designation — Fig. 19.

Number of Examinations

Random Locations

To specify a number of examinations to be conducted on a joint or part at random locations, the number of required examinations shall be placed in parentheses either above or below the letter designation away from the reference line. Figure 20 illustrates the number of examinations, and for the penetrant examination example shown on the left also identifies the length of weld to be examined at each location.

Specific Locations

Where specific locations are required, separate symbols may be used. Alternatively, additional arrows may be added to the reference line to identify the examination locations, as shown in Fig. 21.

Examination of Areas

The nondestructive examination of areas may be specified by one of the following methods.

Plane Areas

To specify the nondestructive examination of an area represented as a plane on the drawing, the area to be examined is enclosed by straight, broken lines with a circle at each change in direction. The letter designations for the nondestructive examinations required are used in conjunction with these lines, as shown in Fig. 22. When necessary, these enclosures shall be located by coordinate dimensions.

Areas of Revolution

For nondestructive examination of areas of revolution, the area is specified by the examine-all-around symbol and the appropriate dimensions. The illustration in Fig. 23 specifies the following:

1. Magnetic particle examination of the bore of the flange for a distance of 3 in. from the right-hand face, all the way around the circumference.

2. Radiographic examination of a designated area of revolution.

The symbol in Fig. 24 specifies an area of revolution subject to an internal proof examination and an external eddy current examination. As no dimensions are given, the entire length is to be examined.

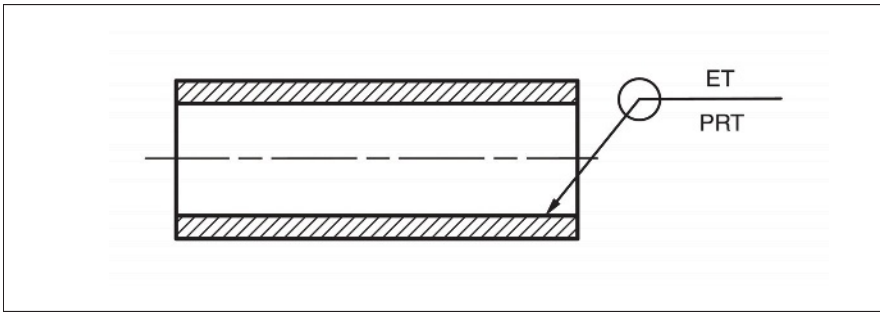


Fig. 24 — NDE of areas of revolution.

Acoustic Emission Examination

Acoustic emission examination (AET) is generally applied to all, or a large portion, of a component, such as a pressure vessel or pipe. The symbol in Fig. 25 represents the application of AET to the component without specific reference to the location of sensors.

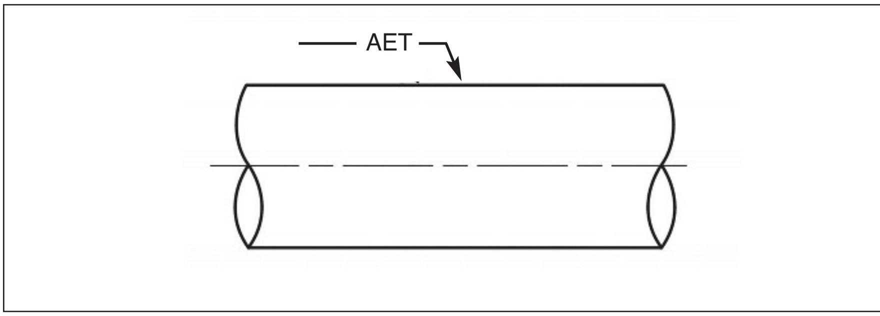


Fig. 25 — Acoustic emission examination.

Summary

This article provided a review of symbols for nondestructive examination. While not used as frequently as welding symbols, these symbols are very powerful and have tremendous applications. This article is part of a series of articles to provide a foundation of basic welding symbol requirements per AWS A2.4. The next article will provide information on symbols for brazing. Final articles will provide a comparison of welding symbols in AWS A2.4 and ISO 2553, *Welding and allied processes — Symbolic representation on drawings — Welded joints*, and typical/common errors or misuse of welding symbols.

J. P. CHRISTEIN (jpc00@verizon.net) *is chair of the AWS A2 Committee on Definitions and Symbols as well as chair of the A2C Subcommittee on Symbols. He is also a member of the AWS Technical Activities Committee.*

RICHARD D. CAMPBELL (rdcampbe@bechtel.com) *is with Bechtel Corp. and has taught AWS CWI seminars for more than 21 years. He also developed a seminar on welding symbols that he teaches for AWS at FABTECH shows and in-house seminars. He is also a member of the AWS D1 Structural Welding Committee.*

Guidelines for Submitting an *Inspection Trends* Feature Article

Have you ever thought about writing a feature article for consideration in Inspection Trends? If so, our staff stays on the lookout for original, noncommercial, practical, and hands-on stories. Take a look at our editorial calendar — available as part of the American Welding Society's Media Kit at aws.org/wj — to see what topics will be highlighted in future issues as well as the editorial deadlines. Potential ideas to focus on could include a case study, recent company project, tips for handling a particular inspection-related activity, and so on.

Here's an easy breakdown of our guidelines:

- The text of the article should be about 1500 to 2000 words and provided in a Word document.
- Line drawings, graphs, and photos should be sent as 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.

If you'd like to discuss a particular idea or e-mail a submission for evaluation, please contact Editor Carlos Guzman at *cguzman@aws.org*.

SPREAD THE WORD

on your company around the world

- Promote your full-color photos of your newest and hottest welding products and services to 80,000 AWS members and customers.
- Reach by email 55,000 AWS members in the digital version of *Welding Marketplace* that is included on the *Welding Journal* announcement letter and also includes active links that send clients directly to your website.
- Downloadable from the AWS website, with active links that send clients directly to your website. Website averages 102,000 plus views a month.
- Ask us how you can get your company photo on the *Welding Marketplace* cover.
- Ask us about our special sponsorship opportunities.
- 4 Issues to get your brand name and product in to the hands of AWS members and customers.

Contact AWS for more information at mediasales@aws.org
Jeff Rhodes at 410-316-9867 · Kim Daniele at 410-316-9862

By Jeffry Strahan

Pipeline Hot Tapping

This necessary pipeline modification and repair method requires the expertise of a CWI at every step to make it safer and meet the standards

Hot tapping is a method used in pipeline repairs, or for attaching a branch outlet to existing pipelines for the purpose of additional service capabilities, without disrupting service. In many cases, the hot tap is done to repair lines and systems damaged or deemed unsafe by inspectors and operators due to anomalies discovered during an in-line inspection (ILI). Hot tapping often creates risky and dangerous situations; however, pipeline operators, contractors, and inspection companies who specialize in the method have acquired enough experience and expertise over the years to accomplish the process safely — Fig. 1. American Welding Society (AWS) Certified Welding Inspectors (CWIs) planning to work in hot tapping should be trained by CWIs experienced in the process to understand the many important steps and safety aspects required.

Hot Tapping and CWIs

Hot tapping can be done with a variety of methods, including split-T fittings, reinforced forgings, sleeves, or specialized fittings. These specialized products must meet strict inspection standards and undergo rigorous material and statistical analysis in their development, from the billet to the final forging, well before being placed in use by tapping contractors.

AWS CWIs play an instrumental role in the visual testing (VT) and nondestructive examination (NDE) of these fittings and devices prior to implementation in the field. Quality assurance of the integrity of these fixtures is mandatory before being placed in pressurized, production situations. CWIs ensure the safety of the operators and the workers who are contracted to complete a hot tapping procedure, but their work starts long before the welding or even before the excavations. The CWI must ensure the fabrication of the components of the particular hot tap follow the exact standards needed to ensure quality, safe completion, and long duration of safe working conditions. Without the experienced, observing eyes of the inspector, substandard materials and workmanship can lead to unsafe conditions.

Common accidents can be traced to improper techniques or material imperfections. The CWI is an essential element in the cycles of the production and implementation of a hot tap and must be involved early in the process to remove any potential threats to safety, environment, or production. Often, production companies and final users of the hot tap product decline to bring a CWI into the process because of the costs associated with having an inspector on site. These costs can be minuscule compared to the costs of repair, replacement, or failure.

Duties of the CWI as the Engineer of Record (EOR) Representative

Before beginning work, the inspection crew should be involved in the ex-

Fig. 1 — Hot tapping allows for a pipeline for be repaired or modified without interrupting service.

amination of the proposed workers and their operator qualification (OQ) status. Workers, including CWIs, must have current OQs that can be demonstrated with field verification reports (FVRs). These reports are issued from the training and registering agencies or an individual production company. Those tapping and contracting employees who will be involved in the work must show their respective operator qualifications are up to date and valid for the work they are going to perform. Rejection of these documents before the work starts can create a sizable delay. CWIs work with their contracted employers to help make this part of the hot tap go quickly and smoothly. A good CWI will often work well ahead of the beginning work date to ensure this sort of interruption does not occur.

A CWI should also be involved in the qualifying of the materials early on to avoid discrepancies after the parts have been manufactured. One example could be an appliance that has been manufactured with a material that does not meet the Charpy impact testing minimums for high-pressure branch work where the appliance must be installed above ground, in an area subject to very low temperatures. Some operating companies require these low-temperature impact values as per their respective safety operating procedure (SOP) manuals. If an essential tapping component is manufactured with a material that does not meet those requirements, a substantial delay can be incurred. An experienced CWI could ensure the requirement would be met, and if the CWI is brought into the early production phase of that process, most delays could be averted.

Positive Material Identification

Emphasis on positive material identification (PMI) has become an essential part of the inspector's duty and generally is done at this front load part of the project. More companies are requiring certified chemical identification to ensure the materials specified are the materials supplied. This is also an integral part of the primary steps of the inspection process for tapping projects. Often, tapping parts arrive with documentation that gives the inspector a readout of the fabricating facility's metallurgical makeup of the parts.

A secondary test, usually done onsite, can determine the validity of the supplier's submission. These are done with portable spectroanalyzers that can give a reliable readout of the chemical makeup. Although not as accurate as an in-lab spectroanalyzer, these portable units are used to verify and release the tapping apparatus sent by the contractors to fabrication and installation. Once again, an experienced CWI with a background in metallurgy and an understanding of specifications and standard operating procedures can be an invaluable asset at this stage of the process — Fig. 2.

Fig. 2 — Billet markings on tap segments showing material specifications.

CWI Duties with Documentation

The next step in this detailed process is to be sure the welding procedures are accurate and in order. Once again, it is helpful to receive the welding documentation well before the crews and equipment arrive on site, as this seems to be the area where many delays arise. When contracted to inspect a hot tap, the CWI must begin with getting the welding documentation to check the parameters and personnel. Beginning with the welding procedure specification (WPS) and following through to the procedure qualification record (PQR), the contracted company that is hired to do the installation welding must produce these to the EOR or his or her designated representative — usually a CWI.

Once these documents have been examined and determined to be accurate and proper for the operation, the attention then turns to the welding personnel. The welders must be qualified to the proper procedures and have the appropriate welder qualification record (WQR).

Welding rod must also be inventoried and documented by size, type, brand, date opened, and hours since opened, for the welding consumable to be monitored and verified when used. Welding rod supply companies must supply manufacturer technical reports (MTRs) to the contractor and the EOR's representative for the welding rod used to be adequately documented before the welding operations. These MTRs must be determined by the actual lot number on the cans and not by the general MTRs given by the local supplier. The document presented by the supplier is usually only an electrode-type MTR and too general to be considered for hot tap work. The chemistry of the actual lot must be determined and documented.

Depending on the diameter of the pipe and the particular company specifications, in many cases at least two welders are needed to be qualified and on site to do the job. Most companies require two welders to work in unison on a weld on opposite sides of the workpiece. This is done so that thermal input is balanced and does not create undue stress and heat issues with the mainline pipe or the hot tap appliance. It is good practice to always have a third qualified welder on site to serve as a backup because the operation requires at least two welders at the same time.

The welding procedures and the welders qualified to that procedure are covered in Appendix B of American Petroleum Institute (API) Standard 1104, *Standard for Welding Pipelines and Related Facilities*. There is also API RP 2201, *Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries,* which gives specific guidelines when conducting a hot tap procedure. Depending upon the particular type of tapping project to be done, the welders must be tested to API 1104 Appendix B "In Service" testing, which involves conducting the welding while a simulated product media is flowing through the test pipe setup — Fig. 3. Most often, this is water or oil flowing at a specified volume-per-time unit through the test setup, and is flowing continuously to simulate a product that removes the heat input from the welding process. The detrimental effect of heat removal in this way can have severe effects on the integrity of the completed weld. If heat input is lost too rapidly, the resulting weld will contain an elevated hardness, which can cause weld failures at pressure. If the heat input is too high, the possibility of pipe wall failure can occur and have catastrophic results. It is for these reasons that an experienced and attentive CWI should be employed in the tapping process. CWIs who have been trained in welding heat input calculations, voltage and amperage management, metallurgy, and visual weld anomaly recognition are needed to the successful completion of any tapping operation.

Fig. 3 — Welder testing for in-service welding.

Preweld Duties

The first step in a hot tap operation is to locate the exact place on the pipe the tap is to occur. If the tapping is to be done in a plant setting, the exact location must be determined, marked appropriately, and prepared. If the tap is to be executed in the field in a remote location, survey crews can determine the precise location by GPS coordinates and then it be verified and agreed upon by company representatives, NDE personnel, and inspection parties before the actual work can begin. Once this has been done and all parties agree to that location, the crew must sandblast the exact areas to be worked to "near white" conditions, and made ready for the NDE crew to complete its job. Before the sandblasting operation, a visual examination must be done to the entire surface to be blasted to locate any anomaly that might interfere with the location of the tapping work to be done.

NDE personnel must then perform ultrasonic testing (UT) examining the areas on the pipe where the actual welding will be done. This is to make sure the welding heat input occurs on pipe wall that can sustain the high energy input, and the pipe wall contains no discontinuity that has not otherwise been detected. Pipe defects such as laminations, dents or wall thinning, internal porosity, corrosion, or damage can lead to compromises in the process that might curtail the tapping being done in that location. After these essential UT exams are performed, defects can be uncovered that require additional attention and a relocation of the tap to an adjacent location to ensure tap integrity. *Smart pigging* and ILI examinations often miss some of these problems. Any discontinuities within the proposed welding areas for tapping must ultimately be dealt with promptly and made inert to the overall pipeline safety and integrity.

CWI Monitoring of Preheat

Preheating takes place at this point, and the inspector must be satisfied by examination using temperature crayons or temperature pyrometers showing the appropriate preheat temperature has been reached before welding may begin. Depending on the grade of the pipe to be worked, this preheat is crucial to setting the proper metal temperature before the actual welding. The preheat process is also instrumental in driving off any water, water vapor, oil, or grease that may have accumulated on the line or fixture. The presence of these substances can severely degrade the whole process, creating defects in the weld or base pipe material during the welding procedure.

Weld Monitoring by the CWI

When the preheat has been met and the welders have been determined to be qualified, the actual welding can begin. Using precise calculation formulas to determine heat

Fig. 4 — Magnetic particle testing (MT) of completed fillet welds on hot tap split sleeve.

Fig. 5 — Completed hot tap ready for backfill.

input, the welders begin welding under the watchful eyes of the CWI. These calculations use product type, pipe pressure, velocity of product flow, volume of product per time unit for the diameter of pipe involved, amperage, voltage, electrode diameter, and pipe wall thickness as input variables, and let the inspector and the welder know how many inches per minute must be welded for the proper amount of heat input to be applied so that martensite creation is held to zero and enough heat input is generated so the weld material has integrity with an absence of discontinuities. The area where the pipe is to be welded is usually marked off in 1-in. marks so the welder and the inspector can monitor and make sure those calculated values are met; too much heat or too little heat can fail the welding or the overall success of the tap project. While the welding is taking place, the inspector is also continuously monitoring the voltage and amperage of the welding equipment to ensure the target values are being utilized. It is an intensive operation that requires continuous attention by the CWI and the tapping contractor personnel. Quite often, the owner or operator of the pipeline is in continuous contact via phone or computer to assist in the monitoring of the parameters of the process, advising the on-site crew of pressure or velocity fluctuations. These changes can alter the in./min speed that the welders must employ at any given moment. These real-time values are determined and recorded with every welding minute, per welder, per electrode.

NDE of the Completed Welding

Once the necessary welding is completed, the NDE crew conducts penetrant testing (PT) on the girth fillet welds and on the longitudinal welds of the split-T groove welds. Magnetic particle testing (MT) can also be used for these fillet weld examinations at the discretion of the EOR — Fig. 4.

In some cases, the EOR requests the welds be tested using acoustic volumetric methods to ensure the soundness of the girth welds. Weld discontinuities, which may be uncovered in the NDE process, most often involve undercutting, underfill, porosity, or slag inclusion that must be addressed. Typically, welding on hot taps is done by highly skilled individuals with many years of experience and the ability to make multiple, high-quality welds with a minimum of weld blemishes — Fig. 5.

Real-time monitoring occasionally finds issues that must be corrected in process and in-situ. One of the more critical weld problems that arises is undercut. It is critical that any undercut is immediately removed by repair and any discrepancies present must be analyzed to determine how they propagated, then removed and repaired.

Future of Hot Tapping

As the welding and pipeline industries move further into the twenty-first century, the demand for hot tapping will likely increase to keep up with the demands of various other industries. The role of CWIs and other engineering and inspection personnel will continue to expand along with technological research and new equipment being pioneered by a host of suppliers.

JEFFRY STRAHAN is an instructor at Weber State University. He is an AWS CWI, CRI, CWE, and API 1169 CWI. He has a BS and MS from Utah State University, and extensive experience on hot tap projects.

By Lance C. Becker

Standard Operating Procedures as a Single Mechanism for Workforce Development and Quality Control Programs

Well-written procedures can provide a foundation for training and development while also establishing standards and expectations for quality control

An active workforce development program is the prequel to an effective quality control (QC) program. Intimately linked to bottom-line business goals, the two programs coexist to equip employees with the skills to safely and efficiently deliver compliant product output. A formal directive to ensure compliance to processes and standards serves as a guide for welders, supervisors, and inspectors through the intended steps of production and inspection.

In the welding and fabrication industry, operation or inspection checklists are too often a standard approach. Although checklists present critical steps and basic requirements, they lack descriptive direction and thorough explanation. Without sufficient details, considerations, and marks of successful step or task completion, there is no tool or mechanism to actively engage, train, direct, and refresh the employee through the task. Rather than providing a mechanism for technical training or quality verification, checklist completion becomes merely another routine step in the process.

The Single Mechanism for Workforce Development and Quality Control

By developing and implementing well-written, detailed procedures, in addition to or even in place of checklists, descriptive technical documents become a mechanism for training and workforce development, while establishing standards for weld and product quality. The standard operating procedure (SOP), as industrial and institutional operations commonly term this approach, is used to provide training, workforce development, and a framework for both general and specific technical operations. Trained and engaged employees actively work a procedure outlining a job setup, product verification, task assessment, or an in-process inspection requirement down to the described detail.

Training and Workforce Development

In the workforce development book, *Developing Technical Training*, author Ruth Colvin Clark describes procedures as clearly defined steps written to result in the successful completion of a specific job task, also noting that the largest proportion of all workforce training and development is procedurally based (Ref. 1). When properly prepared, these documents provide welders, supervisors, and inspectors with an unambiguous objective-driven instructional set containing the technical details of steps involved with proper job setup, quality checks, safety precautions, and other pertinent information. A training and workforce development program is established and attained as welders and supervisors use the SOP to learn to work the details.

Quality Control

Through code compliance and project specifications, the welding industry is experiencing increased demand for the implementation and streamlining of inspection directly into welding production operations and processes. The American Welding Society (AWS) instructional book, *Welding Inspection Technology*, states that in any effective QC program, visual testing (VT) provides the basic element for evaluation of the structures or components being fabricated (Ref. 2). The VT process, which includes many steps before, during, and after welding, provides an excellent subject for the SOP. See the sidebar for a summary of an SOP for VT.

A general SOP for VT suffices for mass-produced or similar product output work. However, in custom jobs, as manufacturing engineers, designers, and QC personnel specify details such as production materials, joint geometry, interpass temperature requirements, and other welding variables, the preparation of a job-specific SOP for VT can establish a framework and descriptive details for inspection requirements. The SOP can serve, in either case, as official post-project QC documentation.

Using the SOP to Meet the Demands of the Welding Industry

The demand for the welding industry, including job shops, production plants, contractors, and various other services, to implement both a workforce development and a QC/VT program is undeniably present. Although the basis for this need is wide, the industry is seeing two primary causes for the surge in demand: costly rework and code conformance. Well-written, detailed SOPs can serve as the mechanism to address these demands.

The SOP to Address Costly Rework and Establish Code Compliance

First, the return-on-investment, or profit, of a welding project is adversely affected by weld discontinuities, defects, and other improper output. Expensive rework and costly repairs must be performed prior to the product being commissioned and put into service. AWS *Welding Inspection Technology* notes that, through VT, an effective QC program "will result in the discovery of the vast majority of those defects which would be found later using some other more expensive nondestructive test method." With an SOP to provide detailed instructions and requirements for an active VT program, these costly repairs can be controlled. Trained and engaged supervisors and welders, with an SOP to work from, will observe and correct potential discontinuities and defects before the finished products are compromised.

Second, the return-on-investment for high-end welding projects in industrial markets is extremely lucrative. High-end project specifications require welding production plants and contractors to be compliant to rigorous formal standards. Detail-oriented standards found in codes created by organizations such as the American Institute for Steel Construction (AISC), American Society of Mechanical Engineers (ASME), American Petroleum Institute (API), and others, require the employment, documentation, and successful third-party auditing of detailed workforce development and QC practices. Although these codes present very complex requirements, the contracts for such projects are among the most financially rewarding in the welding industry. Standard operating procedure documents provide company-specific conformance to many of these requirements.

Summary of Operating Procedures for Visual Testing (VT) — Responsibilities before, during, and after Welding and Fabrication Work

1. VT Responsibilities before Welding and Fabrication Work

- Review project drawings and specifications
- Check purchase order specifications
- Verify job materials
- Verify chemical analysis and mechanical properties test reports
- Investigate for base metal defects
- Check for proper filler metal and condition of storage and filler metals
- Check welding equipment
- Check weld joint edge geometry
- Check weld joint fit
- Check weld joint cleanliness
- Welder qualification check
- Check preheat temperature requirements

2. VT Responsibilities during Welding and Fabrication Work

- Check production welding for compliance with welding procedure
- Check the quality of individual weld passes
- Check interpass cleaning
- Check Interpass temperature
- Complete in-process nondestructive examination (NDE)

3. VT Responsibilities after Welding and Fabrication Work

- Check final weld appearance
- Check final weld sizes and lengths
- Check dimensional accuracy of completed weldment
- Select production test samples
- Evaluate test results
- Complete final NDE requirements
- Maintain records and reports in project quality control documents

Planning for SOP Development

There is not a mandatory approach to creating SOPs. Plants or contractors with a sufficient budget may contract the process out to technical writing specialists while assigning an in-house subject matter expert (SME) to contribute or oversee. Large operations with dedicated workforce development and QC departments may assign communications personnel with an SME to prepare SOP.

Smaller shops may appoint an in-house supervisor or inspector with the assignment of documenting task steps and writing instructions. A writer or editor may make these steps and instructions into procedures. However, whichever approach the company may pursue, be forewarned that the SOP is a direct reflection on the quality of the work you do.

Preparing SOP Documents

A well-written SOP should read like a set of instructions. Always sequential, the SOP should move from first to

The standard operating procedure (SOP) is used to provide training, workforce development, and a framework for both general and specific technical operations. Trained and engaged employees actively work a procedure outlining a job setup, product verification, task assessment, or an in-process inspection requirement down to the described detail.

last. An employee should be able to follow the SOP from the beginning to the end of the step or task.

Each sentence should reflect a step. Start each sentence/step with an action verb, directing the action of the SOP user. Write only one action, or instruction, for each step. After the step, include precise, specific details such as technical information (dimensions, sizes, arrangements) and any necessary explanations (distinguishing criteria, locations, placements).

Explanations are extensions of the steps. They may be presented as substeps, numbered or lettered, or appear in italicized text. However, explanations should always follow the step to which they pertain.

Graphics, such as photographs, illustrations, or technical drawings, may accompany SOPs. Actual photographs of the task or equipment involved in the task may prove very helpful. In the multimedia mode of presentation, videos of successful step or task completion may accompany the SOP. Use complete sentences, avoid the omission of articles (for example, *a*, *an*, and *the*), and follow standard grammar.

Presenting SOP Tasks/Manuals

Standard operating procedure task sheets or manuals should be presented in training rooms or at orientations. The same SOP should be available in workstations or in close proximity to the welder or fabricator. An SOP created for receiving or shipping materials should be located in the same way. Posting the SOP in a glass-bound bulletin board, where employees must walk halfway across the plant to access them, is not the best practice.

A competent person should serve as a controller or director of SOP documents. Responsibilities of this role should include the maintenance of a complete operations manual, which should contain every SOP for every outlined task. The director of SOP documents must ensure that all copies, including all workstation task sheets and supervisor manuals, are updated at every SOP revision, change, or removal.

For internet or intranet versions of the SOP, it is critical that the narratives and presentations are precise matches to shop or field paper copies. When online media is the preferred resource in the shop or field, it should be in close proximity to the welder or fabricator. Even the online SOP must be readily available from pretask analysis through completion.

The physical presentation of the task sheet or manual should be durable and fit for the conditions of use. Often, single page or single task copies are laminated to withstand shop conditions. Covers and bindings can also preserve the life of shop manuals.

Evaluating SOP Content and Effectiveness

There are many ways to evaluate the SOP content and effectiveness. By involving QC personnel, SMEs, welders, and other employees, the process can foster collaboration and employee buy-in. Simple usability testing engages employees with the SOP. In turn, these employees provide feedback and input. Other processes involve field tests, which may be used to evaluate and revise the SOP.

Technical Writing for Success, by Darlene Smith-Worthington and Sue Jefferson, identifies two field tests to evaluate the clarity, wording, and step sequence of SOPs (Ref. 3). Concurrent testing evaluates an SOP while it is being used. During step or task completion, employees are observed performing the instructions. Variables such as accuracy, speed, recall, and attitude can be monitored. In retrospective testing, the subjects complete the task first and then answer questions about the SOP and the task. Surveys, questionnaires, and other tests are used in this method.

Conclusion

Developing, implementing, revising, and maintaining SOPs doesn't come without a dedicated effort. However, this method for addressing training, workforce development, and QC serves as both an efficient and effective mechanism for the two business development needs. The SOP, when properly developed, provides detailed, descriptive instructions for welders, supervisors, and inspectors to engage steps and tasks safely and effectively, while establishing standards for quality verification and inspection.

References

1. Clark, R. C. 2008. *Developing Technical Training*. New York, N.Y.: Wiley.
2. *Welding Inspection Technology*. 2008. American Welding Society, Miami, Fla.
3. Smith-Worthington, D., and Jefferson, S. 2011. *Technical Writing for Success*. Nashville, Tenn.: South-Western Publishing.

LANCE C. BECKER
(lancebecker@illinoiscrane.com) *is a technical writing graduate student from Louisiana Tech University, Ruston, La., an engineer at Illinois Crane Inc., Chicago, Ill., and an AWS Certified Welding Supervisor (CWS).*

Errata

NAVSEA B2.1

The following Erratum has been identified and will be incorporated into the next reprinting of the following documents.

AWS-NAVSEA B2.1-1-311:2018, *Standard Welding Procedure Specification for Naval Applications (SWPS-N) for Gas Tungsten Arc Welding of Carbon Steel (S-1), ⅛ inch [3 mm] through 1-½ inch [38 mm] Thick, MIL-70S-2, in the As-Welded or PWHT Condition, Primarily Pipe for Naval Applications*. Page 12, Joint 6, note 6: Replace "The provisions of note 3" with "The provisions of note 4."

AWS-NAVSEA B2.1-1-312:2015, *Standard Welding Procedure Specification for Naval Applications (SWPS-N) for Shielded Metal Arc Welding of Carbon Steel (S-1), ⅛ inch [3 mm] through 1-½ inch [38 mm] Thick, MIL-7018-M, in the As-Welded or PWHT Condition, Primarily Pipe for Naval Applications*. Page 10, Joint 5, note 6: Replace "The provisions of note 3" with "The provisions of note 4."

AWS-NAVSEA B2.1-1-316:2018, *Standard Welding Procedure Specification for Naval Applications (SWPS-N) for Argon Plus 2% Oxygen Shielded Gas Metal Arc Welding (Spray Transfer Mode) of Carbon Steel (S-1), ⅛ inch [3 mm] through 1-½ inch [38 mm] Thick, MIL-70S-3, in the As-Welded or PWHT Condition, Primarily Pipe for Naval Applications*. Page 11, Joint 5, note 6: Replace "The provisions of note 3" with "The provisions of note 4."

AWS-NAVSEA B2.1-1-317:2018, *Standard Welding Procedure Specification for Naval Applications (SWPS-N) for 75% Argon Plus 25% Carbon Dioxide Shielded Flux Cored Arc Welding of Carbon Steel (S-1), ⅛ inch [3 mm] through 1-½ inch [38 mm] Thick, MIL-70T-1 and MIL-71T-1, in the As-Welded or PWHTCondition, Primarily Pipe for Naval Applications*. Page 11, Joint 5, note 6: Replace "The provisions of note 3" with "The provisions of note 4."

AWS-NAVSEA B2.1-8-318:2016, *Standard Welding Procedure Specification for Naval Applications (SWPS-N) for Gas Tungsten Arc Welding of Austenitic Stainless Steel (S-8), ⅛ inch [3 mm] through 1-½ inch [38 mm] Thick, MIL-3XX, in the As-Welded Condition, Primarily Pipe for Naval Applications*. Page 11, Joint 6, note 6: Replace "The provisions of note 3" with "The provisions of note 4."

AWS-NAVSEA B2.1-8-319:2018, *Standard Welding Procedure Specification for Naval Applications (SWPS-N) for Shielded Metal Arc Welding of Austenitic Stainless Steel (S-8), ⅛ inch [3 mm] through 1-½ inch [38 mm] Thick, MIL-3XX-XX, in the As-Welded Condition, Primarily Pipe for Naval Applications*. Page 10, Joint 5, note 6: Replace "The provisions of note 3" with "The provisions of note 4."

AWS MEMBERSHIP APPLICATION

Join or Renew: **Mail:** Form with your payment, to AWS **Call:** Membership Department at (800) 443-9353, ext. 480
Fax: Completed form to (305) 443-5647 **Online:** www.aws.org/membership

American Welding Society
8669 NW 36 St, # 130
Miami, FL 33166-6672
Telephone (800) 443-9353
FAX (305) 443-5647
Visit our website: www.aws.org

CONTACT INFORMATION

❑ New Member ❑ Renewal

❑ Mr. ❑ Ms. ❑ Mrs. ❑ Dr. Please print • Duplicate this page as needed

Last Name:______________________________

First Name:______________________________ M.I:________

Birthdate:________________ E-Mail:________________

Cell Phone (   )________________ Secondary Phone (   )________________

Were you ever an AWS Member? ❑ YES ❑ NO If "YES," give year________ and Member #:________________

Company (if applicable):______________________________

Mailing Address:______________________________

____

City:________________ State/Province:________________

Zip/PostalCode:________________ Country:________________

❶ Who pays your dues?: ❑ Company ❑ Self-paid ❷ Sex: ❑ Male ❑ Female
❸ Education level: ❑ High school diploma ❑ Associate's ❑ Bachelor's ❑ Master's ❑ Doctoral

❑ Check here if you learned of the Society through an AWS Member? Member's name:________________ Member's # (if known):________

❑ Check here if you would prefer not to receive email updates on AWS programs, new Member benefits, savings opportunities and events.

INDIVIDUAL MEMBERSHIP

➔ Please check each box that applies to the Membership or service you'd like, and then add the cost together to get your Total Payment.

❑ **AWS INDIVIDUAL MEMBERSHIP (One Year)**..$88

❑ **AWS INDIVIDUAL MEMBERSHIP (Two Years) SAVE $25** *New Members Only*........................$151

❑ New Member Initiation Fee..$12

OPTIONS AVAILABLE TO AWS INDIVIDUAL MEMBERS ONLY:

A.) OPTIONAL **Book Selection** (Choose from 12+ titles; up to a $192 value; includes shipping & handling)

❑ Individual Members in the U.S..$35

❑ Individual Members outside the U.S (includes International shipping)..$85

ONLY ONE SELECTION PLEASE. **For more book choices visit https://app.aws.org/membership/books**

❑ *Jefferson's Welding Encyc.*(CD-ROM only) ❑ *Welding Metallurgy* ❑ *Welding Inspection Handbook*

Welding Handbook Selections: ❑ *WHB* (9th Ed., Vol. 5) ❑ *WHB* (9th Ed., Vol. 4) ❑ *WHB* (9th Ed., Vol. 3) ❑ *WHB* (9th Ed., Vol. 2) ❑ *WH* (9th Ed., Vol. 1)

B.) OPTIONAL ***Welding Journal* Hard Copy** (for Members outside North America)

❑ Individual Members outside North America (note: electronic delivery of WJ is standard)..$50

INDIVIDUAL MEMBERSHIP TOTAL PAYMENT..$____________

NOTE: Dues include $17.30 for *Welding Journal* subscription and $4.00 for the AWS Foundation.

STUDENT MEMBERSHIP

❑ **AWS STUDENT MEMBERSHIP (with digital *Welding Journal* magazine)**..$15

❑ **AWS STUDENT MEMBERSHIP (with hard copy *Welding Journal* magazine)**..$35

Option available only to students in U.S., Canada & Mexico.

PAYMENT INFORMATION

Payment can be made (in U.S. dollars) by check or money order (international or foreign), payable to the American Welding Society, or by credit card.

❑ Check ❑ Money Order ❑ AMEX ❑ Diners Club ❑ MasterCard ❑ Visa ❑ Discover ❑ Other

CC#:__________ / __________ / __________ / __________ Expiration Date (mm/yy) ________ / ________

Signature of Applicant:______________________________ Application Date:________________

OFFICE USE ONLY Check #:________________ Account #________________

Source Code: IT Date:________________ Amount:________________

REV. 11/18

Type of Business (Check ONE only)

A ❑ Contract construction
B ❑ Chemicals & allied products
C ❑ Petroleum & coal industries
D ❑ Primary metal industries
E ❑ Fabricated metal products
F ❑ Machinery except elect. (incl. gas welding)
G ❑ Electrical equip., supplies, electrodes
H ❑ Transportation equip. — air, aerospace
I ❑ Transportation equip. — automotive
J ❑ Transportation equip. — boats, ships
K ❑ Transportation equip. — railroad
L ❑ Utilities
M ❑ Welding distributors & retail trade
N ❑ Misc. repair services (incl. welding shops)
O ❑ Educational Services (univ., libraries, schools)
P ❑ Engineering & architectural services (incl. assns.)
Q ❑ Misc. business services (incl. commercial labs)
R ❑ Government (federal, state, local)
S ❑ Other

Job Classification (Check ONE only)

01 ❑ President, owner, partner, officer
02 ❑ Manager, director, superintendent (or assistant)
03 ❑ Sales
04 ❑ Purchasing
05 ❑ Engineer — welding
20 ❑ Engineer — design
21 ❑ Engineer — manufacturing
06 ❑ Engineer — other
10 ❑ Architect designer
12 ❑ Metallurgist
13 ❑ Research & development
22 ❑ Quality control
07 ❑ Inspector, tester
08 ❑ Supervisor, foreman
14 ❑ Technician
09 ❑ Welder, welding or cutting operator
11 ❑ Consultant
15 ❑ Educator
17 ❑ Librarian
16 ❑ Student
18 ❑ Customer Service
19 ❑ Other

Technical Interests (Check all that apply)

A ❑ Ferrous metals
B ❑ Aluminum
C ❑ Nonferrous metals except aluminum
D ❑ Advanced materials/Intermetallics
E ❑ Ceramics
F ❑ High energy beam processes
G ❑ Arc welding
H ❑ Brazing and soldering
I ❑ Resistance welding
J ❑ Thermal spray
K ❑ Cutting
L ❑ NDT
M ❑ Safety and health
N ❑ Bending and shearing
O ❑ Roll forming
P ❑ Stamping and punching
Q ❑ Aerospace
R ❑ Automotive
S ❑ Machinery
T ❑ Marine
U ❑ Piping and tubing
V ❑ Pressure vessels and tanks
W ❑ Sheet metal
X ❑ Structures
Y ❑ Other
Z ❑ Automation
1 ❑ Robotics
2 ❑ Computerization of Welding

ASNT Research Symposium

April 1–4. Hyatt Regency Orange County, Garden Grove, Calif. The theme for the 2019 Research Symposium is “Advancing NDE Technologies, Research and Engineering in a Changing World.” It aims to address key research, development, and innovation of advancing NDE technologies as well as bridge gaps in NDE research, engineering, and technology transfer. Visit *asnt.org*.

ASNT NDT of Composites

April 30–May 2. Motif Seattle, Seattle, Wash. Focusing on the ever-expanding use of composite materials across several industries, this conference will feature presentations, short courses, and an exhibit floor featuring the latest in products and services. This program will provide the opportunity for information exchange on advances in composite NDT technology, NDT of new product forms, in-process NDT, and NDT of composites used in commercial, military, subsurface, and space applications. Visit *asnt.org*.

AMPM2019 Additive Manufacturing with Powder Metallurgy

June 23–26. Sheraton Grand, Phoenix, Ariz. This event brings together industry professionals and decision makers from around the world to network and learn from each other about the latest developments and innovations in metal powder technology. The conferences address powder metallurgy parts and products, metal injection molding, and metal additive manufacturing. Visit *ampm2019.org*.

Educational Opportunities

ASME Section IX Seminar

Learn how to use ASME Section IX quickly and cost effectively. This three-day ASME-sponsored course is scheduled for the following dates and locations: Portland, Ore., April 8–10, and Houston, Tex., June 10–12. Contact Marion Hess, *hessm@asme.org*, (212) 591-7161, or register at *asme.org/products/courses/bpv-code-section-ix-welding-brazing-fusing*.

The Atlas of Welding Procedure Specifications

The AWS Connecticut Section is hosting a three-day seminar/workshop on developing welding procedure specifications, procedure qualification records, and welder qualification records. This event, scheduled for March 25–27 in Simsbury, Conn., will provide instruction and the rationale for developing qualified and prequalified welding procedures that meet AWS and ASME standards. In-class exercises cover the process of writing prequalified WPSs and the mechanics of qualifying WPSs by testing. The welding documents

developed are applicable to AWS, ASME, NAVSEA, and other military standards, and commercial welding standards. Contact Albert Moore, workshop leader, for more information at *amoore999@comcast.net*.

AWS Online CWI Pre-Seminar

The online CWI Pre-Seminar covers fundamental concepts and principles frequently used by CWIs. The ten-course program has been thoughtfully engineered to provide a strong foundation for those who are preparing to take the CWI exam or as a refresher for accomplished CWIs in need of professional development hours (PDHs). Visit *aws.org*.

CWI Exam Prep Course

American Institute of Nondestructive Testing offers a 40-h online CWI exam prep course. Part A covers the fundamentals of welding technology; part B consists of extensive practical hands-on techniques and will be held at the Houston Marriott North in Houston, Tex.; and part C provides in-depth training to the welding code portion of the exam. Contact Jeff LeTourneau, *instructor@trainingndt.com*, (855) 313-0325, or visit *trainingndt.com*.

CWI/CWS Inspector Training

Welder Training & Testing Institute is hosting the following endorsement and CWI/CWS prep course seminars: ASME Section IX/B31.1/B31.3: May 9, 10; Aug. 1, 2; and Nov. 21, 22; D1.1/D1.5/API Endorsement: May 16, Aug. 8, and Dec. 5; CWI: May 13–18, Aug. 5–10, and Dec. 2–7; CWS: March 4–8 and Sept. 16–20. To register, go to *wtti.com*.

CPCC NDE Continuing Education Courses

Central Piedmont Community College presents the following 2019 spring courses: Online: Introduction to NDE, Jan. 14–May 10; NDE Visual Testing Level I & II, Jan. 14–May 10. Classroom: Level I & II Penetrant Testing, March 18–April 1; Ultrasonic Testing Level 2, March 18–April 24. To register, visit *cpcc.edu/cce/register-now*.

CWB Online/Classroom Courses

Courses in NDE disciplines to meet certifications to Canadian General Standards Board or Canadian Nuclear Safety Commission. The Canadian Welding Bureau; (800) 844-6790; *cwbgroup.org*; *info@cwbgroup.org*.

CWI/CWE Course and Exam

A ten-day program presented in Troy, Ohio. Contact Hobart Institute of Welding Technology, (800) 332-9448; *hiwt@welding.org; welding.org*.

E-Courses in Destructive and Nondestructive Testing of Welds and Other Welding-Related Topics

Online video courses taken at one's own pace offer certificates of completion and continuing education units. Hobart Institute of Welding Technology, (800) 332-9448; *welding.org/product-category/online-courses/*.

Certification Schedule

Note: The 2019 schedule for all certifications is posted online at *aws.org/w/a/registrations/prices_schedules.html.*

Certified Welding Inspector (CWI)

Location	Seminar Dates	Exam Date
Orlando, FL	Feb. 17–22	Feb. 23
Seattle, WA	Feb. 17–22	Feb. 23
New Orleans, LA	Feb. 24–March 1	March 2
San Diego, CA	Feb. 24–March 1	March 2
Atlanta, GA	March 3–8	March 9
Salt Lake City, UT	March 10–15	March 16
Annapolis, MD	March 10–15	March 16
Houston, TX	March 10–15	March 16
Chicago, IL	March 17–22	March 23
Phoenix, AZ	March 17–22	March 23
Boston, MA	March 24–29	March 30
Portland, OR	March 24–29	March 30
Miami, FL	March 31–April 5	April 6
Minneapolis, MN	March 31–April 5	April 6
Dallas, TX	April 7–12	April 13
Las Vegas, NV	April 7–12	April 13
Bakersfield, CA	April 28–May 3	May 4
St. Louis, MO	April 28–May 3	May 4
Baton Rouge, LA	May 5–10	May 11
Detroit, MI	May 5–10	May 11
Denver, CO	May 19–24	May 25
Nashville, TN	May 19–24	May 25
Birmingham, AL	June 2–7	June 8
Kansas City, MO	June 2–7	June 8
Pittsburgh, PA	June 9–14	June 15
Spokane, WA	June 9–14	June 15
Beaumont, TX	June 16–21	June 22
Hartford, CT	June 16–21	June 22
Newark, NJ	June 23–28	June 29
Omaha, NE	June 23–28	June 29
Louisville, KY	July 7–12	July 13
Phoenix, AZ	July 7–12	July 13
Norfolk, VA	July 14–19	July 20
Milwaukee, WI	July 21–26	July 27
Orlando, FL	July 21–26	July 27
Cleveland, OH	July 28–Aug. 2	Aug. 3
Los Angeles, CA	July 28–Aug. 2	Aug. 3
Denver, CO	Aug. 4–9	Aug. 10
Philadelphia, PA	Aug. 4–9	Aug. 10
Chicago, IL	Aug. 11–16	Aug. 17
San Diego, CA	Aug. 11–16	Aug. 17
Salt Lake City, UT	Aug. 11–16	Aug. 17
Charlotte, NC	Aug. 18–23	Aug. 24
Sacramento, CA	Aug. 18–23	Aug. 24
Houston, TX	Aug. 25–30	Aug. 31
Seattle, WA	Aug. 25–30	Aug. 31
Minneapolis, MN	Sept. 8–13	Sept. 14
San Francisco, CA	Sept. 8–13	Sept. 14
Orlando, FL	July 21–26	July 27
Cleveland, OH	July 28–Aug. 2	Aug. 3

9-Year Recertification Seminar for CWI/SCWI

For current CWIs and SCWIs needing to meet education requirements without taking the exam. The exam can be taken at any site listed under Certified Welding Inspector.

Location	Seminar Dates
San Diego, CA	Feb. 17–22
New Orleans, LA	March 10–15
Dallas, TX	March 24–29
Seattle, WA	April 7–12
Denver, CO	May 5–10
Miami, FL	May 19–24
Pittsburgh, PA	June 23–28
Charlotte, NC	July 21–26
Houston, TX	Aug. 4–9

Certified Welding Educator (CWE)

Seminar and exam are given at all sites listed under CWI. Seminar attendees will not attend the Code Clinic portion of the seminar (usually the first two days).

Certified Welding Sales Rep. (CWSR)

Prometric testing centers. More information at *aws.org/certification/detail/certified-welding-sales-representative*.

Certified Welding Supervisor (CWS)

Prometric testing centers. More information at *aws.org/certification/detail/certified-welding-supervisor.*

Certified Radiographic Interpreter (CRI)

The CRI certification can be a stand-alone credential or can exempt you from your next 9-Year Recertification. More information at *aws.org/certification/detail/certified-radiographic-interpreter*.

Location	Seminar Dates	Exam Date
Dallas, TX	April 1–5	April 6
Las Vegas, NV	June 3–7	June 8
Pittsburgh, PA	July 29–Aug. 2	Aug. 3
Houston, TX	Sept. 30–Oct. 4	Oct. 5

Certified Robotic Arc Welding (CRAW)

OTC Daihen Inc., Tipp City, OH; (937) 667-0800, ext. 218
Lincoln Electric Co., Cleveland, OH; (216) 383-4723
Wolf Robotics, Fort Collins, CO; (970) 225-7667
Milwaukee Area Technical College, Milwaukee, WI; (414) 456-5454
College of the Canyons, Santa Clarita, CA; (651) 259-7800
Ogden-Weber Applied Technology College, Ogden, UT; (800) 627-8448

***IMPORTANT:** This schedule is subject to change without notice. Please verify your event dates with the Certification Dept. to confirm your course status before making travel plans. Applications are to be received at least six weeks prior to the seminar/exam or exam. Applications received after that time will be assessed a $250 Fast Track fee. Please verify application deadline dates by visiting our website* aws.org/certification/docs/schedules.html. *For information on AWS seminars and certification programs, or to register online, visit* aws.org/certification *or call (800/305) 443-9353, ext. 273, for Certification; or ext. 455 for Seminars.*

The Answer Is

— continued from page 11

between the gun and wire feeder, and the electrode lead. Using the values listed by our example, the voltage meter on the welding machine should be the following:

V= 4 + 3 + 29 + 6 = 42

Yet, the multimeter would indicate the voltage drop at the welding arc is 29 V. In total, there is a 13-V drop due to the resistance of the welding leads and steel framing.

The erector has a choice: purchase power supplies with increased rated amperage that has the capacity to provide the dynamic voltage that is sufficient to accommodate the resistance of long welding leads and increased distance between the welding machine and location where the welder is welding, or move the welding machines up as the height of the building increases to keep the welding leads relatively short.

In consideration of the problem you describe in your inquiry, I suspect the distance between the welding machine and the location where the welding is being performed is too great. Both the amperage and arc voltage are affected.

ALBERT J. MOORE JR. (amoore999@comcast.net) *is vice president, Marion Testing & Inspection, Canton, Conn. He is an AWS Senior Certified Welding Inspector and an ASNT NDT Level III. He is also a member of the AWS Certification Committee and the Committee on Methods of Inspection of Welds.*

News Bulletins

— continued from page 7

AWS Taiwan Section Holds CWI Conference

The American Welding Society (AWS) Taiwan Section recently held its second Certified Welding Inspectors (CWI) conference Oct. 28 and 29, 2018, in Kaohsiung (southern Taiwan). The first CWI conference was held in Taipei (northern Taiwan) in 2011. With more than 220 people in attendance, the 2018 conference included three keynote speeches, four plenary speeches, and nine technical presentations by CWIs and Senior CWIs.

The objective of the conference was to address the opportunities and challenges for AWS CWIs actively participating in Taiwan's fast-growing offshore wind farm development projects. Taiwan's strategic energy goal is to achieve a distribution of 20% in renewable energy in 2025, with a targeted offshore wind power of 5.5 GW.

Discussions held on the second day addressed two topics: AWS certifications for Taiwan's offshore wind farm industry, and the current welding inspector certification system in Taiwan. Additionally, thoughts on integrating the AWS and ISO certification systems were discussed for Taiwan's offshore wind farm development programs — Chon-Liang Tsai, AWS-Taiwan Chairman.

More than 200 people attended the AWS-Taiwan CWI Conference, held Oct. 28 and 29 in Kaohsiung, Taiwan, which addressed the opportunities and challenges of AWS CWIs taking part in Taiwan's offshore windfarm development projects.

Classified Ads

Advertiser Index

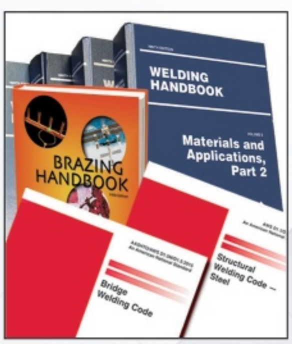
IFC - Inside Front Cover
IBC - Inside Back Cover
OBC - Outside Back Cover

American Welding Society®
MEMBERSHIP
aws.org

3 WAYS TO MAXIMIZE YOUR MEMBERSHIP

1 CONNECT WITH OTHERS

- **MemberNetwork AWS.org** – Access our exclusive, members-only online network and enter an active online community of AWS members who share ideas, discuss technical concerns, and get input and support on welding-related issues
- **Become actively involved in your local AWS Section activities**
- Attend AWS-Sponsored events such as FABTECH USA, Mexico or Canada; Welding Summit, and others



2 ENJOY NUMEROUS DISCOUNTS

- Receive discounts on technical standards, publications, certifications, education offerings and subscriptions
- Enjoy reduced admission to AWS-sponsored events and conferences (FABTECH, etc.)
- Get discounted rates on insurance, travel, shipping, AWS logo merchandise and more

3 ENHANCE YOUR CAREER

- **Increase your welding knowledge through AWS online seminars**, including code clinics, destructive and non-destructive testing, metallurgy, economics, fabrication math and more.
- **Get certified by the organization that sets the standards** including Certified Welder, Welding Inspector, Welding Educator, Engineer, Sales Representative and more.
- Stay informed with complimentary subscriptions to *Welding Journal* (monthly), *American Welder* (quarterly) and *Welding Marketplace* (twice annually)

There's no time like the present to start taking full advantage of your membership!

Spread the news and invite others to join!

aws.org/membership


OLYMPUS®
FlexoFORM™ Pipe Elbow Inspection Solution
• 100% elbow coverage
• Intuitive 2D C-scan imaging
• High-resolution data (1 mm × 1 mm)
• Fast elbow wall thickness measurement
OLYMPUS