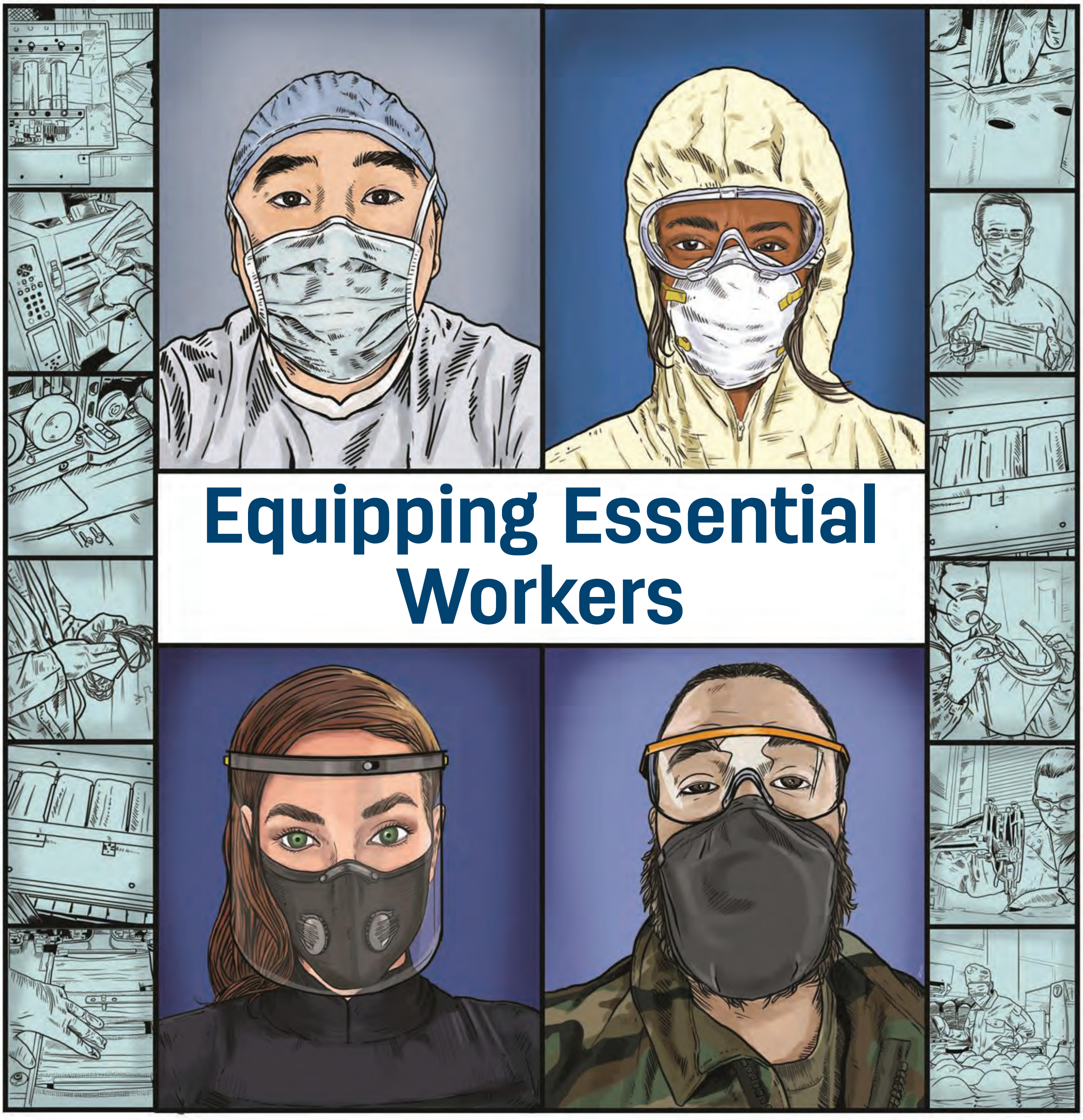
WELDING *Journal*

AWS DECEMBER 2020



Equipping Essential Workers

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

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WELDING JOURNAL

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AWS Promotes Diversity

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.

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More Than 100 Years of Safety Practices

August F. Manz
AWS Fellow

Safety and health teachings have been part of the American Welding Society (AWS) since its very beginning. In its first publication, *Journal of the American Welding Society,* released in October 1919, there was an article titled "Safe Practices for Gas Welding and Cutting Equipment."

Then, in January 1922, the first edition of *Proceedings of the American Welding Society*, Vol. 1, No. 1, which would become the *Welding Journal,* was published. That publication featured several articles on safety and health. One was "Safeguarding the Oxy-Acetylene Process" by J. L. Banash. The other was "A Paint That Will Not Reflect Ultra Violet Rays" by W. S. Andrews. The AWS has followed the example of those safety pioneers ever since.

"Safety and health teachings have been part of the American Welding Society (AWS) since its very beginning."

Fact Sheets Support Safety

The AWS Safety and Health Committee has created more than 40 Safety and Health Fact Sheets on a wide range of subjects. The topics are as follows:

1. Fumes and Gases
2. Radiation
3. Noise
4. Chromium and Nickel in Welding Fume
5. Electrical Hazards
6. Fire and Explosion Prevention
7. Burn Protection
8. Mechanical Hazards
9. Tripping and Falling
10. Falling Objects

These Fact Sheets can be freely downloaded from *aws.org/standards/page/safety-health-fact-sheets*. The Fact Sheets were written for the welding operator. The documents can be used for toolbox safety talks, teaching aids, personal use, and more. These Fact Sheets are periodically revised and updated. Contact AWS Safety and Health Secretary Steve Hedrick (*steveh@aws.org*) if you have a suggestion for another Fact Sheet.

ANSI Z49.1 Offers Additional Protection Practices

Additionally, available from the AWS website is a free download of American National Standards Institute (ANSI) Z49.1, *Safety in Welding, Cutting, and Allied Processes*. This document has been published by AWS since World War II and is considered the Old Testament of welding safety. The U.S. Occupational Safety and Health Administration adapted its teachings in the *Code of Federal Regulations*, 29 CFR 1910 Subpart Q, *Welding, Cutting, and Brazing.*

Stay safe; follow the safe practices taught by the AWS. WJ

Cleveland-Cliffs to Acquire ArcelorMittal USA, Becoming the Largest Flat-Rolled Steel Producer in North America

Cleveland-Cliffs Inc., Cleveland, Ohio, has entered into a definitive agreement with ArcelorMittal S.A., Vanderbijlpark, South Africa. The company will acquire substantially all of the operations of ArcelorMittal USA LLC, Chicago, Ill., and its subsidiaries for approximately $1.4 billion.

Upon closure of the transaction, it's claimed the company will be the largest flat-rolled steel producer in North America, with combined shipments of approximately 17 million net tons in 2019. It will also be the largest iron ore pellet producer in North America.

Cleveland-Cliffs will acquire ArcelorMittal USA on a cash-free and debt-free basis, with a combination of 78.2 million shares of the company's common stock, nonvoting preferred stock with an approximate aggregate value of $373 million, and $505 million in cash. The enterprise value of the transaction is approximately $3.3 billion.

Lourenco Goncalves, chair of the board, president, and CEO of Cleveland-Cliffs, will lead the expanded organization.

"Steelmaking is a business where production volume, operational diversification, dilution of fixed costs, and technical expertise matter above all else, and this transaction achieves all of these," he said.

The transaction is expected to close in the fourth quarter of 2020, subject to the receipt of regulatory approval and the satisfaction of other customary closing conditions.

AWS Virtual Conference Covers the Basics of Aluminum

The AWS Aluminum Virtual Conference brought attendees together for multiple discussions on the fundamentals of aluminum.

The American Welding Society (AWS), Miami, Fla., held the Aluminum Virtual Conference — Back to Basics on October 20 and 21. The conference was designed to provide a basic understanding of aluminum welding and included topics such as aluminum metallurgy, the alloy designation system, gas metal arc welding (GMAW), gas tungsten arc welding (GTAW), weld discontinuities, and more. About 85 attendees took part in the two-day digital event.

Conference Chair Tony Anderson, director of aluminum technology, ITW Welding North America, moderated the live discussion of seven speakers and conducted a presentation on aluminum welding applications and their increased use in the industry. On behalf of all the conference speakers, Anderson thanked all who attended this event.

Some of the technical presentations centered on the following subjects:

Day 1

- Aluminum welding trends and applications, such as high-speed trains, aircraft, and chemical storage tanks
- An overview of wrought and cast alloy designation systems
- Crystal and grain structure and dislocations in aluminum
- Strengthening mechanisms for heat-treatable and nonheat-treatable alloys
- The proper methods and practices of preparing aluminum for welding

Day 2

- Benefits of alternating current (AC) GTAW and inverter advantages
- The importance of level layer winding and wire surface condition for feedability in aluminum GMAW
- Cause and prevention of weld discontinuities, such as porosity, incomplete fusion, incomplete joint penetration, and weld cracking
- Filler metal selection
- Simple qualification using AWS D1.2, *Structural Welding Code — Aluminum*

There were also several question-and-answer sessions that allowed participants to interact with the speakers.

The conference concluded with Wendell Dietz of Miller Electric Mfg. and Hobart Filler Metals offering a prize give-away for the first correct response to the following question: In regard to AC frequency when welding aluminum with the GTAW process, what is the first benefit of increasing the frequency? The correct answer was root penetration, and the participant won a Miller autodarkening helmet.

Conference participants earned 16 Professional Development Hours toward all recertifications and received the AWS D1.2 code. To learn more about his event, visit *awo.aws.org/conferences/past-conferences/aluminum-conference/*.

— Alexandra Quiñones, associate editor

Lake Area Technical College Wins National Award for STEM Welding Education Program

The welding technology program at Lake Area Technical College, Watertown, S.Dak., has been named a winner of the Excellence and Equity in Community College STEM Award by the Aspen Institute College Excellence Program and the Siemens Foundation.

Eight programs across the country have received this award for providing preparation for high-demand jobs in advanced manufacturing, energy, healthcare, or information technology. They are also awarded for providing outreach and support of diverse populations that are typically underrepresented — such as students of color, low-income students, and women — in science, technology, engineering, and math (STEM) careers.

The winning colleges will receive $50,000. Half will be allocated to program development, and half will be allocated to scholarships for outstanding students, known as Siemens Technical Scholars. WJ

OSHA Revises Guidance on COVID-19 Disclosures

The U.S. Occupational Safety and Health Administration (OSHA) has again updated its COVID-19 Frequently Asked Questions, particularly the information regarding the obligation of employers to report work-related hospitalizations and fatalities that occur as a result of COVID-19. Among other things, OSHA advises that a work-related "incident" requiring reporting is an employee's exposure to the coronavirus in the workplace, i.e., if the employee is admitted to the hospital within 24 h of an exposure to COVID-19 in the workplace. For COVID-19 fatalities, employers must report to OSHA only if the employee dies within 30 days of an exposure to COVID-19 in the workplace.

Rural STEM Education Act Passes

The U.S. House of Representatives has voted to approve H.R. 4979, the Rural STEM Education Act, which is intended to address the unique challenges that make it difficult for students in rural areas to access high-quality science, technology, engineering, and mathematics (STEM) education. These challenges include shortages of science and math teachers, high teacher turnover, and difficulty accessing computer-based technology. This Act supports rural schools by giving teachers more resources and training in STEM, engaging students though hands-on education, and increasing access to broadband.

Agencies Seek to Tighten H-1B Visa Rules

The U.S. Department of Labor and the Department of Homeland Security have issued rules that may significantly impact the attractiveness and availability of H-1B visas to employers. The Department of Labor rule, Strengthening Wage Protections for the Temporary and Permanent Employment of Certain Aliens in the United States, became effective on October 8 and sharply increases the "prevailing wage" that employers must pay to H-1B workers. The Department of Homeland Security rule, Strengthening the H-1B Nonimmigrant Visa Classification Program, applies to H-1B applications filed on or after December 7, 2020. It adopts more restrictive definitions and imposes additional paperwork requirements.

White House Issues National Strategy for Critical and Emerging Technologies

The White House released the National Strategy for Critical and Emerging Technologies, which outlines how the United States will promote and protect its competitive edge in fields such as artificial intelligence, energy, quantum information science, communication and networking technologies, semiconductors, military, and space technologies. The strategy has two pillars: promoting the national security innovation base and protecting the technology advantage. The goals of this strategy are as follows:

• Developing the highest-quality science and technology workforce in the world;

• Reducing burdensome regulations, policies, and bureaucratic processes that inhibit innovation and industry growth; and

• Supporting the development of a robust national security innovation base to include academic institutions, laboratories, supporting infrastructure, venture funding, supporting businesses, and industry.

AI Commission Submits Report

The National Security Commission on Artificial Intelligence (AI) has provided its 2020 interim report and third quarter recommendations to the President and Congress. There are 66 nonpartisan recommendations for both the Executive and Legislative branches, including the following:

• Creating a Technology Competitiveness Council to develop and implement a national technology leadership strategy and integrate relevant technological, economic, and security policies;

• Enhancing collaboration between the Department of Defense and industry partners on AI R&D and enabling faster transition of successful technologies;

• Democratizing access to AI and support its application to a range of fields through creation of domain-specific AI testbeds for researchers and industry as well as curation of complex, exemplar data sets; and

• Focusing on creating new career paths for military and civilian government employees, improving STEM and AI undergraduate and graduate education, and continuing education for adults.

House Report Recommends Strengthening Antitrust Laws and Enforcement

The U.S. House Judiciary Committee's Antitrust Subcommittee has released the findings of a 16-month investigation into the state of competition in the digital economy, titled Investigation of Competition in the Digital Marketplace: Majority Staff Report and Recommendations. While focused on dominant companies such as Google and Facebook, the recommendations would apply to all of antitrust law. These include the following:

• Strengthening Section 7 of the Clayton Act through restoring presumptions and bright-line rules, restoring the incipiency standard, protecting nascent competitors, and strengthening the law on vertical mergers;

• Supporting Section 2 of the Sherman Act by introducing a prohibition on abuse of dominance and clarifying prohibitions on monopoly leveraging, predatory pricing, denial of essential facilities, refusals to deal, tying, and anticompetitive self-preferencing and product design;

• Increasing the budgets of the Federal Trade Commission and the Department of Justice Antitrust Division; and

• Bolstering private enforcement by eliminating obstacles such as forced arbitration clauses, limits on class action formation, judicially created standards constraining what constitutes an antitrust injury, and unduly high pleading standards. WJ

HUGH K. WEBSTER, AWS WASHINGTON GOVERNMENT AFFAIRS OFFICE — Contact the AWS Washington Government Affairs Office at 1747 Pennsylvania Ave. NW, Washington, DC 20006; email *hwebster@wc-b.com*; fax (202) 835-0243.

Safety Matters: U.S. Department of Labor Awards $11.2 Million in Grants; SAFER™ One Wins New Product of the Year Award; and Enhanced Efforts at Solar Atmospheres

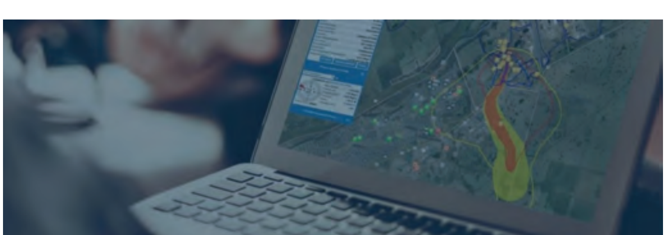
In line with the safety and health focus in this month's *Welding Journal*, here's news from the U.S. Department of Labor's Occupational Safety and Health Administration, Washington, D.C.; Industrial Scientific, Pittsburgh, Pa.; and Solar Atmospheres, Hermitage, Pa.

• The **U.S. Department of Labor's Occupational Safety and Health Administration** has awarded approximately $11.2 million in Susan Harwood federal safety and health training grants to 90 nonprofit organizations nationwide. They will provide education and training programs to help workers and employers recognize workplace hazards (including the coronavirus), implement injury prevention measures, and understand their rights and responsibilities under the Occupational Safety and Health Act of 1970.

Grant recipients included the Port of San Diego Ship Repair Association, San Diego, Calif., with $122,000 to continue building new training capacity by providing 995 h of training for 310 workers in the maritime industry; The University of Texas at Arlington, Arlington, Tex., with $75,000 to develop new training and educational materials for women in the construction industry; and International Finishing Trades Institute of the International Union of Painters and Allied Trades, Hanover, Mary., with $73,575 to develop new training and educational materials on COVID-19 for employers and workers.

• **Industrial Scientific**, a global provider of gas detection and connected safety, has announced *Occupational Health & Safety* (OH&S) magazine's panel of expert judges named SAFER™ One the New Product of the Year for industrial hygiene software. The plume modeling software gives users real-time visibility into chemical releases so they can identify the source, severity, and community impact. It's often used by industrial hygienists/other safety personnel to track and respond to chemical releases, investigate community odor complaints, and simulate possible turnaround and shutdown scenarios.

"OH&S has been celebrating innovation and products optimized to keep workers safe for over ten years. This year, safety products and services are being recognized on a global scale, bringing greater awareness to the important work completed by manufacturers in the industry," said OH&S Editor Sydny Shepard.



Industrial Scientific's plume modeling software has been recognized for improving safety outcomes during a chemical release.

• As the COVID-19 pandemic sparked an unprecedented downturn in business, one that President Bob Hill has not seen in his 25 years with **Solar Atmospheres**, he and his team took a deep dive into their business practices, examining the safety procedures of all employees.

During a recent safety meeting, a quality technician reported performing quarterly thermocouple (TC) and vacuum calibration duties were exponentially more hazardous on larger vacuum furnace chambers. To calibrate against a standard, the technician must access plug-in points, which are traditionally located on the top of a furnace: the main valve port, used for vacuum calibration, and the various Type S thermocouple contacts, used for thermocouple calibrations. Most smaller furnaces could be accessed with a step ladder; however, on larger chambers, the plug-in points could not be accessed by a ladder. Therefore, tying off, climbing, and balancing oneself 12 ft in the air became the mode of access.

"Our team worked extremely hard to devise a system that enabled the calibration process to occur with two feet on solid ground," Hill said. "For the thermocouple calibrations, our team ran extension wires from the TCs with plugs to chest height. Additionally, we identified unused ground level feed through ports within the chambers and adapted them for vacuum calibrations."

Solar's quality team validated the appropriate data from these procedural changes. The continuous improvement initiatives yielded no negative effects on the calibration results and reduced a potential unsafe work hazard.

Solar Atmospheres strives to be safer, as evidenced by this example showing old vs. new calibration methods.

BTD Manufacturing Expands Its Metal Stamping Capabilities in the Southeast

Stamping capacity has been increased at BTD Manufacturing's facility located in Dawsonville, Ga.

BTD Manufacturing, a manufacturing partner providing solutions to brands in the metal fabrication market, has expanded stamping capacity and broadened press offerings at its Dawsonville, Ga. facility. The improvements allow the company to better serve its user base through shorter lead-times, while driving efficiencies in the supply chain.

"We know our customers' success relies on our capabilities to not only provide them with parts that meet the highest standards but also to provide those parts as efficiently as we can. In this market space, customers are relying on improved efficiencies more than ever," said Paul Gintner, BTD Manufacturing president.

The Georgia facility's new stamping press is a Komatsu OBS110. This unit has a 110-ton capacity and offers optimal consistency and part quality. The addition comes on the heels of the installation of a 300-ton stamping press and the acquisition of a 70,000-sq-ft warehouse in Buford, Ga. These commitments to the southeast illustrate its resolve for growth in the region.

Skilled Trades Organizations Partner to Create COVID-19 Resources for CTE Classes

The National Center for Construction Education & Research, Alachua, Fla., along with The Coordinating Committee for Automotive Repair, Palatine, Ill., and Electude, Waltham, Mass., have collaborated to create COVID-19 best practice resources and online training for career and technical education (CTE) students and instructors throughout the pandemic.

Because mastery of hands-on skills requires in-shop and in-person tasks, the organizations created a website with the following resources:

- Strategies to create a blended learning environment that keeps students and staff safe, reserves in-person school time for hands-on training, and provides guidance for conducting classrooms and lectures online;
- Best practices for shops and labs that focus on personal protective equipment and social distancing;
- COVID-19 recommended supplies for schools;
- COVID-19 participant questionnaire, to be used at the beginning of each in-person day;

• Interactive COVID-19 online learning module specifically written for professionals in CTE; and

• Ongoing guidance as the impact of COVID-19 evolves.

For more information, visit *covid19.nccer.org*.

Appalachian Regional Commission Awards Grant to Wallace State's Welding Department

Wallace State Community College's new technical education center for welding and entrepreneurship has been awarded a $200,000 grant from the Appalachian Regional Commission.

Wallace State Community College, Hanceville, Ala., has been awarded a $200,000 grant by the Appalachian Regional Commission for the purchase of workforce training equipment for the welding department's new technical education center for welding and entrepreneurship.

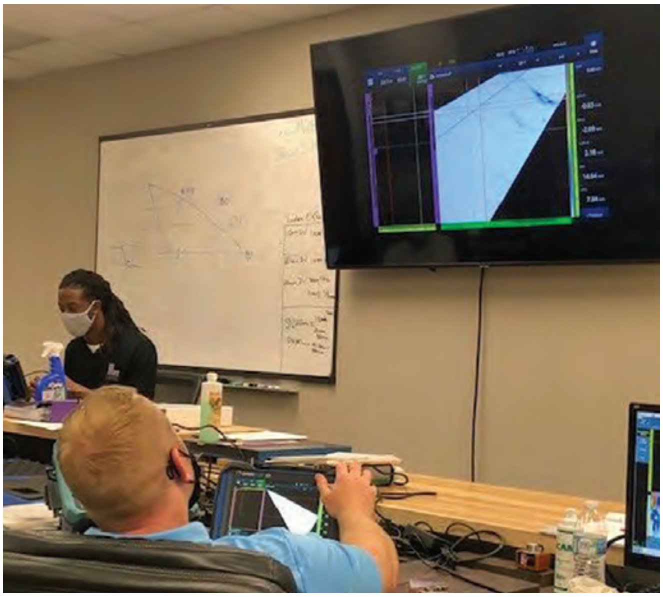
The training facility, anticipated to open in late 2021 or early 2022, will allow the welding program to provide an estimated 110 workers in the southern Appalachian region each year and help meet the employment needs of new and current manufacturing businesses in north Alabama.

The facility will also contain an entrepreneurship center and technology incubator, which will contain seven incubation pods, an ideation station, along with shared conference and works paces.

The facility will grow to an estimated 19,445 sq ft to serve approximately 80 students and growing enrollment. The new space will include 62 welding booths; ten virtual welding simulators; six pipe fitting stations; a destructive and nondestructive examination lab; three robotic welding and resistance welding cells; an additive manufacturing cell; a computer numerical control automation and programming lab for plasma cutting, fiber laser cutting, and water jet cutting; and an overhead crane for safety training in rigging and crane operation.

Olympus and Lavender International Collaborate to Support Advanced NDE Training

Olympus, Waltham, Mass., a manufacturer of nondestructive examination (NDE) inspection equipment, has provided its new OmniScan X3 phased array flaw detectors with full matrix capture (FMC)/total focusing method (TFM) to Lavender International's U.S. facility in Houston, Tex. They were one of the first to provide a high-temperature hydrogen attack detection training course and offer advanced NDE classes in



NDE technicians use OmniScan™ X3 flaw detectors during a PAUT class at Lavender International's training facility in Houston, Tex.

time-of-flight diffraction, phased array ultrasonic testing (PAUT), as well as manual ultrasonic testing. With this collaboration, the entities will help ensure the next generation of inspectors are equipped with the latest technology and knowledge to become experts in FMC and TFM techniques.

— continued on page 57

Nine Months Later: How COVID-19 Has Changed the Workplace Landscape

Nine months ago, phrases like essential business, social distancing, and Centers for Disease Control and Prevention (CDC) guidelines were not part of our everyday workplace vocabulary. Today, as we near the end of what has been a challenging and unpredictable year, those words have become part of our new normal as the COVID-19 pandemic has changed the workplace landscape for the foreseeable future. In June, the *Welding Journal* spoke to employers and employees about how the early days of the pandemic were transforming their day-to-day business operations. This month, we followed up with them to see what's changed since the start of the pandemic and what lessons they have learned.

Social Distancing, Masks, and Temperature Screenings Are Here to Stay

Gone are the days of gossiping around the office water cooler — unless of course it's a virtual water cooler or you're wearing a face mask while maintaining a 6 ft distance.

In the early days of the pandemic, Scott Murray, chief of laboratories, development and testing, engineering directorate, NASA, Kennedy Space Center (KSC), Cape Canaveral, Fla., told us how all on-site work was being conducted following the CDC's social distancing guidelines and/or with appropriate personal protective equipment, which the agency provided to employees. Today, Murray shares not much has changed since that implementation.

"Masks are required at all times in common areas of buildings (e.g., lobbies, hallways) whether one is alone or not, and masks are required whenever someone is unable to maintain social distancing from others in the workplace. Conference room capacities and seating distances have been reduced and increased, respectively. Select locations will require that your temperature is taken before you enter," Murray explained.

For Jeremy Mowry, shop foreman, Broomfield Sheet Metal, Lafayette, Colo., the start of the pandemic meant trying to figure out what precautions needed to be taken to keep employees and customers safe. Now, Mowry explained, not only are employees still making sure to keep their distance from each other, but there are also less interactions with customers. "There are more packaging products for customers to pick up."

*Photo credit: Andres Victorero/*depositphotos.com

A New "Office"

Companies were also forced to reimagine the traditional workspace. In an attempt to keep office workers safe at the beginning of the pandemic, many companies found ways to have employees work from home. An April Gallup poll (Ref. 1) showed that 62% of employed Americans worked at home during the crisis. As 2020 draws to a close, many in our industry with the ability to work from home continue to do so.

"NASA KSC is still in a mandatory telework situation, with personnel allowed on-site on a case-by-case basis to perform mission critical work only. When people are working on-site, CDC guidelines for social distancing and the wearing of masks are followed," Murray said.

Shane Findlan, consulting engineer — welding and materials engineering, Charlotte, N.C., said, "Other than for hard project sites (manufacturing, fabrication, and power plant services), we have gone to a work-from-home status. This is currently in place until January, and perhaps longer."

Findlan explained it has also made the company rethink office space in general. "We have closed and consolidated offices, as we no longer use or plan to use the facilities we had in place. The company is moving to a flex-space program where even when the pandemic is over many will work from home and use the offices as a resource for meetings and when office facilities are necessary to support work activities. The vast majority of the engineers and technical staff will no longer have an assigned work location."

Murray can see how the productivity shown by employees working from home will change the course of where work gets done.

"I believe we've all been surprised at how much work can be accomplished via telework, and we'll likely seek to continue incorporating a great deal of it in the future, when it makes sense, even after a return to more normal circumstances," he said.

For those who don't have the option to work from home, like Ed Abbott, general organizer, apprenticeship and training, Ironworkers International Union, Washington, D.C., the workspace has still needed adjustments.

"Our training programs were closed for two to three months for the most part. During this time, we were learning how to deal with COVID. It meant properly cleaning the facilities, wearing masks, keeping a safe distance from one another, etc.," he said. "Class sizes also had to be adjusted to allow for keeping people at a safe distance. This obviously compounds things due to the fact that you cannot teach the same numbers that you're used to. Therefore, some [instructors] had to split the class size and offer the same course twice. It's been a challenge and we're not out of the woods yet, but I am confident that we will find a way to persevere."

Technology Leads the Way

To Bill Newell, vice president, engineering, and co-owner, Euroweld Ltd., Mooresville, N.C., persistance has meant finding ways to quickly adapt technologies that allowed for not only remote work but also for videoconferencing and other forms of digital collaboration.

"Although the effectiveness of face-to-face meetings cannot ever be replaced, we are getting much more comfortable participating via virtual platforms. It has become necessary to be able to use various platforms," Newell said. "Under the guise of 'COVID,' some long overdue changes in both code rules and mindsets have occurred. Working 'remote' has taken on a whole new meaning. Not just with computers and electronic media but welding-related qualifications, inspection, and auditing functions. Hopefully, we can continue to adapt and develop hybrid approaches with a mixture of face-to-face and virtual technologies for meetings, conferences, and general business."

Lessons Learned

Despite the challenges brought on by 2020, most companies have found ways to quickly adapt to survive and are reflecting on the lessons learned as they get ready to move into the new year.

"We found out that our government and contractor workforce was very resilient, as NASA and KSC accomplished several major goals this year, despite the challenges posed by the pandemic. With one of our Commercial Crew Program partners, SpaceX, we successfully launched American astronauts to space from American soil using American-built spaceships and rockets for the first time since the end of the Space Shuttle program. We also successfully launched the Mars 2020 Perseverance rover on its way to Mars," Murray said.

"We learned how to do the best we can at training our members remotely and virtually. But, ultimately we had to learn to safely train using hands-on methods as well. For instance, in order to train a person how to weld, you're going to have to make some sparks sooner or later," Abbott stated.

"One lesson is that it is not necessary with today's IT tools to have staff located in a facility (or facilities in our case) and have them work face-to-face to be effective," Findlan added.

"We capitalized on the freedom permitted outdoors and held small, impromptu golf outings with clients, customers, and friends," Newell said. "In its own way, being forced to go 'virtual' has resulted in better efficiency and eliminated travel expenses. 2020 has introduced many challenges where we learned to work smarter, not harder."

— *Cindy Weihl, senior editor*

Reference

1. Brenan, M. 2020. U.S. workers discovering affinity for remote work. *Gallup*. April 3, 2020, *gallup.com*.

Welding Programs Show Resiliency in the Face of COVID-19

In March, the number of COVID-19 cases within the United States reached alarming numbers, resulting in school closures throughout the country. Welding education, with its emphasis on tactile learning, faced some unique pedagogical challenges. To find out how welding educators were navigating education in the age of COVID-19, American Welding Society (AWS) staff reached out to instructors at the high school, college, and university levels. Their insightful comments were captured in the June issue of the *Welding Journal* (p. 22).

Six months later, with most of the country adapting to a new normal, AWS staff contacted those same educators for an update on their welding programs. The following Q&A showcases their responses.

What does welding education currently look like at your school?

Jeffrey Carney, Ferris State University: We have reduced in-person lecture section capacities. Courses with 54 or 48 students have split lectures (half one day and half another day) with a Zoom lecture sometime in the week. Lab courses are meeting face to face with reduced section capacity. We have had to add lab sections for social distancing. A few lectures are 100% online (Zoom).

Randy Emery, College of the Sequoias: Currently, at College of the Sequoias, we are delivering our welding education in a hybrid format. To accomplish this, we divided our students into two equal groups. One group would report for in-person welding lab sessions at our 12,000-sq-ft welding facility. The other group would be assigned to engage in our online learning management system (LMS). To accommodate the online learning element, we used our Canvas LMS. Along with the Canvas system, we have continued to use the AWS Online Educational Library LMS. This student rotation has worked into a very productive practice and will be continued and further developed into our upcoming spring 2021 semester.

Doug Desrochers, Old Colony Regional Vocational Technical High School (RVTHS): We are currently using a hybrid method of teaching. Fifty percent of the students are at home online learning their academics while the other 50% of students are in their vocational shops. They alternate out on a two-week basis [every] ten days.

Zhenzhen Yu, Colorado School of Mines: There has been no major change since my last response. Our welding trainings are all in person. The only difference is that now every student has their own set of PPE [personal protective equipment] instead of sharing. The PPE is still provided by us. We distribute the PPE to the students and have them put it in their own lockers outside of the welding lab.

Fig. 1 — A student welds at PCC prior to the COVID-19 pandemic. To keep students and faculty safe, the school's welding program has switched to remote learning. It will reopen its doors in spring 2021.

Matt Scott, Portland Community College (PCC): At PCC, we are still operating under the guidelines of remote learning. This means that career technical education shops are closed until the 2021 spring term when the college plans to reopen for in-person classes — Fig. 1. This is the avenue that our administrative team has followed because our district covers multiple counties that we draw students from. Remote instruction via Zoom has provided an excellent platform to deliver the didactic portion of our lecture classes — Fig. 2. We are also in the process of revising shop curriculum to pull out the didactic portion and offer that remotely. This, in conjunction with developing new lecture classes in nondestructive testing and math for welders, will help prepare our students to enter the workforce. Although this is a time where we have "paused" the actual hands-on portion of our training, our students have pivoted with us. The willingness to change has allowed them to complete their welding lecture series courses as well as general education studies. This shift is less desirable than anyone would want; however, the change has provided a path for our students to catch up in both their general education and welding lecture areas. Hence, they will be well prepared to complete their shop work once we return to face-to-face instruction in the spring.

Richard Baumer, LeTourneau University: With additional campus COVID-19 safety protocols in place, we have already successfully completed nine weeks of in-person, residential instruction for the fall 2020 semester. The welding engineering program applied many of these approaches over summer 2020, enabling our industrially sponsored research to continue. [For example,] Senior Aaron Wells performed summer research with Dr. Dana Medlin, Kielhorn professor

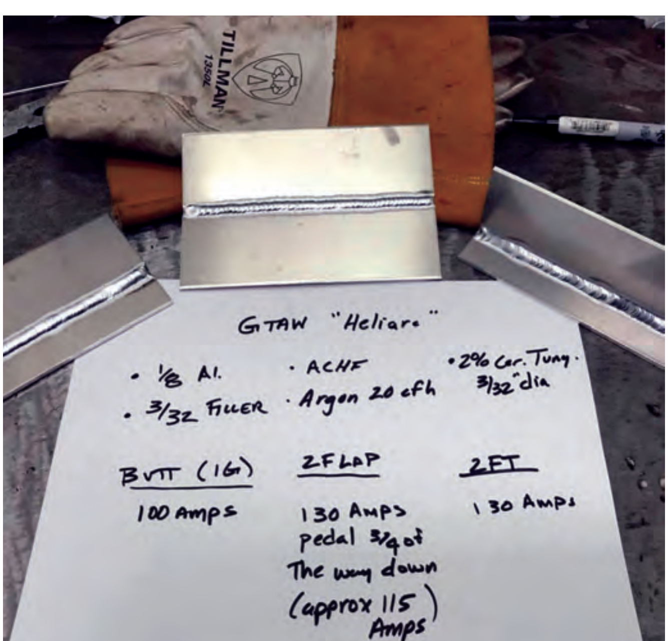


Fig. 2 — A PCC instructor's setup prior to an online welding demonstration of gas tungsten arc welding for remote students.

Fig. 3 — LeTourneau University Senior Aaron Wells (left) dons a face mask while working on his summer research project with the school's Kielhorn Professor of Welding Engineering Dana Medlin.

of welding engineering — Fig. 3. Medlin is a longtime member of a multidisciplinary research team performing a corrosion assessment of the *USS Arizona*, which sunk during the surprise attack on Pearl Harbor on December 7, 1941. In June 2020, LeTourneau University received the first metallurgical samples ever extracted from the sunken vessel to quantify corrosion rates of selected plate hull steel and rivets and assess the structural integrity of the sunken vessel. We look forward to continuing residential, in-person instruction in spring 2021.

Greg Siepert, Hutchinson Community College: We are 100% face to face since beginning classes in August. Hopefully that remains the same!

What has changed about the welding program since we last reached out to you?

Jeffrey Carney, Ferris State University: In fall 2018, we opened our $30-million welding and manufacturing facility. Welding technology (WELT) associate of applied science (AAS) degree first-year enrollment has grown 50% (from 40 students to 60 students) with the new facility. Welding engineering technology (WELE) bachelor of science (BS) degree third-year enrollment increased approximately 35%. This enrollment increase is currently rippling through all years of the program. Both the WELT AAS and WELE BS degrees are showing strong enrollment into the future. We will accept applicants to the WELT AAS after completion of their junior year in high school if they have met the GPA [grade point average] and SAT/ACT [Scholastic Assessment Test/American College Testing] entry requirements.

Randy Emery, College of the Sequoias: During the pandemic, we have practiced and enforced everyone wearing face coverings during in-person learning sessions. Along with these safety protocols, we are tracking all students' health status. All students complete a health survey before all in-person sessions. One key benefit of these new requirements has been a better teacher-student relationship. This smaller student-to-teacher ratio has improved student performance and overall engagement. One key element of this past semester has been the realization that students need to become more inspired to become self-motivated. I believe we are seeing evidence of more students developing an autodidactic learning plan.

Doug Desrochers, Old Colony RVTHS:

• New protocols: Spraying tools down before and after use with a product that kills the virus in 30 s. Assigning students to a particular welding booth for the week with no tool sharing. Shop lockers are no longer used to limit contact surfaces. Painted numbers on the shop floor that match the classroom desk are used to keep students 6 ft apart during inside mask breaks.

• Teaching techniques: No real changes except for wearing a mask all day, and both a mask and shield when instructing within 3 ft of any student.

• New challenges: Students must remain 3 ft apart at all times. They get frequent mask breaks outdoors when possible and must remain 6 ft apart.

• Student graduation: The same number of students have graduated as before. Having missed the last trimester in 2020, they had legally achieved enough vocational requirements to graduate. They had to maintain their academic grades online until the end of May to meet those requirements for graduation.

• Renovations: Nothing major because of COVID-19, just removal of any extra layout tables to open space in the shop for required state social distancing guidelines/laws.

Fig. 4 — Pictured is PCC's Rock Creek Campus welding shop prior to renovation, which is currently underway. When the college's students return to in-person learning in spring 2021, they will be welcomed with a new state-of-the-art facility.

Fig. 5 — PCC Welding Instructors (from left) Dave Williams, Lauren Cobb, Scott Judy, and Matt Scott gear up in PPE to help with the school's welding shop renovation.

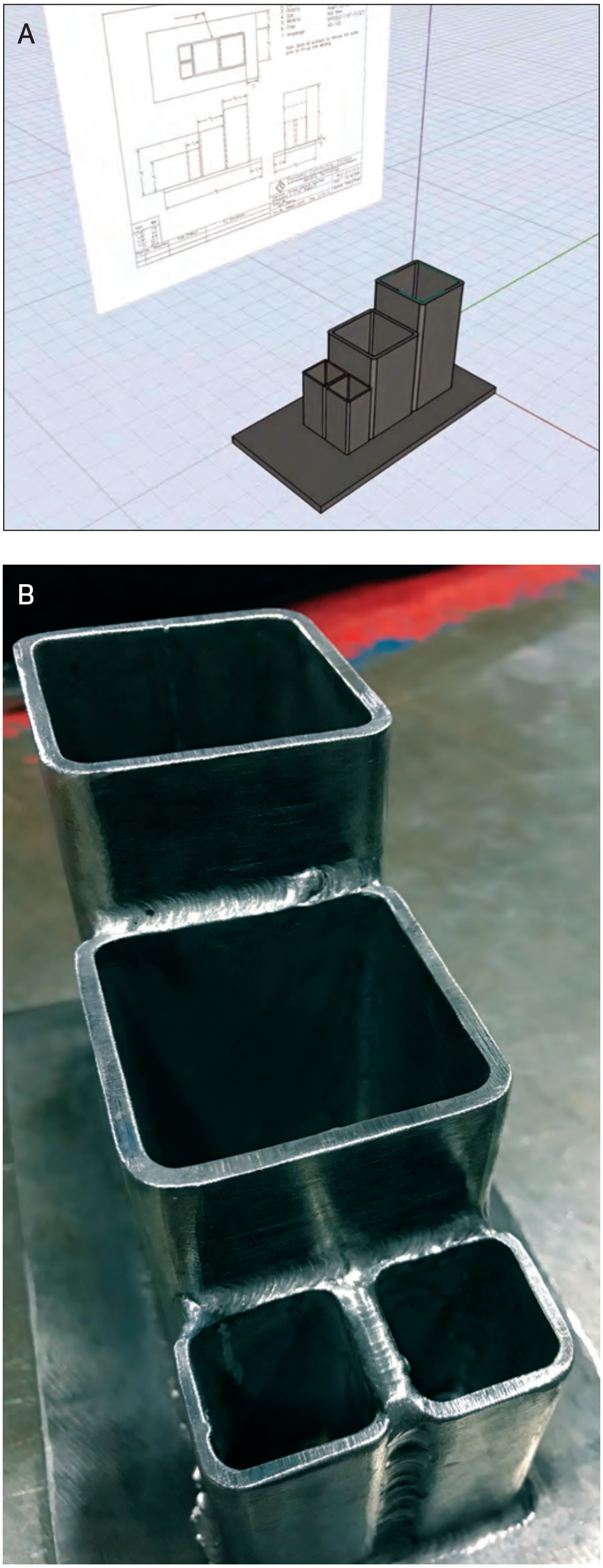


Fig. 6 — Kevin Longueil, PCC welding instructor, is leading the way in revising PCC's curriculum during COVID-19 by creating computer models for shop projects: A — Computer model; B — finished project.

Matt Scott, PCC: Program changes at PCC have been immense. First and foremost is the renovation of our weld shop at the Rock Creek Campus — Fig. 4. Everything in the shop has been dismantled and pulled out — Fig. 5. The build out includes everything from new paint, new floor, new welding booths, and all-new mechanical and electrical systems to run an energy-efficient facility. Upon reopening, we will be greeted with a state-of-the-art facility to train the next generation of welders! Additionally, this temporary shutdown has provided us with the time to revise our program's curriculum. Every aspect of it has been put on the table to be reevaluated. Our new development areas include creating computer models for our shop projects as well as video tutorials — Fig. 6A, B. This, combined with implementing our learning management system, will allow the students a streamlined approach to their welding education. In addition to the above-mentioned items, PCC is also supporting the program by purchasing new welding machines. This new equipment will not only bring our students into the next generation of welding technology, but it will also reduce our power consumption. Unprecedented times have brought unprecedented support from our college, and we are profoundly grateful!

Greg Siepert, Hutchinson Community College: The biggest change is the social distancing protocols instituted in the classroom environment. We now have half of every table blocked off, and classroom numbers have been capped at the number of tables we have in the classroom. Other than that, the biggest change has been we no longer have paper-based homework, as all homework is now submitted online. Shop-wise, the main thing that has stuck is no rotation of booths and sanitation by each individual as they finish using equipment. Outside of the stressors of the unknown . . . it has kind of become business as usual with a face covering on. We haven't run into many supply chain issues other than some delays in the beginning with shipping.

How have your welding students responded to learning in the age of coronavirus?

Jeffrey Carney, Ferris State University: Very well! They realize it is not the faculty's or university's doing or fault. They have adapted to the challenges and are doing better than expected.

Randy Emery, College of the Sequoias: I am happy to say that our welding students have responded in a very positive and productive manner. The students seem to be engaging in their learning efforts and showing resilience in accomplishing their goals.

Doug Desrochers, Old Colony RVTHS: The welding students have responded excellently under the circumstances. Even though they did not enjoy the four months from March to June of 2020, they did adapt quickly to learning online. They adjusted to the academic work, and we purchased the AWS Online Educational Library. Like any other student, they did not want to do the work, but later they appreciated the new material. They were able to learn at their own pace. Several of the students went ahead of what was assigned and watched the modules and did the pre- and post-tests along with the exams. We have always prepared our students with the fact that everything is subject to change in our environment, such as you may be on one job today and a totally different job the next several days. This helps them be ready for the welding industry.

Matt Scott, PCC: The welding students at PCC have risen to the occasion! They realize that health and safety is the college's number one priority and have bought into the new course scheduling. This, combined with active engagement with our industry partners, has helped ease the pain of this pandemic.

Greg Siepert, Hutchinson Community College: When we started, you could cut the tension and uneasiness among students, but they have adapted well and now it kind of seems like just about any other class. Truthfully, they have stepped up to the challenges of it all and made the best of it. If we weren't face to face, I don't know if I could say the same thing.

After nine months of teaching in the age of coronavirus, what new insights have you gained about welding education and best practices for teaching?

Jeffrey Carney, Ferris State University: Online learning content is here to stay! I do not see COVID-19 going away soon. Anticipate teaching in the same format in fall 2021 as fall 2020. Online content must be engaging and have meaningful activities. Students are resilient! They will adapt to the challenges. Faculty must continuously demonstrate that the situation is challenging for us also, and we are not giving up.

Randy Emery, College of the Sequoias: After this experience with a hybrid learning delivery system, I believe it is a highly valuable model for future welding education. I further believe this could lead to a new way of doing business in career technical education. Some of the benefits of this delivery system are as follows:

- Smaller teacher-to-student ratio, which will increase student learning and individual instruction time;
- Productive online options will increase access to students who are working adults;
- A hybrid learning model will expose students to remote learning technologies, which may become standard practices; and
- A hybrid education model can reduce student cost of travel to and from school sites.

Doug Desrochers, Old Colony RVTHS: Everyone is handling it differently. Many factors are involved, such as parents who have lost their jobs, and they have one computer at home with several students of different ages needing the computer at the same time for their classes. Keeping in mind that they may have family members who have been hospitalized without my knowing. I have given it a lot of thought, and my method has been to give a lot of grace and understanding, and I am listening to them more than doing the talking. Taking the time to make sure they're mentally and emotionally healthy are first on my list. I have also adjusted in time management. I'm allowing much more time than usual for students to learn the material, knowing they are under such a different working environment. The saddest thing is that we do not get to see their smiling faces instantly. We always try to have fun and keep things exciting. Work does not have to be unpleasant; it should be fun as well. So not being able to see their instant reactions because of having a mask on loses its full authenticity, and that is incredibly sad.

Matt Scott, PCC: The number one lesson learned is to keep pushing ahead! The adage of "embrace the suck" comes to mind. None of us want to be in the middle of this pandemic, but we must strive to be better than when we entered this crisis. Another lesson learned is to reach out to everyone from program graduates to local and national colleagues as well as industry professionals. The concept of "we are all in this together, and we will all make it through this together" is really the predominant lesson. The assistance of our partners by dropping in via Zoom to be a guest speaker or them having one-on-one time with our students has been a tremendous benefit. Reaching out and networking has been incredibly valuable. Case in point is a PCC graduate who met industry professionals through our guest speaker lecture series. He was able to connect with two of our partners to glean information to develop a duplex stainless steel pipe procedure. It is this type of networking that forges our relationships into a "weld-bonded" community.

Greg Siepert, Hutchinson Community College: We will never get away from the time spent one-on-one in the booths with students, and it has taken a bit for that to return. While it seems to still have a sense of apprehension, I have learned that I am a poor instructor if I am afraid of what could be and far more effective at trying my best to protect myself while providing the instruction that the students need.

Conclusion

The responses from the educators who contributed to this Q&A unveiled that there is no one-size-fits-all solution for welding programs dealing with the COVID-19 pandemic. While some schools have remained entirely in person and one school has switched to fully online, the majority of the instructors have embraced a blended approach that provides both face-to-face instruction and online learning. Those schools providing in-person instruction have reduced class sizes and enforced protocols for social distancing and wearing face masks.

Additionally, the instructors all expressed that their students have responded well to the changes and are making good progress in their studies. Many of the instructors have also used COVID-19 as an opportunity to help their welding programs evolve by expanding the curriculum, renovating welding labs, or adopting new technology and teaching methods.

If there is a silver lining in this COVID-19 cloud, it is that the pandemic has shined a light on the resiliency of welding programs, educators, and students. WJ

— Katie Pacheco, associate editor

A Metal Artist Dedicated to the Details

Stephanie Hoffman uses her craftmanship to refine the welder Statue of Liberty

The welder Lady Liberty is getting closer to her final form as metal artists Stephanie Hoffman and Barbie the Welder work diligently on the statue.

Episodes 2 and 3 of the American Welding Society's (AWS's) Arc 2 Art project focused on the larger components of the statue. Hoffman discussed her work on the foundation, and Barbie explained how she built the frame of the body. With the big pieces wrapping up, Hoffman is shifting her attention to the finer details of the project, which she discussed in episode 4. For more information on the Arc 2 Art project and to watch the episodes, visit *aws.org/art2arc*.

Three more episodes are slated to be released, with episode 8 showcasing the completed statue. Following is an overview of episode 4.

Episode 4 — Artistry in Action

Episode 4 of Arc 2 Art featured Hoffman showing her work on the engraved copper panels, the aluminum code book, and the aluminum welding helmet.

The four copper panels to be attached to the statue's base are a testament to Hoffman's craftsmanship. Each panel is engraved with intricate line work portraying different industry scenes, such as oil derricks, a refinery, and an airplane. Hoffman engraved the artwork with multiple passes to get the sharpness and detail she wanted. She also drilled numerous holes into each panel.

"I actually sanded and polished everything, then engraved, then drilled all the holes in the copper," Hoffman

Fig. 1 — Hoffman showcases her industry engravings on a polished copper panel.

Fig. 2 — Hoffman uses a welding back filling technique to fill in gaps on the aluminum helmet. Credit: Stephanie Hoffman (@underground_metal_works)*/Instragram.*

explained. "I had to drill all of the holes in the copper first, then lay out the holes on the aluminum. I couldn't just clamp them together because the clamps could leave marks on the copper."

For Hoffman, the most challenging aspects of this part of the project were getting a high-quality shine on the copper and engraving the detailed imagery. She proudly displayed her work, holding one of the copper panels up while wearing rubber gloves to preserve the shine — Fig. 1.

"I just worked so hard polishing all this," Hoffman said. "The oils . . . from my fingers will leave all sorts of dirty marks all over it, and I don't want to have to re-polish it."

Next, Hoffman explained her process for constructing the welder's helmet out of aluminum. She used ¼-in. round rod to frame out the helmet and then used a back filling technique to fill in the gaps between the rods — Fig. 2. Back filling is when the welder adds filler to the back side of the weld puddle, allowing the material to build up along the edges of the gap.

"That's a little trick for filling any type of big, massive gaps when working with aluminum. I wouldn't recommend doing this with other types of materials, but I can assure you it does work very, very well with aluminum," said Hoffman.

Once she finished welding the hood, she grinded it with 80- and 120-grit flap discs and then filled in any remaining holes.

For the code book, Hoffman used ⅛-in. aluminum for the cover and foil for the pages.

Hoffman's next steps for the project are acid etching AWS D1.2, *Structural Welding Code — Aluminum*, onto the book cover and epoxying the pages together, adding a lens to the helmet, and attaching the copper panels to the foundation.

To see more of Hoffman's work on the statue, visit her Instagram account *@underground_metal_works*. WJ

ALEXANDRA QUIÑONES (aquinones@aws.org) *is associate editor of the* Welding Journal.

BY TONY ANDERSON

Q: Below are the questions and answers along with the names of the six winners of the quiz that was in the last Aluminum Q&A published in the October 2020 *Welding Journal*.

The names of the six respondents, selected at random from those who answered all the questions correctly, are as follows:

1. Jawed Akhter from York, Pa.

2. Jose Caprarulo from Argentina

3. Eric Caswell from Ucluelet, BC, Canada

4. Levi George from Grafton, Wis.

5. Matt Maczollek from Menomonee Falls, Wis.

6. Richard Manginell from Churchville, N.Y.

They will receive a signed copy of the American Welding Society publication *Welding Aluminum — Questions and Answers* (2nd edition) along with their choice between a Dri Duck fleece pullover or a Digital Elite™ series welding helmet.

1. What is the most suitable 5xxx series filler metal to be used for welding a structure made from 5454 base metal that will see prolonged exposure to temperatures between 150° and 350°F?

a) ER5356
b) ER5554
c) ER5556
d) ER5183
e) ER5087

The answer is **b**. Stress-corrosion cracking (SCC) in 5xxx series alloys containing more than 3% magnesium can occur when they are exposed to temperatures between 150°and 350°F for prolonged times. Base alloy 5454 and filler alloy 5554 both have magnesium content below 3%. Therefore, both alloys are suitable for elevated temperature applications and are not susceptible to SCC. Filler alloys 5356, 5183, 5556, and 5087 all have more than 3% magnesium and are not suitable for prolonged elevated temperature applications.

2. The statement "solution heat treated, cold worked, and then artificially aged" describes which of the following tempers used for a heat-treatable aluminum alloy?

a) -T2
b) -T5
c) -T6
d) -T8
e) -T10

The answer is **d**. This information is found in ANSI H35.1/H35.1M, *Alloy and Temper Designation Systems for Aluminum*.

3. When plasma cutting aluminum on a water table, what gas can be created through a reaction of the water and molten aluminum, become trapped, and potentially cause an explosion?

a) Hydrogen
b) Nitrogen
c) Ozone
d) Acetylene
e) Propane

The answer is **a**. When aluminum is plasma arc cut on a water table, molten aluminum dropping into the water will "steal" oxygen from the water and release hydrogen gas. If the hydrogen becomes trapped between the aluminum and the water surface, an explosive mixture can develop and be ignited by the cutting arc. Forced air cross flow must be used between the aluminum and the water to avoid a buildup of hydrogen. Similarly, when aluminum is plasma arc cut under water, the molten aluminum reacts with the water to release hydrogen. Dangerous concentrations should be avoided by inserting a perforated piping system in the tank to aerate the water.

4. When compared to steel, resistance spot welding (RSW) of aluminum typically requires welding schedules and equipment that deliver:

a) Lower currents but much longer weld times
b) Higher currents but much shorter weld times
c) Alternating current (AC) only
d) Direct current (DC) only
e) Both a and c

The answer is **b**. Because of the higher thermal and electrical conductivity of aluminum alloys, they require some variations in equipment and welding schedules. For example, the weld current must be two to three times higher, but only one-third the cycle time of that required for a comparable joint between steel sections.

5. After gas metal arc welding (GMAW) a complete joint penetration double-V-groove weld in base metal 6061-T6 using a welding procedure qualified to D1.2/D1.2M:2014, *Structural Welding Code — Aluminum*, and an ER5183 filler metal, what would be the expected as-welded condition of the weld heat-affected zone (HAZ)?

a) Higher strength than the weld metal
b) Lower strength than the weld metal
c) Naturally aged to the -T4 temper
d) Overaged and partially annealed
e) Both b and d above

The answer is **e**. The as-welded condition of a groove weld HAZ in 6061-T6 base material using a welding procedure qualified to AWS D1.2 would be described as overaged and partially annealed. Its strength would be a little above the minimum requirement for the as-welded base metal as provided in Table 3.2 of the AWS D1.2 code, which is 24 ksi (165 MPa). The all-weld-metal ultimate tensile strength of 5183 is recognized as 40 ksi (275 MPa). Therefore, the HAZ of such a welded joint would be expected to be of a much lower strength than the weld metal.

6. What is the primary cause of porosity in aluminum welds?

a) The absorption of oxygen during welding
b) The absorption of hydrogen during welding
c) The absorption of nitrogen during welding
d) The absorption of carbon dioxide during welding

e) All of the above because they are all in the atmosphere.

The answer is **b**. Weld porosity in aluminum welds results from the absorption of hydrogen during melting and the expulsion of hydrogen during solidification of the weld. The solubility of hydrogen in aluminum increases dramatically after the material reaches its liquid stage. When aluminum is heated to temperatures above its melting point, it becomes very susceptible to hydrogen absorption. The hydrogen can then form bubbles in the molten aluminum as it solidifies, and these bubbles are then trapped in the metal, causing porosity. The primary sources of hydrogen that create porosity in aluminum welds are hydrocarbons, hydrated aluminum oxide, and moisture.

7. In accordance with AWS D1.2/D1.2M:2014, *Structural Welding Code — Aluminum*, welding shall not be performed in a wind exceeding what speed?

a) 5 mph
b) 10 mph
c) 15 mph
d) 20 mph
e) Wind speed is not addressed in the code.

The answer is **a**. According to AWS D1.2/D1.2M:2014, subclause 4.10, Welding Environment: "Welding shall not be performed in a wind exceeding 5 mph (8 kph), nor when the surfaces are wet or exposed to precipitation."

8. In accordance with AWS D1.2/D1.2M:2014, *Structural Welding Code — Aluminum*, when welding 5086 with 5356 using a welding procedure specification (WPS) qualified to D1.2, what is the maximum allowable increase in preheat from that specified on the WPS?

a) An increase of > 25°F
b) An increase of > 50°F
c) An increase of > 100°F
d) An increase of > 150°F
e) There is no limit specified for this weld.

The answer is **e**. According to AWS D1.2/D1.2M:2014, Table 3.1, Limitation of Essential Variables of a WPS, Preheat (31), "Increase from specified (heat treatable alloy only) by >100°F." As 5086 is not a heat-treatable alloy, there are no specified limits relating to the increase in preheat for this weld.

9. Stress-corrosion cracking is a common issue in 5xxx series aluminum when alloys over 3% Mg are exposed to elevated service temperatures (between 150° and 350°F). In the case of 5xxx series weldments, this phenomenon is caused by:

a) Galvanic cells between the bulk Al and the dissolved Mg
b) Secondary phases forming on metal grain boundaries
c) Secondary phases forming in metal grain interiors
d) Residual stress on welded joints
e) Both a and d
f) Both b and d

The answer is **f**. For stress-corrosion cracking to occur, both an induced stress and a corrosive environment are necessary. In a corrosive environment without induced stress, the material may still corrode, and without a corrosive environment a material under stress will hold residual stress, but stress-corrosion cracking requires both ingredients. In the case of 5xxx series welding, the heat from welding and contraction during solidification provide the stress. The corrosive environment arises when, in a process known as sensitization, the secondary Al_3Mg_2 phase forms, enveloping the aluminum grain boundaries and creating a galvanic cell between the continuous Al_3Mg_2 and the bulk aluminum.

10. When considering 2xxx, 6xxx, and 7xxx series aluminum, the terms "aging" and "heat treatability" are used to describe the changes in mechanical properties from exposure to specific heating processes. Physically, the changes in the aluminum metal contributing to the strength during heat treating are:

a) Changes to the aluminum grain structure
b) Precipitate formation and growth
c) Solute segregation
d) Temperature-induced strain hardening
e) None of the above

The correct answer is **b**. In many alloys, not just aluminum, the elements that are used for alloying can form secondary phases (often called precipitates) within the bulk material, where the primary phase constitutes the main bulk of the material. Not all these secondary phases are beneficial, but in the case of the heat-treatable aluminum alloys, the targeted secondary phases significantly strengthen the material. Specific heat treatment schedules can be used to achieve specific temper conditions, and the process of secondary phase or precipitate development is known as aging. However, continued exposure to sufficient heat conditions can cause the secondary phases or precipitates to over-age, at which point the strengthening effect of the precipitates is lessened.

As a technical note, solute segregation does indeed play a part in the nucleation and growth of precipitates. However, the actual formation and development of the precipitates is what contributes to the alloys' strength. WJ

TONY ANDERSON is director of aluminum technology, ITW Welding North America. He is a Fellow of the British Welding Institute (TWI), a Registered Chartered Engineer with the British Engineering Council, and holds numerous positions on AWS technical committees. He is chair of the Aluminum Association Technical Advisory Committee for Welding and author of the book Welding Aluminum — Questions and Answers *currently available from AWS. Questions may be sent to Tony Anderson c/o* Welding Journal, *8669 NW 36 St., #130, Miami, FL 33166-6672, or via email at* tony.anderson@millerwelds.com.

BY TIM HIRTHE

Q: I'm hoping for clarification on minimum capillary action requirements. We are brazing mostly copper to copper with American Welding Society (AWS) A5.8 BCuP-5 filler metal. When we are training future brazers we want 100% capillary action like anyone else, but we tell them an industry standard is 70%. Is that a factual statement based on your experience? Also, is there an AWS document showing if a joint was only 10% fill, what the likelihood of a failure would be? The reason I ask is because we currently allow one joint at 10% fill to be acceptable. From a training standpoint, I don't feel comfortable with that percentage fill. For me to sell changing this to our management and engineering group, I'd like to back it up with some data as to why we would like more fill in the joint. Do you have any information about limitations on under-filled joints?

A: When we spoke, the first thing we did was clarify the term capillary action. It is the ability of liquids, in this case, molten BCuP-5 filler metal, to be drawn into a narrow, closely fitted space. In your application, it is the space created between the outside diameter of the Cu tube and the inside diameter of the Cu fitting over the length of tube insertion.

The concern you expressed is a lack of filler metal in the joint. You are right in bringing up capillary action because it is responsible for drawing the BCuP-5 into the joint. You mentioned that you investigated the issue of braze joint fill with several entities around the industry and came up with a consensus that the typical joint fill is between 50 and 70%. This is for torch-brazed joints, as you are using a propylene and oxygen flame, and are not using flux of any kind. From experience, I would agree that this range is typical. However, I am not aware of any industry-wide study on the subject.

You explained that the braze joint in question is part of a test setup, which contains four joints. Three need to meet a higher percentage fill but one is given an okay if it is as low as 10%. For clarity, these percentages are determined by a peel test. In looking at Cu tube joints, peel tests are standard practice as a destructive test to aid in assessing joint quality. Given the above, I would agree a 10% fill is on the low side.

Your second question is about the limitation of under-filled joints. I know of no data available on the subject. One of the problems is you may test a joint after it is made, leak testing in particular, which is another standard test method for these joints, and it passes. Then, after a period of time in the field, as part of a finished unit, it fails. The failure mechanism, be it lack of joint fill or something else, is not determined until and unless a unit is returned for analysis. This is done by the company that manufactured the unit and the information never gets published.

Common culprits that contribute to lack of joint fill are part fitup, contamination, and heating/process methods. These issues can be addressed to improve the brazing results across all of your joints. The American Welding Society (AWS) has a number of publications and specifications that can help.

The document I would draw your attention to first, to illustrate the issue, is AWS C3.4, *Specification for Torch Brazing*. It states that it ". . . presents the minimum fabrication and quality requirements for the torch brazing of materials . . ." One of the first things it requires is to classify your braze joints.

There are three classifications in the specification: Class A, Class B, and Class C. These are based on the following two criteria: "the design requirements and the consequences of their failure." It goes on to say that, "It is the responsibility of the Organization Having Quality Responsibility to evaluate these or other factors and assign the proper classification. This classification controls which inspection methods and limits are required." This is the short story, as this Q&A column has space limitations, so I urge you to obtain a copy of the specification to make an informed decision on your situation.

Class A and Class B are for braze joints whose failure "could result in significant risk to persons or property, or significant operational failure." Class C is for joints, "the failure of which would have no risk to persons or property." Based on our discussion and knowledge of your application, it would be my assessment that these are Class C joints.

To address this in terms of joint fill, or the total measured amount of void or unbounded area, you need to look at subclause 6.6.2. Class A and Class B joints require you to use either ultrasonic pulse-echo examination or radiographic examination to determine the extent of internal discontinuities. Class C joints do not have any internal inspection requirements. So, while you may look at the percentage of joint fill, the specification requirements for Class C joints does not tell you if the results you get are good or bad.

For reference, joint fill of Class A joints is required to be a minimum of 85%. For Class B, a 75% minimum is required. Keep in mind, these joints are critical components where the failure would be catastrophic.

The upshot for you is your organization needs to design a process and assess the quality of your joints. Long-term performance requirements would be the guide to what is an acceptable joint. The goal would be to use best practices in design, fabrication, process, and brazer training. There are several AWS documents and publications that can help.

AWS C3.3, *Recommended Practices for the Design, Manufacture, and Examination of Critical Brazed Components,* can help with a roadmap of things to consider. The AWS *Brazing Handbook* can be an invaluable source of information to help you make decisions on all facets of your braze application. AWS B2.2, *Specification for Brazing Procedure and Performance Qualification,* will

— *continued on page 57*

Improved Grinding Face Shield Increases Safety and Comfort

The upgraded Command PRO™ grinding shield assembly includes an injection-molded, polycarbonate visor along with a multifit, ratchet-style headgear for high-impact face protection. The clear face shield comfortably fits over protective eyewear and respirators, accommodates a variety of headgear with its universal slots, and features a thickness of 0.060 in. to provide more protection compared to the standard 0.040-in. window. Additionally, the headgear can be quickly adjusted with its push and turn ratchet sizing feature. Measuring 15½ × 8 in., the shield assembly is lightweight for enhanced comfort. It also meets the requirements of ANSI Z87.1, *American National Standard for Occupational and Educational Personal Eye and Face Protection Devices*.

Forney Industries Inc.
forneyind.com
(800) 521-6038

Gloves Deliver Cut, Abrasion, and Puncture Resistance

The Tillman® 1477 TrueFit® gloves provide ANSI A7 cut resistance coupled with level 4 abrasion and puncture resistance. The cut resistance is achieved through its para-aramid lining located on the fingers, palm, and back of hand. The abrasion resistance is bolstered by the gloves' soft, top-grain, goatskin

leather. The leather sides and fingers offer additional protection for side surface work and heavy-wear areas. The gloves' other features include the following: a high-visibility color to ensure hands are seen; a rough-side out double palm for longer life and better gripping; a reinforced thumb to safeguard against stress areas; a smooth surface on fingers for improved handling; an elastic cuff with a thermoplastic rubber, as well as a hook and loop closure, for a secure fit; and a breathable, form-fitting spandex back that keeps hands cool and provides a precision fit. The gloves come in sizes small–3X.

John Tillman Co.
jtillman.com
(800) 255-5480

AWS Summer/Fall Catalog Showcases New Offerings

The American Welding Society's (AWS's) *2020 Summer/Fall Products and Services Catalog* covers professional, career development, and academic resources; exposition programs; and publications on reference materials, welding processes, industry applications, and more. The 94-page digital catalog also announces nine new products, including A2.4:2020, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*; A5.26/A5.26M:2020, *Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding*; C3.8M/C3.8:2020, *Specification for the Ultrasonic Pulse-Echo Examination of Brazed Joints*; C3.9M/C3.9:2020, *Specification for Resistance Brazing*; AASHTO/AWS D1.5M/D1.5:2020, *Bridge Welding Code*; and F4.2:2020, *Safety Guidelines for Proper Selection of Welding Cables*. Other highlights consist of the Certified Resistance Welding Technician Certification, the Welder Performance Qualifier Endorsement, and new courses, such as the 2-Week Online CWI Seminar, Professional Development Training Series, Welding Fundamentals Curriculum, and Instructional Strategies for Welding Educators. The catalog can be accessed at *aws.org/standards/page/products-and-services-catalog*.

American Welding Society
aws.org
(800) 443-9353

Waterproof Bandage Alerts Wearers When Wet

The waterproof bandage with wetness indicator provides a secure covering for low-exudate wounds. If the seal of the bandage is broken and the wound site gets wet, the gauze at the perimeter of the bandage, or at the center covering the wound site, will turn blue to indicate the bandage needs to be changed and that contamination may have occurred. This notifies the wearer that a bandage change is necessary. The bandage is suitable for industrial environments, where keeping a wound clean, whether it's fresh or healing, can be a challenge. Average bandages found in a first aid kit don't fully seal off a wound. With its wetness indicator, the bandage can help those on job sites keep their wounds dry, thus reducing the number of infections. Offered in packages of 25 for online purchase, the bandage is waterproof, sterile, disposable, breathable, and nonlatex. Additionally, one bandage can be used for up to three days.

DrySee®
drysee.com
(866) 221-2785

Dust Collector Designed for Laser Cutting Applications

The Senturion® dust collector handles the volume and type of dust produced by fiber laser cutting. It features a motor-blower combination that ensures adequate airflow, a lower air-to-cloth ratio (more filter media per ft^3/min of air) to accommodate large volumes of dust, a pulsing system to prevent dust from becoming embedded in the filter media, and Pleatlock® filters with better pleats and more filter media to capture more dust with less loading. The dust collector also comes with a touch-screen control system and the SafeSensor™ particulate monitor, which detects leaks and shuts down the dust collector if a leak is detected. Designed to keep up with the demands of high-production manufacturing facilities, the plug-and-play unit is easy to use upon start up.

RoboVent®
robovent.com
(888) 298-4214

Line of Gas Monitors Provides Cellular Connectivity

The line of Ventis® Pro5 multigas monitors comes with a cellular battery that allows data to be instantly transmitted to the iNet® Now monitoring software. The gas monitors with cellular connectivity enable supervisors to

respond quickly in an emergency through instant alerts that include name, location, and hazard data; allow efficient communication with teams in the field through two-way text messaging; and provide 14 h of run time on a single charge. They are compatible with existing DSX™ docking stations and iNet® Exchange for maintenance and repairs. The cellular battery can be ordered with all gas monitors in the line. Reliable coverage is provided through Verizon and AT&T services in the United States, as well as Bell, Rogers, and Telus services in Canada.

Industrial Scientific Corp.
indsci.com
(800) 338-3287

Report Analyzes the Global Welding Helmet Market Pre- and Post-Coronavirus

Global Welding Helmet Market Insights, Forecast to 2025 posits this market was valued at $650 million in 2018 and projected to reach $840 million by 2025, at a compound annual growth rate of 3.3%, prior to the COVID-19 pandemic. However, it indicates this data has changed due to the global impact of COVID-19. It states the solicitation of proposals by governments and public-private companies across the world is helping to mitigate the economic effects of the COVID-19 pandemic and propel the growth of the welding helmet market. The 122-page report is organized by helmet manufacturers, type (e.g., passive, auto-darkening, etc.), application (e.g., shipbuilding, energy, automotive, etc.), and region.

360 Market Updates
360marketupdates.com
(424) 253-0807

Blog Addresses Welding Safety

The *Welding Safety Tips and Guidelines for 2020* blog tackles why welding safety is important as well as the different types of welding hazards and how to avoid them. The hazards covered are electric shock, exposure to fumes and gases, physical injuries, and fire and explosions. The blog also lists 11 rules that should be followed to increase safety while welding. Colorful illustrations and photographs accompany the text. The blog can be found at *uti.edu/blog/welding/welding-safety-tips-2020*.

Universal Technical Institute
uti.edu
(800) 834-7308

Wide Scissor Lift Suited for Large and Bulky Materials

The double-wide scissor lift easily hoists and positions large, heavy, and bulky items. With the expanded dimensions of 72 × 96 in., the lift can accommodate 6000 lb. It includes heavy-duty cylinders, internal power units, lubricated bearings, tubular legs, safety maintenance blocks, and standard hand controls. Designed for a long service life, the robust lift is durable yet economical to purchase and operate. Vertical travel can be added from 24 to 60 in. to aid ergonomics and enhance productivity. Its other options for matching the lift tables to the task at hand are accordion skirting, oversized platforms, platforms with beveled edges, pit-mounted units, portability packages, turntable tops, detent stops, tilt table mounted to lift, conveyor, programmable logic controller, foot pedal control, external power modules, high-cycle count packages, and more.

Verti-Lift Inc.
verti-lift.com
(502) 361-0180

The Heroes amongst Us

A special tribute to the essential businesses that changed gears to support COVID-19 frontline workers

BY KRISTIN CAMPBELL, CINDY WEIHL, KATIE PACHECO, ALEXANDRA QUIÑONES, AND ROLINE PASCAL

Ahhh, 2020. Your 12 months have made quite an impact on history. In January, the new year started off so swell . . . then two and a half months later, the COVID-19 pandemic hit, changing everyday life as we knew it. And here we are, already, at the end of the year.

Along the uphill, winding road of 2020, there have been some positive marks. For example, medical personnel in hospitals were recognized, maybe more than ever, for their incredible efforts to save lives. And essential businesses and workers, including those in our industry, modified their production to supply personal protective equipment (PPE).

Merriam-Webster has many definitions for hero, ranging from "one who shows great courage" to "the central figure in an event, period, or movement." Throughout this time, too many to count have gone above and beyond the call of duty, acting as heroes. This article pays tribute to merely a handful of them.

Breathe Easier with Triple-Layer Masks and Air Purifiers

Where there's a will, there's a way. Rensa Filtration, Warrenville, Ill., a family of air filtration companies that includes RoboVent, Sterling Heights, Mich., and Permatron Corp., Elk Grove Village, Ill., recently proved this old adage true.

Earlier in the year, a brief attempt to work with local, state, and federal government officials to secure public funding to rapidly ramp up domestic PPE manufacturing seemed to drag on. Rensa leadership took matters into their own hands and formed a 100% U.S.-based supply chain for surgical face masks. Working with raw material suppliers and The RDI Group, Itasca, Ill., they funded their own effort to quickly make machinery and finished face masks to address the need for locally made PPE.

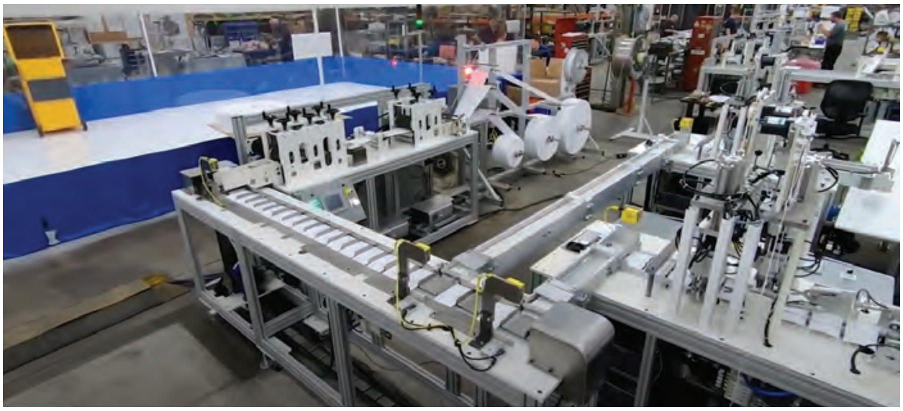


Fig. 1 — This screenshot, taken from a video that highlights the machine built to manufacture the masks, shows its test-build area. Since then, the machine has been moved to the production facility in Illinois.

"Essentially, we make all types of air filters and saw an opportunity to use that knowledge and expertise to bring face masks to the market quickly," said Frank Cea, director, marketing and development, RoboVent, and product manager for the masks. The companies also wanted to combine their engineering and technology expertise to do something good, producing a new product that would help keep people safe.

A partnership formed with The RDI Group, which operates business units specializing in the design and manufacture of automated manufacturing systems. One custom-built machine was fabricated for the face mask assembly; it works as a production line, starting with spools of filter material, and ends with the finished product. Housed at Permatron, its operations began in July. To watch a short video, visit *youtu.be/88-glolC9ZQ* — Fig. 1.

Features of the Clearcare™ surgical face masks *(robovent.com/masks)* are as follows: triple layers for protection, filtration, and comfort; breathable material; polypropylene ear straps; virgin fibers; and nonwoven materials for a softer feel — Fig. 2.

Helping Americans return to work safely is important to the companies, akin to standing up and serving.

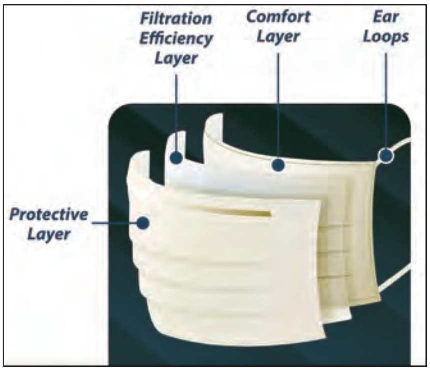


Fig. 2 — Various parts of the Clearcare surgical face mask are detailed above. (Courtesy of RoboVent.)

"It's a sense of patriotism and wanting to take care of our fellow Americans," Cea emphasized, "since we were an American-made manufacturer. Our products, at all of our different companies, are sourced, made, and fabricated here in the United States . . . it's really just about answering the call."

On a given day, 60–100 masks/min are fabricated. That equals a daily output of around 60,000 and a volume of approximately 1.25 million a month. It's expected production won't cease.

Now that the masks have been certified and tested by Nelson Labs, achieving ASTM Level 2 and 3 certification, Rensa has stock and is ready to ship throughout the United States. A stock has also been made available for mask donations to organizations in true need. Contact *orders@rensahealth.com* for mask donation inquiries.

In addition, RoboVent's PRC Series has been in demand due to COVID-19. The commercial and industrial air purifier, a supplemental filtration unit, captures up to 99.95% of particulate; comes in two models; and is standard with two filters, a MERV 15 cartridge filter and a MERV 8 carbon prefilter (high-efficiency particulate air [HEPA] filters can also be used). It's serving more places, including gyms and theaters, that didn't necessarily utilize it before. And with winter weather coming, doors will start shutting vs. staying open like in the summer.

"Indoor ventilation and indoor air quality is important for everyone," Cea said.

To further grasp the significance of clean air circulation, Cea encouraged reading the *USA TODAY* article titled "Ventilation and air filtration play a key role in preventing the spread of COVID-19 indoors" (Ref. 1).

During this tricky time, Cea concluded with these words of wisdom: "Do anything and everything to help somebody else." We're in this together.

3M Tapes Off the Spread of COVID-19

The COVID-19 pandemic has changed the world in unforeseeable ways. With so many aspects of everyday life affected, recovering from this crisis calls for a multipronged approach. 3M, Saint Paul, Minn., was up for the challenge.

The company spans a spectrum of industries, from healthcare, manufacturing, safety, and beyond, and produces more than 60,000 products. Its efforts in responding to this global crisis have been diverse and industrious.

The company's early response to the COVID-19 outbreak included supplying critical products to the frontline healthcare workers and first responders fighting the pandemic. Since January, the conglomerate has doubled respirator production globally and expects to deliver 2 billion respirators worldwide by the end of the year.

As the largest manufacturer of N95 respirators in the United States, 3M continues to increase domestic production as well. At the Aberdeen, S.Dak., plant, the company is adding new equipment, buildings, and manufacturing lines, which also means more jobs — Fig. 3. The goal is to increase N95 production in the United States to 95 million a month.

With the conglomerate's internal operations geared to assist in the pandemic, it sought to expand its impact by collaborating with outside companies and organizations to find innovative solutions. Some of the work it has done to approach the challenge includes the following:

- Working with the Massachusetts Institute of Technology to develop a rapid diagnostic test for COVID-19;
- Providing expertise in personal safety equipment, technology, and regulatory requirements to help Ford Motor Co. rapidly design a new powered air-purifying respirator;
- Collaborating with several manufacturers and institutions that are investigating ways for hospitals to safely decontaminate, reuse, and extend the life of N95 respirators under U.S. Food and Drug Administration (FDA) Emergency Use Authorizations; and
- Partnering with Nissha Medical Technologies to develop a face shield with antifog capabilities to improve the visibility and comfort of healthcare providers during prolonged clinical wear.

The company has also helped the pharmaceutical field with its 3M™ Emphaze™ AEX hybrid purifier line, which uses a filter material that captures impurities while allowing the necessary drug substances to pass

Fig. 3 — 3M is expanding its Aberdeen, S.Dak., plant to increase production on N95 respirators.

through. These products are now being used by researchers and pharmaceutical companies to pursue therapies and vaccines to treat and protect against COVID-19.

While many have banded together to fight the pandemic, some have exploited the crisis. To combat this, 3M launched an effort to stop fraud and price gouging. The company has not and will not increase its prices for N95 and other respirators. Furthermore, its legal team members have investigated more than 4000 reports of suspected fraud, counterfeiting, and price gouging. It has successfully secured the removal of more than 7000 e-commerce listings with fraudulent or counterfeit product offerings and more than 10,000 false or deceptive social media posts to date. 3M will donate any monetary damages from these lawsuits to COVID-19-related nonprofits, including Direct Relief.

Furthermore, the company has committed $20 million as a cornerstone financial gift supporting community partners working to address critical needs. 3M and the 3M Foundation have also committed $10 million in cash and product donations to COVID-19 response efforts throughout 2020.

As a company famously known for its adhesives, 3M has proven to be a figurative glue, supporting many different industries during these challenging times.

Powering through the Pandemic with Batteries

When the global need for respirators outnumbered output, Stanley Black & Decker, New Britain, Conn., a manufacturer of industrial and household tools, joined forces with Ford and 3M to help design and create a powered air-purifying respirator (PAPR) for healthcare professionals. Stanley Black & Decker's role in this partnership was to deliver the batteries needed to power the respirators through its trademark company, DeWalt®, a manufacturer of power tools — Fig. 4. Providing the thousands of DeWalt batteries that would be needed for the PAPRs was no easy feat, but the company was spurred by the call to action.

"We felt that it was important to assist our governments and communities in mitigating the spread and impact of the virus around the globe," said Kyle Dancho, vice president of global licensing at Stanley Black & Decker. "Our company's president and CEO, Jim Loree, recently said in a press release, 'Now is the time for corporations like ours to demonstrate how we can align our resources to help deliver the innovative solutions the world needs right now.' With that, we established a comprehensive COVID-19 response program in alignment with our purpose — for those who make the world — using our expertise and innovation, and our resources, to be a force for good and make a difference in our communities."

The company's quick response included modifications to its production process to be able to meet the immediate need for extra batteries. One change it made was diverting promotional sales volume to utilize existing inventory.

"We then pivoted to work these orders into our normal production process," Dancho said.

The company also lent its engineering expertise for the design of the PAPRs (Fig. 5) and considered other ways it could lend a hand in the battle against the COVID-19 pandemic.

"We consulted on this project and provided engineering support to ensure Ford and 3M had a proper connection system for the battery pack. To fit the battery need, we manufactured a wiring system to the PAPR," Dancho explained. "DeWalt also looked at utilizing batteries and vacuums for other COVID-19 applications, such as intubation chambers to protect patients and doctors."

The result of the partnership is a new, portable PAPR that offers a hood with a face shield, a HEPA filter for clean air supply, and battery power that

Fig. 4 — An engineer assembles the battery system for the new PAPR using two types of DeWalt batteries. (Photo credit: Ford.)

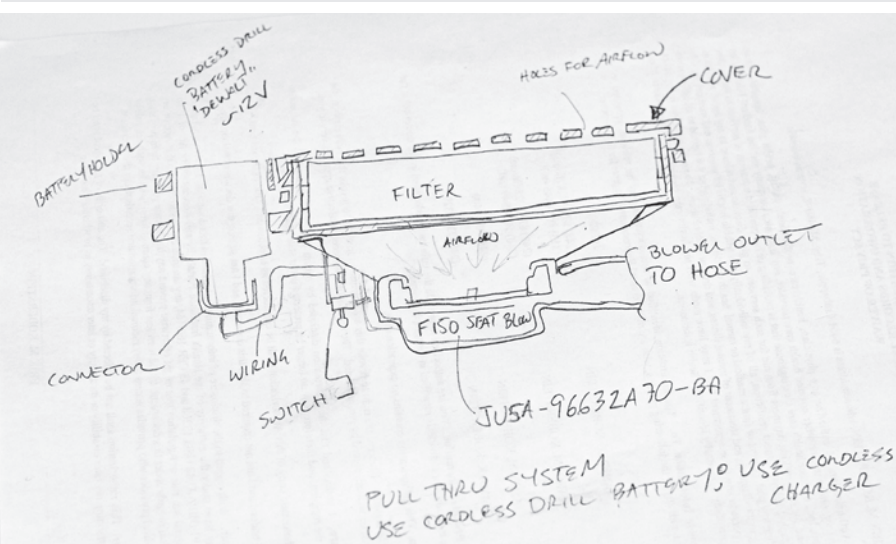


Fig. 5 — This sketch details the new PAPR design, including how the battery system integrates into the respirator. (Photo credit: Ford.)

lasts up to 8 h. The PAPR uses DeWalt 3.0- and 5.0-Ah batteries. It also features a custom wiring harness to allow for the easy exchange of battery packs for recharging and continued use.

Thus far, DeWalt has shipped 75,000 batteries for respirators. According to Dancho, the company is prepared to deliver much more if needed.

Boeing Launches Face Shields and Sanitation Wands

In early April, Boeing, Chicago, Ill. — one of the world's largest aerospace companies and provider of commercial airplanes; defense, space, and security systems; and global services — delivered its first set of 3D-printed face shields to support healthcare professionals working to stop the spread of COVID-19. The 2300 face shields were accepted by the U.S. Department of Health and Human Services. The Federal Emergency Management Agency then delivered the shields to the Kay Bailey Hutchison Convention Center in Dallas, Tex., which was established as an alternate care site to treat patients with COVID-19.

Boeing workers produced the face shields with additive manufacturing machines at company sites in St. Louis, Mo.; China Lake, El Segundo, and Huntington Beach, Calif.; the Puget Sound region of Washington state; Mesa, Ariz.; Charleston, S.C.; San Antonio, Tex.; Salt Lake City, Utah; and Portland, Ore. Boeing subsidiary Argon ST in Smithfield, Pa., also participated in the project.

Solvay, a long-time Boeing supplier, provided the clear film for the face shields. Another supplier, Trelleborg Sealing Solutions, donated the elastic used for the adjustable headband.

Face shield production and donations are part of a larger Boeing effort to leverage company and employee resources to aid with COVID-19 recovery and relief efforts. In addition to the production of face shields, the company has donated tens of thousands of units of PPE, including face masks, goggles, gloves, safety glasses, and protective bodysuits to support healthcare professionals battling COVID-19.

Boeing's efforts don't end there. This fall, the company announced it entered into a patent and technology license with Florida-based Healthe® Inc., under which Healthe will manufacture an ultraviolet (UV) wand designed to sanitize airplane interiors. Boeing designed and developed the UV wand as part of the company's Confident Travel Initiative (CTI) to support customers and enhance the safety and well-being of passengers and crews during the pandemic.

Fig. 6 — The UV wand can disinfect high-touch surfaces. (Photo by Marian Lockhart/ Boeing.)

The UV wand uses 222-nm UVC light. Research indicates 222-nm UVC inactivates pathogens effectively.

Using the self-contained apparatus that resembles a carry-on suitcase, crews can pass the UV light over high-touch surfaces, sanitizing everywhere the light reaches — Fig. 6. The UV wand is particularly effective in compact spaces and sanitizes a flight deck in less than 15 min.

As part of the CTI, Boeing solicited feedback from multiple industry sources, which aided in quickly validating this technology. Etihad Airways was the first to evaluate the device, and the UV wand was demonstrated on the Etihad 787-10 ecoDemonstrator airplane on Aug. 21.

Healthe will produce and distribute the commercial wand.

Transitioning from Food Bags to Protective Gear

As the need for advanced protective gear and equipment for healthcare and frontline workers soars on top of every checklist, companies have been retooling their manufacturing capabilities to produce PPE to fight the spread of COVID-19. One such company, Novolex®, Hartsville, S.C., has used its facilities to develop protective gear, such as isolation gowns, face shields, and headgear, in response to this unprecedented time.

Novolex is a paper and plastic packaging company that serves customers from retail, grocery, convenience stores, delis, and food services to hospitality, institutional, food processing, and industrial and construction markets.

In March, Shields™, a Novolex brand located in Yakima, Wash., answered a call from the Association of Washington Business asking for manufacturers that could repurpose their operations to make PPE such as masks, gowns, face shields, and other gear. Shields fabricates custom-engineered food packaging and has been operating since the mid-1950s. As a plastic packaging provider, Novolex was equipped to produce PPE.

"When we learned there was a critical need for PPE, we immediately got to work adapting our facilities to produce medical gowns," said Scott Houtz, regional manufacturing director of Novolex.

During the early months of the pandemic, the company began to compress a typical six- to eight-month product development process into three weeks to assemble up to 25,000 face shields and 100,000 medical isolation gowns per week. By May, the company was

Fig. 7 — Novolex is offering two styles of face shields for consumers. Pictured is the two-piece model, which comes in a three pack and is secured around the back of the head with an elastic band.

knocking out a million ASTM Level 1, 2, and 3 isolation gowns per week with equipment that had been used to make bags for tortillas and other food products. In addition, Polar Pak®, a Canadian-based Novolex brand, began developing more than two million medical face shields for Health Canada and other potential customers.

As schools, restaurants, and small businesses reopen, the company is also offering its face shields directly to consumers.

The lightweight face shields, which are produced by the WNA division of Novolex, come in a one- and two-piece model — Fig. 7. The two-piece model comes in a three pack and is secured around the back of the head with an elastic band. The one-piece model comes in a five pack and secures with an attached head band.

The face shields can be purchased at several online outlets, including *Amazon.com* and *Boxed.com*, and retail locations, such as Smart & Final.

The plastic packaging company adjusted the infrastructure at its plants, which make transparent polyethylene terephthalate sheet (a thermoplastic that is strong, lightweight, FDA compliant, and recyclable) and fit-for-purpose injected molded plastic fittings for constructing face shield components.

By adapting its manufacturing structure, Novolex's facilities across North America are pushing out protective equipment at a record scale. In addition to enhancing production, the company has assembled a national transportation and supply chain system to continue with the work until the demand subsides. **WJ**

Reference

1. Padilla, R. 2020. Ventilation and air filtration play a key role in preventing the spread of COVID-19 indoors. *USA TODAY*. Retrieved Oct. 29, 2020, from *usatoday.com/in-depth/graphics/2020/10/18/improving-indoor-air-quality-prevent-covid-19/3566978001/*.

Recapping Acts of Kindness

There has been a wide range of COVID-19 coverage going back to the May 2020 *Welding Journal*. In particular, two inspiring tales about a welder who sews and a father/son joining forces for a good cause are being shared once more.

• Sgt. Edwin Rodriguez, a full-time welder for the **California Army National Guard's** combined support maintenance shop (CSMS) in Long Beach, has been busy working with different tools — namely, a sewing machine, fabric, and thread.

He is sewing cloth masks that will help protect his fellow service members from COVID-19. The entire process takes him less than 3 min.

"Sewing is the easy part," he said. "I'd say cutting and cleaning takes the most time."

Rodriguez, who also serves as a wheeled-vehicle mechanic, has sewn more than 90 masks for fellow soldiers since COVID-19 began to influence uniform standards. The Department of Defense and the California National Guard require service members to include face coverings as part of their personal protective equipment (PPE) when physical distancing cannot be achieved.

U.S. Army Sgt. Edwin Rodriguez, a welder at the California National Guard's Combined Support Maintenance Shop, sewed face masks for soldiers on a vintage sewing machine in the Long Beach, Calif., facility. (Credit: Staff Sgt. Matthew Ramelb.)

Chief Warrant Officer 2 Ben Johnson and Chief Warrant Officer 2 Mark T. Bun, California National Guard technicians who work with Rodriguez, approached the Compton, Calif., native with the idea of making masks.

After guidelines required the use of face masks to help slow the spread of the virus, Bun, the CSMS foreman, began thinking of ways he and his soldiers could help those without access to PPE. He consulted with his mother, an avid sewer, to create a prototype based on the Centers for Disease Control and Prevention specifications, then showed the design to Rodriguez.

"I asked him if he could start sewing some stuff for us to protect the soldiers. That's the least we could do, make them feel safer here and give them peace of mind," Bun said.

Sewing machines aren't commonly thought of as maintenance shop equipment, but they are occasionally used to repair Humvee doors, Rodriguez mentioned. While he knew the CSMS had three 40-year-old sewing machines, he also knew some hadn't been used in years. After repairing two of the three machines, Rodriguez began sewing, using his civilian skills as a former upholstery technician. Johnson and Bun gathered fabric donations of T-shirts and trousers from the maneuver area training equipment shop (MATES) at Fort Irwin, as well as the 118th Maintenance Co. in Stockton.

While making the masks, Rodriguez noticed an issue when sewing the fabric together, but he solved that by adding a layer of gauze within the fabric, he noted.

The masks were given to California Guard soldiers at the CSMS, MATES, and the 118th Maintenance Co. facility.

• Cory Thompson, an emergency room nurse at St. Anthony Regional Hospital, Carroll, Iowa, and a 2013 graduate of the **Des Moines Area Community College (DMACC)** Carroll Campus nursing program, knew he and his fellow healthcare workers were going to need more PPE during the COVID-19 pandemic. He also knew to call his father, DMACC Emeritus Industrial-Electro Mechanical Technology Professor Jack Thompson.

"After some thinking, I asked my son if [the hospital workers] could use a full face shield, and he said that would be the preferred type of protection," Thompson said.

The elder Thompson took a closer look at his DMACC welding gear. He noticed the headgear was in good shape, but the plastic lenses weren't. His next call was to Matheson Industrial Gas Supplier in Carroll; it didn't have replacement lenses for the type of headgear he was asking about, but it did have an older version. Thompson was excited upon determining he could cut them to fit. He then called DMACC Carroll Campus Provost Joel Lundstrom to ask if he could use the DMACC headgear, explaining how it would be used at the hospital. Thompson purchased enough of the older version lenses to begin his new project, which included modifying the older lenses to fit the new headgear.

"Before I could put the lenses into the headgear, I had to disassemble the headgear and clean them, so I ran them through three cycles in my dishwasher," Thompson added.

After reassembling the face shields, he called his son, who picked them up and took them to St. Anthony. It proved to be a popular delivery. To learn more about this project, visit *dmacc.edu/news/Pages/20200416.aspx*.

St. Anthony Regional Hospital Emergency Room Nurse Cory Thompson (left) and his father, DMACC Emeritus Industrial-Electro Mechanical Technology Professor Jack Thompson, pose with the face shields the elder Thompson made for the medical staff at the hospital. (Credit: DMACC.)

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Wash Your Gloves and Fight the Spread of COVID-19

For long-term protection, follow these steps — work, wash, and repeat

Ryan Kibbe, CEO at Kibbetech Offroad Fabrication and product tester for Mechanix Wear, adds hardware to one of his signature suspension arms.

Just as we are expected to wash our hands, it's equally important to routinely wash our gloves during the pandemic. COVID-19 is vulnerable to standard interventions like soap, water, bleach, ultraviolet light, and alcohol-based cleaners.

How do you wash your gloves? Better yet, how do you wash synthetic vs. leather gloves, or nitrile-coated knit and insulated gloves? If you own a set of work gloves from the Los Angeles-based brand Mechanix Wear, follow its wash guide for tips and safe glove care (learn more at *mechanix.com/us-en/care-guide*).

Washing Tips

Synthetic Gloves

Mechanix Wear's synthetic leather is one of its showpieces, along with its family of high-performance synthetics. The company recommends washing its synthetic gloves with household laundry detergent and warm water — Fig. 1. Machine dry your gloves with low heat to prevent material shrinkage, or air dry to maintain long-term material performance.

Coated Knit Gloves

You might hesitate before throwing seamless coated gloves in the wash, but rest easy knowing they are machine-wash friendly and fast drying — Fig. 2. The company recommends washing its palm-coated gloves with household laundry detergent and warm water. Machine dry your gloves with low heat to prevent material shrinkage, or air dry to maintain long-term material performance.

Durahide™ Leather Gloves

Durahide performance leather is treated to be machine washable and resist water to prevent cracking or splitting like standard leather gloves. The company recommends washing its Du-

Fig. 1 — Instructions for synthetic leather and cotton gloves.

Fig. 2 — Instructions for coated knit gloves.

Fig. 3 — Instructions for Durahide leather gloves.

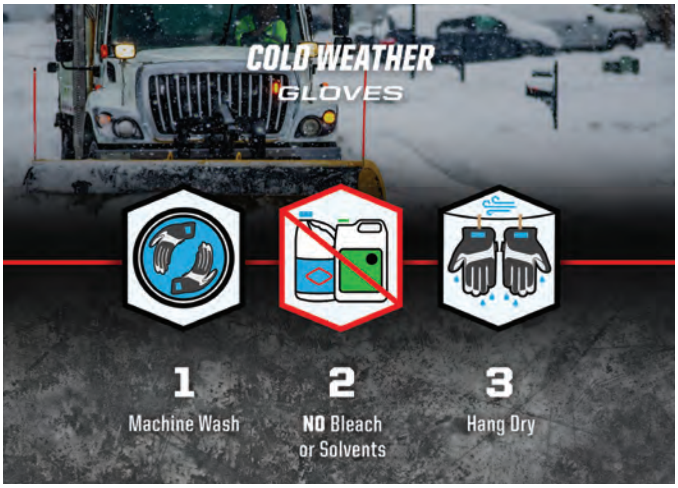

Fig. 4 — Instructions for cold-weather gloves.

rahide leather gloves with household laundry detergent and cold water — Fig. 3. Also, it suggests air drying your gloves to maintain long-term material performance, but you may also machine dry with low heat. Note: Not all leather gloves are washable like the company's Durahide leather gloves; the graphic shown is unique to its leather technology, which makes them washable.

Insulated Gloves

Performance insulation, like 3M Thinsulate™ and PrimaLoft®, utilizes synthetic down to trap warm air and protect your hands. The company recommends washing its insulated gloves with common laundry detergent and warm water — Fig. 4. In addition, it suggests air drying your gloves to maintain long-term material performance, but you may also machine dry with low heat.

Five Steps for Safe Glove Care

1. **Wear** gloves when using high-contact surfaces in the workplace and keep your gloves away from your eyes, nose, and mouth.

2. **Wash** your hands after extended glove use.

3. **Store** your gloves in a safe place, such as a washable or disposable bag.

4. **Launder** or hand wash your gloves routinely.

5. **Repeat**

Conclusion

Please stay safe during this time, and don't forget by working, washing, and repeating, long-term protection may be achieved. WJ

Information and images supplied by Mechanix Wear LLC (mechanix.com), *Valencia, Calif.*

This guidance is provided as a courtesy in the interest of promoting public health and good hygiene during these challenging times. It does not serve as any guarantee, additional warranty, or promise regarding the effectiveness of such practices, and the public should take all other recommended measures to protect against spread of the virus, including those guidelines set by the Centers for Disease Control and Prevention and the World Health Organization.

Adjusting Safety Best Practices during a Pandemic

How companies can adapt to working in an ever-changing COVID-19 environment

BY JERRY ZIEGENBEIN

The COVID-19 pandemic has differing impacts on businesses of all types across all industries. In the manufacturing space, specifically, it has influenced changes in the supply chain, put extra pressure on suppliers and partners, and prompted operations to take a close look at health and safety protocols to ensure those practices are aligning with the findings and advice of medical experts — Fig. 1.

As a result, companies have had to quickly adapt to an ever-changing COVID-19 environment. This article highlights factors that allowed companies to endure the impact of the pandemic, the importance of investing in technology that enhances employee safety and productivity, and employee training for the future.

Factors That Enabled Companies to Endure the Tough Times

The companies that have been most successful in handling safety and health considerations to keep operations running during the pandemic were prepared to react quickly and thoroughly from the start. Some of the factors that positioned businesses well to weather the initial months of the pandemic include the following:

• **Having extra inventory of sanitation materials and personal protective equipment (PPE).** This includes products like hand sanitizer, disinfecting cleaners, and face masks. Organizations that were stocked up for the traditional flu season benefit-

Fig. 1 — The COVID-19 pandemic has prompted manufacturers to bring a laser-like focus on safety, personal protective equipment, sanitization, and personal hygiene in the workplace. Pictured is a Kapco Metal Stamping employee handing out face masks amidst the COVID-19 pandemic.

ted from being prepared. However, as all companies operate under this new normal for an unknown period of time, it is best practice to make sure your company is well stocked with sanitization and safety materials. Other sanitation practices that companies embraced include spacing shift changes by at least 30 min to ensure the entire facility — shops, equipment, bathrooms, and lunchrooms — can be properly disinfected.

• **Acting quickly and appropriately.** When medical experts and epidemiologists make recommendations, companies should react appropriately, even when those recommendations change with new information — Fig. 2. There is certainly a significant cost associated with making hard decisions that change the norm of an operating environment. However, companies that reacted quickly to the facts and information related to the pandemic made difficult choices, such as discontinuing in-person department meetings, customer and vendor visits, and travel between internal offices and business sites. Those interactions continued virtually unless absolutely necessary, in which case appropriate mask wearing and social distancing guidelines were followed. Employees in the

Fig. 2 — Acting quickly and appropriately to the recommendations of medical experts is key to adapting to a COVID-19 environment. Pictured is a resource folder that all Kapco Metal Stamping employees can access to cope with the impact of COVID-19.

industry who were able to get their jobs done remotely embraced the work-from-home norm. Meanwhile, those skilled workers responsible for the welding and manufacture of many of the products that companies produce were supplied with face masks and PPE while social distancing mandates were enacted — Fig. 3.

• **Maintaining a diverse set of skilled workers.** Organizations with a diverse skill range of welders were able to react swiftly at the onset of the pandemic. Take for example an organization that may have seen initial demand changes when the full realization of the pandemic's impact took hold. By having welders with a diverse skill range, organizations can toggle output capacity without significant layoffs due to the variety of roles and responsibilities within their staff. Less experienced welders can operate welding robots while more experienced welders can assist those team members with robot setups, programming, inspections, and quality control. Additionally, the most experienced and skilled welders can continue executing manual welding work. That skill balance affords the flexibility to right-size to meet demand without having to change employment levels or adjust hiring practices, even during times of great uncertainty.

Investing in Employee Safety and Productivity through Technology

In typical times, it was already easy to trace the investment of new tech-

Fig. 3 — Skilled workers responsible for the welding and manufacture of products that organizations produce were supplied with face masks and PPE while social distancing mandates were enacted.

Fig. 4 — Investing in technology and automation allows employees to focus more time and energy on following safety protocols and health policies during the COVID-19 pandemic.

nology and equipment to improved employee safety and increased efficiency and productivity. To have the organizational mindset and leadership buy-in that adding new technology is more than just about the financial investment can be a key difference maker in developing a corporate culture that is focused on excellence. It also shows employees that the organization wants them to have the very best tools at their disposal.

Just before and during the COVID-19 pandemic, Kapco Metal Stamping (*kapcoinc.com*), a family-owned fabrication and stamping company located in Grafton, Wis., actively invested in a suite of welding technology. Each year, the company sees 80-million lb of metal through its facilities and performs cutting, forming, joining, and finishing of sheet and tube into numerous products. The company's investment in technology played a pivotal role in it being able to maintain production demand while also keeping the welding team safe, socially distanced, and healthy — Fig. 4.

Some of that equipment included a pair of aluminum welding robots with servo torches. These machines have minimized welders' exposure to fumes and physical repetitions, while also improving quality consistency and production rates. These robots feature touch-sense capabilities that detect any missing parts, which can eventually lead to expensive fixture repairs if not caught immediately, not to mention rework for the welding team.

Another intelligent welding system provides preset programs to keep the company compliant with customers' requirements and ISO standards. It also monitors arc-on time status and wire usage. From a spot welding perspective, added bowl feeders and dual-palm buttons helped the company make improvements to pinch-point safety and cycle times.

The other thing that should be invested is time. Organizations that are serious about safety should perform daily safety audits to make sure employees are using their company-provided protective equipment properly while following corporate safety guidelines.

While you may look at that kind of investment and think, "What does that have to do with keeping my weld team safe, healthy, and productive as it relates to COVID-19?" These investments can help keep the team fresh and focused. New technology and safety audits can help take the taxing, day-to-day demands of their work off their shoulders so they can spend their energy delivering quality work while also keeping health and safety protocols top of mind.

Training for Now, Training for the Future

As demand for manufacturing has rebounded, especially as manufacturers look to source parts and components domestically, it has prompted many organizations to hire new welders and robot operators. While recruiting and retaining employees is a challenge in and of itself, getting those new hires in the door and trained is pivotal for guiding their success as good employees. It is also important for making a new hire a safe and responsible team member in the current COVID-19 environment that all organizations are navigating.

Manufacturers should have robust

safety training in place as well as a culture around safety excellence. New welder training should consist of at least a week-long welding technology and technique class for all new hires immediately after corporate orientation, regardless of experience level. In addition, if possible, organizations dedicated to continuing excellence should have an onsite welding trainer who offers personalized instruction for aluminum and steel; gas metal and gas tungsten arc welding; and specific equipment training. It's also a good practice to offer reimbursement for American Welding Society Certified Welding Inspector (CWI) and Certified Welding Educator (CWE) seminars; other training and testing; and designated, paid study time with experienced CWIs on staff. This doesn't just go for manual welders. All robot technicians and engineers should have basic and advanced training in robotic systems covered.

Having a welding team that is trained to thrive will help to establish a culture of excellence for safety, as well as productivity and quality.

Conclusion

While the COVID-19 pandemic is still evolving, we as manufacturers and welding providers can come together to help organizations strive toward keeping employees healthy and business strong.

That all starts with listening to experts and respecting the science of what is known about the virus. If and when new information comes to light, have a conversation with your team about how any additional findings can be dealt with and what practices and policies may be appropriate.

Meanwhile, when it comes to having a robust inventory of sanitation products and PPE on hand, if you need it, it's too late. If this pandemic has taught us anything, it's to always be prepared with even the most basic health and safety equipment — from hand sanitizers to face masks.

Furthermore, if your organization is considering an investment in new technology and machinery, the pandemic may have pushed that possibility to the forefront. Even if your bottom line took a hit, big or small, this is the time to make investments in improvement. Not only could it help employees work safer and smarter, it could also allow them to focus more of their energy on following health protocols and eliminating the potential risk for a COVID-19 outbreak in the facility.

Finally, there's never been a better time to hit refresh on training. Are you requiring all new welders, regardless of experience, to take mandatory training? Are you footing the bill for skills development and training? Might it be time to bring on a full-time trainer to provide individualized coaching and training? Or are there other potential holes in your program?

Now is the time to update those practices. Trained employees work smarter, produce better, stay at your organization longer, and help instill a culture of excellence. WJ

JERRY ZIEGENBEIN (ziegenbein@kapcoinc.com) *is director of weld operations, Kapco Metal Stamping, Grafton, Wis.*

Note: The 2021 schedule for all certifications are posted online at *awo.aws.org/instructor-led-seminars/seminar-exam-schedule.*

Certified Welding Inspector (CWI)

Seminar covers Parts A, B, and C of the CWI exam. Only Part B of the exam is taken following the conclusion of the seminar. Parts A and C are given at Prometric testing centers.

Location	Seminar Dates	Part B Exam Date
Dallas, TX	Jan. 10–15	Jan. 16
Charlotte, NC	Jan. 10–15	Jan. 16
Long Beach, CA	Jan. 17–22	Jan. 23
Denver, CO	Jan. 17–22	Jan. 23
Milwaukee, WI	Jan. 24–29	Jan. 30
Houston, TX	Jan. 24–29	Jan. 30
Pittsburgh, PA	Feb. 7–12	Feb. 13
Los Angeles, CA	Feb. 7–12	Feb. 13
Seattle, WA	Feb. 14–19	Feb. 20
Orlando, FL	Feb. 14–19	Feb. 20
Indianapolis, IN	Feb. 21–26	Feb. 27
San Diego, CA	Feb. 21–26	Feb. 27
Cleveland, OH	Feb. 28–March 5	March 6
Atlanta, GA	Feb. 28–March 5	March 6
Waco, TX	Feb. 28–March 5	March 6
Miami, FL	March 7–12	March 13
Salt Lake City, UT	March 7–12	March 13
Houston, TX	March 7–12	March 13
Chicago, IL	March 14–20	March 21
Phoenix, AZ	March 14–20	March 21
Boston, MA	March 21–26	March 27
Portland, OR	March 21–26	March 27
Dallas, TX	April 11–16	April 17
Minneapolis, MN	April 11–16	April 17
Norfolk, VA	April 11–16	April 17
Las Vegas, NV	April 18–23	April 24
St. Louis, MO	April 18–23	April 24
Cleveland, OH	April 25–30	May 1
Bakersfield, CA	April 25–30	May 1
Baton Rouge, LA	May 2–7	May 8
Sacramento, CA	May 2–7	May 8
Detroit, MI	May 2–7	May 8
Denver, CO	May 16–21	May 22
Nashville, TN	May 16–21	May 22

Certified Welding Inspector (CWI) Part B

Course covers only Part B of the CWI exam. The Part B exam follows the conclusion of the three-day course.

Location	Seminar Dates	Part B Exam Date
Dallas, TX	Jan. 13–15	Jan. 16
Sacramento, CA	March 10–12	March 13
Minneapolis, MN	July 28–30	July 31
Cleveland, OH	Sept. 29–Oct. 1	Oct. 2
Miami, FL	Dec. 15–17	Dec. 18

9-Year Recertification Seminar for CWI/SCWI

For current CWIs and SCWIs needing to meet education requirements without taking the exam.

Location	Seminar Dates
Miami, FL	Jan. 17–22
Houston, TX	Feb. 7–22
San Diego, CA	Feb. 14–19
St. Louis, MO	March 7–12
Seattle, WA	March 21–26

Certified Welding Educator (CWE)

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

Certified Welding Sales Representative (CWSR)

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

Certified Resistance Welding Technician (CRWT)

A comprehensive two-day seminar to arm attendees with the knowledge needed to take the exam with confidence. More information at *aws.org/certification/page/certified-resistance-welding-technician*.

Certified Welding Supervisor (CWS)

CWS exams are given at 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
Houston, TX	Jan. 24–29	Jan. 30
Dallas, TX	April 26–30	May 1

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; (661) 259-7800, ext. 3062
Ogden-Weber Applied Technology College, Ogden, UT; (801) 627-8448
Genesis Systems IPG Photonics Co., Davenport, IA; (563) 445-5688

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 $395 Fast Track fee. Please verify application deadline dates by visiting our website at *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.

AWS Debuts Virtual Modern Pipe Welding Conference

Nearly 100 professionals from around the world gathered in front of their computers to attend the Modern Pipe Welding Conference held September 29 and 30. The virtual event was organized by the American Welding Society (AWS) and the Conference Committee, which consisted of Chair Gary Lewis, president, Lewis Reliability Resources; Co-chair John Stoll, application engineering representative, ARC Specialties; and Advisor Bill Newell, president, Euroweld and Newell & Associates. The event was also made possible with the support of 31 sponsor companies.

The first of its kind, the two-day virtual conference gave subject-matter experts and industry leaders a platform to share their knowledge and experience within the safety of their own homes and offices. It focused on the reliable, economical, and progressive approaches being implemented in pipe welding today across a variety of industries; recent developments in equipment, processes, and procedures; and best practices for pipe welding.

Fig. 1 — Conference Chair Gary Lewis delivers the opening remarks at AWS's first virtual Modern Pipe Welding Conference.

Fig. 2 — AWS Executive Director and CEO Gary Konarska II engages attendees by asking them to raise their hands if they've ever seen a pipe joint like the one pictured here.

Opening Remarks Highlight "the Next Normal"

The conference kicked off with opening remarks from Lewis (Fig. 1), who explained that the event was originally going to be in person. He thanked those who helped the conference pivot to a virtual mode in response to COVID-19 and highlighted some of the benefits of a virtual platform.

"The one thing about a virtual conference like this is that it gives you a lot of flexibility in how you participate and how you watch the presentations that are being given," he affirmed. "The flexibility to actually archive this material and share it with your colleagues is something that is going to be tremendously beneficial to everyone who participates."

Lewis acknowledged that while some businesses are struggling due to the pandemic, others have flourished.

"Some of them have taken advantage of this time to really advance their organizations and their work processes," he said.

Moving on to pipe welding, Lewis described it as an essential industry and manufacturing infrastructure that is critical to the success of operations throughout the world.

"Pipe welding and its associated, critical, complementary services, processes, etc., are so important when it comes to life management of a facility, safety in a facility, fitness for service, return on investment," he explained.

He emphasized that the pandemic, coupled with the disappearance of skilled labor and expertise, has accelerated change in processes and work flow, leading to "the next normal" in pipe welding.

"A lot of these terms have been floating around for some time now, whether its digitization, data analytics, 3D scanning and modeling, VR [virtual reality], and AI [artificial intelligence]. Well, they're really becoming a reality in the work that we do today," he said. "Expertise, as you know, is disappearing quickly."

Welcome Speech Discusses AWS and Pipe Automation

Lewis's opening remarks were followed by a welcome speech by AWS Executive Director and CEO Gary Konarska II. He began by sharing details about his 20-year career in the welding industry, which included working as a technical sales representative, living in Asia for ten years to serve the international welding industry, and moving back to the United States to lead automation integration companies.

Konarska then provided a brief overview on how AWS supports the global welding community through membership services; technical standards; certifications and accreditations; educational and training programs; industry and technical publications; scholarships for students; grants for schools; and shows, exhibitions, and conferences.

His talk on AWS also touched upon

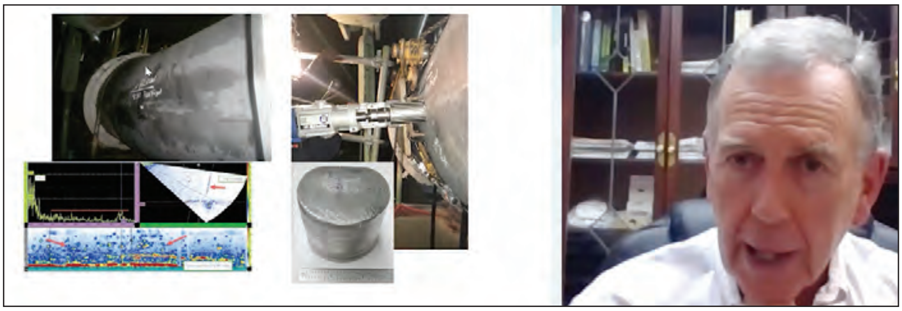

Fig. 3 — Keynote Speaker Jeff Henry discusses a fitness-for-service study involving a long-seam pipe section.

the following four strategic objectives the Society is working on: implementing a digital transformation that enhances customer experience, ensuring a product portfolio that focuses on the needs and challenges of today, addressing the shortage of welding personnel by providing a positive image of careers in welding, and having a global presence to support the international welding community.

Konarska concluded his presentation with a discussion on how to implement automation in pipe processes based on his personal experiences with automation — Fig. 2.

"I'm coming at this from a practical standpoint," he explained. "I'm really trying to impart some of the knowledge I've picked up as a technical sales representative working hand-in-hand in workshops and then eventually leading automation companies."

Konarska underscored that the road to automation should be a progressive one, with welders being able to first weld manually before moving on to other phases that lead to fully automated welding.

"If you can't weld it by hand, then you can't weld it with automation," he affirmed. "That's something that's very important as we look to increase productivity and address the shortage of welders through automation . . . You first have be able to consistently weld it by hand before you go down the path of automation."

To evolve the pipe welding processes, he recommends the following six progressive phases: pre-production; manual root, fill and cap; manual root, semiautomatic fill and cap; semiautomatic root, fill and cap; semiautomatic root, automatic fill and cap; and automatic root, fill and cap.

Keynote Targets Young Engineers

The keynote speech, titled Life Management and Fitness for Service, was delivered by Jeff Henry, co-owner, president, and chief operating officer of Combustion Engineering Solutions — Fig. 3. Geared toward novice engineers who are in high-responsibility roles, the talk offered a general understanding of how life management and fitness for service practices can be applied to pressure parts.

"We'd like to provide a conceptional framework for younger engineers so they at least understand what are some of the major issues involved whenever these types of practices are carried out," he said.

The presentation included basic definitions for the terms, the tools and information needed to both manage the lives of critical parts properly and conduct a fitness-for-service study, and real-life examples to illustrate how the principles can help achieve the objective. For life management, Henry focused on a longitudinal seam weld on high-energy piping. When discussing service for fitness, he highlighted three different scenarios involving an original, manufacturing-related defect.

Technical Program Covers Diverse Topics

The conference featured 26 technical presentations on a wide range of topics related to pipe welding. Some of the subjects covered included pipeline data and digital twins, project execution in a changing market, community-based welding training, root pass options, keyhole gas tungsten arc welding (Fig. 4), analyzing petrochem duplex failure, pipe and tube welding in power plants, simulation of weld performance, advanced facilities inspection, acoustic emission monitoring, automation planning solutions, and digital collaboration tools in construction.

During presentations, attendees engaged with the content through the chat function, which allowed them to post comments and questions as well as interact with other attendees.

Roundtable Sessions Unveil Differing Points of View

The conference showcased two roundtable events that took place on Zoom and showcased a who's-who lineup of industry experts. The first day's roundtable presentation was titled Automation and Technology: Adapt or Die. It featured panelists Lewis; Konarska; Martijn Glass, global director of innovation, Stork; and Dan Allford, owner and president, ARC Specialties. The discussion underscored the crucial role automation plays in innovating for the future,

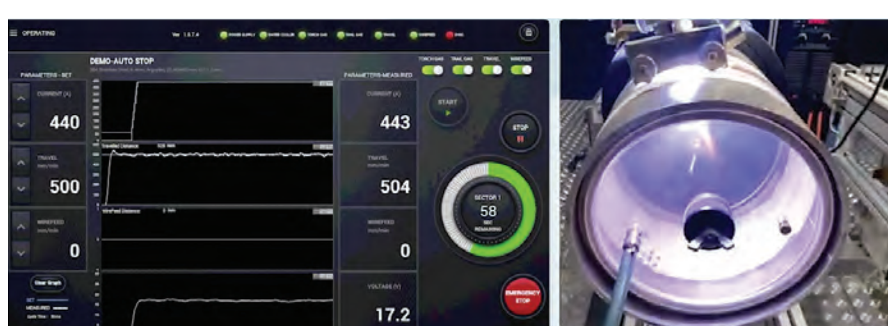

Fig. 4 — A live demonstration by Guest Presenter Billy Kelly shows how the keyhole gas tungsten arc welding process achieves clean and fast welds.

staying competitive in a global economy, attracting and retaining talent, and reducing the impact of the skilled labor shortage.

"Those of us who are fortunate enough to live in societies with a high standard of living, that's funded with high wages. If you want to make twice as much as someone in a low-wage country to maintain your standard of living, you've got to be twice as efficient," affirmed Allford. "You do that with automation and robots. These are labor-saving devices."

The second day's roundtable discussion was titled Supply Chain Challenges. Its panelists were Newell; Stoll; Mike Lang, vice president of execution and strategy, Arc Energy Services; and Jeff Houtz, principal consultant, Constructing Supply Change. The discussion honed in on the following subjects: areas that will be impacted by the current labor shortage, such as modular construction; supporting modularization with codes; issues with sourcing materials and going mill-direct; and ordering consumables earlier in the process to avoid delays.

"When we start talking about the welding, we start talking about the material," Lang said. "For instance, if we're going to order some P91 material, we have to give some consideration to everything that goes into making that weld as well. Maybe we're not necessarily buying it at the same time we buy the fittings, but it has to figure into that supply chain schedule. There has to be that time."

"I'm proud to say I picked up something from every presentation, and that's the mark of a good conference." — Bill Newell

The different viewpoints expressed by the roundtable panelists served as a learning experience for attendees.

"I loved the sparring among the experts in the roundtable. When you get gentlemen who agree to disagree on camera . . . we, as the audience, sure do learn from that," said Newell in his wrap-up presentation. "You heard fellas speaking from the gut, and when they start doing that . . . that's when we learn."

Conclusion: Conference Wrap up

From technical presentations to live roundtable discussions, the inaugural virtual Modern Pipe Welding Conference covered many different disciplines within pipe welding, thus offering something for everyone.

"I'm proud to say I picked up something from every presentation, and that's the mark of a good conference," said Newell in his wrap-up speech.

Addressing how the COVID-19 pandemic and the skilled labor shortage are affecting the current pipe welding and fitting industry, the conference also stressed the need for businesses to embrace new technology and practices.

"Maybe this is the good that comes out of COVID," said Stoll in his wrap-up speech. "Everybody in the world is going to have to adapt. They're going to have to automate and they're going to have to change the way they do business, or they're not going to be around."

To learn more about this event, visit *awo.aws.org/conferences/past-conferences/pipe-welding-conference-2020*. WJ

AWS Education & Training Committee Seeks New Members

The AWS Education & Training Committee is welcoming new members from secondary education, higher education, and industry. The committee continues to work toward the betterment of welding education by reviewing present state and developing criteria to improve training standards nationwide.

If you are interested in becoming a member, contact Alicia Garcia at *agarcia@aws.org* for more information.

Nominate AWS Members to be Profiled

The *Welding Journal* is celebrating the diversity of its membership by profiling AWS members each month in its Society News section. Ikechukwu Oluchukwu is profiled on page 48.

To nominate an AWS member, submit a short statement about what makes the nominee a noteworthy member, along with the nominee's contact information, to Katie Pacheco, *kpacheco@aws.org*.

To see member profiles from previous issues, visit *aws.org/about/page/diversity-inclusion*.

MEMBERSHIP ACTIVITIES

Corporate Member Milestones

American Welding Society (AWS) Corporate Members are vital to the strength and advancement of the Society's global mission and to the welding industry in general. In appreciation of the ongoing membership and support of our Corporate Members, AWS launched the Corporate Member Milestone Appreciation Program recognizing companies that achieved significant membership milestones during the calendar year. AWS is pleased to recognize Corporate Members that achieved Gold, Silver, and Sapphire Member status in 2020.

Gold Members — 50 years

Company Name	Location	Member Category
AGL Welding Supply Co. Inc.	Clifton, NJ	Sustaining
AO Smith Corp.	Milwaukee, WI	Sustaining
Welders Supply Co.	Beloit, WI	Supporting

Silver Members — 25 years

Company Name	Location	Member Category
Carver Career Center	Charleston, WV	Educational Institute
Centralia College	Centralia, WA	Educational Institute
Conn-Weld Industries	Princeton, WV	Supporting
Cor-Met Inc.	Brighton, MI	Sustaining
Manatee Technical College	Bradenton, FL	Educational Institute
Milwaukee Area Technical College – West	Milwaukee, WI	Educational Institute
New Castle Area Career Programs	New Castle, IN	Educational Institute
University of Alaska – Anchorage	Anchorage, AK	Educational Institute
Western Technical College	La Crosse, WI	Educational Institute
Withlacoochee Technical College	Inverness, FL	Educational Institute

Sapphire Members — 10 years

Company Name	Location	Member Category
ABW Technologies Inc.	Arlington, WA	Sustaining
Air Liquide Canada Inc.	Montreal, Canada	Sustaining
Altoona Pipe and Steel Supply Co.	Altoona, PA	Affiliate
American Technical Publishers	Orland Park, IL	Educational Institute
AMG Metals Inc.	Ontario, Canada	Affiliate
AMK Welding Inc.	South Windsor, CT	Sustaining
Atlanta Ironworkers JAC	Atlanta, GA	Educational Institute
Blount Boats Inc.	Warren, RI	Affiliate
Cives Steel Co.	Alpharetta, GA	Sustaining
Code Welding & Mfg. Inc.	Blaine, MN	Affiliate
Concrete Connectors	Wildwood, FL	Affiliate
Container Products Corp.	Wilmington, NC	Affiliate
Custom Biogenic Systems	Bruce Township, MI	Affiliate
D & H Industries	Oconomowoc, WI	Affiliate
Denyo Co.	Danville, KY	Sustaining
Fab-Tech Inc.	Colchester, VT	Affiliate
Federal Aviation Administration	Oklahoma City, OK	Sustaining
Folsom State Greystone Adult School – PIA	Represa, CA	Sustaining
Four Rivers Career Center	Washington, MO	Educational Institute

Company Name	Location	Member Category
Fraser Shipyards Inc.	Superior, WI	Sustaining
Garden City Community College	Garden City, KS	Educational Institute
Gem Industries Inc.	Cocoa, FL	Affiliate
Glauber Equipment	Lancaster, NY	Affiliate
Group Mfg. Services Inc.	Tempe, AZ	Affiliate
Hefco Enterprises Inc.	Fresno, TX	Affiliate
I.U.E.C. Local 8 Joint Apprenticeship	San Francisco, CA	Educational Institute
Indian Hills Community College	Ottumwa, IA	Sustaining
Industrial Contractors Inc.	Evansville, IN	Sustaining
Inertia Friction Welding	South Bend, IN	Sustaining
Inspect Testing Inc.	National City, CA	Sustaining
Ironworkers Local 40 & 361 JAC	Astoria, NY	Educational Institute
Kellogg Community College	Battle Creek, MI	Educational Institute
Kennett School District No. 39	Kennett, MO	Educational Institute
Kentucky Machine and Engineering Inc.	Cadiz, KY	Affiliate
LDI Industries Inc.	Manitowoc, WI	Sustaining
Livingston Area Career Center	Pontiac, IL	Educational Institute
Lost River Career Cooperative	Paoli, IN	Educational Institute
Master Steel LLC	Hardeeville, SC	Supporting
McAllen Careers Institute	McAllen, TX	Educational Institute
Meridian Prof. Tech Center – West Ada School Dist.	Meridian, ID	Educational Institute
Metro Technology Center	Oklahoma City, OK	Educational Institute
Metropolitan Community College – Kansas	Kansas City, MO	Educational Institute
Miller Mechanical Services Inc.	Glens Falls, NY	Supporting
Mohave Community College	Kingman, AZ	Educational Institute
Mountainland Technical College	Orem, UT	Educational Institute
Naugatuck Valley Community College	Waterbury, CT	Educational Institute
Pelco Products Inc.	Edmond, OK	Sustaining
Praxair Inc.	Tonawanda, NY	Sustaining
Royale Inc.	Calumet, MI	Supporting
SC Steel LLC	Taylors, SC	Supporting
Southern Arkansas University Tech	Camden, AR	Educational Institute
State Technical College of Missouri	Linn, MO	Educational Institute
Stonebridge Steel Erection	South Plainfield, NJ	Affiliate
TPI Chile	Santiago de Chile, Chile	Sustaining
USA Shade & Fabric Structures	DFW Airport, TX	Affiliate
Van Buren Tech Center Welding	Lawrence, MI	Educational Institute
Vegter Steel Fabrication	Morrison, IL	Affiliate
Washington Alloy Co.	Rockwell, TX	Sustaining
Weld Management Solutions Inc.	Gibsons, BC, Canada	Supporting
Welding Services Inc.	Butte, MT	Sustaining
Zephyr Products Inc.	Leavenworth, KS	Educational Institute

2020 Membership Challenge

Listed here are the members who participated in the 2020 Membership Challenge — point standings as of October 19. The campaign runs from Jan. 1 to Dec. 31, 2020. Members receive 5 points for each Individual Member and 1 point for every Student Member they recruit.

For more information, please see page 49 of this *Welding Journal* or call the AWS Membership Dept. at (800) 443-9353, ext. 480.

J. W. Fregia, Houston — 95
J. W. Morris, Mobile — 75
A. D. Dillon, Detroit — 38
S. A. Milner, San Francisco — 36
B. J. Cain, Los Angeles/Inland Empire — 34
J. P. Theberge, Boston — 31
A. D. Stute, Madison-Beloit — 30
J. C. Durbin, Tri-River — 30
D. L. Galiher, Detroit — 29
T. A. Uff, Lehigh Valley — 29

D. P. Thompson, Southwest Virginia — 29
A. P. Duris, Northwest Ohio — 27
R. Young, Iowa — 24
T. Edwards, Tulsa — 20
H. J. Merrill II, Louisville — 20
D. S. Beecher, San Diego — 20
R. K. McClure, Los Angeles/Inland Empire — 18
W. H. Wilson, New Orleans — 17
B. A. Cheatham, Columbia — 17
O. Ortiz, Los Angeles/Inland Empire — 16
G. J. Smith, Lehigh Valley — 15
C. W. Gilbertson, Northern Plains — 14
C. Consentino, Pittsburgh — 13
R. Riggs, Tulsa — 13
V. O. Harthun, Northern Plains — 13
T. A. Harris, Johnstown-Altoona — 13
S. Silverstein, Milwaukee — 12
M. D. Stein, Detroit — 11

New AWS Supporters

Educational Institute Members

Coastal Washington County Institute of Technology
11 Addison Rd.
Columbia, ME 04623

Crowder College Advanced Training & Technology Center
420 Grand Ave.
Joplin, MO 64801

Franklin County Career Technical Center
85 Jail Springs Rd.
Russellville, AL 35653

Gateway Community College – Maricopa Central City Campus
1245 E. Buckeye Rd.
Phoenix, AZ 85034

Hillsdale Area Career Center
279 Industrial Dr.
Hillsdale, MI 49242

Jefferson County High School
P.O. Box 1749
Dandridge, TN 37725

Red Hill High School
908 Church St.
Bridgeport, IL 62417

Santa Fe Unit School
2629 Santa Fe Pike
Santa Fe, TN 38482

Southeastern Louisiana University
500 W. University Ave.
Hammond, LA 70402

Southern Arc Welding Services Ltd. Co.
302 Magnolia St.
Channelview, TX 77530

Stuart W. Cramer High School – Gaston County Schools
101 Lakewood Rd.
Belmont, NC 28012

Sustaining Company Member

Maverick Welder and Material Testing
5218 Spencer Hwy.
Pasadena, TX 77505

Supporting Company Members

Dynamic Fabrication Inc.
2615 S. Hickory St.
Santa Ana, CA 92707

Elite Mechanical Integrity Services
3612 Hawk Ridge St.
Round Rock, TX 78665

Affiliate Corporate Members

Arlington Structural Steel Co. Inc.
1727 E. Davis St.
Arlington Heights, IL 60005

Bridge Brothers Inc.
225 Pumpkintown Hwy., Bldg. 19
Pickens, SC 29671

C&T Engineering and Inspection LLC
1113 Murfreesboro Rd.
Ste. 106-102
Franklin, TN 37064

Carolina Fab Inc.
2129 Charles Raper Jonas Hwy.
Mt. Holly, NC 28120

Consolidated Pipe and Supply
1205 Hilltop Pkwy.
Birmingham, AL 35204

Kirby Welding Co.
3020 Brandaur Rd.
Hermitage, TN 37076

Mainsource Metalfab LLC
34 Edward Ct.
Clifton, NJ 07011

Northwest Precast LLC
212 10 St. SE
Puyallup, WA 98372

Proacero s.r.l.
Calle Parábola #11 Esquina Elipse
Urbanización Fernandez
Santo Domingo, Distrito Nacional
Dominican Republic 10129

Spanco Inc.
604 Hemlock Rd.
Morgantown, PA 19543

Temperature Specialists Inc.
3175 Bridge St. NW
St. Francis, MN 55070

Wicked Welding Inc.
5703 Webster St., Ste. J
Dayton, OH 45414

AWS Member Counts November 1, 2020

Sustaining	*573*
Supporting	*350*
Educational	*834*
Affiliate	*628*
Welding Distributor	*63*
Total Corporate	***2448***
Individual	*55,943*
Student + Transitional	*10,280*
Total Members	***66,223***

TECH TOPICS

Opportunities to Contribute to AWS Technical Committees

The following committees welcome new members. Some committees are recruiting members with specific interests in regard to the committee's scope, as marked below: Producers (P), General Interest (G), Educators (E), Consultants (C), and Users (U). For more information, contact the staff member listed or visit *aws.org/library/doclib/Technical-Committee-Application.pdf.*

S. Borrero, *sborrero@aws.org*, ext. 334. **Definitions and symbols**, A2 Committee (E). **Titanium and zirconium filler metals**, A5K Subcommittee. **Piping and tubing**, D10 Committee (C, E, U). **Welding practices and procedures for austenitic steels**, D10C Subcommittee. **Aluminum piping**, D10H Subcommittee. **Chromium molybdenum steel piping**, D10I Subcommittee. **Welding of titanium piping**, D10K Subcommittee. **Purging and root pass welding**, D10S Subcommittee. **Low-carbon steel pipe**, D10T Subcommittee. **Orbital pipe welding**, D10U Subcommittee. **Duplex pipe welding**, D10Y Subcommittee. **Joining metals and alloys**, G2 Committee (E, G, U). **Reactive alloys**, G2D Subcommittee (G).

R. Gupta, *gupta@aws.org*, ext. 301. **Filler metals and allied materials**, A5 Committee (E). **Magnesium alloy filler metals**, A5L Subcommittee.

P. Portela, *pportela@aws.org*, ext. 311. **Additive manufacturing**, D20 Committee (C, E, G). **Titanium structural welding**, D1N Subcommittee (C, E, G, P, U).

J. Molin, *jmolin@aws.org*, ext. 304. **Structural welding**, D1 Committee (E). **Sheet metal welding**, D9 Committee (C, G, P).

K. Bulger, *kbulger@aws.org*, ext. 306. **Methods of weld inspection**, B1 Committee (C, E). **Brazing and soldering**, C3 Committee (C, E, G). **Welding in marine construction**, D3 Committee (C, E, G, U). **High energy beam welding and cutting**, C7 Committee (C, E, G). **Hybrid welding**, C7D Subcommittee (G). **Welding of machinery and equipment**, D14 Committee (C, E, G, U).

M. Diaz, *mdiaz@aws.org*, ext. 310. **Resistance welding**, C1 Committee (C, E, G, U). **Friction welding**, C6 Committee (C, E). **Automotive welding**, D8 Committee (C, E, G, U). **Resistance welding equipment**, J1 Committee (C, E, G, U). **Welding in the aircraft and aerospace industry**, D17 Subcommittee (C, E, G).

S. Hedrick, *steveh@aws.org*, ext. 305. **Metric practice**, A1 Committee (C, E). **Mechanical testing of welds**, B4 Committee (E, G, P). **Joining of plastics and composites**, G1 Committee (C, E, G). **Safety and health**, SHC Committee (E, G). **Welding in sanitary applications**, D18 Committee.

J. Rosario, *jrosario@aws.org*, ext. 308. **Procedure and performance qualification**, B2 Committee (E, G). **Thermal spraying**, C2 Committee (C, E, G, U). **Oxyfuel gas welding and cutting**, C4 Committee (C, E, G). **Welding iron castings**, D11 Committee (C, E, G, P, U). **Railroad welding**, D15 Committee (C, E, G, U). **Robotic and automatic welding**, D16 Committee (C, E).

New Standards Projects

Development work has begun on the following new or revised standards. Affected individuals are invited to contribute to their development. Participation in AWS technical committees is open to all persons.

C3.6M/C3.6:2016-AMD2, *Specification for Furnace Brazing*. This specification provides the minimum fabrication, equipment, material, process procedure, and inspection requirements for the furnace brazing of steels, copper, copper alloys, and heat- and corrosion-resistant alloys and other materials that can be adequately furnace brazed. It also provides the criteria for classifying furnace brazed joints based on loading and consequences of failure as well as the quality assurance criteria for defining the limits of acceptability in each class of joint. Stakeholders: brazing engineers, educators, and general interest groups. Revised Standard. Contact: K. Bulger, *kbulger@aws.org,* ext. 306.

Standards for Public Review

AWS was approved as an accredited standards-preparing organization by the American National Standards Institute (ANSI) in 1979. AWS rules, as approved by ANSI, require that all standards be open to public review for comment during the approval process. This column also advises of ANSI approval of documents.

B4.0:2016-AMD1, *Standard Methods for Mechanical Testing of Welds*. Addenda Standard. $64.00. ANSI public review expired 11/23/2020. Contact: S. Hedrick, *steveh@aws.org*, ext. 305.

C6.2/C6.2M:20XX, *Specification for Rotary Friction Welding*. Revised Standard. $34.00. ANSI public review expired 11/23/2020. Contact: M. Diaz, *mdiaz@aws.org*, ext. 310.

C6.3M/C6.3:20XX, *Recommended Practice for Friction Stir Welding*. New Standard. $33.00. ANSI public review expired 11/30/2020. Contact: M. Diaz, *mdiaz@aws.org*, ext. 310.

D16.2M/D16.2:20XX, *Guide for Components of Robotic and Automatic Arc Welding Installations*. New Standard. $68.00. ANSI public review expires 12/14/2020. Contact: J. Rosario, *jrosario@aws.org*, ext. 308.

Revised Standard Approved by ANSI

A5.10/A5.10M:2021 (ISO 18273-2015 MOD), *Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*. Approval Date: 10/13/2020.

Change of Address? Moving?

Make sure delivery of your *Welding Journal* is not interrupted. Contact Kim Hugley in the Membership Department with your new address information — (800) 443-9353, ext. 204; *khugley@aws.org*.

AWS Member Profile

Ikechukwu Oluchukwu

"I always assumed welding was easy until a pressure welder I was working with on a project allowed me to practice on a piece of scrap. I realized that it takes a lot of skill to make a quality weld."

Born and raised in Nigeria, Ikechukwu Oluchukwu recalls having an innate fascination with earth, rocks, oil, and solid minerals from the time he was a child. This interest inspired him to earn a bachelor's in geology from Obafemi Awolowo University, followed by a master's in geophysics from the University of Ibadan.

"My desire to understand the earth and nature played a huge role in my decision to study an earth science course," he recollected.

Armed with his degrees, Oluchukwu secured a job as an exploration geologist with Dap Mineral Resources Ltd. after his graduation. His job entailed geological mapping, management of mine activities, geochemical analyses, and geophysical investigations.

"My role as an exploration geologist was very exciting because it involved going to places where I would never have been to. I loved the ability to apply science to potentially discover minerals that could be of economic value," he explained. "The role also offered me the opportunity to develop survival skills to be able to navigate and survive in the wild. It was very thrilling."

Oluchukwu was later offered a job as a project engineer with PESO Energy Services, an oil-servicing company in Lagos, where he performed an expansive list of tasks involving geotechnics, IT, asset integrity, pressure envelopes, and pipeline projects. He also participated in inline inspections of pipeline, assisted in interpreting engineering drawings, supervised the internal inspection of vessels, and reviewed nondestructive examination (NDE) results and techniques for each equipment.

"Each project I worked on afforded me the opportunity to learn, grow professionally, and acquire new skills," he said.

Working alongside specialist engineers gave Oluchukwu insight into some of the challenges faced by the industry, including a shortage of skilled, local workers.

"Working as a project engineer on pressure envelopes and pipelines in Nigeria opened my eyes to the limited human resources present in the line of work," he said. "Each time there was a failure or a need to do an inspection, the company always had to hire an expatriate from outside the country to assist with the project."

In his three years working with the company, Oluchukwu became more familiar with welding, an experience which would change the course of his career path.

"Working closely with pressure vessels, I was intrigued by the amount of detailed work that had to be done to reduce the risk of failure on pressure envelopes and pipelines. I always assumed welding was easy until a pressure welder I was working with on a project allowed me to practice on a piece of scrap. I realized that it takes a lot of skill to make a quality weld," he recalled. "I quickly fell in love with the idea of learning how to weld and inspect welds."

In 2017, Oluchukwu's new-found passion for welding motivated him to migrate to Canada as a permanent resident in pursuit of higher education. He is currently a student in the welding engineering technology (WET) diploma program at Southern Alberta Institute of Technology (SAIT), Calgary, Canada.

Although Oluchukwu is not studying to become a welder, the program has taught him how to perform various welding processes, including shielded metal, gas metal, flux cored, gas tungsten, and submerged arc welding. The most interesting welded projects he has worked on include a pipe spool that was constructed according to ASME B31.3, *Process Piping*, and a horizontal vessel made to ASME Section VIII, *Boiler and Pressure Vessel Code*.

"The documentations, NDE, and visual inspections involved in the projects were enlightening," he said.

Additionally, Oluchukwu is an active member of the SAIT's WET Club. He has helped organize welding events and aided WET junior members in connecting with the resources they need to succeed in the program.

Oluchukwu is scheduled to graduate before the end of the year. After graduation, he hopes to land a job as either a quality control representative, welding inspector, or asset integrity engineer.

"My vision is to become an expert in welding processes, failure mitigation, and quality control," he explained. "This will enable me to offer long-lasting solutions to challenges ravaging our industries."

One day he would also like to take on the role of educator.

"Ultimately, I would like to return to the classroom as an instructor to pass on the knowledge and experiences I have garnered for posterity," he said.

When Oluchukwu isn't busy with his studies, he enjoys playing chess and soccer, as well as spending time with his wife and one-year-old son. Oluchukwu also delights in attaining new knowledge and constantly strives to better himself.

"I am always excited by the prospect of learning new skills," he affirmed. "My mantra is to always keep learning and improving so that my latter achievement always surpasses my former."

AWS

American Welding Society®

MEMBERSHIP

SPARKING CONNECTIONS – 2020 AWS MEMBERSHIP CHALLENGE

■ *What it is:*

Be the spark that ignites the people you know to become AWS members, and get rewards.

■ *How it works:*

Build up points throughout the year for each AWS Member you recruit: **5 Points** per Individual Membership and **1 Point** per Student Membership.

■ *What you get:*

Grand Prize Winner:	$200 gift card
2nd Place:	$100 gift card
3rd Place:	$100 gift card
4th Place:	$100 gift card

All other participants earning 10 or more points will get AWS branded merchandise based on points accrued throughout 2020.

The Fine Print: *All AWS members in good standing may participate and are eligible to receive rewards based on points accrued January 1 – December 31, 2020. Participant eligibility is determined at the sole discretion of AWS program administrators. AWS staff members and administrators of commercial / corporate or educational packages that include AWS memberships in the pricing structure are not eligible to participate. For more information, visit aws.org/be-the-spark*

AWS
American Welding Society®
MEMBERSHIP

8669 NW 36 ST. #130 | Miami, FL 33166-6672
T: 800.443.9353 | F: 305.443.5647 | aws.org

Application for Membership

PRIMARY CONTACT INFORMATION (Please Print)

☐ Mr. ☐ Ms. ☐ Mrs. ☐ Dr.

Last Name: ____________ First Name: ____________ M.I: ________ Birthdate: ________

E-Mail: ____________ Mobile Phone: ( ) ________ Secondary Phone: ( ) ________ ☐ Home ☐ Work

Company/School (if applicable): ____________

Mailing Address: ____________

City: ____________ State/Province: ________ Zip/Postal Code: ________ Country: ________

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

Technical Interests (Circle 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

STUDENT MEMBERSHIP ☐ New ☐ Renewal, Member #:

☐ 1 Year-Digital *Welding Journal* $15
☐ 1 Year-Print and Digital *Welding Journal* (US, Canada, and Mexico) $35
☐ 1 Year-Print and Digital *Welding Journal* .... $85 (outside of US, Canada, and Mexico)

$ ________

INDIVIDUAL MEMBERSHIP ☐ New ☐ Renewal, Member #:

Were you referred to AWS by an AWS Member? ☐ Yes ☐ No

Member's Name: ____________ Member's # (if known) ____________

DOMESTIC (INCLUDES US, CANADA, AND MEXICO)

New Member

☐ Initiation Fee $12
☐ 1 Year - Print and Digital *Welding Journal* $88
☐ 2 Year - Print and Digital *Welding Journal* $151

$ ________

Renewing Member

☐ 1 Year - Print and Digital *Welding Journal* $88
☐ 2 Year - Print and Digital *Welding Journal* $171

$ ________

INTERNATIONAL (OUTSIDE OF US, CANADA, OR MEXICO)

New Member

☐ Initiation Fee $12
☐ 1 Year - Digital *Welding Journal* $88
☐ 1 Year - Print and Digital *Welding Journal* $138
☐ 2 Year - Digital *Welding Journal* $151
☐ 2 Year - Print and Digital *Welding Journal* $251

$ ________

Renewing Member

☐ 1 Year - Digital *Welding Journal* $88
☐ 1 Year - Print and Digital *Welding Journal* $138
☐ 2 Year - Digital *Welding Journal* $171
☐ 2 Year - Print and Digital *Welding Journal* $271

$ ________

NEW MEMBER OPTIONAL BOOK SELECTION (Not available to renewals. Choose ONE option ONLY. Includes shipping & handling.) Visit *aws.org/memberships/page/new-member-book-offer* to view selections and write your choice here:

☐ Domestic $35
☐ International $85

$ ________

TOTAL $ ________

Business (Circle ONE Letter Only)

A Contract Construction
B Chemicals & Allied Products
C Petroleum & Coal Industries
D Primary Metal Industries
E Fabricated Metal Products
F Machinery Except Electric (Incl. Gas Welding)
G Electrical Equipment, Supplies, Electrodes
H Transport Equip. – Air, Aerospace
I Transport Equip. — Automotive
J Transport Equip. — Boats, Ships
K Transport Equip. — Railroad
L Utilities
M Welding Distributors & Retail Trade
N Misc. Repair Services (Including Welding Shops)
O Educational Services (Univ., Libraries, Schools)
P Engineering & Architectural Services (Including Assns.)
Q Misc. Business Services (Including Commercial Labs)
R Government (Federal, State, Local)
S Other

Job Classification (Circle ONE Letter 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

PAYMENT INFORMATION

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

☐ Check ☐ Money Order

☐ AMEX ☐ Diners Club ☐ MasterCard ☐ Visa ☐ Discover ☐ Other Application Date: ____________

Name on Card: ____________ CC#: ______ / ______ / ______ / ______

Expiration Date (mm/yy): ______ / ______ CVV: ________ Applicant Signature: ____________

OFFICE USE ONLY Source Code: **WJ** Account #: ________ Check #: ________ Amount: ________

Date: ____________ AWS Staff: ____________

District 1

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District 2

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harland.w.thompson@ul.com

District 3

Sean Moran, director
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District 4

Mr. Lynn Showalter, director
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lynneshowalter@gmail.com

District 5

Howard Record, director
(352) 816-0835
howard@rtdtools.com

ATLANTA

September 18

Location: Georgia Trade School, Acworth, Ga.

Summary: The Section held a welding competition at Georgia Trade School. Five schools — Georgia Trade School, Fortis Technical College, Georgia Northwestern Technical College, Gwinnett College, and Southern Crescent Technical College — sent two competitors each. In addition to the competition, local welding suppliers and distributors, including Lincoln Electric, Miller Electric, ESAB, EAS/Gas & Supply, and Techniweld sent representatives to answer students' technical questions. The winner was awarded a $1000 Section scholarship and second place was awarded a $500 scholarship. All competitors received welding supplies and tools donated by the vendors.

District 6

Ronald Stahura, director
(716) 207-7869
rstahura@esab.com

District 7

Roger E. Hilty, director
(740) 317-9073
rhilty@comcast.net

ATLANTA — *District 5 Director Howard Record (left) is seen with competition winner Andrew Harrell (center) and Instructor Clint Chadwick.*

ATLANTA — *Seen (from left) are Rachelle Lee, Robert Trudelle, second-place winner Tucker Mobbs, Section Chair Rene Engeron, and Instructor Clint Chadwick.*

ATLANTA — *AWS Certified Welding Inspectors (from left) Robert Trudelle and Mike Hyde helped judge the competition.*

ATLANTA — *Attendees and vendors are seen at the Section's welding competition held at the Georgia Trade School.*

COLUMBUS

September 17

Presenter: Edye S. Buchanan, CMfgT, marketing strategist, BriskHeat Corp.
Title: Optimizing your heating system for energy efficiency by Briskheat
Summary: The Section held a webinar where Buchanan spoke about the keys to efficient and cost-effective industrial heating systems. Topics discussed included, applications for electrical heating systems, heat loss calculations, selecting insulation materials, types of surface heaters, and translating efficiency to cost savings.

District 8

James Thompson, director
(256) 347-6481
jim.thompson@wallacestate.edu

District 9

Michael Skiles, director
(337) 501-0304
michaelskiles@cox.net

MOBILE

September 10

Location: Alabama Pipe Welders Academy, Mobile, Ala.
Summary: A dinner meeting kicked off the Section's first gathering for the 2020–2021 season. There were 48 people in attendance, including 34 students. Shannon Noel and Phillip "Eric" Kramer were recognized as scholarship recipients for the year. Additionally, Section Chair Jody Heusman was presented with a plaque of appreciation for his service and dedication to the Section. Heusman served as chair last year and has graciously offered to serve a second year. Attendees also listened to a presentation by Alabama Pipe Welders Academy Owner and Instructor Trey Byrum on codes and standards. Door prizes were given out at the meeting. The Section is grateful to Byrum and the staff at his school for hosting the meeting. Dinner was catered by Café Catering.

October 8

Location: Alabama Pipe Welders Academy, Mobile, Ala.
Presenter: Tomasz Andraka, technical sales engineer, Lincoln Electric Co.
Summary: Andraka gave a presentation on welding distortion and practical ways to minimize it. The Section is grateful to have had Alabama Pipe Welders Academy host the monthly meeting again and Lincoln Electric for sponsoring it. Professional development hour certificates were issued to those in attendance wanting AWS Certified Welding Inspector credits. A DeWalt grinder and t-shirts were given away as door prizes. The Section successfully utilizes Eventbrite for registration at monthly meetings. Members and guests can pay for their meal online when registering for the meeting which speeds up the registration process on-site. There were 31 attendees at the meeting.

District 10

Mike Sherman, director
(216) 570-9348
mike@shermanswelding.com

MOBILE — *Section Chair Jody Heusman (left) is seen with Guest Speaker Trey Byrum.*

MOBILE — *Clay Byron (right) presented Section Chair Jody Heusman with a plaque of appreciation for his service.*

MOBILE — *Section Chair Jody Heusman (left) is seen with Guest Speaker Tomasz Andraka.*

MOBILE — *Section Scholarship Chair Clay Byron (far left), District 9 Director Mike Skiles (second from left), and Section Chair Jody Heusman (far right) posed with scholarship recipients Shannon Noel and Phillip "Eric" Kramer.*

District 11

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(734) 546-4298
nwcllc_ptemple@att.net

District 12

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District 13

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District 14

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District 15

Michael Hanson, director
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mikhan318@comcast.com

District 16

Karl Fogleman, director
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fogleman3@cox.net

SOUTHEAST NEBRASKA

September 24
Location: Bailey's Local, Eagle, Neb.
Summary: The first meeting of the season was aimed at informing attendees of the benefits of membership, how to become a member, and what to expect from the Section this coming year. Five new members joined through paper applications at the event. All new and existing members participated in a raffle and received a free meal.

SOUTHEAST NEBRASKA — *Members are seen enjoying the first meeting of the season.*

District 17

J Jones, director
(832) 506-5986
drtourch@yahoo.com

District 18

Thomas Holt, director
(409) 721-5777
tholt@techcorr.com

HOUSTON

September 16
Presenter: John Stoll, sales application engineer, ARC Specialties
Topic: Adaptive automated open root pipe welding
Summary: The Section hosted a virtual meeting where Stoll provided a presentation focused on the latest equipment, innovations, and proficiencies required to complete open root welds using adaptive welding equipment without the need for operator intervention during welding. Various pipe joint examples were presented to demonstrate the ability to weld joints with variables, such as root openings, root faces, and mismatch of the joint, and establish welding parameters for these variable conditions.

September 26
Location: Waller County Fairgrounds, Waller, Tex.
Summary: The Section participated in the Texas High School Welding Series Waller County Welding Contest. Welding students Gavin Mudd, Joseph Ni-

HOUSTON — *Waller County Queen Anna Gunderson (far left) and District Director Tom Holt (far right) are seen with scholarship recipients (from left) Joseph Nieto, Savannah Jensen, and Gavin Mudd.*

eto, and Savannah Jensen were each awarded an AWS Foundation Competition Scholarship. Section Officer Caity Brown handed out student membership applications, and the Section paid 50% of the membership dues for any student who signed up that day.

District 19

Shawn McDaniel, director
(509) 793-5182
shawnm@bigbend.edu

PORTLAND
August 22
Location: Mid-Valley Clays and Shooting School, Gervais, Ore.

HOUSTON — *Section Officer Caity Brown handed out student membership applications.*

Summary: The Section hosted a very successful first Annual Sporting Clays Scholarship Fundraiser. Participants had a great time shooting clays, eating a delicious BBQ lunch, and winning raffle prizes. At the conclusion of the fundraiser, Section Officer Boyce Towell and District 19 Director Shawn McDaniel presented Anna Lever with the Section Meritorious Award, which recognizes her loyalty and devotion to the affairs of the Society, effective service in the advancement of welding, and generous contributions of time and effort on behalf of the Society.

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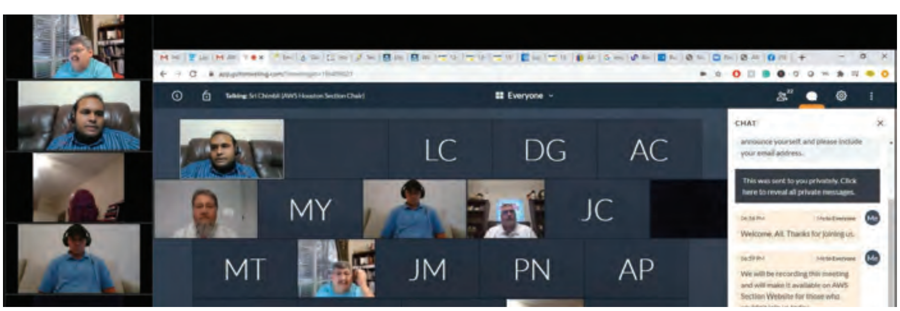
SAN FRANCISCO
October 14
Presenter: Josh Pawley, Vectis Automation
Summary: The Section hosted a virtual meeting where Pawley spoke about welding with collaborative robots and provided a live demonstration of the programming and weld quality of the cobot welding tool.

PORTLAND — *Pictured are sporting clay winners Ryan Donohue, first place; Neil Shannon, second place; and David Williams, third place.*

PORTLAND — *Section Chair Boyce Towell (left) and District 19 Director Shawn McDaniel (right) presented Anna Lever with the Section Meritorious Award.*

SAN FRANCISCO — *Section members held a virtual meeting where they watched Josh Pawley, from Vectis Automation, speak about collaborative robots and give a live demonstration.*



HOUSTON — *The Section held a virtual meeting to discuss adaptive automated open root pipe welding.*

PORTLAND — *Seen are participants of the first Annual Portland Section Sporting Clays Scholarship Fundraiser.*

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AWS American Welding Society

Lincoln Electric Names President of the Americas Welding and International Welding Segments


S. B. Hedlund

Lincoln Electric, Cleveland, Ohio, a designer, developer, and manufacturer of arc welding products, automated joining, assembly and cutting systems, plasma, and oxyfuel cutting equipment, has promoted Steven B. Hedlund as executive vice president and president of both the Americas and International welding segments. Regional presidents in the Americas; Europe, Middle East, Africa, and Russia; and Asia Pacific will report directly to him. In this newly expanded role, he will lead the welding segments' Higher Standard 2025 Strategy initiatives to advance growth and enhance margin and return performance. Hedlund joined the company in 2008 and has served as executive vice president and president of international welding since 2017. He previously served as president of global automation and vice president of strategy and business development. Prior to that, he was with Fortune Brands, where he served as vice president of growth and innovation for the company's Master Lock subsidiary as well as vice president of strategic planning and new business development for Fortune's Home and Hardware Group. Previously, he was a principal with the management consulting firm Booz Allen & Hamilton.

Xiris Recruits Special Adviser

Xiris Automation, Burlington, Ontario, Canada, a developer of specialized machine vision products, has signed Patricio Menendez as a special adviser to help the company develop camera and inspection technologies for the welding industry. Menendez is a professor, Weldco/industry chair in welding and joining, and director of the Canadian Centre for Welding and Joining at the University of Alberta.


P. Mendez

His teaching and research focuses on the physics and mathematics of welding and materials processing, including heat transfer, magnetohydrodynamics, arc plasma, thermodynamics, and kinetics. He is the recipient of various research and teaching awards and has 78 indexed publications and nine patents.

Pure Safety Group Appoints CEO


J. Ward

Pure Safety Group (PSG), Houston, Tex., a height safety product development, manufacturing, and training company, has selected Jeff Ward as CEO. Previously, Ward was president of the company's international operations. He spent the last 20 years in marketing, sales, operations, and general management roles within premium industrial and consumer goods companies. Prior to joining PSG, he was CEO of Centurion Safety Products and director of the British Safety Industry Federation.

Eriez® Executive Vice President and Chief Marketing Officer Retires

Charlie Ingram, executive vice president and chief marketing officer, will retire from Eriez®, Erie, Pa., a separation technologies company, at the end of this year. Ingram joined the company in 1994 as national sales manager, rising to vice president of sales and marketing in 2004. He was one of the architects of Eriez' three-fold growth while he directed the sales organization in the Americas. As executive vice president and chief marketing officer,


C. Ingram

he oversaw the company's global marketing operations and introduced new products to target countries, as well as managed product line re-alignment and standardization based on market intelligence. He was elected to serve on the board of directors for the Manufacturers' Agents National Association (MANA) and frequently participates as a presenter and panelist for MANA at events. Ingram has written numerous articles for the association's *Agency Sales* magazine. He also currently serves as a trustee fellow of Denison University and is on the board of directors of Sterling Technologies Inc.

Washington Alloy Hires Regional Account Manager for the Northeast


L. Connolly

Lisa Connolly has joined Washington Alloy Co. as regional account manager for the Northeast. She will be responsible for promoting and growing the company's Northeast sales and marketing efforts while managing its newest office and warehouse location in Avon, Mass. Connolly brings 30 years of experience and knowledge of the welding industry.

Obituaries

Seiuemon Inaba

FANUC Robotics Founder and Honorary Chair Seiuemon Inaba passed away on October 2 of natural causes. He was 95. Inaba significantly contributed to the development of the ro-

S. Inaba

bot industry not only in Japan but also the world. He is considered to be the pioneer of flexible automation systems, known as numerical control (NC). In 1946, Inaba graduated from The University of Tokyo with an engineering degree, then went on to join Fujitsu Ltd. as a young engineer. The company approached Inaba to lead a new subsidiary, where he developed the first NC device at 31 years old. After Fujitsu Fanuc Ltd. (later to be renamed FANUC Corp.) became independent from Fujitsu in 1972, Inaba joined FANUC as executive director. He became president and CEO in 1975, then chair and CEO in 1995 until he retired in 2000. He was an adviser and honorary chair of the company until his passing. Inaba was also president of the Japan Society of Precision Engineering and a recipient of his country's highest national honors, including the Medal of Honor with Purple Ribbon; Medal of Honor with Blue Ribbon; and Order of the Sacred Treasure, Gold and Silver Star. He was also awarded the Commandeur de l'Ordre Grand-Ducal de la Couronne de Chêne du Grand-Duché de Luxembourg in 1985, and the Grand Officier de l'Ordre de Mérite du Grand-Duché de Luxembourg in 1989.

Gerald A. Duchon

Gerald A. Duchon of Fitchburg, Wis., passed away on August 24. He was 87. Duchon attended Lincoln High School, graduating in 1951. During his high school years, he worked for the *Herald Times* newspaper, Kaufman Mfg., and the Manitowoc Shipbuilding Co. He then attended Stout Institute (now University of Wisconsin [UW]-Stout), earning a bachelor of science degree in 1955, and a master of science degree in industrial education in 1957. He was with the U.S. Army Signal Corps from 1955 to 1957, where he was stationed at Fort Monmouth, N.J. and worked at the Evans Signal Lab in Belmar, N.J., Duchon was also

G. A. Duchon

emeritus professor of mechanical engineering at UW-Madison for 38 years. He retired in 1995. He also assisted the Wisconsin State Crime Laboratory in the design and construction of laboratory equipment for 30 years. In addition, he worked for the U.S. Armed Forces Institute, then the UW Extension (now known as UW-Madison Division of Extension), and directed the farm and industry short course in welding for 35 years. Duchon was a long-time member of the American Welding Society (AWS). He joined the Society in 1959 and achieved Life Member status in 1994. He achieved AWS Gold Member status in 2009 upon reaching 50 years of membership with the organization. He is survived by his wife of 62 years, Maureen; four children, Kelly, Douglas, Jane, and Brent; ten grandchildren; and five great grandchildren with one expected this month. WJ

NEWS OF THE INDUSTRY

— *continued from page 11*

Champion Cutting Tool Corp. Acquires Mercer Industries

Champion Cutting Tool Corp., Rockville Centre, N.Y., a 123-year-old supplier of metal and concrete cutting tools, has acquired Mercer Industries, Ronkonkoma, N.Y., a supplier of coated and bonded abrasives. The latter's portfolio also includes carbide and diamond blades, industrial files, wire wheels, and safety products. Since 1968, Mercer's commitment to supply the industrial market with high-quality, cost-effective tools has served as a foundation for its success.

As a part of Champion Cutting Tool's expansion, the acquisition will give the company's existing customers the benefit of purchasing from a broader catalog of tools and a new offering of safety products.

"Mercer customers will benefit from the many resources that Champion has to offer, including extremely dedicated and knowledgeable employees and some of the highest service levels in the industry. I am looking forward to joining team Champion as the global director of sales – abrasives division," said Jim Wallick, past president, Mercer Industries.

Both are New York-based, multigenerational family businesses who value people and embrace family-like cultures.

"The synergies that exist between the two companies just make sense. We are enthusiastic to be able to offer even more value to our customers and professional tool users. Hole-making tools and deburring tools go hand-in-hand. By adding complementary cutting, grinding, and finishing tools to our line, we are truly offering complete jobsite solutions," said Lowell Frey, president, Champion Cutting Tool Corp.

As a part of the acquisition, Champion's geographic footprint will expand. It will take over operations at Mercer's second distribution center in Fullerton, Calif. WJ

BRAZING Q&A

— *continued from page 23*

provide a format for making sure everything critical to your process is considered and that your brazers are equipped with what they need to be effective.

The bottom line is your organization is responsible for determining what constitutes an acceptable braze joint. Your concern for unacceptable braze joint fill would seem to be justified. The quality of each joint should be similar and not just three out of four. WJ

TIM P. HIRTHE (timhirthe@aol.com) is a consultant. This column is written sequentially by TIM P. HIRTHE, ALEXANDER E. SHAPIRO, and DAN KAY. Hirthe and Shapiro are members of and Kay is an advisor to the C3 Committee on Brazing and Soldering. All three have contributed to the 5th edition of the AWS Brazing Handbook. *Readers are requested to email their questions for use in this column to the authors, cweihl@aws.org, or send to their attention at* Welding Journal, *8669 NW 36 St., #130, Miami, FL 33166.*

Brazers and Welders Craft Custom Copper Lighting Fixtures

A family-owned Mississippi business designs and manufactures handcrafted lanterns, chandeliers, and more

BY CINDY WEIHL

In a society of mass-produced goods, St. James Lighting, Columbia, Miss., is in a bright spot. The company, which just celebrated its 12th anniversary this summer, manufactures handcrafted copper lighting fixtures, including gas and electrical interior and exterior lanterns and chandeliers.

Jim Ragan started St. James Lighting in 2008 after having worked for many years at Mississippi Valley Gas (MVG), a natural gas distribution company in Jackson, Miss. MVG started a gas light business, which Ragan was involved with for seven years. Once MVG dissolved the business, he decided to start his own. Today, he and son Patrick run the day-to-day operations of the company and oversee 45 employees — Fig. 1.

Fig. 1 — Employees in St. James Lighting's steel shop manufacture and fabricate all of the company's lighting fixtures.

Fig. 2 — An employee brazes copper parts for a lighting fixture.

Copper Lighting Design Specialists

"Everything we make is handcrafted. Every single piece of copper in the shop is brazed. All the roofs, doors, hinges, sockets, basically all the components that hold a lighting fixture together are fabricated, welded, and assembled on site," Ragan said.

The company uses a copper phosphorus brazing rod that is 93% copper and 7% phosphorus. Ragan explained that his company strives to make high-quality products, which is why it uses copper brazing rods instead of soldering its products. Soldering parts tends to be faster and more inexpensive than copper brazing rods, which have a higher melting temperature and require more expensive equipment along with a more highly skilled craftsperson — Fig. 2.

Oxygen and ametalene gas are piped in from outside the building to the ten copper brazing workstations in the shop. The company's lead brazer, Kenny Robbins, does brazing training in-house.

"We are big enough that some of the work load is simple and repetitive, which allows us to see if a new hire can do the work. Over time, we move them to more difficult jobs until they have mastered what is required. Not all of the brazers can do the more difficult jobs," Ragan stated.

Welders Play a Key Role

The company also has six full-time welders in its steel shop. Lead Welder Justin Reed moved from Tennessee to Mississippi a little more than five years ago. St. James's six welders bring years of combined welding industry experience.

Finding welders is not always an easy task for the Columbia-based company. According to Ragan, the small town is considered part of the "oil patch," and high-paying pipeline jobs are hard to compete with when oil prices are high.

Copper and steel are the two metals used by the company to create its lighting fixtures. Most welded parts are fabricated using the gas metal arc welding process, and occasionally some parts require shielded metal arc welding.

"We buy castings and weld casting to steel pipe to create light posts. Everything is precision metal," Ragan explained.

Fig. 3 — A — The Magnolia copper wall mount is the company's bestselling model from its standard product line; B — clients often ask for custom pieces like this pineapple-shaped lighting fixture.

When the space allows, he said a gas tungsten arc welding (GTAW) machine, and someone who can run it, will be the next investment he makes in the shop.

"Some custom pieces have been difficult to make without a GTAW welder [welding machine] because we do a lot of sheet metal and long lines," Ragan added.

The shop mostly uses 11-gauge and 16-gauge steel sheets and ⅛-in. flat bars as well as ¼- and ½-in. steel plates. Two plasma-cutting machines cut out components and then the pieces are welded. The company also has a powder coat paint system in-house.

One-of-a-Kind Lighting

While St. James Lighting manufactures a standard line of lighting fixtures, like the bestselling Magnolia lantern, a large part of its business is custom work — Fig. 3.

"Copper and steel go together beautifully," Ragan proclaimed. "The new big-custom-fixture craze has been using raw steel and putting a clear coat powder over it, which creates a really nice finish."

The company's standard line is available for purchase from lighting and home design dealers throughout the United States and Canada, while its custom orders come from designers, architects, and home and business owners. Ragan's son, Patrick, serves as both operations manager and lead designer, and is responsible for making a client's vision come to life.

"I get a lot of callers who are like, 'Hey Jim, I saw this light fixture in a magazine, but it's only 3 ft and I want something like it, but 8 ft, and I want it to have this and that.' And well, we get to drawing and then make it happen," Ragan said.

Aside from doing work for homeowners, St. James Lighting has done custom work for boutiques, resort hotels, restaurants, and retail stores.

Ragan believes what sets St. James Lighting apart from other companies is its dedication to handcrafted products and the relationships it establishes and maintains with all of its clients.

"We have grown for many years into one of the industry leaders due to high quality, very competitive prices, and a can-do attitude. We always take care of our customers," he concluded.

To see the complete St. James Lighting product line, visit *stjameslighting.com*. WJ

CINDY WEIHL (cweihl@aws.org) *is senior editor,* Welding Journal.

A Turnkey Turntable Brings Art to Life

Koike manufactured custom equipment for an uncommon application

BY CLIFF WHITE

Metallurgic Mythology

Ashland, Kentucky, is located on the southern bank of the Ohio River, and as of January 2020, it is now home to the country's largest combination of classic mythological and contemporary art, thanks to a very generous but anonymous benefactor (Ref. 1). This benefactor and his close friend, world-renowned artist Ginés Serrán-Pagán, were inspired to donate sculptures to Ashland's riverfront property in 2019.

To honor the city's metallurgical history, the two decided to create sculptures of Venus, Vulcan, and Genesis, an abstract element based on images from Ashland's Blazer High School's original art designs — Fig. 1. Genesis represents a new beginning in Ashland with the five rods in the sculpture representing four elements of life (earth, air, water, fire) and God. Venus and Vulcan stand

The Port of Ashland Sculptures by world-renowned artist Ginés Serrán-Pagán are the largest group of bronze sculptures placed on a single site in the United States.

Fig. 1 — The three sculptures light up the riverside at night and represent the energy, culture, and metallurgic history of Ashland.

Fig. 2 — Custom Koike turntable fabricated to support and continuously rotate the 40-ft statue of Genesis.

at 25 ft tall, while Genesis is 40 ft tall and rotates 360 deg.

An Untraditional Turntable

As the sculptures were being created by Serrán-Pagán in China, Ashland's mayor was busy looking for a firm that could construct the pedestals needed for these three statues, including a rotation mechanism to bring Genesis to life. Chapman Technical Group, a West Virginia-based engineering, architectural, and geospatial firm, was working in Ashland at the time and took on this challenge. David Hoy, a structural engineer at Chapman Technical Group, headed the project.

"As we started putting together a structural design for Genesis's pedestal, we recognized that we were going to need a very specific and one-of-a-kind mechanism to accomplish six revolutions an hour continuously," Hoy said. "At first, we wanted to fabricate our own mechanism; however, we realized it would be difficult to service in the future if someone from our team was not available. We needed something reliable with readily available parts and service."

Hoy began researching rotation mechanisms and discovered Koike Aronson Ransome, Arcade, N.Y., a supplier of advanced laser, waterjet, plasma and oxyfuel cutting machines, welding positioning equipment, portable cutting/welding machines, and gas apparatus (cutting and welding accessories). The company had rare turntable capabilities that fit the needs of this project.

"Our team was so excited because we found something that was traditionally not used for this kind of application, but it fit perfectly for what we wanted to do with this piece of art," Hoy explained. "I worked extensively with the Koike engineering division, and they had some superb data available that gave me confidence that the turntable would be able to support the gravity and lateral loads we were anticipating."

Project Particulars

The project called for a mechanism that could run continuously at 6 revolutions per hour with minimum maintenance and down time. These requirements fit with Koike's basic equipment features, as approximately 80% of their positioning products are built to order and around specific applications.

The end product was a turntable specifically fabricated for this uncommon application — Fig. 2. A heavy-duty motor was added so the turntable could run continuously. Harder bearings were used for extra support. Within an eight- to 12-week fabrication process, the turntable was delivered to the site and fit seamlessly into the pedestal's design.

"This turntable is really the brain of the entire project, and I am still shocked to this day that we were able to find something so turnkey for such a unique project," Hoy said.

Although most of Koike's equipment is designed for fairly high-duty cycles, this project is above and beyond that. With 100% duty cycle, the company had to pay more attention to the specific wear items such as the gearing, the drives, and the motors. It designed this table so it could run continuously for years before it would need any major maintenance.

Happiness Reigns

"Overall, it was such a great project from beginning to end," Hoy said. "The benefactor is happy. The team is happy. And the city is happy." WJ

Reference

1. *ashlandky.gov/news_detail_T2_R130.php*

CLIFF WHITE (positioners@koike.com) *is a welding project manager at Koike Aronson Ransome, Arcade, N.Y.*

The American Welding Academy Bridges the Gap between Pipe Dreams and Reality

This new school for beginning welders is attracting students with its future-forward curriculum

BY ROLINE PASCAL

The American Welding Academy (AWA), Union, Mo., opened its doors in February in the midst of a global health crisis. However, AWA powered through and, nine months later, the results look to be very promising for the school and future of the welding industry.

The brainchild of Rob Knoll, owner and president, the notion to open a welding school came about when Knoll's son, Joey, was exploring his career choices. Many students enter college without a plan or direction and hope they'll figure it out once they are there. However, Joey hoped to avoid the uncertainty. He attended an open house at South Technical High School in St. Louis, Mo. After meeting Adam Holt, a welding instructor and American Welding Society (AWS) Certified Welding Inspector (CWI), and sitting in a welding class, Joey was inspired. Holt would later become a key figure in the creation of AWA.

The American Welding Academy located in Union, Mo., prepares students for the demands of the welding industry via real-world training.

While visiting many welding schools with his son, Knoll noticed a gap in the welding industry.

"As he [Joey] entered his senior year, we attended many of the competitions held by other welding schools around the country," said Knoll.

"I was able to get a good look at what post-secondary training looked like and saw there were no programs in the Midwest that offered a high level of training with a modern approach to both academic and hands-on learning in a state-of-the-art environment."

As an entrepreneur for more than 20 years, Knoll was filled with ideas. However, with his diverse set of experiences, he knew he needed someone who understood the ins and outs of the industry, what was successful and what was lacking.

"I have a bachelor of science degree in criminal justice . . . and I have been working professionally for 20-plus years," said Knoll.

He was a police officer for more than 12 years. He then transitioned to the construction business, building new homes, and buying/rehabbing

Fig. 1 — Rob Knoll (right), a businessman for more than 20 years, and Adam Holt, a welding instructor and AWS CWI, partnered up to develop AWA, a school for aspiring welders.

Fig. 2 — An instructor demonstrates a gas tungsten arc welding cover pass in the school's pipe lab. AWA believes confidence is built both in the booth and while welding in typical field settings.

houses for sale or keeping them as rentals. In 2001, he joined a sports company, where he developed a sales team. Within a few years, he became vice president and later president of that company. Later, Knoll would enter the welding industry.

"When I saw how welding changed my son's outlook on life, I knew that there was something that I could do to help more people. After talking to other parents of kids like mine, I was hooked," he said.

Knoll approached Holt with the thought of opening a facility that would be a training ground for aspiring welders — Fig. 1.

"He [Holt] saw what a traditional school looks like firsthand and had lots of ideas around reinventing for the future. We decided to partner up and spent the next year designing, planning courses, and developing an experience that would set us apart from other schools. After that, we spent an additional year under construction building a top-of-the-line school with what we believe is the best facility in the country," Knoll said.

The academy's mission is to provide a welding training and education program that ensures academic success, develops a diverse skill set, and prepares students for the demands of the welding industry. The conclusion is to gain employment upon graduation.

Building from Idea to Reality

From the initial concept to the grand opening of the welding school was a two-year process. Knoll and Holt designed the building around the flow and processes Holt had built over his experiences as a welding instructor.

"Every aspect was strategically planned from booth size, machine types [to] lighting, ventilation, electric supply," said Knoll.

The new 24,000-sq-ft facility contains 64 welding booths as well as, a pipe lab, cutting room, grinding room, and testing lab — Fig. 2. AWA uses an array of Miller welding machines, including the Dynasty®, Millermatic®, and CST™ 280. The welding equipment also includes track torches; Watts-Mueller beveling torches; plasma cutting machines; and fabrication tools, such as a band saw, drill press, and more. The school was also slated to purchase a computer numerical control plasma table.

The classes have a 15:1 student/teacher ratio. Each instructor has an aisle of students with a demonstration table at the head. This allows the student and instructor time to be maximized. There are also two classrooms set up with demo welding units, 75-in. TVs, and more.

Knoll explained that AWA is a great resource for students from Illinois, Indiana, Ohio, Tennessee, and Oklahoma, where access to high-level welding training is limited. Currently, the school has students from as far away as Portland, Ore.

AWA is certified by the Missouri Department of Higher Education and accepts students with funding from

Fig. 3 — Skills are earned as students advance through each industry-recognized certification.

Fig. 4 — Sean "Dabs" Flottmann demonstrates his gas tungsten arc welding artwork on mirror polished stainless steel.

the Workforce Innovation and Opportunity Act, United Migrant Opportunity Services, and Vocational Rehabilitation, among others.

Curriculum Teaches Welding and Life Skills

The academy currently offers the following three 10- to 20-week training for the following courses: professional pipe welding and fitting, professional fabricator welding, and professional structural welding and fitting. The most popular is the 20-week pipe welding course.

"The pipe course is by far the most popular. It is the most in-depth program that would prepare students for a career on a pipeline, shutdowns, or any pipe specific work," said Knoll.

This course allows students to earn up to ten industry-recognized structural and pipe certifications — Fig. 3.

Students who opt for the professional fabricator welding course can earn up to seven certificates that will allow them to work in manufacturing plants and custom fabrication shops. The course runs for 12 weeks.

The professional structural welding and fitting course runs for ten weeks.

In addition to welding courses, students are engaged in classes that teach life skills. When implementing the courses' blueprints, Knoll believed students needed more than welding skills to succeed in today's world.

"As the leader of a company that had workers in an under developed country, I implemented several programs that set us apart from others," he explained. "I offered free classes teaching the employees how to manage money, learn English, and I started in-house basic health, dental, hearing, and eye care."

Knoll took that experience with him when constructing the programs' curriculum. He included classes that teach job prepping (résumés), money management (investment opportunities, savings, retirement, 401k), and legal governance (trusts, wills, contracts).

"Students gain valuable information on what they should be thinking about as they transition from a student to a wage-earning adult," Knoll said. "Many of our students are straight out of high school and the most money they have made is minimum wage . . . The skills taught will help them make smart decisions on how to build a life that they can enjoy and save for the future."

AWA Reassembles after COVID-19 Setback

The development of AWA involved a huge amount of effort, dedication, and hard work that nearly faltered when the COVID-19 pandemic hit.

"COVID-19 impacted us shortly after opening our doors in February," explained Knoll. "This was a big blow for our inaugural class."

The school had to close for five weeks, starting at the end of February. Once they were able to reopen, Knoll and Holt implemented several new safety procedures.

"Limiting visitors was a must, which was hard since we are a new business and had everyone from potential students to vendors trying to visit," Knoll said. "For our students, we had and continue to have daily questions on their out-of-school travels and any new symptoms. We spread out our classroom seating to allow social distancing and have strict handwashing procedures throughout the building."

Additionally, door handles, desktops, and any surfaces that are of high usage are sanitized multiple times throughout the day. Knoll also asserted that the students are wearing helmets, respirators, and gloves as well as working in their assigned booths most of the day; therefore, the process of learning welding naturally creates social distancing.

"The students are very excited to learn this trade in our new facility, and they don't want to jeopardize their ability to complete the course and get on a jobsite making money. They are motivated to ensure they don't put anyone in harm's way before they graduate," Knoll said.

Although there was a setback due to the pandemic, current numbers show the school is on its way to success. Most recently, AWA organized a second open house in September with 57 potential students touring the facility and several signing up on the spot.

"Our first class started with 13 students. Today, we have 43 and growing," Knoll said.

His goal is to have up to 60 students per shift once they are able to offer day, evening, and midnight shifts for training.

AWA Offers Insight to the Future of the Industry

Recently, Knoll hired Sean Flottmann, a powerhouse welder and social media influencer with the Instagram handle *@dabswellington*. Flottmann has more than 20 years of experience performing fabrication/metal work. His passion for the trade is on display with thousands of posts featuring welded works of art, videos, and more — Fig. 4. He demonstrates his welding skills, techniques, and tricks to his more than 130,000 followers. He has been featured in several welding magazines, the Arc Junkies podcast, and more for his welding videos. Flottmann is drawing in young people to the welding world.

"In a few short weeks, Sean has been able make AWA more visible by posting videos of our facility and following students through a weld procedure from beginning to the final test," Knoll said. "He is able to capture and create short videos that drive enthusiasm for welding and spotlight AWA as the new top welding school."

Knoll plans to offer evening classes by the summer of 2021 and continue to grow to three shifts of training. Preliminary plans are underway to build housing for students onsite. According to Knoll, this may be the only welding school in the country to have a training facility and housing onsite. Additionally, the building site is set to be able to incorporate an extra 15,000 sq ft when needed, which will include an indoor structure training multistory fabrication and pipe lab to look less like a learning institution and more like a real-world jobsite.

"The future is very exciting for AWA as we hope to offer the best training and best instructors in the country as well as have a top-notch training facility," Knoll concluded. WJ

AWA is hosting its second annual High School Senior Welding Competition on February 6, 2021. The competition is open to all high school seniors. More than $200,000 worth of prizes and AWA scholarships will be awarded. The registration deadline is January 15, 2021. To learn more about the school or competition, call (636) 800-9353 or visit *awaweld.com*.

ROLINE PASCAL (rpascal@aws.org) *is education editor of the* Welding Journal.

Style Guidelines for Safety and Health Documents

Adapted from American Welding Society (AWS) Safety and Health Fact Sheet No. 15. All of the AWS Safety and Health Fact Sheets are available through the AWS website at aws.org. *Click on Standards on the home page and then on Safety and Health.*

Style for welding and cutting documents means two things — matter and manner, otherwise known as content and form or subject and format. Style refers not only to what is said, but also to how it is stated and presented to the reader.

Background of Current Style

The recommended writing style evolved from precautionary labeling practices. It also arose from the obligation to users found in standards and codes, as well as from an industry-wide concern for the well-being of its customers. The text should *warn* and *instruct* the reader about the normal use and reasonably foreseeable misuse and abuse of a product or process. The instruction literature that accompanies a product or process is considered as part of that practice.

• The *warn* part of the requirement is met by a statement of the hazard and consequences of the failure to act as specified.

• The *instruct* part of the requirement is met by explaining how to avoid the hazard and consequences.

• It is not mandatory to have a particular order to the statements. It can be warn and instruct or instruct and warn. Either sequence is satisfactory, though warn and instruct is preferred.

• This order preference is based on current precautionary labeling practices, which warn first and instruct second.

• For all safety and health information published by AWS, try to follow the warn and instruct requirements for the normal use as well as for the foreseeable misuse and abuse of the product or process.

Style Methods and Features

The matter and manner for welding and cutting documents have evolved with time. It is recommended that documents state the hazards and include the consequences along with how to avoid them. The stylistic features are as follows:

• Use the active voice.

• Use strong, clear, action verbs in the imperative mood.

• Use short, direct sentences.

• Use a checklist. Do not skip any items. Omitting steps can cause personal injury or equipment damage.

• Use quality-control procedures to meet intended performance requirements and minimize costs.

Use of Precautionary Signal Words

There are three signal words used to identify the levels of hazard in ANSI Z535.4, *Product Safety Signs and Labels*. These are as follows: DANGER, WARNING, and CAUTION. Wherever possible, reserve these words for use on labels and collateral materials only. Avoid the use of signal words in prose. Use the word *precautionary* or other such words instead of signal words for text.

Format Suggestions

Several formats satisfy these requirements. The following are two of the most popular formats:

• Put all information in one or two simple sentences.

• Use a hazard statement containing the precautionary statement (description of hazard and its consequences) followed by a list of simple instructions telling readers how to avoid the hazard.

The example in Fig. 1 is adapted from the National Electrical Manufacturers Association (NEMA) EW 6, *Guidelines for Precautionary Labeling of Arc-Welding and Cutting Products*.

WARNING: ELECTRIC SHOCK can kill:
FUMES AND GASES can be hazardous;
ARC RAYS can injure eyes and burn skin.

- Do not touch live electrical parts.
- Keep your head out of the fumes.
- Wear dry insulating gloves and clothing
- Use enough ventilation or exhaust at the arc to keep fumes and gases from your breathing zone, and the general area.
- Wear correct eye, ear, and body protection.
- Read and follow the manufacturer's instructions, employer's safety practices, and Safety Data Sheets (SDSs).

Fig. 1 — Example of a safety and health document. (Credit: Adapted from NEMA EW 6.)

Summary

Read and understand all instructions, especially those containing safety or health information.

• Quickly get to the point to keep the reader's attention and save time.

• Be clear, direct, and simple in communicating with the reader.

• Use easy-to-read, short instructions. WJ

AWS disclaims liability for any injury to persons or property, or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this information. AWS also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

NOMINATION DEADLINE FOR
AWS FELLOW OF THE SOCIETY

American Welding Society®

Friends and Colleagues:

The American Welding Society, in 1990, established the honor of Fellow to recognize members for distinguished contributions to the field of welding science and technology, and for promoting and sustaining the professional stature of the field. Election as a Fellow of the Society is based on outstanding accomplishments and the technical impact of the individual. Such accomplishments will have advanced the science, technology and application of welding, brazing, or soldering, as evidenced by:

- Sustained service and performance in the advancement of welding and joining science and technology
- Publication of papers, articles and books which enhance knowledge of welding and allied processes
- Innovative development of welding and allied technologies
- Society and Section contributions
- Professional recognitions

I want to encourage you to submit nomination packages for those individuals whom you feel have a history of accomplishments and contributions to our profession consistent with the standards set by the existing AWS Fellows. In particular, I would make a special request that, in considering members for nomination, you look to the most senior members of your Section or District. In many cases, the colleagues and peers of these individuals who are the most familiar with their contributions, and who would normally nominate the candidate, are no longer with us. I want to be sure that we make the extra effort required to ensure that those truly worthy are not overlooked because no obvious individual was available to start the nominating process.

For specifics on nomination requirements, please contact Chelsea Steel at csteel@aws.org at AWS headquarters in Miami, or simply follow the instructions on the Fellow nomination form located at *www.aws.org/fellow*. Please remember, we all benefit in the honoring of those who have made major contributions to our chosen profession and livelihood. The deadline for submission is August 1, 2021.
The Fellows Committee looks forward to receiving numerous Fellow nominations for 2022 consideration.

Sincerely,

Dr. Sudarsanam Babu
Chair, AWS Fellows Committee

IMPORTANT
Announcement

Do you know a leader with outstanding contributions to the advancement of welding science and technology?

Elect them now for the honor of Fellow of the Society.

August 1, 2021
Submission Deadline

AWS COUNSELOR NOMINATION

American Welding Society®

Friends and Colleagues:

The American Welding Society established the honor of Counselor of the Society to recognize members for a career of distinguished leadership contributions in the advancement of welding science and technology. Election as a Counselor is based upon an individual's career of outstanding achievements and accomplishments. The selection committee is seeking qualified individuals who can demonstrate their leadership in the welding industry as evidenced by:

- Sustained service and performance in the advancement of welding science and technology
- Publication of papers, articles and books which enhance knowledge of welding
- Innovative development of welding technology
- Society, National and Section contributions
- Professional recognition
- Leadership in AWS or other corporate levels, particularly as it impacts the advancement of welding technology
- Facilitating others to participate as a volunteer in the advancement of welding technology

For specifics on the nomination requirements, please contact Chelsea Steel at csteel@aws.org at AWS headquarters in Miami, or simply follow the instructions on the Counselor nomination form located at *www.aws.org/counselor*. Please remember, we all benefit in the honoring of those who have made major contributions to our chosen profession and livelihood. The deadline for submission is July 1, 2021. The Counselor Committee looks forward to receiving numerous Counselor nominations for 2022 consideration.

Sincerely,

David J. Nangle
Chair, Counselor Committee

IMPORTANT
Announcement

Now is your opportunity to recommend someone with a career of outstanding achievements and accomplishments in the welding industry.

Nominations
For Counselor of the Society are Open.

July 1, 2021
Submission Deadline

American Welding Society®

AMERICAN WELDING SOCIETY 2020 - 2021 FOUNDATION SCHOLARSHIPS

Through the support of its generous donors, and the members of the American Welding Society, the AWS Foundation has awarded more than $2 million in scholarships, grants, and fellowships in 2020 to support education and workforce development in welding and related fields.

NATIONAL SCHOLARSHIPS

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CHRISTOPHER NGUYEN
University of Oklahoma

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Cleveland State University

COLE SUTYAK
University of Akron

LAUREN SUTYAK
University of Toledo

MITCHELL KLASERNER
Ferris State University

EMILY O'NELL
Ithaca College

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Ohio State University

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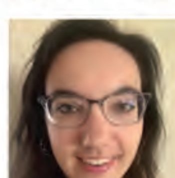

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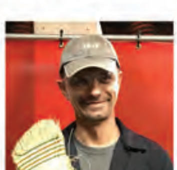

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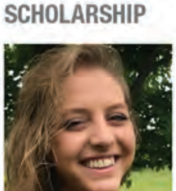

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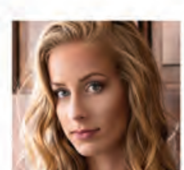

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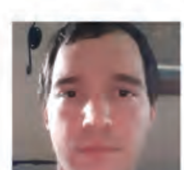

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Ferris State University

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Elgin Community College

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Lewis and Clark Community College

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Boilermakers Local 27 Apprenticeship School

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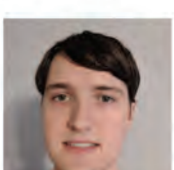

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KASSIDY KITZMILLER
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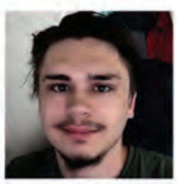

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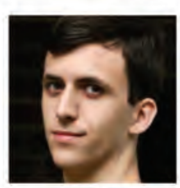

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SARAH TULLIS
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RUSLAN PARYLYAK
American River College

VLADIMIR TSOY
American River College

ANATOLII VIDENCHUK
American River College

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DISTRICT 1

Francisco DeCandio
Hobart Institute of Welding Technology
Brenda Hickey
University of Northwestern Ohio
Barb LeGeyt
Pennsylvania College of Technology
Sean Reilly
Morash Institute of Welding and Safety

DISTRICT 2

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Alfred State College
Ryan McEnery
Pennsylvania College of Technology
Kevin McIlvaine
Ohio State University
Luca Pantano
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Anthony Plewes
Middle Bucks Institute of Technology
Austin Rudd
Salem County Vocational School
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Austin Truitt
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Nathan Ricketts
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Rachel Downing
Manatee Technical College
Ian Eastridge
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University of South Carolina–Aiken
Katherine Simmons
Savannah Technical College
Ridgeway Stone, Jr.
Lively Technical College

DISTRICT 6

Aiden Cannon
Hobart Institute of Welding Technology
Bailey Dakos
Ohio Technical College
Aaron Morehouse
Alfred State College
Benjamin Rogemoser
Alfred State College
Noah Shackelton
SUNY College of Technology at Delhi
Charles Welsh
Advanced Welding Institute
Andrew Yambor
Alfred University

DISTRICT 7

Brandon Cramer
Westmoreland County Community College
Kyle Gaghan
Pittsburgh Technical College
Parker Gies
Triangle Tech
Donavan Leady
Ohio State University
Brian Mee
Ohio State University
William Pitzer
Cincinnati State Technical and Community College
Keagan Sherry
Ferris State University
Heather Shultz
Penn State New Kensington

DISTRICT 8

James Daves
East Mississippi Community College
Jackson Dollar
Calhoun Community College
Austin Jeane
Northwest Shoals Community College–Muscle Shoals
Alejandro Lugo
Northwest Shoals Community College–Muscle Shoals
Daniel Lugo Barrera
Northwest Shoals Community College–Muscle Shoals
Kenneth Mason
East Mississippi Community College
Travis Parmley
Somerset Community College
Marshall Parrish
Southwestern Community College
Raychel Smith
Chattahoochee Technical College

DISTRICT 9

David Donald
Hinds Community College
Peter Kolar
Southern Union State Community College
Triston Michot
Louisiana Technical College–Alexandria Campus
Philip Miles
Wallace Community College
Justin Mixon
Meridian Community College
Tori Slechta
Jefferson State Community College
Brandon Smith
Central Alabama Community College
De'Mykiel Williams
Central Louisiana Technical Community College
William Winters
Shelton State Community College
Andrew Woods
Wallace Community College

DISTRICT 10

Jeremy Carlson
Pennsylvania College of Technology
Benjamin Middleton
Pennsylvania College of Technology
Cody Nikolai
Pennsylvania State University
Jesse Porter
Ferris State University
Marcus Spring
Ohio State University

DISTRICT 11

Nicholas Berchert
Ferris State University
Joseph Carney
Ferris State University
Noah Heimmermann
Ferris State University
Trevor Hofman
Michigan State University
Jordan Martz
Ferris State University
Jenna McFarland
Washtenaw Community College
Jesse Oosterhouse
Ferris State University
Randee Poirer
Ferris State University
Thomas Riss
Ohio State University

DISTRICT 12

Devin Dennee
Northcentral Technical College
Trevor Dennee
Northcentral Technical College
Sean Durian
University of Wisconsin
Ethan Farrell
Fox Valley Technical College
Robert Hendrix
Fox Valley Technical Coll ege
Luke Hieronimus
Northcentral Technical College
Austin Newsom
Moraine Park Technical College
Chance Thomas Rosenstock
Gateway Technical College
Adelyn Soda
Fox Valley Technical College
Jordy Vega
Milwaukee Area Technical College

DISTRICT 13

Jeanine Beaver
Ferris State University
Henry Kingswill
College of Lake County

DISTRICT SCHOLARSHIPS

Joseph Kleindienst
LeTourneau University
Donovan Litteral
Ferris State University
John Sabo
Elgin Community College
Marcus Wesson
Advanced Welding Institute

DISTRICT 14

Levi Beard
Hobart Institute of Welding Technology
Gary Buske
Lewis and Clark Community College
Jaimie Fordyce
Somerset Community College
Logan Henry
State Technical College of Missouri
Roger Hood
Hobart Institute of Welding Technology
Brenten Rodgers
Trine University

DISTRICT 15

Jacob Bredeson
North Dakota State College of Science
Erik Bruner
Hennepin Technical College
Alexander Hartman
North Dakota State College of Science
Russell Hellendrung
Alexandria Technical College
Sara Hodek
North Dakota State College of Science
Alex Johannsen
North Dakota State College of Science
Sydney Nelson
North Dakota State College of Science
Luke Tollefson
Ridgewater College
Tamara Topley
Minneapolis Community and Technical College
Tanner Wierschem
Dunwoody College of Technology

DISTRICT 16

Riley Ash
Linn State Technical College
Jayden Benzel
Central Community College
Kolton Krick
Northeast Community College
Bryce Mason
North Central Kansas Technical College
Tyler Tellez
Southeast Community College

DISTRICT 17

Drew Ables
Ozarks Technical Community College
Joseph Kleindienst
LeTourneau University
Jessica Munoz
Austin Community College
Kendra Murphy
LeTourneau University

DISTRICT 18

John Castillo
Del Mar College
Adrian Garcia
Texas State Technical College
Javier Garcia–Rodriguez
St. Phillip College
Jordan Jones
Universal Technical Institute
Raquel Morales
San Jacinto Community College
Tommy Nguyen
Lamar Institute of Technology
Sandra Osorio
Houston Community College
Alexander Raleigh
San Antonio College
Gilbert Torres
San Jacinto Community College
Amber Van Duyn
LeTourneau University

DISTRICT 19

Dylan Bietsch
Alaska Vocational Technical Center
Matthew Chase
Brigham Young University
Philip Schmidt
Montana Tech of the University of Montana
Evan Tolar
Columbia Basin College

DISTRICT 20

Tyler Arndt
Sheridan College
Ryan Benally
Navajo Technical College
Zechariah Duvall
Pueblo Community College
Trevor Ellis
Brigham Young University
William Giovannetti
Montana Tech of the University of Montana
Kyle Morehead
Aims Community College
Jared O'Shell
Santa Fe Community College
Benjamin Wergin
Western Wyoming Community College

DISTRICT 21

Gildardo Ambriz
Cerritos College
Joseph Dorame
Central Arizona College
Brandon Ellsworth
Brigham Young University
Joshua Gardner
Mesa Community College
Derek Gedlinske
Cochise College
Franklin Gilbert
Mohave Community College
Joshua Hunt
Pima Community College
Ian Ordaz
Arizona Western College
Joseph Ramirez
Mesa Community College
Zoey Sisneroz
Cochise College

DISTRICT 22

Chris Bailey
Fresno City College
Shanker Barron
Laney College
Froylan Cantu
College of the Sequoias
Daniel De Jesus
Universal Technical Institute
Valentin Jiltov
American River College
Jonathan Meadlin
Butte College
Bradley Sorensen
Brigham Young University
Samantha Sutton
Laney College

SECTION AND DISTRICT NAMED SCHOLARSHIPS

DISTRICT 1

BOSTON SECTION (SEABURY WARING) SCHOLARSHIP

Dylan Belair
Lincoln Technical Institute
Shane Mazaros
Morash Institute of Welding and Safety

CENTRAL MASS/RHODE ISLAND SECTION SCHOLARSHIP

Trenton Andrews
Hobart Institute of Welding Technology

CONNECTICUT SECTION SCHOLARSHIP

Austin Kilduff
Advanced Welding Institute
Denise Wall
Lincoln Technical Institute

PERRY, JAMES AND SALEBRA SCHOLARSHIP (GREEN & WHITE MOUNTAINS)

Francisco DeCandio
Hobart Institute of Welding Technology
George Gides III
Hobart Institute of Welding Technology
Jarrett Tillotson
White Mountains Community College

DISTRICT 2

AL AND PAT FLEURY SCHOLARSHIP (NEW JERSEY SECTION)

Devin Van Dusen
Sheridan College

AWISCO SCHOLARSHIP

Thomas McKenna
SUNY College of Technology at Delhi

KEEN COMPRESSED GAS SCHOLARSHIP

Ian Salisbury-Timmons
Delaware Technical Community College

NEW YORK SECTION SCHOLARSHIP

Dominic Ciaccio
Lincoln Technical Institute

PHILADELPHIA SECTION SCHOLARSHIP

Stephen Kougoures
Pennsylvania College of Technology
Zachary Smith
Pennsylvania College of Technology

DISTRICT 3

B.W. BAIN AND D.A. NICHOLAS SCHOLARSHIP (CUMBERLAND VALLEY)

Abram Fox
Pennsylvania College of Technology

CLAUDIA BOTTENFIELD MEMORIAL SCHOLARSHIP (YORK CENTRAL)

Rachel Sauers
Thaddeus Stevens College of Technology
Andrew Stafford
Pennsylvania College of Technology

DISTRICT 3 SCHOLARSHIP (BALTIMORE)

Rachel Sauers
Thaddeus Stevens College of Technology

DR. ROBERT D. STOUT LEHIGH VALLEY SECTION SCHOLARSHIP

Skyler Graver
Pennsylvania College of Technology
Wade Haydt
Northampton Community College
Chad Phillips
Pennsylvania College of Technology

DR. ROBERT WORDEN, JR. MEMORIAL SCHOLARSHIP (WASHINGTON DC)

Ryan Berry
College of Southern Maryland
Sarah Schaupp
University of Maryland Central Park

LANCASTER SECTION SCHOLARSHIP

Rachel Sauers
Thaddeus Stevens College of Technology

READING SECTION MILLENNIUM SCHOLARSHIP

Jack Yengo
Pennsylvania College of Technology

SHIRLEY BOLLINGER – DISTRICT 3 SCHOLARSHIP

Jack Yengo
Pennsylvania College of Technology

SECTION AND DISTRICT NAMED SCHOLARSHIPS

YORK CENTRAL PA SECTION SCHOLARSHIP
Jordan Brabham
Pennsylvania College of Technology
Rachel Sauers
Thaddeus Stevens College of Technology

DISTRICT 4

ARC3 GASES SCHOLARSHIP
Sawyer Smith
York Technical College

CHARLOTTE SECTION SCHOLARSHIP
Shang Jiang
Central Piedmont Community College
Levin Williams
Central Piedmont Community College

DISTRICT 4 NAMED SCHOLARSHIP
James Silver
East Carolina University
Herman Tant III
Wake Technical Community College
Hannah Wolfe
Dabney S. Lancaster Community College

TIDEWATER SECTION SCHOLARSHIP
Luke Foreman
Liberty University

TRIANGLE SECTION SCHOLARSHIP
James Doeffinger
Wake Technical Community College

DISTRICT 5

ATLANTA SECTION SCHOLARSHIP
Katherine Simmons
Savannah Technical College

DAVID PEARL DR. SCHOLARSHIP (SOUTH FLORIDA)
Jose Afonso
University of South Florida

H.D. RIVIERE – SOUTH FLORIDA SECTION SCHOLARSHIP
Jose Afonso
University of South Florida

MALCOLM T. GILLILAND SCHOLARSHIP (DISTRICT 5)
Andrew Campbell
Ohio State University

NORTH CENTRAL FLORIDA SECTION SCHOLARSHIP
Harley Hatch
Withlacoochee Technical College
Scott Kinnaugh, Jr.
Marion Technical College

SOUTH CAROLINA WELD STRONG SCHOLARSHIP
Victoria Shekastehband
University of South Carolina - Aiken

DISTRICT 6

BILL MYERS – ALLEGHANY SECTION SCHOLARSHIP (DISTRICT 6)
Nicholas Miller
Alfred State College

DISTRICT 7

CARLISLE SMITH – TRI-STATE SECTION SCHOLARSHIP
Thomas Collins
Hobart Institute of Welding Technology

COLUMBUS SECTION SCHOLARSHIP
Luke Kumler
Ohio State University
Michael McCarthy
Ohio State University
Elliot Ogles
Ohio State University
Keagan Sherry
Ferris State University
Harleigh Watson
Hobart Institute of Welding Technology
Owen Zellner
Hobart Institute of Welding Technology

DAVID L. & DOLLY MCQUAID SCHOLARSHIP
Jordan Schmeider
Rosedale Technical College
Heather Schultz
Penn State New Kensington

DAYTON SECTION SCHOLARSHIP
River Carpenter
Ohio State University

ED CABLE/BUG-O DISTRICT 7 SCHOLARSHIP
River Carpenter
Ohio State University

LES VESEY – DAYTON SECTION SCHOLARSHIP
Carter Roell
Hobart Institute of Welding Technology

PITTSBURGH SECTION SCHOLARSHIP
Kyle Gaghan
Pittsburgh Technical College
Devon Gilbert
Triangle Technical Institute
Erich Kupecz
Pittsburgh Technical College
Allina Molinaro
Ohio State University
Patrick Moran
Pennsylvania College of Technology
Soraya Sayles
Triangle Technical Institute

WOMEN OF GASES AND WELDING – DISTRICT 7 SCHOLARSHIP
Allina Molinaro
Ohio State University

DISTRICT 8

CHATTANOOGA SECTION SCHOLARSHIP
Stefan Blain
Georgia Northwestern Technical College
Jeffrey Humphrey
Chattahoochee Technical College
Jennifer Leggett
Chattahoochee Technical College
Raychel Smith
Chattahoochee Technical College
Cameron Williams
Georgia Trade School

DISTRICT 8 WOMEN OF GASES AND WELDING SCHOLARSHIP
Luna Bagley
Tennessee College of Applied Technology

nexAIR LLC - GARY ENDERS SCHOLARSHIP (DISTRICT 8)
Bennett Sutton
Missouri Welding Institute

GREATER HUNTSVILLE SECTION SCHOLARSHIP
Jackson Dollar
Calhoun Community College

JIMMY WALKER SR. /SAF-T-CART SCHOLARSHIP
Abigail Weaver
East Mississippi Community College

NASHVILLE SECTION SCHOLARSHIP
Luna Bagley
Tennessee College of Applied Technology

RAYBURN JOHNSON SCHOLARSHIP (GREATER HUNTSVILLE)
Guy Greenhaw
Calhoun Community College

TOO MITCHELL MEMORIAL SCHOLARSHIP (GREATER HUNTSVILLE)
Alejandro Lugo
Northwest Shoals Community College

TOO MITCHELL MEMORIAL/ NASA FRIENDS & FAMILY SCHOLARSHIP (GREATER HUNTSVILLE)
Daniel Lugo Barrera
Northwest Shoals Community College

DISTRICT 9

ANTHONY J. DEMARCO & BRUCE HALLILA SCHOLARSHIP (NEW ORLEANS)
Jason Bruskotter
Northshore Technical Community College

ATLAS WELDING SUPPLY SCHOLARSHIP – DISTRICT 9
Modesty Parker
Jefferson State Community College

BATON ROUGE SECTION SCHOLARSHIP
Jordan Mazzeno
Louisiana Tech University
Jeremy Whittemore
Southeastern Louisiana University

CENTRAL LOUISIANA SECTION SCHOLARSHIP
De'Mykiel Williams
Central Louisiana Technical Community College

CHARLES LEWIS JR. – ACADIANA SECTION SCHOLARSHIP
Taylor LeBlanc
South Louisiana Community College

ELEANOR EZELL MEMORIAL SCHOLARSHIP (MOBILE)
Emily Sinclair
Mississippi State University

JOHN ANGERS – ACADIANA SECTION SCHOLARSHIP
Kyler Laperouse
South Louisiana Community College

LEO VEAL – MOBILE SECTION SCHOLARSHIP
Shawn McLeod
Northwest Florida State College

LES BERTRAND SCHOLARSHIP (ACADIANA)
Brock Touchet
South Louisiana Community College

PASCAGOULA SECTION SCHOLARSHIP
Matthew Johnson
Hinds Community College

PAUL "JERRY" BETTS MEMORIAL SCHOLARSHIP (MOBILE)
Dalton Lehman
University of South Alabama

RONALD C. & JOYCE PIERCE – MOBILE SECTION SCHOLARSHIP
Ryan McCall
Mississippi State University
Emily Sinclair
Mississippi State University
Sean Robertson
Georgia Southern University

SHELTON L. RITTER – NEW ORLEANS SECTION SCHOLARSHIP
Benjamin Diggs
Southeastern Louisiana University

STEPHEN F. CARLISLE SCHOLARSHIP (MOBILE)
Stephen Holliman
Wallace Community College
William Parsons
Wallace Community College

WESCO GAS – ITW – MOBILE SECTION SCHOLARSHIP
Jensen Brahier
University of Central Florida

DISTRICT 10

DR. JOHN GERKEN – CLEVELAND SECTION SCHOLARSHIP
Jesse Porter
Ferris State University

LOWBROW CUSTOMS SCHOLARSHIP (CLEVELAND)
Jack Waltenbaugh
Lincoln Electric Welding School

ROD BELDEN – OE MEYER CO. SCHOLARSHIP (CLEVELAND)
Jesse Porter
Ferris State University

DISTRICT 11

AIM HIGH – JERRY CLAY SCHOLARSHIP (WEST MICHIGAN)
Jeanine Beaver
Ferris State University
Kyah Fisher
Ferris State University
Leah Jodoin
Ferris State University
Matthew Kramer
Ferris State University
Cody Langlois
Ferris State University
Randee Poirier
Ferris State University
Marc Tallieu
Ferris State University
Alex Teed
Ferris State University

AMOS & MARILYN WINSAND – DETROIT SECTION SCHOLARSHIP
Michael Kreuzer
Ferris State University

APEX CONTROLS – BERNIE TEBOS SCHOLARSHIP (WEST MICHIGAN)
Trevor Hofman
Michigan State University

CENTRAL MICHIGAN SECTION SCHOLARSHIP
Wayne Dotson
Washtenaw Community College

DETROIT ELLICOT/ARC WELDING – DISTRICT 11 SCHOLARSHIP
RaeAnn Kievit
Ferris State University

DETROIT ROTH/RESISTANCE WELDING – DISTRICT 11 SCHOLARSHIP
Leah Jodoin
Ferris State University

SECTION AND DISTRICT NAMED SCHOLARSHIPS

DETROIT SECTION SCHOLARSHIP
Nicholas Berchert
Ferris State University
Avery Bury
Ferris State University
Joseph Carney
Ferris State University
Gage Davis
Ferris State University
Hunter Diehl
Ferris State University
Thomas Gallets
Ferris State University
Laurel Garbers
Hobart Institute of Welding Technology
Victoria Hall
Ferris State University
Mark Hanss
Washtenaw Community College
Noah Heimmerman
Ferris State University
Christian Hutnik
Ferris State University
Leah Jodoin
Ferris State University
RaeAnn Kievit
Ferris State University
Mitchell Klaserner
Ferris State University
Karl Ludwig
Ferris State University
Spencer Lyon
Ferris State University
Jordan Martz
Ferris State University
Patrick Micallef
Washtenaw Community College
Jesse Oosterhouse
Ferris State University
Raymond Pippin
Northern Michigan University
Alexander Pizana
Washtenaw Community College
Jesse Porter
Ferris State University
Thomas Riss
Ohio State University
Jacob Schlaud
Ferris State University
Kanyon Sherrick
Ferris State University
Daniel Sims
Washtenaw Community College
Haley Swiger
Ferris State University
Marc Tallieu
Ferris State University
Frank Thornton
Washtenaw Community College
Jonathan Threet
Ferris State University
Jeffery Waldschmidt
Ferris State University
John Zaremba
Ferris State University

DIETRICH AND BETTY ROTH SCHOLARSHIP (WEST MICHIGAN)
Frederick Heurtebise, Jr.
Ferris State University

JAMES KOSTER SCHOLARSHIP (WEST MICHIGAN)
Carson Shorkey
Ferris State University

ROMAN MANUFACTURING – WEST MICHIGAN SECTION SCHOLARSHIP
Steve Heiner
Grand Rapids Community College

SAGINAW VALLEY SECTION SCHOLARSHIP
Jeremy Gordon
Delta College
Victoria Hall
Ferris State University
Anthony Reszke
Ferris State University

WEST MICHIGAN SECTION SCHOLARSHIP #1
Benjamin Fath
Ferris State University
Owen Harley
Southwestern Michigan College
Donovan Litteral
Ferris State University
Keagan Sherry
Ferris State University
Gregory Jonker
Northwestern University

WEST MICHIGAN SECTION SCHOLARSHIP #2
Douglas Trutzl
Ferris State University

DISTRICT 12

FOX VALLEY SECTION SCHOLARSHIP
Daniel Hedden
Fox Valley Technical College

DAVID J. RAMSEUR LAKESHORE SECTION SCHOLARSHIP
William Haase
Northeast Wisconsin Technical College
Taylor Hau
Ferris State University

MADISON-BELOIT SECTION SCHOLARSHIP
Abigail Bachim
Madison Area Technical College
Joshua Bartlett
Dordt College

WELDERS SUPPLY CO. SCHOLARSHIP
Darby Moffatt
Blackhawk Technical College

MILWAUKEE SECTION SCHOLARSHIP
Jordan Ybarra
Milwaukee Area Technical College

DISTRICT 13

DISTRICT 13 SCHOLARSHIP
Emmanuel Bannerman-Blankson
Ferris State University

CHICAGO SECTION SCHOLARSHIP
Marco Carbajal
Lincoln College of Technology
Henry Kingwill
College of Lake County
Maurice Williams
Richard J. Daley College

MARIE & WALTER POLANIN FAMILY – PEORIA SECTION SCHOLARSHIP
Hunter Bevirt
Illinois Central College
Robert Hohulin
Illinois Central College

DISTRICT 14

BRANT FAMILY/INDIANA OXYGEN SCHOLARSHIP
Roger Hood
Hobart Welding Institute of Technology

BOB RICHWINE – INDIANA SECTION SCHOLARSHIP
Jonathan Williams
Hobart Welding Institute of Technology

EARL YOUNG TRI-RIVER SECTION SCHOLARSHIP
Luke Hatfield
Ivy Tech Community College

SKY CYLINDER TESTING SCHOLARSHIP
Noah Hief
Ivy Tech Community College

BAE SYSTEMS- LOUISVILLE SECTION SCHOLARSHIP
Brenten Rodgers
Trine University

HIL BAX – ST. LOUIS SECTION SCHOLARSHIP
Terry Mobbs
Boilermakers Local 27 Apprenticeship School

PAT CODY MEMORIAL ST. LOUIS SECTION SCHOLARSHIP
Logan Henry
State Technical College of Missouri

GARNER KIMBRELL – ST. LOUIS SECTION SCHOLARSHIP
Noah Fink
Lewis and Clark Community College

DISTRICT 15

LYNNES WELDING TRAINING SCHOLARSHIP
Brandon Farley
Lynnes Welding Training
Jacob Johnson
Lynnes Welding Training

DISTRICT 15 NAMED SCHOLARSHIP
Caleb Hasbargen
Central Lakes College

NORTHERN PLAINS SECTION SCHOLARSHIP
Alexander Hartman
North Dakota State College of Science
Sara Hodek
North Dakota State College of Science

MACE HARRIS – NORTHWEST SECTION SCHOLARSHIP
Karl Ludwig
Ferris State University

MIKE HANSON & BOB SANDS – NORTHWEST SECTION SCHOLARSHIP
Luke Tollefson
Ridgewater College

PRODUCTION ENGINEERING/ MIKE ALBERS – N.W. SECTION SCHOLARSHIP
Kyler Kimmick
Anoka Technical College

DISTRICT 16

KARL FOGLEMAN – DISTRICT 16 SCHOLARSHIP
William DeNooy
Missouri Welding Institute

CENTRAL NEBRASKA SECTION SCHOLARSHIP
Elias Wildenstein
Missouri Welding Institute

CHARLES F. BURG – IOWA SECTION SCHOLARSHIP
Christopher Daily
Iowa State University

DAVID LANDON – IOWA SECTION SCHOLARSHIP
Trey Derry
Tulsa Welding School

IOWA SECTION SCHOLARSHIP #1
Christian Birks
Des Moines Area Community College

IOWA SECTION SCHOLARSHIP #2
Austin Paulsen
Missouri Welding Institute

KANSAS SECTION 035 SCHOLARSHIP
Avery Berkley
Washburn Institute of Technology
Tara Conn
Hutchinson Community College
Seth Wright
Flint Hills Technical College

RICHARD "DICK" EMMIT BLAISDELL – KANSAS CITY SECTION SCHOLARSHIP
Erin Avenaim
Johnson County Community College

ROLAND EDWARD "BUCK" EMMERT SCHOLARSHIP
Riley Ash
Linn State Technical College

BRIAN "BIGFOOT" MCKEE WELDER SCHOLARSHIP
Ryan Fitzgerald
LeTourneau University

MONTY RODGERS – NEBRASKA SECTION SCHOLARSHIP
Kolton Matthew Krick
Northeast Community College

PAT WAGNER – S.E. NEBRASKA SECTION SCHOLARSHIP
Nick Novacek
Southeast Community College
Tagert Osborne
Southeast Community College

DISTRICT 17

DANIELLE RIVERA MEMORIAL – DISTRICT 17 SCHOLARSHIP
Kendra Murphy
LeTourneau University

JOHN W. BAILEY MEMORIAL SCHOLARSHIP
Jeffrey Estright
National Park Community College

STEPHEN E. HARRISON MEMORIAL SCHOLARSHIP
Hannah Rawlings
Arkansas Elite Welding Academy

THOMAS B. SCHUECK MEMORIAL SCHOLARSHIP – CENTRAL ARKANSAS SECTION
Blaine Sowers
Arkansas Elite Welding Academy

CENTRAL TEXAS SECTION SCHOLARSHIP
Mallory Ritcher
Austin Community College

LONESTAR – BLACKGOLD SCHOLARSHIP
Kendra Murphy
LeTourneau University

TIM HATTEN MEMORIAL CERTIFICATION SCHOLARSHIP
Thomas Gongloff
AWS CWI Exam

OKLAHOMA CITY SECTION SCHOLARSHIP
Christine Santoro
Tulsa Welding School

SECTION AND DISTRICT NAMED SCHOLARSHIPS

JAMES W. GARDNER - OZARK SECTION SCHOLARSHIP
Drew Ables
Ozarks Technical Community College
Lucas Hertzberg
OXARC Welding School

TULSA SECTION SCHOLARSHIP
Bryan Dennis
Indian Capital Technology Center
Jackson Rich
Mountain Community College

DISTRICT 18

JOHN R. BRAY SCHOLARSHIP
Kenneth Harrison
Tulsa Welding School

BARNEY BURKS SCHOLARSHIP
David McWhorter
Lone Star College
Joshua Rupert
LeTourneau University
Ian Suarez
Texas A&M University
Kelly Taylor
San Jacinto Community College

DENNIS K. & ROBIN ECK HOUSTON SECTION SCHOLARSHIP
Nathan Blizzard
The University of Texas
Yolanda Jones-Robertson
Houston Community College

GEORGE KAMPSCHAFER - HOUSTON SECTION SCHOLARSHIP
Shawn Spellman
San Jacinto Community College

DR. DARYLE MORGAN - HOUSTON SECTION SCHOLARSHIP
Camie Black
Brigham Young University
Justin Vanderwilt
San Jacinto Community College

RONALD S. THEISS - HOUSTON SECTION SCHOLARSHIP
Jose Gomez
San Jacinto Community College
Jonathan Palacios
Lone Star College

RON VANARSDALE-HOUSTON SECTION SCHOLARSHIP
Ezequiel Hernandez
Lone Star College

HOUSTON SECTION SPIRIT OF WELDING SCHOLARSHIP
Conner Graves
Texas State Technical School

AMERICAN BOILER MANUFACTURERS ASSOCIATION SCHOLARSHIP
Jose Santacruz
Lone Star College

DISTRICT 19

JERRY HOPE MEMORIAL SCHOLARSHIP
Mackenzi Johnston
University of Alberta

ALBERTA SECTION SCHOLARSHIP
Jonah Bartsch
Southern Alberta Institute of Technology
Jolene Borrelli
University of Alberta
Calum Brittain
Southern Alberta Institute of Technology
Mackenzi Johnston
University of Alberta
Ikechukwu Oluchukwu
Southern Alberta Institute of Technology

CHUCK DAILY SCHOLARSHIP
Mary Cole
Peninsula College
Gemma Hodgins
Everett Community College
Alexandra Machado
Bellingham Technical College
Wyatt Mercer
Universal Technical Institute
Jeffery Myhre
Grays Harbor College
Riley Smith
Bellingham Technical College

DON & JEAN CLEVELAND - WILLAMETTE SECTION SCHOLARSHIP
Kyle Northcut
Chemeketa Community College

WILLAMETTE VALLEY SECTION SCHOLARSHIP
Toshiana Minjares
Chemeketa Community College

DISTRICT 20

WOMEN OF GASES AND WELDING - DISTRICT 20 SCHOLARSHIP
Emerald Gower
Southern Utah University

COLORADO SECTION SCHOLARSHIP
Blake Bell
Aims Community College
Alexei Buchanan
Community College of Denver
Jesse Cruz
Aims Community College
Brandon Durbin
Northeastern Junior College
Nathan Heurkens
Front Range Community College
Allan Jiricka
Community College of Denver
Benjamin Payne
Community College of Denver
Michael Weeks
Front Range Community College
Ezekiel Young
Aims Community College

IDAHO/MONTANA SECTION SCHOLARSHIP
Jeremy Broyles
Brigham Young University
Brandon Ellsworth
Brigham Young University
Ryan Greenwood
Montana State University
Jacob Holmquist
Brigham Young University
Tyler Humphreys
Montana Tech of the University of Montana
Evan Locke
Idaho State University
Gregory McCleerey
Flathead Valley Community College
Garrett Wilson
Idaho State University

DALE & MAROLYN MORTENSEN - IDAHO/MONTANA SECTION SCHOLARSHIP
Calvin Bake
Brigham Young University
Bradley Nicoll
Brigham Young University
Issac Vail
Brigham Young University
Daniel Wohlgemuth
Brigham Young University

PAUL O'LEARY MEMORIAL - IDAHO/MONTANA SECTION SCHOLARSHIP
Jase Seekell
University of Montana-Helena College of Technology
Mason Skains
Helena College University of Montana

BAUMAN INDUSTRIAL LABS - NEW MEXICO SECTION SCHOLARSHIP
Khiem Do
Central New Mexico College

NEW MEXICO SECTION #75 SCHOLARSHIP #1
Jett Emms
New Mexico Institute of Mining and Technology

NEW MEXICO SECTION #75 SCHOLARSHIP #2
Matthew Liguori
Eastern New Mexico University-Roswell Campus

JACK DAMMANN - SOUTH COLORADO SECTION SCHOLARSHIP
Isabel Martinez
Pueblo Community College
Ryan Moore
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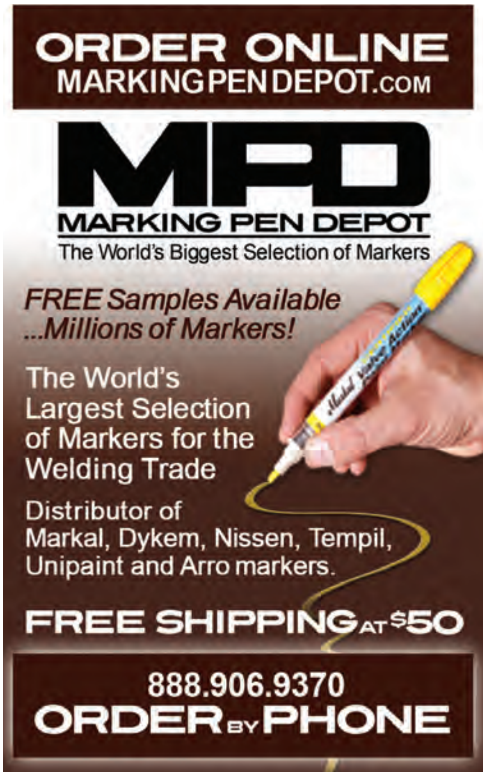

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Underwater Pulse-Current FCAW — Part 2: Bubble Behaviors and Waveform Optimization

Droplet detachment was facilitated by controlling the bubble separation modes

BY J. WU, Y. HAN, C. JIA, C. WU, AND Q. YANG

ABSTRACT

Underwater pulse-current wet welding was proposed in part 1 of this two-part report. The novel technology obtained improved metal transfer and welding process stability. The main reason for droplet oversizing and long transfer cycles was found to be the deviated large droplet stage. In this part, the waveform optimization for both bubble behaviors and metal transfer were investigated. Efforts were made for shortening the duration of the deviated large droplet stage. Pulse current influences on bubble evolution was studied. It was found that two different separation modes can be adjusted by appropriately changing the current values when the bubbles are necking. Quickly reducing the welding current can sharply lower the impact force on the droplets due to intense gas flow changes inside. Under the optimized pulse current, the range of the metal transfer cycle became narrower, and droplet diameters were smaller than that of the original condition. Stable and improved metal transfer processes were achieved with a frequency of 7.52 Hz and an average droplet diameter of 2.4 mm, which was about 1.5 times the wire diameter. The optimized pulse waveform greatly improved weld formation with less spatter and a more uniform appearance.

KEYWORDS

• Underwater Welding • Metal Transfer • Bubble Evolution • Pulse Current • Process Control

Introduction

In underwater wet flux cored arc welding (FCAW), the unstable metal transfer and generated spatter deteriorate process stability and weld quality. The metal transfer process has characteristics such as oversize, low frequency, unregulated trajectory, etc. Based on visual sensing technologies, it is thought that the main metal transfer mode is large droplet repel transfer (Refs. 1, 2). Typically, the droplet size is about four times the wire diameter, the metal transfer cycle is about 0.225 s, and the transfer frequency is about 4.44 Hz. The slow-moving, large droplets are unstably transferred to the weld pool. As a result, there is an intense impact on the weld pool along with bubble disturbances on the transferring droplets, producing spatter and a bad weld appearance.

In part 1 of this two-part report, a novel underwater pulse-current FCAW process was proposed to periodically change the forces applied on droplets (Ref. 3). The regulated metal transfer processes had the maximum droplet diameter of less than 5 mm; large droplet repel transfer was achieved without hardly any unstable short-circuit transfer and surface tension transfer; and the performance of the pulse-current FCAW was much better than the constant-voltage condition. According to the divided six metal transfer stages, the long duration of the deviated large droplet stage was the main factor deciding the long transfer cycle. Under the present pulse current, the time length of the deviated large droplet stage was successfully decreased but with a wide range (30–200 ms). The pulse-current effect was still not stable and needs further optimization.

According to previous research, the bubbles' behaviors are critical for maintaining stable arc burning and smooth metal transfer (Ref. 4). The spatter generation processes are closely related to the bubble evolution (Ref. 5). In part 1 of this two-part report, the related bubble behaviors in pulse-current welding and the relevant influences were neglected.

In part 2 of this two-part report, cooperative regulation of both bubble evolution and metal transfer was investigated. The specific effect of bubble necking on metal transfer were revealed. By exploring the influencing mechanisms of pulse current on wet FCAW, the pulse-current waveform was optimized for higher-frequency, smaller-size metal transfer in a stable welding process.

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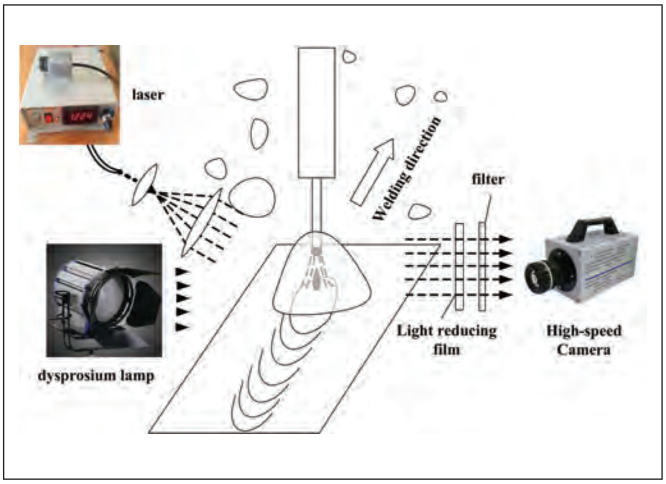

Fig. 1 — Equipment platform and signal acquisition system.

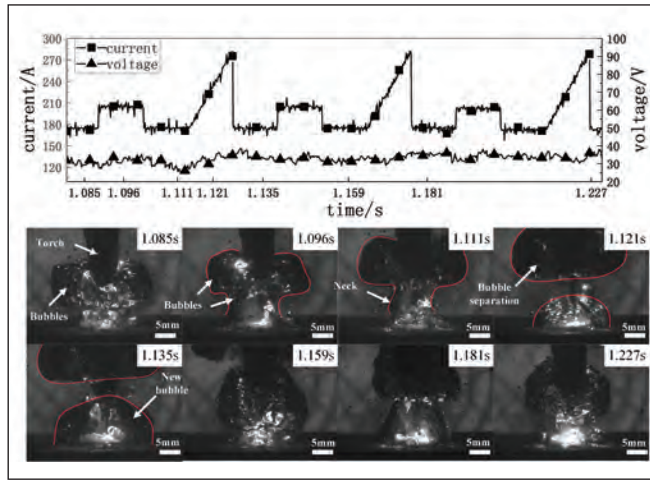

Fig. 2 — Bubble behaviors under a 20-Hz pulse current.

Table 1 — Experiment Parameters with Pulse Current

Welding Parameters	Wire Feed Rate	Welding Speed	Wire Diameter	Average Current
Values	4.4 m/min	180 mm/min	1.6 mm	200 A

Experimental Procedure

To obtain clear bubble images, a dysprosium lamp was employed as the additional background light source on the basis of the previously developed experimental platform (Ref. 1). As shown in Fig. 1, the dysprosium lamp can provide a large-diameter, ultra-bright background (0.5 m), which is a great supplement to the laser beam source for observing the bubble behaviors. Bead-on-plate welding experiments were carried out under the water depth of 0.5 m. The base metal was Q235 with a thickness of 8 mm. The consumable was a self-shielded, rutile-type, flux-cored wire (PPS-AN1, 1.6 mm diameter), which is developed by the E. O. Paton Electric Welding Institute, Kiev, Ukraine, especially for underwater wet welding. The electrode extension was 16 mm. The torch and wire were directly positioned in a water tank. Most of the experimental procedures were the same as those in part 1 of this two-part report. Experiments were first conducted using the existing original pulse-current waveform. The related experimental parameters are shown in Table 1. Based on the acquired images, the bubble behaviors were visually investigated to evaluate the pulse-current influences.

Results

Effect of Pulse Current on Bubble Behaviors

The change of current can influence the behavior of bubbles. Therefore, relevant experiments were carried out for the purpose of regulating and controlling the growth behavior of bubbles using pulse current. The pulse-current waveform used in the experiment was unchanged, and the values of each section were adjusted. The current-output frequency was changed from 60 to 20 Hz, i.e., the cycle of each waveform was adjusted from 16.7 to 50 ms. Reducing the frequency meant reducing the frequency of current variation at the same time. By reducing the degree of arc variation, the bubbles were more regular and no longer fragmented, so they could be regulated to a certain extent.

Based on the relationship between bubble formation frequency and average current levels, the output pulse frequency was set accordingly. For example, when the average current was 190 A, the frequency of bubble formation was 18 Hz. The collected data was randomly selected for observation and analysis. When the output frequency of the pulse current was 20 Hz, the bubble growth behavior was more regular.

Figure 2 shows the synchronously collected electrical and visual signals. A certain relationship between bubble behavior and pulse current could be observed. When the pulse current changed from peak value to base value at 1.096–1.111 s, the instantaneous decrease of the current made the heat production decrease and the arc fluctuate, which led to the breakdown of the internal dynamic balance and the changing bubble shapes. At 1.111 s, there was a neck between the two bubbles. When the length of the neck reached a certain degree, the two bubbles separated and a new bubble below continued to grow.

According to the statistics, the bubble separation behavior during stable welding processes can be generally divided into two modes: complete separation and adhesion separation, as shown in Fig. 3. To more accurately identify the outline of the bubble, it was marked with lines. The left picture shows the complete separation mode of two bubbles, and the right picture shows the bubble adhesion mode in which the two bubbles were not completely separated.

For the bubble complete separation mode, during the for-

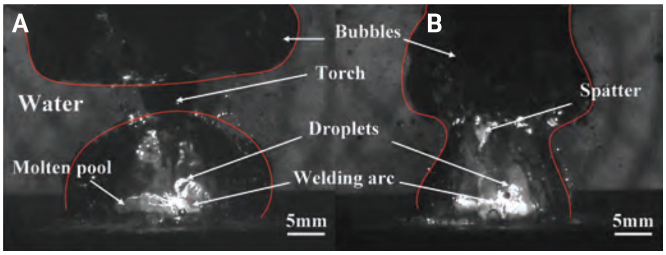

Fig. 3 — Two separation modes of bubbles: A — Complete separation; B — adhesion separation.

mation and growth of the next bubble, the former bubble completely detached from the old bubble, and the two bubbles were not connected, or very few parts were connected. The effect of water pressure on the top of the new bubble was obvious. The main reason for this mode was because, when the bubble separated, the current was low and in the base current section. The volume of gas produced by the decomposition of the core and the arc heat was significantly reduced. As a result, the next bubble was not large enough to adhere to the former bubble when separating, as shown in Fig. 2 (1.121 s). When the necking of the bubble was about to break away at 1.085 s, the current increased to the background current at 1.096 s, which made two bubbles completely unable to separate at 1.096 s. Then, when the current decreased again at 1.121 s, the gas production was insufficient to sustain the growth of the new bubble below to be large enough, so the new bubble directly broke down.

For the bubble adhesion separation mode, the separating old bubble was connected to the newly generated bubble. Both of the two bubbles were sleeve shaped. The main reason for this mode was because the current was still large when the bubble necked and tended to separate. Additionally, the gas production did not decrease, resulting in the expansion of a new bubble directly from the neck of the former bubble. When the former bubble floated up, the new bubble grew and formed a sleeve shape, as shown in Fig. 2, from 1.159 to 1.181 s. Because of the continuous increase of current and the sufficient gas production in this section, the new bubble began to expand directly at the neck of the former bubble when necking occurred.

Pulse-Current Waveform Optimization

Based on the bubble separation time when the average current was 180 A, the whole waveform cycle was set as 71 ms. Under the pulse-current condition, the bubble separation time was affected by the valley current of the waveform. Considering the delay time of the bubble behaviors, it was extended by 11 ms in the previous design. In this case, the output-current pulse frequency was 14 Hz.

As shown in Fig. 4, the optimized waveform was designed with four stages. In actual welding experiments, it was found that the time required for droplet growth fluctuated greatly and varied with the change of current levels. According to the previous analysis of the metal transfer process in part 1 of this report, the time for droplet formation (i.e., initial stage, growing up, and deviation) was about 60–70 ms, and the time for the deviated large droplet stage was about 40–50 ms (Ref. 3). It was found that under the same average

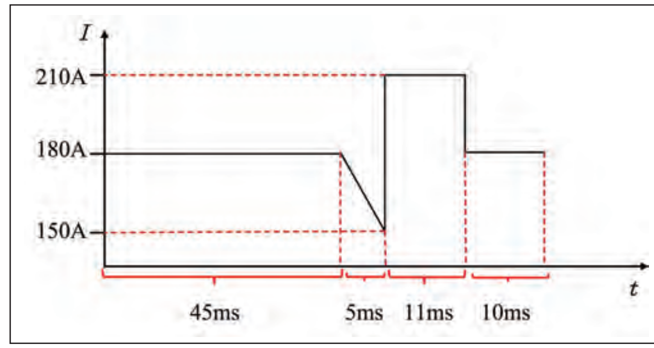

Fig. 4 — Optimized pulse-current waveform in wet FCAW.

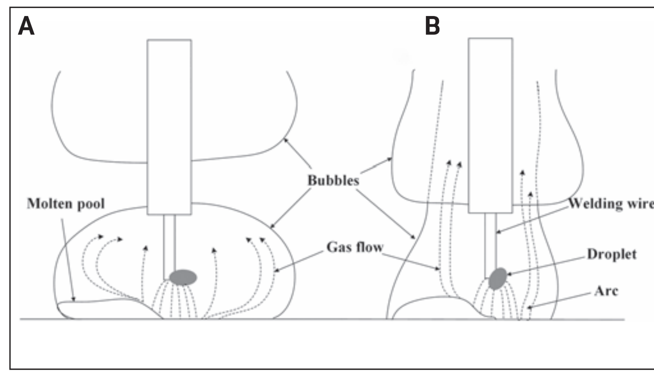

Fig. 5 — Schematic of different gas flows under two separation modes of bubbles: A — Complete separation; B — adhesion separation.

current level, the droplet formation stage took almost the same length of time in the conventional constant-voltage and the pulse-current FCAW processes. Therefore, the purpose of waveform optimization was to significantly reduce the time length of the deviated large droplet stage.

The first section of the waveform (45 ms) was used to cover the droplet formation stages. A suitable welding current value (210 A) was used to provide sufficient power support for melting the wire quickly and stably. In the second section (following 5 ms), the droplets fluctuated when the current decreased and then moved into the deviated large droplet stage ahead of time. At the same time, because of the sudden change of arc burning status, the bubbles necked in advance. The current rose steeply in the third section (11 ms) with the variation amplitude of 60 A.

The purpose was to make the droplets deviate immediately and begin to detach from the wire. It is expected that the duration of the deviated large droplet stage can be shortened significantly, or even directly enter the detaching stage. Considering the corresponding bubble behaviors at this stage, the bubble necking tended to accelerate and gradually break away. The previous research verified that increasing the current when the bubble necked produced the complete separation mode. In this way, the quickly separated bubbles could avoid the intense gas flow disturbances on the detaching droplet, and spatter would not be formed without excessive impact and dragging force.

The fourth section of the waveform was designed for droplet transferring, new droplets, and the new bubble formation stage. Because there was an overlap time between

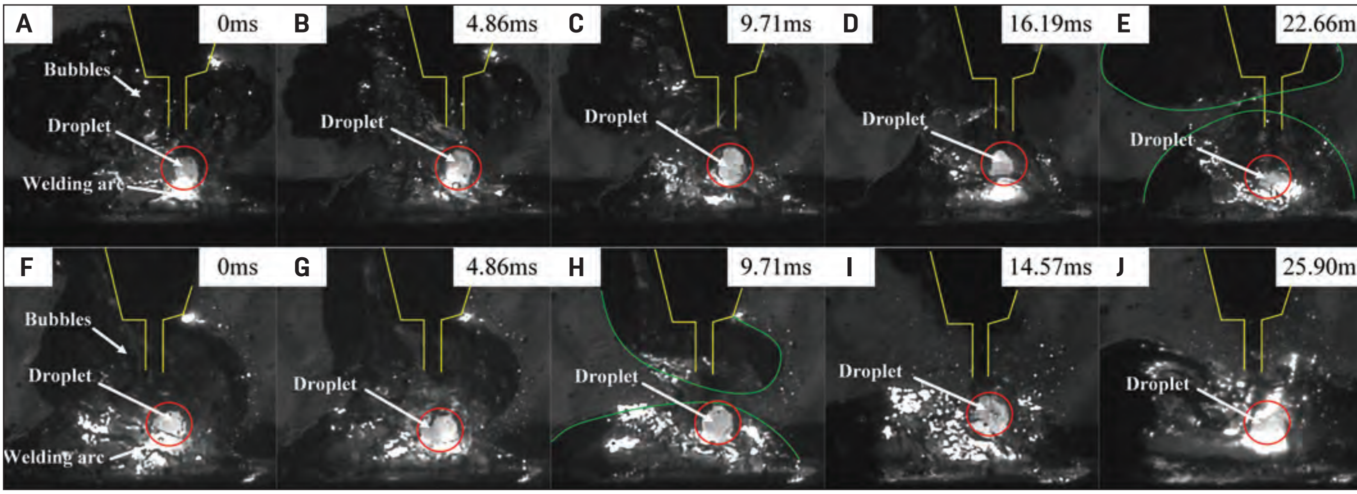

Fig. 6 — Droplet and bubble behaviors in two typical periods under the complete bubble separation mode.

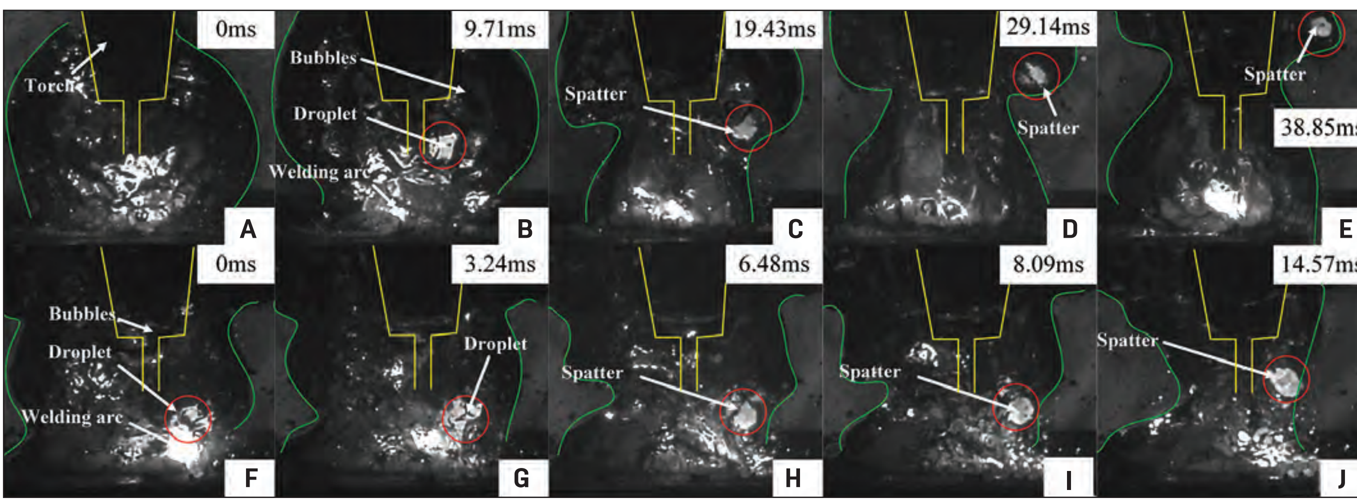

Fig. 7 — Typical spatter formation processes under the adhesion separation mode of bubbles.

the bubble detachment and the growth of new bubbles, there was also a period for droplets to detach from the wire and transfer to the molten pool. Compared with the actual processes, the time from bubble shrinkage to leaving the arc region was approximately 11.3 ms. The complete separation time of bubbles was about 17.8 ms. Because the third and fourth sections of the waveform were used to cover the whole stage from necking to complete separation of bubbles, the fourth section time length of the pulse-current waveform was set as 10 ms. The waveform was used as the preset waveform 1. The welding parameters were as follows: the arc voltage was 27 V, the wire feed rate was 4.4 m/min, and the welding speed was 180 mm/min.

Discussions

Bubble Evolution Influences on Droplets

During underwater pulse-current wet FCAW, the different bubble shapes under the two separation modes led to different dragging forces acting on droplets. The bubbles, under the complete separation mode, completely separated from the former bubble. They were ellipsoidal or inverted-bowl shaped under the action of water pressure. At this time, the internal gas flow was roughly shown in Fig. 5A. Under the influence of water pressure and water resistance for bubble moving, the bubbles tended to expand horizontally. The acting forces applied on droplets were mainly caused by the gas flow inside the bubbles.

The gas flow was expressed in a dotted line, as shown in Fig. 5A. Please note the gas produced by flux thermal decomposition struck intensely around the end of the welding wire. The distance from the wire end to the workpiece was very short (3–4 mm). In this case, the gaseous jet after impinging on the weld pool spread around and then went upward. Because of the influence of the water environment, the expansion of the bubbles in the horizontal direction was limited by the effect of water pressure, which resulted in the upward movement of gas flow. This can be clearly observed from the expansion behavior of bubbles, i.e., the bubbles expanded horizontally to a certain size and then moved directly upward. The bubble expansion and spatter behaviors under the action of gas flow showed that gas flow impact forces exist.

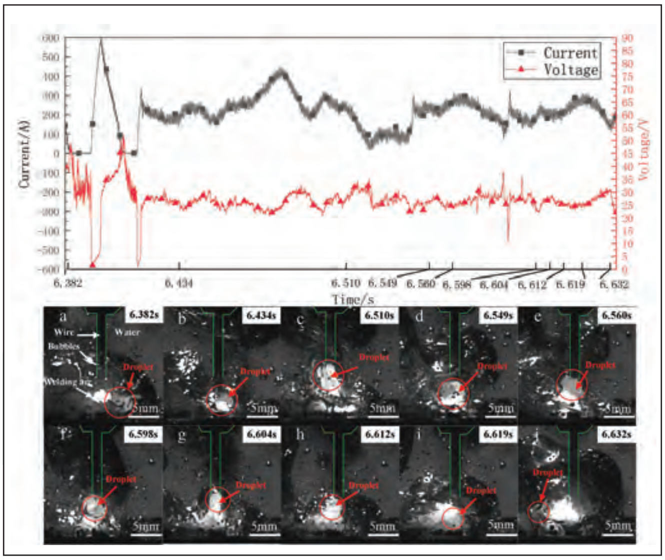

Fig. 8 — Metal transfer process under the constant-voltage mode.

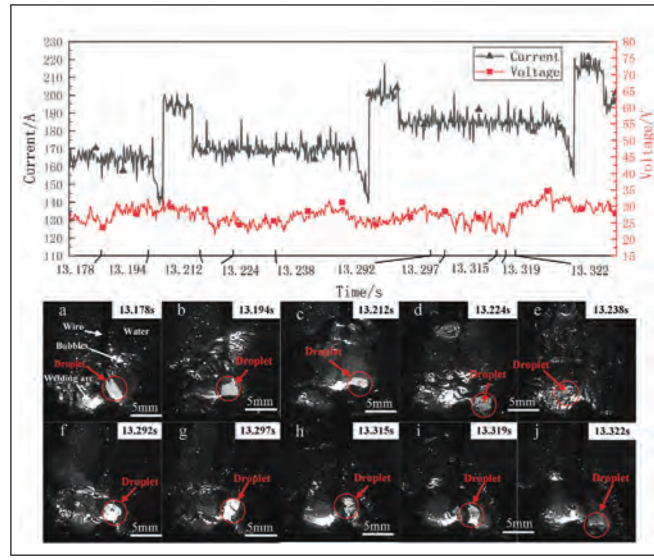

Fig. 9 — Metal transfer process under the optimized pulse-current waveform mode.

Therefore, when the new bubbles expanded horizontally, the acting forces applied on the droplets were not significant. With the welding process going on, the existence of the molten pool also heated the water to evaporate, increasing the gas production so that the equilibrium diameter of the bubbles expanded and the gas flow impact acting on the droplets in the bubbles was significantly reduced.

Under the adhesion detachment mode, as shown in Fig. 5B, the new bubbles were connected with the previous one when the bubbles separated from each other. The generated gas in the new bubbles flowed upward through the common gas channel between two bubbles and got into the rising, old bubble's space. The shape of the bubbles was cylinder or sleeve shaped. Bubbles tended to expand upward. The gas flow directions are shown using dotted lines in Fig. 5B.

The acting forces applied on the droplets in the bubbles were much greater than that under the completely detached mode. When new bubbles rose up, the volume of the bubble in the arc column region was small because of the necking of the former bubble. Meanwhile, the gas production inside new bubbles was still intense, and large amounts of gas rapidly expanded upward in a short time. The forces acting on the droplet mainly included drag force from the former bubble and impact force from the gas flow in the new bubble. A droplet that has grown to a certain volume can be easily pushed upward under the drag force to impact force. In this case, once the droplet detached, the upward momentum made it become spatter. As shown in Fig. 3B, spatter is formed along with the bubble separating process; it can be clearly observed at the junction of former and new bubbles.

To explore the effects of the above-mentioned, two-bubble separation modes on metal transfer, statistical analysis was carried out. It was found that when the bubbles were separated completely, a certain drag force acted on the droplets. The drag force made the droplets move upward along the wire, which resulted in the long residence time of the droplets in the deviated large droplet stage and the longer transfer time. However, the drag force was not big enough to push the droplet to detach from the wire end and form spatter.

As shown in Fig. 6, two typical periods of bubble detachment under the complete separation mode were selected, and the time of bubble necking was set as the starting time. Due to the interference of uneven light, to more easily identify the shape of the droplet, the droplet was marked with a circle and the outline of the torch was traced with a line. As seen in Fig. 6, because of the insufficient gas production, there were gaps between the former and new bubbles when the bubble necked and the surrounding water pressed the new bubble to form a shape like an inverted bowl.

As the welding process proceeded, the new bubble expanded horizontally while the former one moved upward. Generally, when the bubble necking occurs, the droplet is located at the upper position of the new bubble, as shown in Fig. 6A and F at 0 ms. At this point, the droplet was not only subjected to the drag force produced by the upward detachment of bubbles but also to the upward impact of the gas in the new bubbles below. However, due to the effect caused by the complete separation of bubbles (i.e., the relative reduction of gas production at this time), the upward gas impact effect in the new bubbles was not obvious. Therefore, with the separation of the former bubbles, the droplet tended to move upward with a small amplitude, as shown in Fig. 6C and H (9.71 ms). Under the action of arc forces, surface tension, droplet gravity, etc., the droplet was not dragged away from the wire end by the drag force when the former bubble moved upward. Instead, it remained in a sagging status after rising for a limited distance. Because the former bubble moved away, there was only a very thin gas layer above the molten droplet. Inside the continuously growing and expanding new bubbles, the droplets were pulled back into the new bubbles, as shown in Fig. 6E and J (22.66 and 25.90 ms, respectively). In the complete bubble separation mode, as shown in Fig. 6E and H, there was no gas flow channel between the two bubbles, but they were completely separated.

As shown in Fig. 7, two typical periods of bubble separating behaviors under the adhesion separation mode were se-

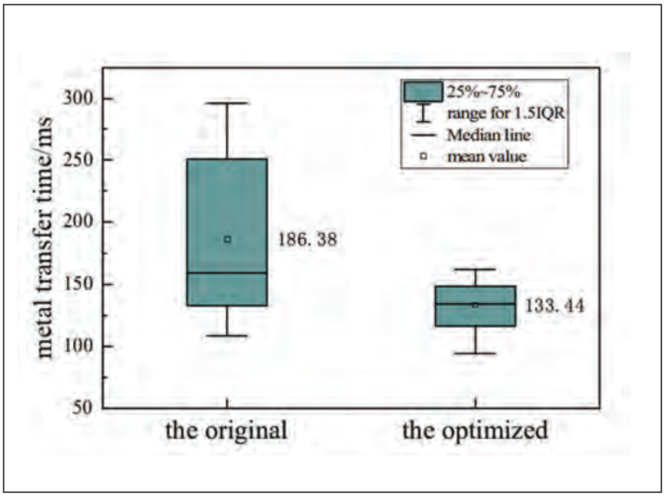

Fig. 10 — Metal transfer cycles under different pulse-current waveforms.

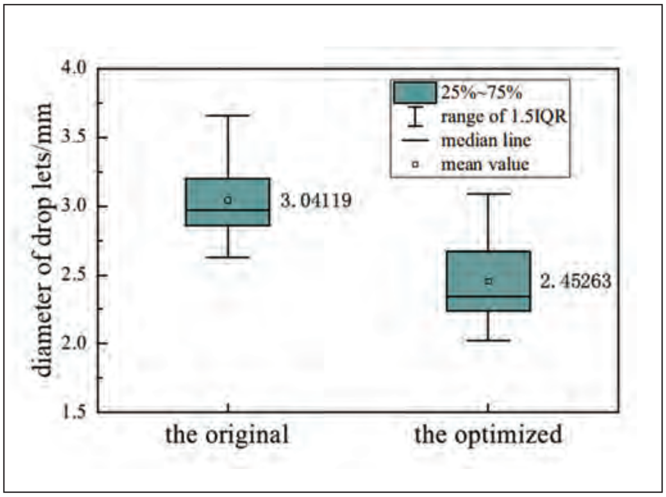

Fig. 11 — Droplet diameters under different pulse-current waveforms.

lected. The outline of the bubble was marked with lines. Similarly, the initial time (0 ms) was set as the bubble necking beginning. The bubbles' morphology was quite different from that under the complete detachment mode. In Fig. 7, it can be can seen that in the bubble adhesion separation mode, the bubble did not completely separate, but there was an obvious gas flow channel in the middle of the bubble. Theoretically, there was no water pressure difference between the former bubble and the new bubbles. The new bubbles had obvious, oblique boundaries rather than sphere shapes; the whole was like a cylinder or sleeve, as shown in Fig. 7D (29.14 ms). As previously analyzed, the droplets under this mode easily formed spatter directly with the former bubbles floating out of the arc column. The droplets were pushed away from the wire tip shortly after the bubble necking, as shown in Fig. 7B and G (9.71 and 3.24 ms, respectively). Upward and outward movement of the droplets can be observed due to the initial momentum. A droplet even flew far away from the welding area and formed a spatter, as shown in Fig. 7E.

Based on the above analysis, it can be concluded that the impact forces acting on droplets reached the maximum when the bubble necked. At this moment, the gas production in the bubble determined the effect of the bubble influence acting on droplets, while the current value directly affected the gas production rate in the bubble. When the current increased, the bubbles were in the adhesion separation mode, and the droplets probably moved out to form spatter. When the current decreased, the bubble's evolution worked under the complete separation mode. In this case, with the significantly decreased bubble drag force and arc forces, the droplets detached from the welding wire and transferred to the molten pool more smoothly. Therefore, by reasonably adjusting the pulse-current waveform and its output frequency, the regulation and control of metal transfer was realized.

Control Effect Evaluation of Optimized Pulse-Current Wet Welding

In the underwater wet FCAW process, the constant-voltage mode was used to keep the stable arc length. However, the periodically detaching bubbles strongly interfered with the arc burning and the droplet transfer processes, which led to poor weld formation. In part 1 of this two-part report, a novel pulse-current welding method was proposed, and experiments showed the pulse current had a better control effect on the droplet transfer and weld formation. In this case, by considering the bubble separation modes, the pulse-current waveform and its output frequency were optimized accordingly. By examining the control effect of optimized, pulse-current wet welding, the metal transfer processes and the improved bubble evolution behaviors were compared with both constant voltage and the original pulse-current FCAW.

First, welding experiments under constant voltage were carried out for comparison. Under the constant-voltage welding condition, the power source kept the arc voltage almost constant by adjusting the welding current from time to time to match the wire feed rate. As shown in Fig. 8, the metal transfer images and corresponding electrical signals under constant-voltage and pulse-current conditions were collected, compared, and analyzed. The images show a typical metal transfer cycle in the constant-voltage welding process with a period of 250 ms. There was already an obvious deviation of the droplet at 6.549 s (Fig. 8D), 115 ms later than that of the initial droplet stage (Fig. 8A). Thereafter, the current decreased, and the droplet continued to grow under the action of the bubble drag force and arc forces. The welding current varied irregularly during this stage until the droplet grew to a sufficient size to contact the molten pool under gravity (Fig. 8G, 6.604 s). A short circuit occurred and the metal transferred to the molten pool due to the surface tension. The duration of the deviated large droplet stage was about 94 ms.

In the process of metal transfer, the current decreased when the bubble necked, which also resulted in the formation of the bubble complete separation mode. In Fig. 8 (6.51 s), it can be clearly seen that there was an obvious drag force acting on the droplet while the bubble floated up and separated. Additionally, the droplet moved upward in an ellipsoid shape due to the pulling effect from the intense gas

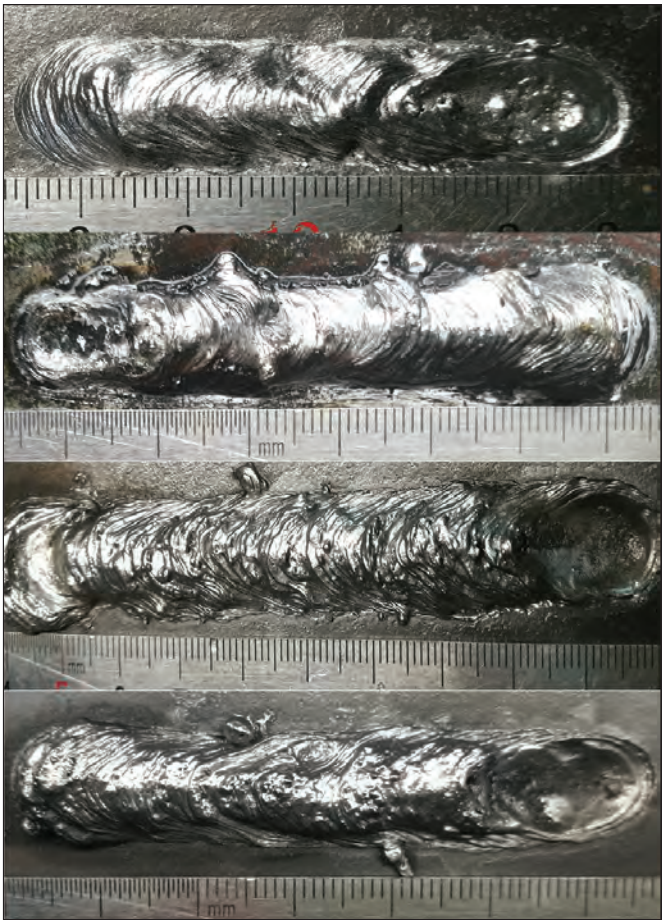

Fig. 12 — Comparison of weld bead appearance under the original waveform (left) and the optimized waveform (right).

flow. Finally, the bubble completed the separation. Bubbles in the complete separation mode exerted a considerable drag force on the droplet, but the gas in the new bubble did not exert a great impact on the droplet. Therefore, the droplet did not fly out of the bubble to form spatter.

Second, as discussed in part 1 of this report, the original applied pulse current changed the period from 150 to 200 ms in the constant-voltage mode into 30 to 200 ms. That is to say, the metal transfer period can be effectively shortened to some extent. During the mentioned six stages of metal transfer, the long duration of the deviated large droplet stage was the main factor causing the long period, low frequency, and instability of the metal transfer. The acquired results show that the pulse current in this stage significantly influenced the droplet separation behaviors and decreased the metal transfer cycle in a large amplitude. However, the effect of the present pulse current was not stable and accurate. The control effect needed to be further optimized. In this paper, the influences of the bubble separation mode were considered significant for the metal transfer processes. The optimized waveform was expected to more effectively regulate the metal transfer processes.

Third, the physical processes of the optimized pulse-current FCAW were visually investigated. Figure 9 shows two metal transfer cycles during pulse-current wet welding. Under the pulse-current mode and the parameters shown in Figs. 4 and 9A, a significant droplet deviation can be seen. Thereafter, the current experienced a steep rise after the decrease. After 34 ms (Fig. 9C, 13.212 s), the droplet detached from the tip of the wire toward one side of the welding wire and then dropped into the molten pool at 13.224 s, as shown in Fig. 9D. When the droplet entered the molten pool, a new one was clearly observed after 14 ms at 13.238 s (Fig. 9E). After another 54 ms, the new droplet grew to a certain size and then deviated obviously (Fig. 9F, 13.292 s). Subsequently, from Fig. 9G to J, the droplet went through short-deviation detaching and transferring stages. The droplet finally entered into the molten pool at 13.322 s.

During the droplet transfer processes, the bubble evolution processes played an important role. At 13.238 s, the bubble necking can be seen. With the decreased current in the pulse-current waveform, the gas production decreased to a certain extent, and the bubbles separated from each other under the complete separation mode. Compared with the metal transfer processes in constant-voltage welding, the droplet directly detached from the wire when it entered the deviated, large droplet stage under the applied pulse current with the new waveform. It greatly reduced the duration of the deviated large droplet stage, which is considered the main factor determining the long metal transfer cycles. The droplet transfer was significantly improved with smaller diameter and higher transfer frequency.

In the metal transfer process (from Fig. 9A to D), it can be clearly seen that no bubble separation occurred, and the shape of the bubble was more regular. Because the droplet and welding arc were always covered inside, the bubble didn't nearly influence the droplet behaviors during this period. The regular bubble shape shows that its expansion was uniform, and the gas flow did not fluctuate greatly.

Therefore, combined with the electrical signal waveform at this moment, what could be concluded is that the droplet was repelled outward and forced to detach from the wire end at 13.212 s, as shown in Fig. 9C, under the action of optimized pulse current. Please note that the sharply increased welding current (between 13.194 and 13.212 s) at the third stage of the new waveform, as shown in Fig. 4, produced gases. The inner intense gas flow was applied to the droplet and helped it to detach from the wire end. Due to the thermal lag effect and droplet movement time, the deviated and detached droplet was observed after the pulse-current application. In addition, the bubble necked near the workpiece, and then the droplet dropped into the molten pool at 13.224 s.

The second metal transfer period was shown from Fig. 9E to J. In Fig. 9D, the transferred droplet caused the bubble's oscillation and collapse; thus, a new bubble emerged. Different from the previous metal transfer cycle, the should-be-separating bubble collapsed, which disrupted the original purpose of the optimized current waveform. According to the initial purpose, the new waveform was designed to accelerate the bubble separation and the droplet transfer processes via adjusting drag force inside the bubbles. However, the above phenomenon verifies that the droplet detachment may not be accomplished by only relying on pulse current. The collapse of bubbles resulted in the slow growth of new bubbles.

As shown in Fig. 9F, at 13.292 s the bubble was still small even after the current went through a sharp increase. At the following moment of 13.297 s, the droplet volume seemed relatively larger than that at 13.212 s of the previous transfer period, as shown in Fig. 9C; the droplet was not directly repelled off the wire end compared with that at 13.212 s. In addition, inside the small-volume bubble, as shown in Fig. 9G, the bottom of the droplet did not neck like that at 13.212 s. Therefore, the droplet only oscillated during this period without detaching. After another 25 ms (Fig. 9J, 13.322 s), the droplet dropped off under the action of inertia momentum and gravity, entering into the molten pool. Compared with the former metal transfer process, the droplet in this period experienced two current waveforms before detaching.

By analyzing both metal transfer images and electrical signals, it was found that the frequency of bubble evolution coincided with the frequency of the present optimized pulse-current waveform. That is to say, the optimized bubble evolution frequency was approximately 14 Hz with the period of about 71 ms. While under the original pulse-current waveform (average current 190 ~ 200 A), as shown in Fig. 2, the bubble evolution frequency was about 18 ~ 19 Hz. Therefore, it can be concluded that the optimized pulse-current waveform also significantly reduced the bubble evolution frequency, which was important for maintaining stable arc burning and metal transfer.

For the pulse-current waveform, the amplitude from the lowest value (150 A) to the pulse current (210 A) was set as 60 A. The time lengths of different waveform segments can be designed according to the periodical evolution and behaviors of the bubble and droplet. Droplets and bubbles grew steadily under a certain current. When the droplets deviated, the rapidly changed welding current caused the bubbles to neck and separate. Under the combined influence of pulse current and bubble behaviors, the droplets entered the deviated large droplet stage, and the detachment occurred soon after.

Improved Metal Transfer and Weld Formation

In the underwater wet welding process, a large droplet size and a low transfer frequency are the main reasons for poor weld formation. Based on analyzing the signals from Fig. 9, it was found that under the optimized pulse-current waveform, the droplet transfer process was more stable than that of the original one (Ref. 3). In other words, under the original pulse current, there existed a large portion of the adhesion separation mode as well as some of the complete separation mode in the bubble separation processes. On one side, the typical metal transfer under the adhesion separation mode was the repelled globular transfer with a large droplet size and a low transfer frequency. On the other side, under the optimized pulse-current waveform, a bigger portion of the complete separation modes and a more stable welding process were obtained, and the metal transfer mode still repelled globular transfer but with a smaller droplet size and a higher transfer frequency. Therefore, it regulated and controlled the metal transfer process to a certain extent. However, there were still some unexpected phenomena in the welding process, such as the above-mentioned bubble collapse due to droplets entering the molten pool. Considering these situations, further optimization of the waveform is needed in the future.

The improved droplet transfer process was conducive to obtaining good weld formation. The metal transfer cycles of the original waveform and the optimized waveform were statistically analyzed, as shown in Fig. 10. Compared with the metal transfer time of the original preset waveform, the variation range of metal transfer periods under the optimized waveform was significantly reduced, i.e., the metal transfer became more stable with less fluctuation caused by unpredictable disturbances. The distribution range of the metal transfer cycles became much narrower. Furthermore, the average transfer period significantly reduced from 186.38 to 133.44 ms. The decreased metal transfer period means the increased metal transfer frequency can reach up to 7.52 Hz under this optimized waveform. That is to say, the metal transfer processes became more stable.

The droplet diameters were also critical to the stability of the metal transfer processes. The droplet diameters under the original and optimized waveforms were calculated and compared. As shown in Fig. 11, the average droplet diameter under the optimized waveform decreased to 2.45 mm from the former 3.04 mm under the original waveform. The maximum droplet diameter did not exceed twice the diameter of the wire, and the minimum was close to the wire diameter of 1.6 mm. The reduction of the droplet diameter was beneficial to the stability of the welding process to a certain extent. In other words, the optimized metal transfer processes had a higher frequency and smaller diameters. Thus, the impact from the liquid droplets on the weld pool can be significantly reduced along with less spatter generation.

As mentioned in part 1 of this two-part report, the novel pulse-current underwater FCAW was better than the constant voltage mode in improving weld formation (Ref. 3). In this section, we further compared the weld formation under the original waveform and the optimized waveform. As shown in Fig. 12, the weld bead formation was further improved by the optimized pulse current. The weld bead surface became more uniform with less defects, such as spatter, weld beading, etc. Different from the images on the left, the weld beads on the right had nearly constant widths and reinforcement. It can be deduced that, under the optimized pulse-current FCAW, the molten metal droplets were much more smoothly transferred to the weld pool and then solidified with uniform weld beads formed. Compared to the serious spatter generation in traditional underwater FCAW, much less droplets were transformed into spatter (Ref. 6).

Conclusions

1) During pulse-current wet FCAW, the periodically changed current produced two different bubble separation modes, i.e., complete separation and adhesion separation. Different bubble shapes were observed due to the complex inner gas expansion behaviors. When a new bubble was formed under the adhesion separation mode, there was a junction gas channel between the former bubble and the new bubbles. The gas flow inside the channel significantly influenced the welding processes.

2) According to the synchronous observation of bubble and droplet behaviors, it was found that two bubble separation modes had different influences on the droplet transfer. Under the adhesion separation mode, droplets were subject to not only the gas flow impact inside the new bubbles, but also the drag force produced by the intense gas flow inside the junction channel between the two bubbles. The resultant forces resisted the droplets falling downward and even pushed them out of the bubbles. The resistance force applied on droplets was relatively small in the complete separation mode, which was more conducive for the more smooth droplet transfer.

3) When optimizing the pulse-current waveform, the pulse-current influences on bubbles were taken into account for significantly shortening the deviated large droplet stage of metal transfer. Four sections of the new waveform were defined for droplet growing, fluctuation, detaching, and transferring, respectively. Note the current was rapidly decreased in the second section to reduce not only the repulsive force on the droplet but also to decrease the generated gas flow to avoid the bubble adhesion separation. With the optimized waveform, the bubble expansion and evolution happened in the complete separation mode. The quickly and completely separated bubbles could avoid the intense gas flow disturbances on the detaching droplet, and spatter was not formed.

4) Under the optimized pulse-current waveform, the droplet transfer process was more stable than that of the original one. It can effectively regulate and control the metal transfer as well as the bubble evolution processes. The metal transfer cycle range became narrower, the average transfer cycle was reduced by 28.5%, the droplet diameter was reduced by 19%, and metal transfer frequency reached 7.52 Hz. At the same time, the optimized pulse waveform significantly improved weld formation with less spatter and uniform appearance. Note that the complicated underwater environment may disrupt the process unexpectedly and occasionally, such as a sudden bubble collapse due to droplets entering the molten pool. The robustness of this study could be enhanced in the future.

Acknowledgments

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Filler Metal 16-8-2 for Structural Welds on 304H and 347H Stainless Steels for High-Temperature Service

Studying the stability of the weld metal microstructure during elevated temperature exposure, impact toughness of the welds, and susceptibility to stress-relief cracking

BY C. FINK, H. WANG, B. T. ALEXANDROV, AND J. PENSO

ABSTRACT

The use of Type 16-8-2 filler metal was examined for application in structural welds on 304H and 347H stainless steels for high-temperature service applications and compared to welds with matching filler metals 308H and 347, respectively. Microstructural stability during elevated temperature exposure, weld metal impact properties, and susceptibility to stress-relief cracking were examined. It was found that the lean composition and low ferrite (~ 2 Ferrite Number [FN]) in 16-8-2 weld metal provide high resistance to intermetallic phase formation. No hot cracking was observed despite the low ferrite level. The 16-8-2 weld metals displayed superior toughness as compared to the matching filler metal welds, especially after longer elevated-temperature exposure. Experimental evidence for some martensite transformation in aged 16-8-2 weld metal upon cooling to ambient temperature was presented and explained an increase in magnetic response (as FN) after postweld heat treatment at 1300°F (705°C). None of the tested weld metals failed by stress-relief cracking mechanisms under the applied test conditions. The 16-8-2 filler metal welds exhibited significantly lower levels of stress relief during high-temperature exposure and significantly higher tensile strength after high-temperature hold as compared to the matching filler metal welds.

KEYWORDS

- Stainless Steel • 16-8-2 Filler Metal
- Impact Properties • Microstructure Stability
- Stress Relief Cracking (SRC)

Introduction

Type 16-8-2 (16 wt-% Cr, 8 wt-% Ni, 2 wt-% Mo, nominally) filler metal is the leanest of the austenitic stainless steel weld metal specifications. This weld metal composition was originally developed in the mid-1950s for welding of austenitic pressure vessel and piping components for high-temperature service applications (Refs. 1, 2). Composition limits for the solid wire (American Welding Society [AWS] A5.9, *Specification for Bare Stainless Steel Welding Electrodes and Rods*) and the shielded metal arc (SMA) weld metal deposit (AWS A5.4, *Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding*) are given in Table 1.

Austenitic stainless steel weld metals are typically susceptible to embrittlement by the formation of intermetallic phases (Ref. 3). Sigma (σ) and chi (χ) phase precipitate during long-term elevated-temperature exposure. The presence of ferrite in the weld metal microstructure significantly accelerates intermetallic phase formation. The low total level of Cr + Mo and low ferrite (< 5 Ferrite [FN]) found in Type 16-8-2 weld metals restrict the formation of brittle intermetallic phases (Refs. 4–7). Ferrite levels above 3 FN are usually required in austenitic stainless steel weld metals to avoid weld solidification cracking (Ref. 3). Despite its low ferrite content, Type 16-8-2 weld metal has been shown to be very resistant to solidification cracking (Refs. 8–10).

Figure 1 plots the nominal chemical composition range from Table 1 on the WRC-1992 diagram modified with extended axes and the martensite boundary for 1% Mn (Ref. 11). A nitrogen content of 0.05 wt-% and a typical minimum carbon content of 0.04 wt-% were assumed and are close to the actual composition of the filler metals used in this study (Table 2). Several Type 16-8-2 weld metals were included in the original WRC weld metal database (Refs. 12, 13). However, the leanest compositions extend beyond the iso-ferrite lines of the diagram. It can be seen that primary ferrite (FA) solidification is predicted for Type 16-8-2 weld metals even at less than 2 FN, which explains the high resistance to solidification cracking at very low ferrite levels. The leanest corner of the 16-8-2 composition box touches the lower limit of the martensite boundary. Martensite is predicted for weld metal compositions below and to the left of this martensite boundary. Compositions within the shaded region of the martensite boundary are unpredictable (Ref. 11). As-deposited martensite has not been reported in Type 16-

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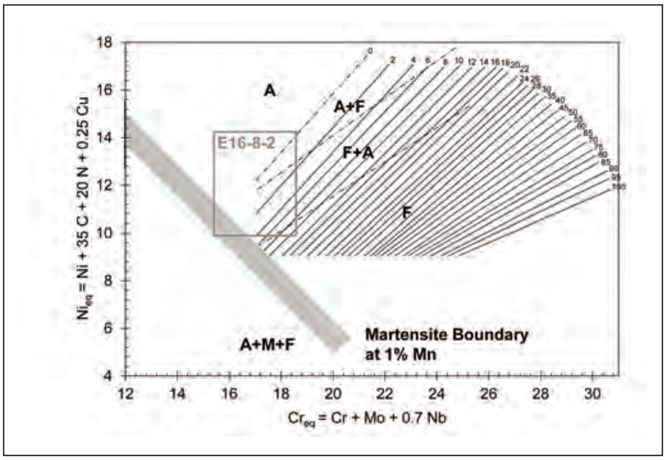

Fig. 1 — Modified WRC-1992 diagram indicating Type 16-8-2 composition range. Reproduced from Kotecki (Ref. 11).

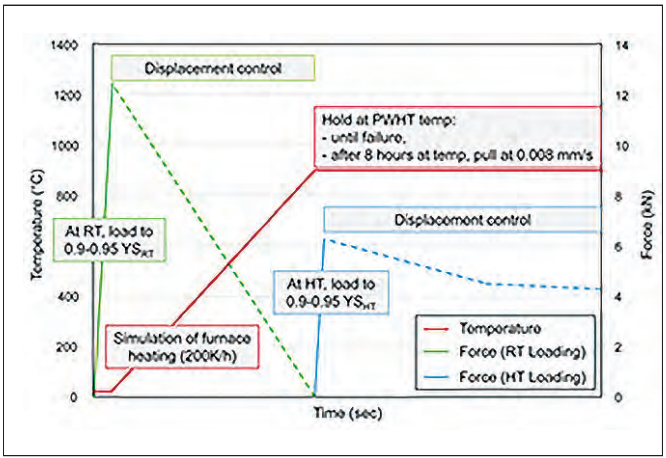

Fig. 2 — Temperature and force profile during the OSU SRC test.

8-2 weld metal and is considered unlikely because dilution effects would lower the Mn content, and the final weld metal composition would shift to the left and up, farther away from the martensite boundary. However, strain-induced martensite formation upon bending has been previously observed in Type 16-8-2 weld metals (Ref. 10).

The excellent microstructural stability and good weldability of Type 16-8-2 compositions make it a candidate filler metal for structural high-temperature applications in the oil and gas downstream industry. Catalytic cracking units used in the petroleum refining process experience long-term high-temperature exposure, typically in the range of 1200°–1400°F (650°–760°C), and require materials that balance creep resistance, oxidation resistance, and overall cost. Type 304H and 347H stainless steels are predominantly used for this application. Welds using matching filler metals 308H and 347, respectively, have been associated with loss of high-temperature ductility and creep property degradation due to intermetallic phase formation (Refs. 14, 15).

The purpose of this investigation was to explore the potential application of Type 16-8-2 filler metal for high-temperature structural welds in oil and gas downstream applications. A comparative evaluation of the microstructural stability during elevated-temperature exposure, impact toughness, and susceptibility to stress-relief cracking of 304H and 347 steel welds produced with Type 16-8-2 and with matching filler metals was conducted.

Experimental Procedures

Base and Filler Metals

The base metals used in the present work are commercial 304H and 347H stainless steel. Welds on each base material were made using Type 16-8-2 filler metal, and as a reference,

Table 1 — Weld Metal Specifications for Lean Austenitic Type 16-8-2 Stainless Steel (wt-%)

Specification	C	Cr	Ni	Mo	Mn	Cu	Si	P	S
ER16-8-2 AWS A5.9	< 0.10	14.5–16.5	7.5–9.5	1.0–2.0	1.0–2.0	< 0.75	0.30–0.65	< 0.03	< 0.03
E16-8-2-15 AWS A5.4	< 0.10	14.5–16.5	7.5–9.5	1.0–2.0	0.5–2.5	< 0.75	< 0.60	< 0.03	< 0.03

Table 2 — Chemical Composition (wt-%) of Base Metals and Filler Metals

	C	Cr	Ni	Mo	Mn	N	Cu	Nb + Ta	Si	P	S
Base Metals											
304H	0.050	18.45	8.17	0.32	1.46	0.060	0.46	0.034	0.55	0.034	0.001
347H	0.040	17.35	9.08	0.38	1.63	0.040	0.42	0.730	0.40	0.036	0.001
Filler Metals											
ER308H	0.044	19.65	9.61	0.09	2.12	0.038	0.16	—	0.55	0.024	0.016
E308H	0.060	18.70	10.00	0.03	0.60	—	0.15	—	0.70	0.032	0.021
ER347	0.050	19.40	9.40	0.01	1.81	0.016	0.11	0.570	0.33	0.019	0.004
E347	0.018	19.60	9.78	0.02	1.70	0.074	0.04	1.000	0.13	0.027	0.004
ER16-8-2	0.048	14.97	7.79	1.25	1.36	0.058	0.14	—	0.38	0.026	0.011
E16-8-2-15	0.050	14.80	7.80	1.00	1.40	—	0.08	—	0.37	0.020	0.004

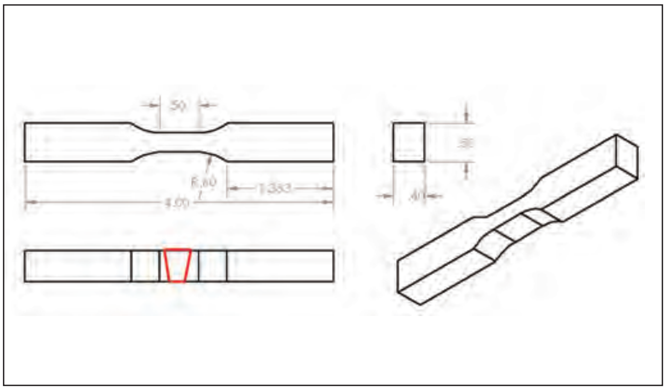

Fig. 3 — Stress-relief cracking test sample design with the weld location (red) in the gauge section.

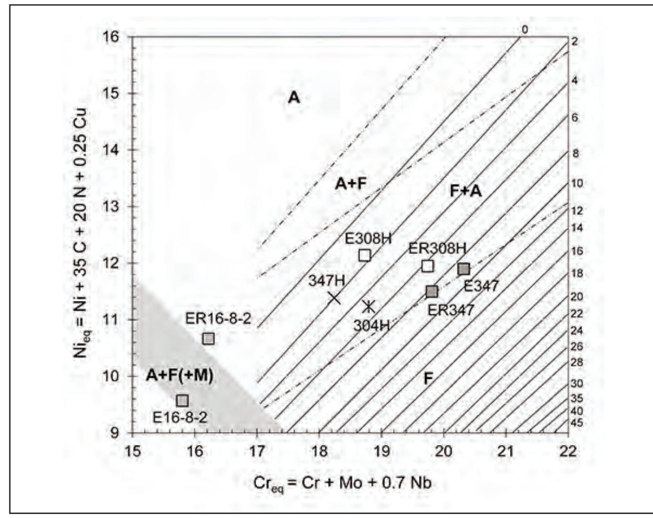

Fig. 4 — Modified WRC-1992 diagram with location of 304H and 347H base metals, matching Type 308H and 347 filler metals, and lean composition Type 16-8-2 filler metals. Shaded region indicates martensite boundary at 1% Mn. Reproduced from Kotecki (Ref. 11).

using matching filler metal 308H or 347, respectively. The chemical composition of the base and filler metals is presented in Table 2. Notice the lean composition of the Type 16-8-2 filler metal as compared to the 308H and 347 filler metals.

Welding Conditions

Two welded joints were fabricated for each base material to compare the effect of using Type 16-8-2 filler metal over the corresponding matching filler metal. Multipass welding was conducted in accordance with the ASME *Boiler and Pressure Vessel Code*, Section IX, using 12.7-mm- (1/2-in.-) thick plates with a 75-deg Y-groove and a root face of 0.8–2.4 mm (1/32–3/32 in.). The first (root) passes (4–6 passes) of each weld were fabricated using gas tungsten arc welding (GTAW) followed by subsequent passes (3–4 passes) utilizing the shielded metal arc welding (SMAW) process to complete the weld. The filler metal rods and covered electrodes were 3.2 mm (1/8 in.) in diameter. The welding parameters are given in Table 3.

High-Temperature Exposure

Upon completion of welding, welded samples were extracted for characterization of weld metal and heat-affected zone (HAZ) microstructures, impact toughness and high-temperature tensile testing, and stress-relief cracking (SRC) testing. Part of the samples were subjected to shorter and longer time heat-treatment (HT) procedures; others remained in the as-welded condition. The heat-treatment temperatures of 1650°F (900°C) and 1300°F (705°C) complied with stabilization heat treatment and high-temperature service conditions for 347H and 304H structural welds, respectively. The holding time was 4 and 168 h with subsequent air cooling. Table 4 presents an overview of the applied heat-treatment (aging) procedures.

Metallurgical Characterization

The welds were sectioned in as-welded and heat-treated conditions and prepared for light optical microscopy, scanning electron microscopy, and energy dispersive spectroscopy using standard metallography procedures. For observation of the weld metal microstructure, electrolytic etching was performed with a 10% aqueous oxalic ($C_2H_2O_4$) solution at 5 V for 10–20 s. To reveal the presence of sigma phase in the weld metal, a solution of 45-g KOH and 60-mL water was used for electrolytic etching at 2.5 V for 6-s. This etchant turns sigma and chi phase into a yellow color, ferrite appears gray to blue-gray, carbides are barely etched, and austenite is not etched. Selected welds were dipped in a solution of 6-g $CuCl_2$, 60-mL HCl, and 66 mL of distilled water (Kane's etch, diluted with an equal volume of water). The samples were immersed for 10 s. Kane's etch darkens martensite, outlines ferrite, and leaves austenite unetched (Ref. 11).

Ferrite Number Measurement

All welds were analyzed for their ferrite content in as-welded and heat-treated conditions. Magnetic measurements of FN were performed using a Magne-Gage (tear-off force) calibrated according to AWS A4.2M:2006, *Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal*. The Fischer FeritScope™, which measures

Table 3 — Parameters for the GTAW and SMAW Process

Welding Process	Arc Current	Arc Voltage	Welding Speed	Calculated Heat Input
GTAW	95–155 A	11–12.5 V	0.72–1.35 mm/s	1.3–2.2 kJ/mm
SMAW	110–125 A	22.5–24 V	0.8–1.4 mm/s	1.7–3.4 kJ/mm

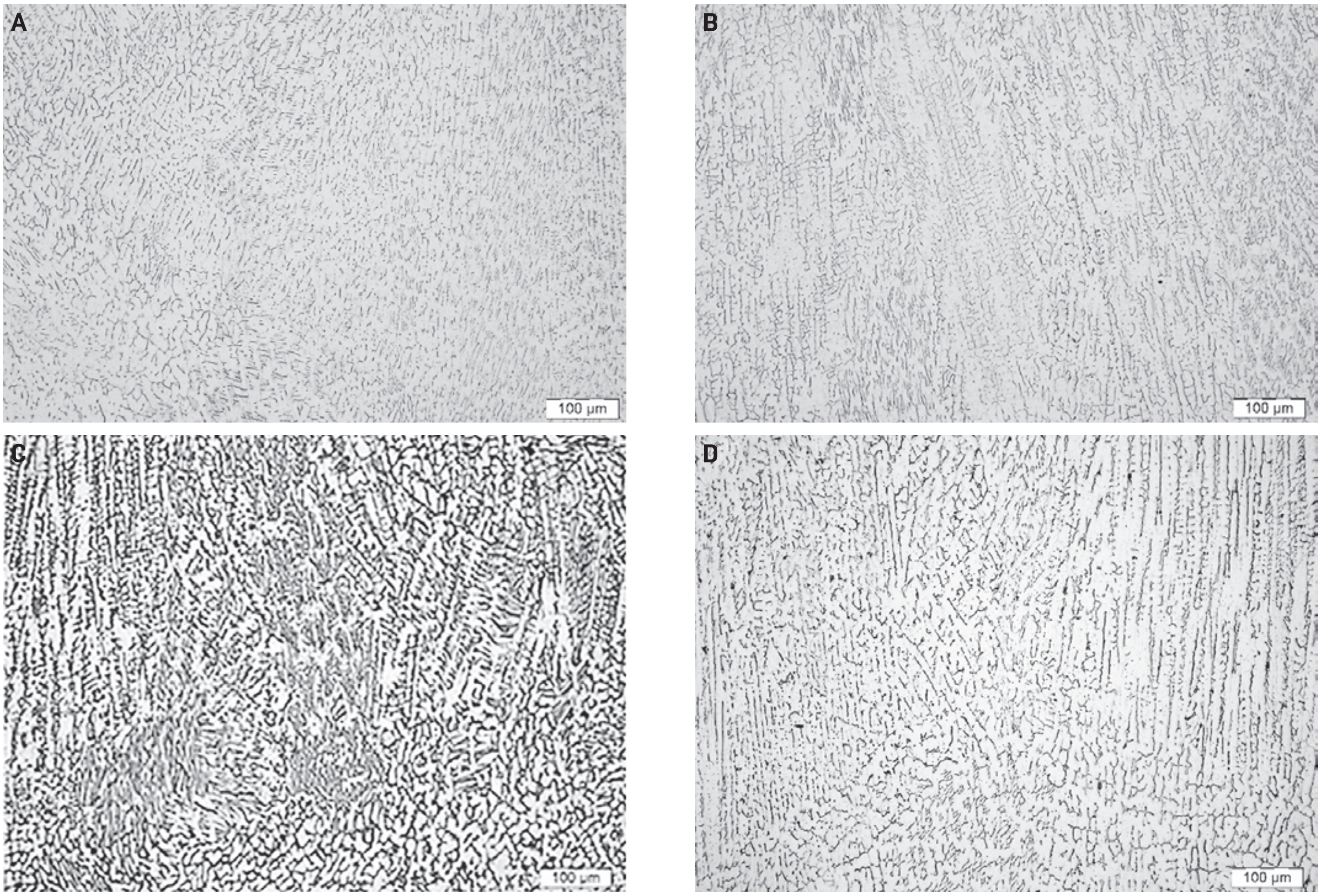

Fig. 5 — As-welded microstructures of gas tungsten arc weld metal: A — 347H/16-8-2; B — 304H/16-8-2; C — 347H/347; D — 304H/308H (base metal/filler metal).

the ferrite content based on magnetic permeability, was also utilized. Measurements were taken on cross sections in the weld metal spaced from weld root to weld cap to obtain a total of five measurements per weld. Note: This is a departure from AWS A4.2M:2006, which specifies measurement on the smoothed top weld surface of a weld.

Table 4 — Heat-Treatment (HT) Procedures

Base Metal	Filler Metal	HT 1 (4 h)	HT 2 (168 h)
347H	347	1650°F (900°C)	1650°F (900°C)
347H	16-8-2	1650°F (900°C)	1650°F (900°C)
304H	308H	1300°F (705°C)	1300°F (705°C)
304H	16-8-2	1300°F (705°C)	1300°F (705°C)

Impact Toughness Testing

For evaluation of weld metal toughness, a total number of 36 samples in the as-welded condition were machined transverse to the weld direction with dimensions of 11 × 11 × 56 mm. Part of the samples were subjected to heat-treatment procedures, as previously described (Table 4). All samples were then milled into Charpy V-notch size test bars (10 × 10 × 55 mm) with a 2-mm notch (45-deg angle) in accordance with ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*. The notch was

Table 5 — High-Temperature Tensile Test Results

Base Metal	Filler Metal	Test Temperature	Yield Strength (MPa)	Tensile Strength (MPa)
347H	347	1650°F (900°C)	110	140
347H	16-8-2	1650°F (900°C)	115	132
347H*	—	RT	205	515
304H	308H	1300°F (705°C)	153	255
304H	16-8-2	1300°F (705°C)	170	268
304H*	—	RT	205	515

*Specified minimum room temperature (RT) properties for the base metals taken from ASTM A240/A240M-19 are shown as reference.

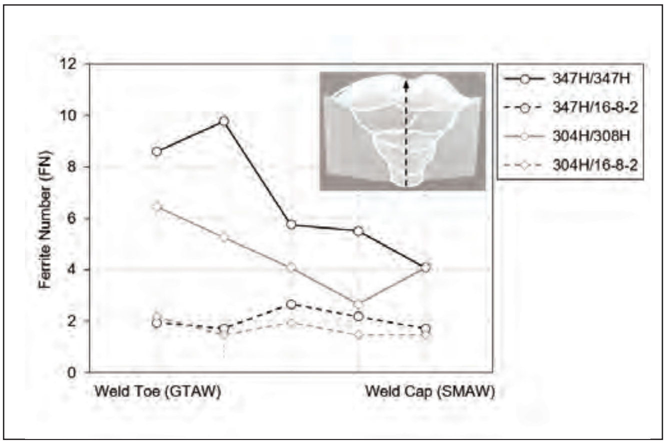

Fig. 6 — Plots of FN as measured (Magne-Gage) in the weld toe (GTAW) and weld cap (SMAW).

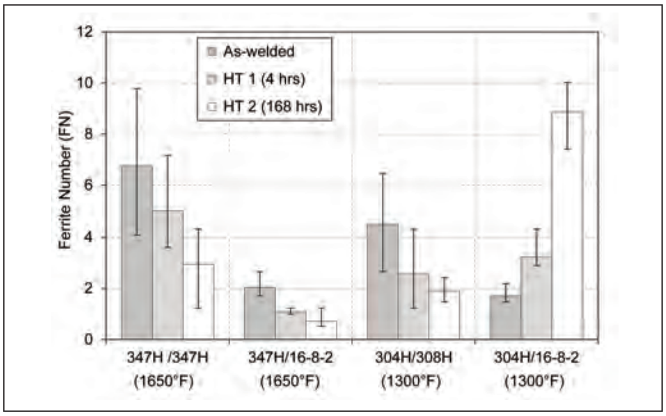

Fig. 7 — Effect of exposure at high temperature on FN (Magne-Gage) in stainless steel weld metals. Error bars represent minimum and maximum values obtained.

placed at the weld centerline parallel to the surface. Testing was performed at a temperature of 0°F (–18°C). For all welds, a total number of three samples were tested in the as-welded condition and three samples for each heat-treatment condition (4 and 168 h).

High-Temperature Tensile Test

Limited high-temperature tensile tests were performed, testing one sample transverse to the welding direction for each weld. Samples were heated to the heat-treatment temperature (1650° and 1300°F, respectively) at 200 K/h and pulled to failure at a stroke rate of approximately 0.008 mm/s. The results are shown in Table 5. The high-temperature yield strength and tensile strength were used as input parameters for the SRC tests.

Stress-Relief Cracking Test

Evaluation for SRC susceptibility at heat-treatment temperatures (1650° and 1300°F) was performed utilizing a Gleeble®-based SRC test developed at The Ohio State University (OSU) (Refs. 16, 17). This test was designed to replicate postweld heat treatment (PWHT) in highly restrained welds with high levels of residual welding stress. An example of the SRC testing procedure, as performed in this work, is shown in Fig. 2.

Test samples were extracted transverse to the welding direction with the weld located in the center of the gauge section, as shown in Fig. 3. A minimum of two samples were tested for each base metal/filler metal combination.

The high-temperature mechanical properties used for development of the SRC testing procedure are listed in Table 5. To simulate high-level welding residual stresses, samples were initially loaded with 90–95% of the 304H and 347H steel and specified minimum room temperature yield strength (YS_{RT}) (Table 5). After loading, the displacement was fixed to simulate high weld restraint. The samples were then heated to the heat-treatment temperature with a heating rate of 200 K/h. The heat-treatment temperature was 1300°F (705°C) and 1650°F (900°C) for the 304H and 347H weld samples, respectively. Due to the high thermal expansion coefficient of the tested materials, full stress relaxation occurred on heating to the heat-treatment temperature for all tested samples, as schematically shown in Fig. 2. Once the heat-treatment temperature was reached, the 347H and 304H stainless steel weld samples were reloaded with 90–95% of the high-temperature yield strength (YS_{HT}) (Table 5). After reloading, the samples were held at fixed displacement for 8 h. The level of stress relaxation and strain evolution were monitored during this stage of the SRC test. If no failure occurred during the 8-h, high-temperature hold, the samples were pulled to failure at a stroke rate of 0.008 mm/s and the ultimate tensile strength (UTS_{SRC}) and elongation ($\varepsilon_{@failure}$) were determined. The strain over the uniformly heated gauge section was monitored using a strain gauge and recorded throughout the entire test duration.

Results and Discussion

Microstructural Characterization in the As-Welded Condition

The modified WRC-1992 diagram (Ref. 11) shown in Fig.

Table 6 — Solidification Mode and Ferrite Number (FN) as Predicted by the Modified WRC-1992 Diagram and Results of FN Measurements (average values reported)

Base metal	Filler Metal	Solidification Mode	Modified WRC-1992	Fischer FeritScope®	Magne-Gage
347H	347	FA	8	5.4	6.7
347H	16-8-2	FA	1.5	2.2	2.0
304H	308H	FA	4	2.4	4.5
304H	16-8-2	FA	2	2.2	1.7

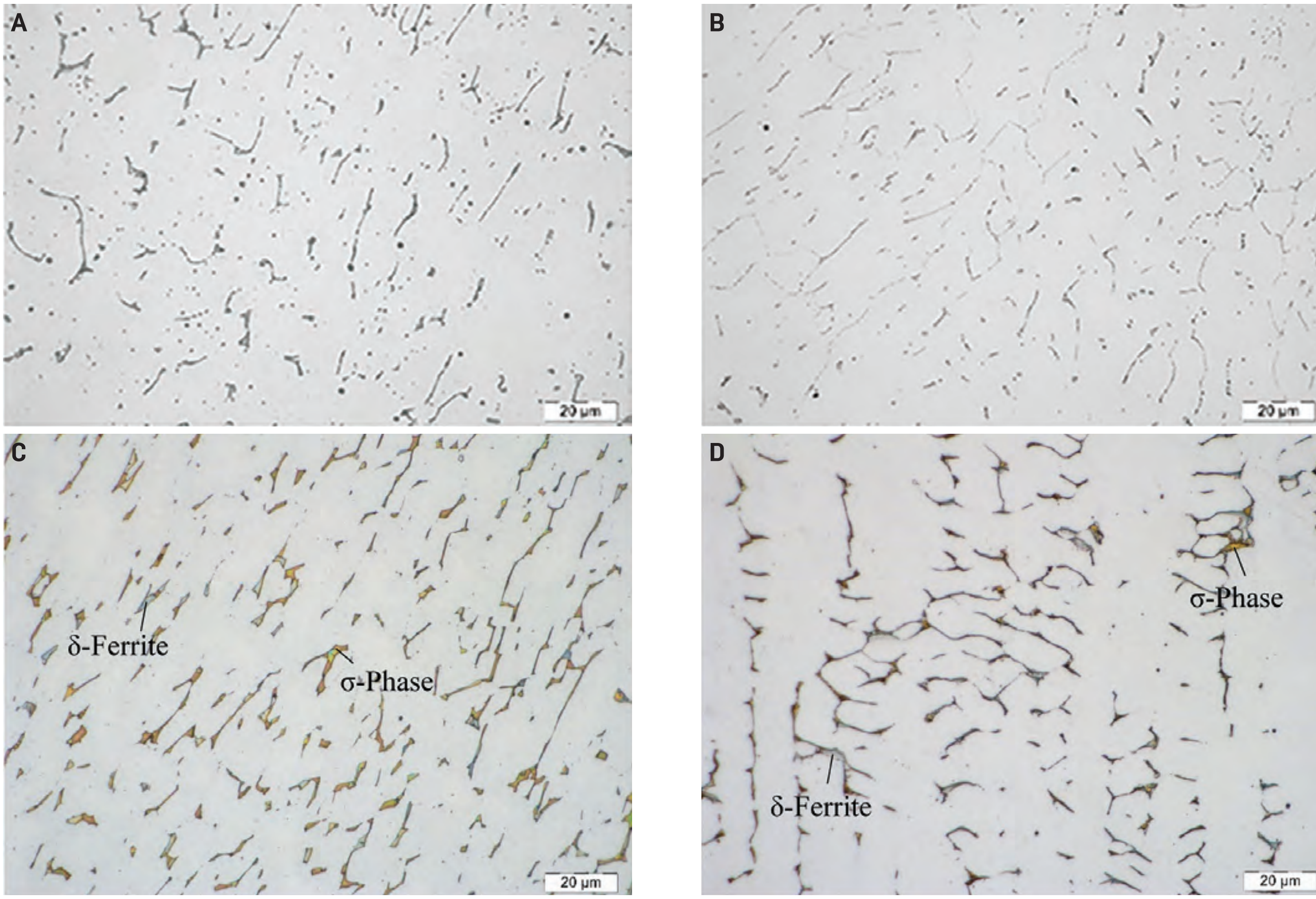

Fig. 8 — Aged (168 h) weld metal microstructures: A — 347H/16-8-2; B — 304H/16-8-2; C — 347H/347; and D — 304H/308H (base metal/filler metal). Note sigma (yellow) in matching filler metal welds (C, D).

4 was used to predict the weld metal microstructures and ferrite levels in the as-welded condition. Note that both Type 16-8-2 filler metals extend beyond the iso-ferrite lines of the diagram. However, the prediction of microstructures using the WRC-1992 diagram has been reported to remain reasonably accurate as long as the actual weld metal compositions, considering dilution effects, fall within the original iso-ferrite bounds (Ref. 3). The dilution of the welds was assumed to be approximately 30%. It was noted that the final weld passes were performed with the SMAW process. The predicted solidification mode and FN for each weld are presented in Table 6. All weld metal compositions are predicted to fall within the austenite + ferrite region with primary ferrite solidification (FA), thus greatly reducing the susceptibility to weld solidification cracking (Ref. 3). However, the 16-8-2 filler metals, especially the lean composition of the SMAW electrode (E16-8-2), clearly extend the predictions beyond the limits of the iso-ferrite lines in the WRC-1992 diagram. This leanest composition touches the lower end of the martensite boundary at 1% Mn (shaded region in Fig. 4). However, given the associated base metals in this study, the formation of martensite in the welds is unlikely. The dilution with the base metal will shift the final weld metal composition up and to the right, farther away from the martensite boundary. More than 70% dilution would be required before the as-welded martensite would be present in the actual Type 16-8-2 weld metal microstructure.

Table 6 shows results for predicted and measured FN. The two measurement techniques used align reasonably well and were in good correlation to the prediction of the modified WRC-1992 diagram. The 347H weld with matching filler metal was found to have the highest ferrite level of all welds, although slightly lower than what was predicted. The use of Type 16-8-2 filler metals resulted for both base materials in much lower ferrite in the final weld metal microstructure as compared to their respective matching filler metal welds.

The as-welded microstructures were examined light optically and compared in terms of ferrite content and morphology. In general, the micrographs in Fig. 5 are in good qualitative agreement with the measured ferrite levels in the four weld metals. Both Type 16-8-2 welds contain less ferrite than their respective matching filler metal welds, and the 347H weld with matching filler metal has the highest weld metal ferrite content. In general, the ferrite morphologies for all welds were found to be similar. The examples of the GTAW portion of the weld microstructures in Fig. 5 show a skeletal ferrite morphology that is indicative of the FA solidification mode (Ref. 3). In the higher ferrite matching filler metal welds, the ferrite is more interconnected than for the low-ferrite Type 16-8-2 welds. Evidence of a partial lathy ferrite morphology was found only in the higher ferrite

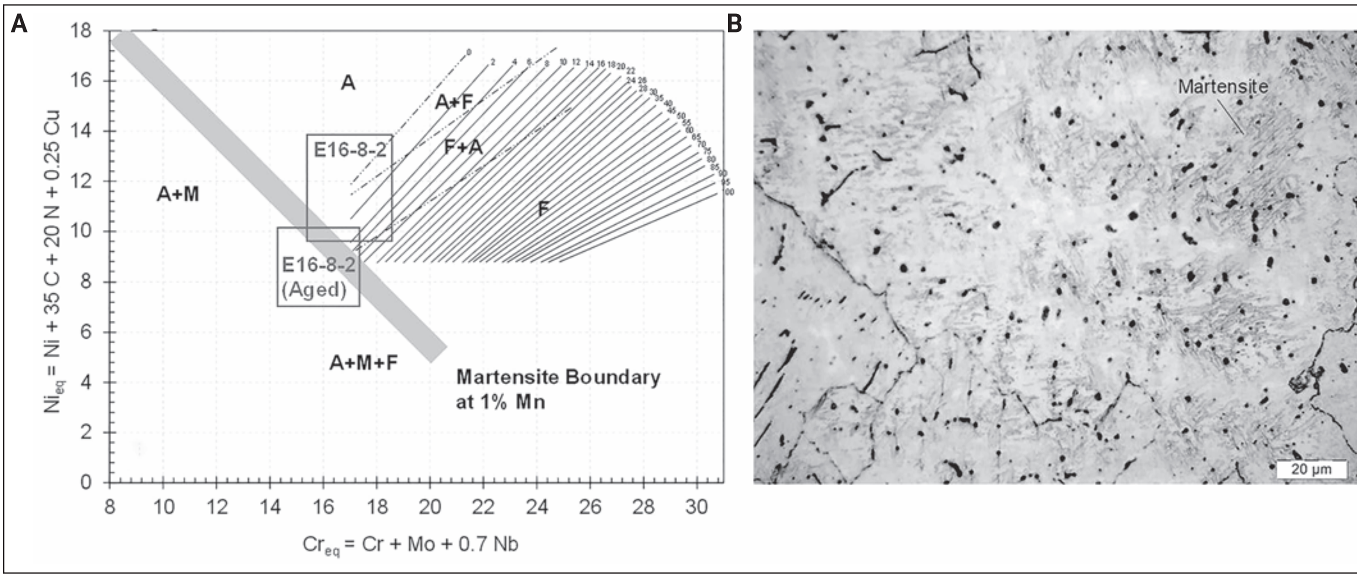

Fig. 9 — A — Modified WRC-1992 diagram indicating shifted composition range of aged 16-8-2 weld metal (carbon and chromium were removed from the matrix as $M_{23}C_6$ carbides), reproduced from Marshall and Farrar (Ref. 21); B — light optical micrograph showing martensite (dark regions) in aged Type 16-8-2 weld (304H base metal) after aging at 1300°F (705°C) for 168 h (Kane's etch).

347H weld with matching filler metal — Fig. 5C. The SMAW portion of all welds exhibits the same FA solidification mode with a skeletal ferrite morphology but contains more porosity. No evidence of solidification or liquation cracking in the base metal HAZ or in the reheated weld metal was found in any of the welds.

The weld metal ferrite level is shown in Fig. 6 for all welds as FN measured from weld root to weld cap using the Magne-Gage. Again, it can be seen that the Type 16-8-2 welds contain much less ferrite than their respective matching filler metal welds. A difference in FN between the GTA weld root and the SMA weld cap was apparent for the welds with matching filler metal. The higher ferrite level in the weld root is somewhat unexpected, at least for the 347H weld, since both Type 347 covered electrode and wire have very similar Cr_{eq}/Ni_{eq} — Fig. 4. A higher base metal dilution in the root pass, and dissolution of ferrite resulting from thermal cycles during subsequent weld passes, would be expected to result in slightly lower ferrite in the GTA weld root. The lower heat input and associated higher cooling rates as compared to the SMAW process used for the fill and cap passes might be an explanation for the instead higher ferrite level.

Microstructural Stability During High-Temperature Exposure

The microstructural stability of the stainless steel weld metals was studied by monitoring the ferrite level remaining after high-temperature exposure for 4 and 168 h. The results of FN measurements using the Magne-Gage are presented in Fig. 7. Upon high-temperature exposure, the FN in the 347H and 304H welds with matching filler metals decreased with increasing holding time at 1650° and 1300°F (900° and 705°C), respectively. In both welds, the ferrite level decreased within 168 h to less than 50%.

The decrease in ferrite level is a result of two mechanisms: 1) The ferrite phase partially dissolves upon high-temperature exposure. Vitek and David (Ref. 18) reported that for aging of Type 308 weld metals in the range of 1200° to 1580°F (650° to 850°C), the initial $M_{23}C_6$ carbide formation along the austenite/ferrite interface is followed by the dissolution of the ferrite phase. The ferrite dissolution occurs relatively quickly. In their welds, the ferrite level decreased by nearly 40% within the first hour of aging. 2) With additional holding time, any further depletion in weld metal ferrite occurs by the transformation of ferrite into sigma phase. Nucleation is the rate-limiting step of the ferrite-to-sigma transformation. Once nucleation occurs, growth of sigma in the ferrite phase proceeds quite rapidly (Ref. 18). For Type 308 weld metals, sigma phase formed within less than 100 h in the temperature range of 1200° to 1580°F (650° to 850°C) (Refs. 18, 19).

In the present study, examination of etched weld metal microstructures after 168 h of high-temperature exposure revealed the occurrence of sigma phase in both matching filler metal welds. Figure 8C and D shows that a large number of ferrite grains (gray) transformed partially to sigma phase (yellow). Sigma phase formation seemed more pronounced in the Type 347 weld metal after 168 h — Fig. 8C. The faster ferrite-to-sigma transformation might be due, in part, to the absence of $M_{23}C_6$ carbides (Ref. 18). Niobium and titanium in 347 are more potent carbide formers than chromium and minimize $M_{23}C_6$ formation. In Type 308H weld metal, chromium-rich $M_{23}C_6$ carbides compete with the sigma for the chromium available in the ferrite phase so that less ferrite transforms to sigma phase (Ref. 18). $M_{23}C_6$ carbides cannot be observed by light optical microscopy — Fig. 8D. Electron microscopy is necessary to identify these precipitates at the austenite/ferrite interface. Vitek and David (Ref. 18) have shown for Type 308 weld metal that $M_{23}C_6$ carbides form an extensive network throughout the austenite matrix after aging at 1200° to 1580°F (650° to 850°C) within less than 1 h.

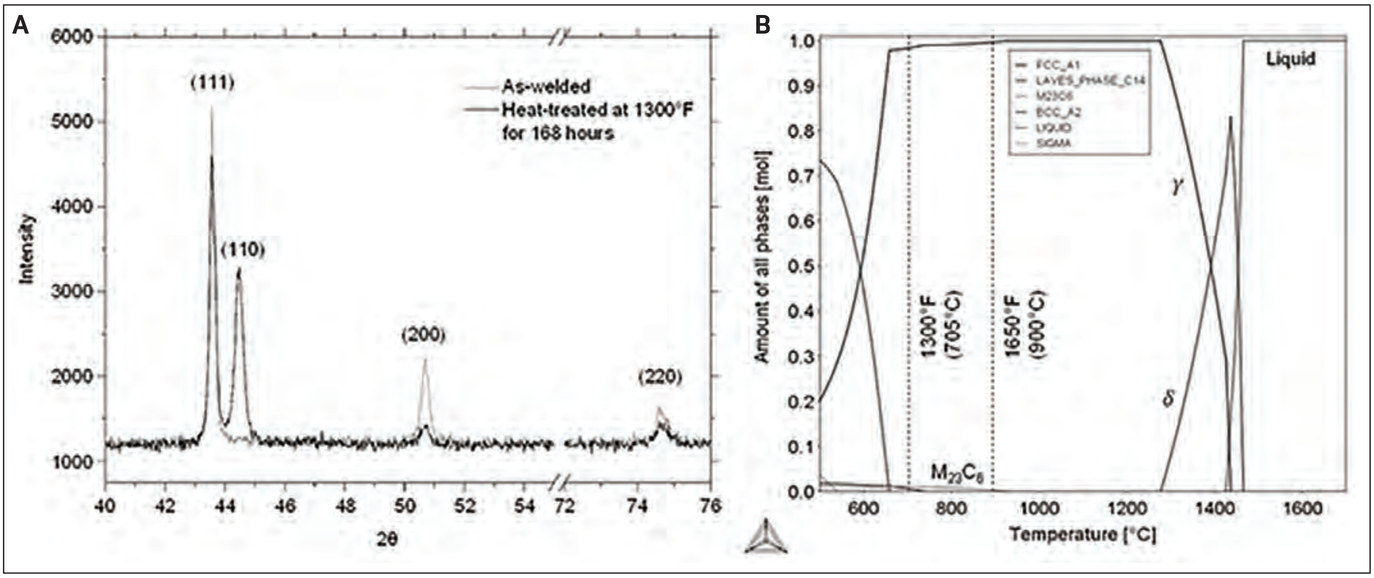

Fig. 10 — A — X-ray diffraction data of Type 16-8-2 weld metal in as-welded and aged conditions; B — equilibrium property diagram from Thermo-Calc® for Type 16-8-2 composition.

For the Type 16-8-2 weld metals, Fig. 7 shows that the weld on Type 347H base metal exhibits a decrease in measured FN with increasing holding time similar to the behavior observed for the matching filler metal welds. The ferrite level decreases to less than 1 FN after aging for 168 h at 1650°F (900°C). The micrographs confirm the partial dissolution of the ferrite phase (Fig. 8A) as compared to the as-welded condition. No evidence of sigma phase formation was found in the etched weld metal microstructure.

The opposite observation in terms of apparent ferrite level was made for the aged 16-8-2 filler metal weld on 304H base metal. Figure 7 shows an unexpected increase in the measured FN with increasing holding time at 1300°F (705°C). The measured magnetic response after aging for 168 h is more than four times higher as compared to the as-welded condition. This apparent increase in ferrite content, however, is not reflected in micrographs of the aged weld metal microstructure. Figure 8B shows a very low amount of ferrite phase throughout the matrix. Small, chain-shaped $M_{23}C_6$ carbides formed along the austenite/ferrite interface showing the prior ferrite grain structure. Leitnaker (Ref. 6) showed that aging of Type 16-8-2 weld metal at 1200° and 1350°F (649° and 732°C) results in Type $M_{23}C_6$ carbide precipitation. No evidence of sigma phase formation was found in the etched weld metal microstructure, with the exception of small amounts of sigma phase in regions highly diluted with the 304H base metal on both sides of the GTAW root pass.

An increase in measured FN in Type 16-8-2 weld metal after high-temperature exposure at 1382°F (750°C) has previously been reported in a study by Marshall and Farrar (Ref. 20). This unexpected behavior was explained with the formation of martensite in the weld metal upon cooling to ambient temperature. During high-temperature exposure, the precipitation of carbides consumes chromium and carbon from the matrix, thus destabilizing a portion of the austenite phase. This compositional change raises the martensite start (M_s) temperature of the austenite, leading to some transformation to martensite during cooling (Ref. 21). The high measured FN in the aged weld metal was observed because both martensite and ferrite are ferromagnetic and trigger a magnetic response. Marshall and Farrar (Ref. 20) did not show further experimental evidence of martensite formation after high-temperature exposure in Type 16-8-2 weld metal. They noted, however, that this behavior is actually predicted by the WRC-1992 diagram. The removal of chromium and carbon from the austenite phase shifts the composition box of the aged Type 16-8-2 weld metal to the left and down toward the martensitic zone — Fig. 9A.

In the present study, a special etchant (Kane's etch) was used to reveal the presence of martensite in the 16-8-2 filler metal weld on 304H base metal. Figure 9B shows patches of dark-etching martensite in an austenite matrix, along with numerous precipitates and little residual ferrite. X-ray diffraction data of this weld in the as-welded condition shows face-centered cubic peaks (111, 200, 220) for the austenitic weld metal — Fig. 10A. The as-welded amount of ferrite was too low (< 2 FN) to be observed in x-ray diffraction. After high-temperature exposure for 168 h, a significant body-centered cubic/body-centered tetragonal peak (110) correlates to the martensite in the weld metal microstructure, which triggered the high-measured FN (9 FN) in this weld metal.

The 16-8-2 filler metal weld on 347H base metal did not experience an increase in measured ferrite upon high-temperature exposure, thus not indicating any weld metal martensite after aging. The reason for this is the higher aging temperature of 1650°F (900°C) used for this weld. The phase equilibrium in Fig. 10B was calculated using Thermo-Calc®. The diagram shows that an aging temperature of 1650°F (900°C) is above the temperature range for $M_{23}C_6$ carbide precipitation in the Type 16-8-2 composition. Hence, carbon and chromium are not removed from the matrix during high-temperature exposure, and the austenite phase remains stable and does not experience a martensite transformation during cooling to ambient temperature.

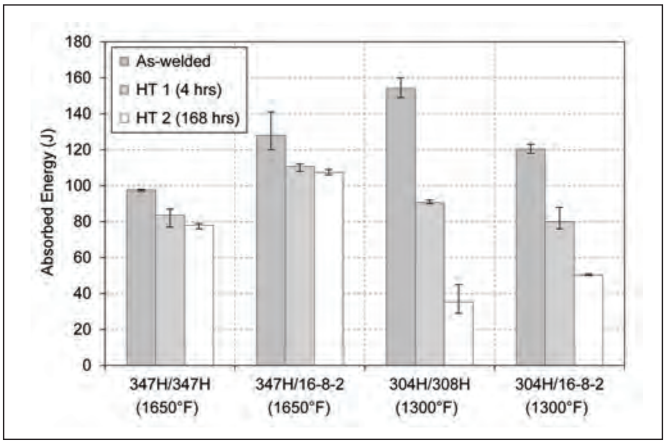

Fig. 11 — Effect of exposure at high temperature on Charpy-impact energy of stainless steel weld metals. Error bars represent minimum and maximum values obtained.

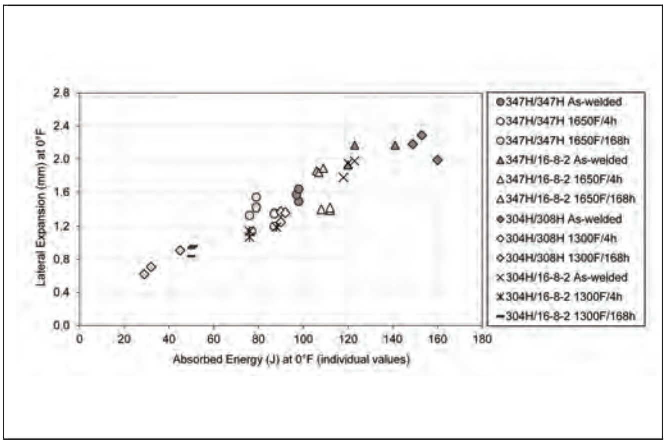

Fig. 12 — Relationship between Charpy-impact energy and lateral expansion for stainless steel weld metals in as-welded and aged conditions at 0°F (–18°C).

It should be noted that no published reports could be found on martensite in Type 16-8-2 weld metals after high-temperature service or postweld heat treatment for commercial welds. As Marshall and Farrar (Ref. 20) pointed out, this effect in 16-8-2 weld metal is likely to not impose a problem for high-temperature service applications, which are typically above 1004°F (540°C). The formed weld metal martensite will have a low A1 temperature so that it will easily reverse to austenite upon high-temperature service conditions or postweld heat treatment.

Effect of High-Temperature Exposure on Impact Toughness

The Charpy-impact properties of the stainless steel weld metals in the as-welded condition and after high-temperature exposure for 4 and 168 h are shown in Figs. 11 and 12. Both Type 16-8-2 filler metal welds showed high toughness and ductility in the as-welded condition. All welds experienced a reduction in toughne ss after high-temperature exposure. Impact toughness decreased in all welds with increasing holding time at 1650° and 1300°F (900° and 705°C), respectively. In both matching filler metal welds, sigma phase formation led to a drop in impact properties. This is more pronounced in the 308H filler metal weld, which might be due to the $M_{23}C_6$ carbides in this weld metal, providing an easy path for crack propagation when forming a continuous network along the austenite/ferrite interface. For the welds on 347H base metal, the use of Type 16-8-2 filler metal significantly increased toughness as compared to the matching filler metal weld in the as-welded condition and after high-temperature exposure. For the welds on 304H base metal, the matching filler metal weld obtained better toughness than the Type 16-8-2 filler metal weld in the as-welded condition. However, with increasing holding time at 1300°F (900°C), the properties of the 16-8-2 weld dropped significantly less than the impact toughness of the matching filler metal weld, so that the use of 16-8-2 filler metal provides superior toughness when welding 304H stainless steel, especially at longer high-temperature exposure. The drop in impact properties of the 16-8-2 filler metal weld was due to the martensite formation upon cooling to ambient temperature coupled with carbide precipitation, as described earlier.

Stress-Relief Cracking Susceptibility at Elevated Temperatures

None of the tested Type 16-8-2 and matching filler metal welds on 347H and 304H base metal failed in stress-relief cracking mode under the applied SRC test conditions. However, the tested welds exhibited notable differences in terms of stress relaxation behavior and mechanical properties. Examples of stress and strain curves from SRC testing are shown in Fig. 13. Tables 7 and 8 summarize the test results in terms of room and test temperature preload (σ_{RT}, σ_{HT}, and

Table 7 — SRC Test Results on 347H Base Metal Welds with Matching and 16-8-2 Filler Metals

# Sample	Base Metal	Filler Metal	σ_{RT} (MPa)	σ_{HT} (MPa)	ε_{HT}	σ_{PW} (MPa)	ε_{PW}	UTS_{SRC} (MPa)	$\varepsilon_{@failure}$
1	347H	347	205	149	0.030	12.1	0.130	22.0	0.196
2*	347H	347	186	145	0.019	27.9	0.086	49.4	0.539
3	347H	347	193	133	0.020	7.1	0.129	8.2	0.135
1	347H	16-8-2	171	124	0.022	30.3	0.052	53.9	0.261
2*	347H	16-8-2	193	128	0.022	46.2	0.045	84.4	0.251
3	347H	16-8-2	194	126	0.022	33.3	0.038	54.1	0.044

*Run at lower peak RT load (11 kN) and HT load (5.8 kN) to attempt to compensate for load overshooting

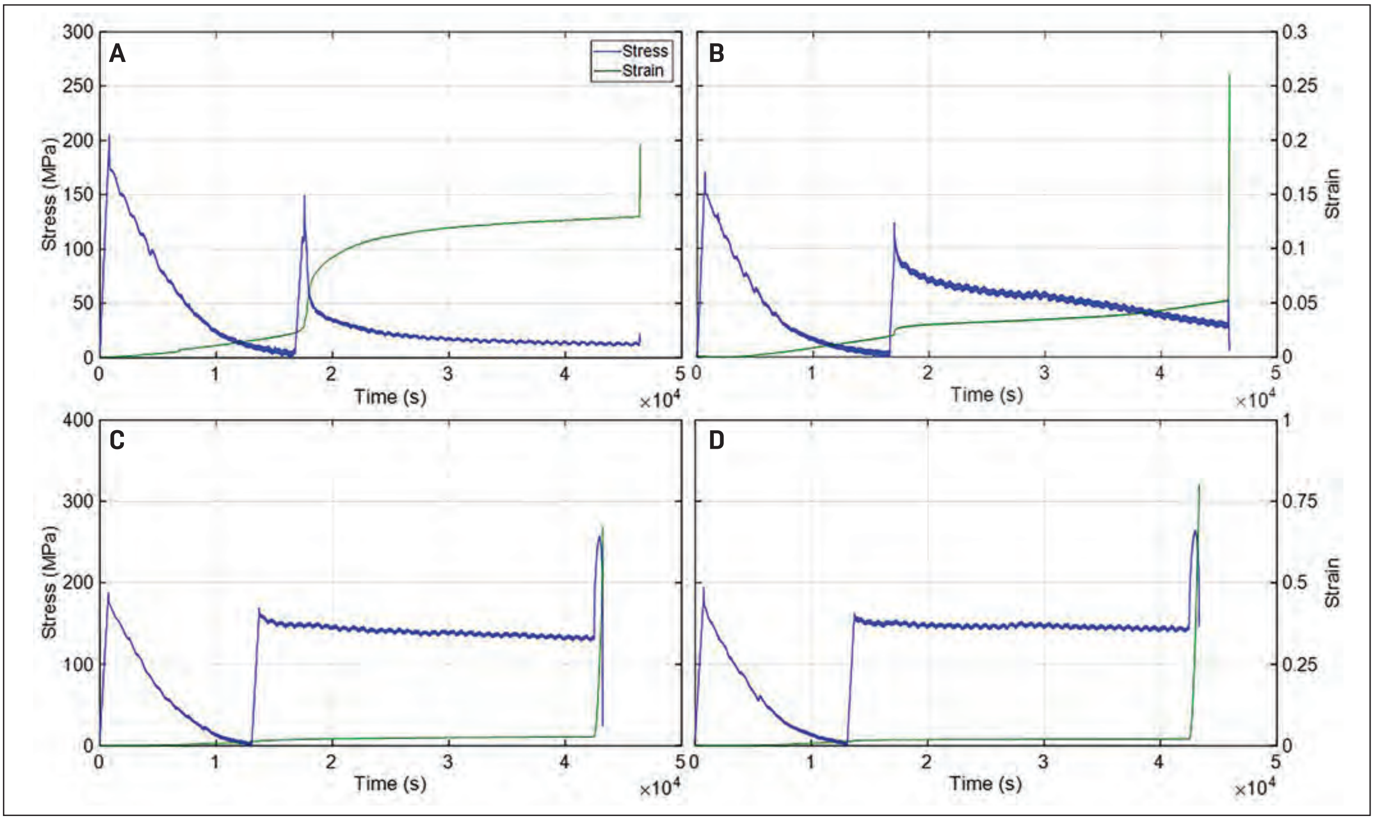

Fig. 13 — Examples of stress and strain curves from SRC testing of stainless steel welds: A — 347H/347; B — 347H/16-8-2; C — 304H/308H; D — 304H/16-8-2 (base metal/filler metal).

ε_{HT}), stress relaxation and strain accumulation at the end of the 8-h high-temperature hold (σ_{PW} and ε_{PW}), and high-temperature ultimate tensile strength (UTS) and elongation when pulled to failure after the 8-h hold (UTS_{SRC} and $\varepsilon_{@failure}$).

Preloading at the test temperature of 1650°F (900°C) resulted in slightly higher stress and strain values (σ_{HT} and ε_{HT}) for the 347H steel weld with matching Type 347 filler metal as compared to the Type 16-8-2 weld (see Table 7). This preloading with stress close to the high-temperature UTS was followed by a significant stress relaxation during the 8-h high-temperature hold under fixed displacement (from σ_{HT} to σ_{PW}) for both filler metal welds. The Type 347 weld experienced a larger stress reduction as compared to the Type 16-8-2 weld, 127 vs. 89 MPa on average, respectively. When pulled to failure after the 8-h high-temperature hold, the Type 347 filler metal weld displayed a lower UTS_{SRC} as compared to the Type 16-8-2 weld. Both welds exhibited a significant reduction in tensile strength (UTS_{SRC}), as compared to the high-temperature UTS_{HT} that was obtained in the as-welded condition (see Table 5).

The 304H steel welds with both filler metals exhibited similar stress and strain values (σ_{HT} and ε_{HT}) when preloaded at the test temperature of 1300°F (705°C) (see Table 8). The matching Type 308H filler metal weld displayed a higher amount of stress relaxation during the 8-h high-temperature hold (from σ_{HT} to σ_{PW}) as compared to the Type 16-8-2 weld, 32 vs. 10 MPa on average, respectively. When pulled to failure after the 8-h high-temperature hold, both filler metal welds displayed a tensile strength (UTS_{SRC}) that was equal to the high-temperature strength (UTS_{HT}) obtained in the as-welded condition (see Table 5).

Conclusion

Type 16-8-2 filler metal was examined for application in structural welds on 304H and 347H stainless steels for high-temperature service applications and compared to welds with matching filler metals 308H and 347, respectively. The

Table 8 — SRC Test Results on 304H Base Metal Welds with Matching and 16-8-2 Filler Metals

#Sample	Base metal	Filler metal	σ_{RT} (MPa)	σ_{HT} (MPa)	ε_{HT}	σ_{PW} (MPa)	ε_{PW}	UTS_{SRC} (MPa)	$\varepsilon_{@failure}$
1	304H	308H	187	164	0.015	137	0.023	260	0.621
2	304H	308H	188	169	0.015	132	0.028	258	0.673
1	304H	16-8-2	189	172	0.016	169	0.019	298	0.817
2	304H	16-8-2	195	163	0.016	146	0.021	264	0.800

stability of the weld metal microstructure during elevated-temperature exposure, impact toughness of the welds, and susceptibility to stress-relief cracking were studied.

Based on these investigations, the following conclusions can be drawn:

1. Low ferrite levels (≈ 2 FN) were obtained in Type 16-8-2 filler metal welds on 347H and 304H stainless steels as compared to much higher ferrite (up to 9 FN) when using matching filler metals 347 and 308H. Skeletal (and partly lathy) ferrite morphology was observed in the stainless steel weld metals.

2. No evidence of weld solidification cracking or liquation cracking in the reheated weld metal was observed in the Type 16-8-2 filler metal welds.

3. All stainless steel weld metals experienced a reduction in toughness after high-temperature exposure. However, both Type 16-8-2 filler metal welds showed superior toughness as compared to the matching filler metals welds, especially after longer high-temperature exposure (168 h).

4. An unexpected increase in magnetic response (FN) for the aged Type 16-8-2 filler metal weld on 304H base metal was shown to be due to martensite formation upon cooling to ambient temperature after high-temperature exposure at 1300°F (705°C). $M_{23}C_6$ carbide precipitation raises the M_s temperature of the austenite phase by removing carbon and chromium from the matrix. The transformed martensite will have a low Ac_1 temperature and will likely reverse to austenite under high-temperature service conditions.

5. Sigma phase formation in aged Type 16-8-2 weld metals occurred only locally in highly diluted regions with the base metal (GTA root), while significant amount of sigma phase formed in the matching filler metal welds. High resistance to intermetallic phase formation of Type 16-8-2 weld metal is due to the low Cr + Mo level, controlled carbon, and low ferrite content.

6. None of the tested weld metals failed by stress-relief cracking during simulated PWHT at 1650°F or 1300°F for the 347H and 304H steel welds, respectively, tensile stress testing at 90% of the PWHT temperature yield strength or fixed displacement replicating high weld restraint. The Type 16-8-2 weld metals exhibited significantly lower levels of stress relief during PWHT and significantly higher UTS at the respective PWHT temperature compared to the 347 and 308H weld metals.

7. Filler metal 16-8-2 provides a viable alternative for high-temperature service welds on Type 347H and 304H stainless steels.

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When the world is counting on you, you can count on us.
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