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- 40-foot bed

At Greiner, we’ve always been about absolute precision and constant quality. Over the years, we’ve added equipment to handle jobs that few could match. We continue to “super-size” our capabilities while doing more on the fabrication end that reduces labor time on the installation end – resulting in a better product at a lower cost. How’s that for value-added?

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On the cover: On-tool extraction equipment is an efficient method for keeping fumes out of the welder’s breathing zone. (Photo courtesy of Nederman USA, Westland, Mich.)
Thermadyne Holdings to Be Acquired by Irving Place Capital

Thermadyne Holdings Corp., St. Louis, Mo., a global manufacturer and marketer of metal cutting and welding products and accessories, has entered into a definitive agreement to be acquired by affiliates of Irving Place Capital, a middle-market private equity firm, in a transaction valued at approximately $422 million, excluding fees and expenses.

Thermadyne’s shareholders will receive $15 per share in cash for each share of the company’s common stock, representing a premium of 18% over the average closing share price of $12.71 during the last 30 trading days ending October 4, 2010, and a 25% premium over its average closing share price of $12.05 during the last 90 trading days ending October 4, 2010.

Thermadyne’s board of directors unanimously approved the transaction and recommended the company’s shareholders adopt the agreement. Investment funds managed by Angelo, Gordon & Co., L.P., which collectively own approximately 33% of Thermadyne’s outstanding common stock, executed an agreement with an affiliate of Irving Place Capital to vote their shares in favor of the transaction.

The deal, subject to shareholder approval and other customary closing conditions, is targeted to close in December.

Technologies Sought to Reduce Environmental Emissions during Shipbreaking

The Naval Facilities Engineering Services Center (NFESC) and the Naval Surface Warfare Center, Carderock Division, are seeking new technologies to reduce air and water environmental emissions during shipbreaking and demolition efforts.

In particular, NFESC is interested in reducing and eliminating metal cutting emissions and occupational exposures in Navy shipyards and other locations. New technologies will be required to meet proposed regulations may impact Department of Defense operations in 50 states, District of Columbia, Guam, and Puerto Rico.

The NFESC is also interested in identifying technologies that focus on shipbreaking, streamlining the demilitarization process of stricken Navy vessels, and working to reduce the emissions associated with these cutting operations. The principal recipients of the new technologies are military equipment demolition managers, and the Navy and Marine Corps facilities. These tools must have a baseline set of data to indicate they are viable options for ship demolition applications.

The NFESC is not interested in technologies previously demonstrated at Navy shipyard facilities, but Army, U.S. Marine Corps, and Air Force sites are acceptable. In addition, the technologies must be ready for transfer to real operations. Enclosure tents and/or industrial ventilation systems are not desired unless innovative technology/methodologies are demonstrated that will meet the aforementioned requirements.

Providers have until Dec. 31 to submit their technology by responding to Sources Sought – N6258310R0466 at www.fbo.gov or https://www.ncoh.navy.mil/, clicking on the synopsis, and typing the solicitation number. Because this is a sources sought announcement, participants will not receive an evaluation letter.

Concurrent Technologies to Continue Operation of Navy Metalworking Center

The Office of Naval Research has awarded Concurrent Technologies Corp. (CTC), Johnstown, Pa., a competitively bid contract to continue operation of the Navy Metalworking Center. The Indefinite Delivery Indefinite Quantity contract has a two-year base period, with three option years, and a ceiling of $99 million. It will ensure the retention of more than 100 professional and technical jobs.

The Navy Metalworking Center’s recent successes include a track weld shaver used in the production of DDG 1000 and DDG 51 ships that is expected to save $2.77 million on three DDG 1000 hulls. In another initiative, the Center-identified welding and cutting process parameters are improving the connection of the DDG 1000 deckhouse to the ship’s deck, which will save 4700 labor hours and $282,000 per ship.

The CTC has operated the Navy Metalworking Center program since its inception in 1988. The original contract to operate the National Center for Excellence in Metalworking Technology was the company’s first contract.
For smarter welding and cutting solutions

Rethink arc equipment with the advanced multi-process welding system, plus the new portable Caddy™ Mig and Tig machines.

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Rethink traditional welding processes with the productivity and versatility of hybrid laser and friction stir welding.

Rethink mechanized cutting by discovering the innovative Vision™ T5 control.

Rethink safety with the introduction of our Weld Warrior™ line of personal protection equipment.

Rethink filler metals by checking out the most complete line of consumables, including the new Atom Arc® 7018 Acclaim stick electrode and premium AlcoTec® aluminum wire.

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For Info go to www.aws.org/ad-index
An AWS Foundation Update

As chair of the AWS Foundation, I’ll share some of the initiatives we have underway. Our major focuses are addressing the shortage of skilled welders and our Welder Workforce Development fund-raising efforts.

Market research conducted in 2010 by the Weld-Ed Center with funds from the National Science Foundation shows that despite the economic downturn, the anticipated skilled welder shortage will exceed 200,000 persons by 2019. This research has been released as part of the “State of the Welding Industry” report available on www.careersinwelding.com and www.weld-ed.org.

The AWS Foundation has a two-pronged approach to helping with the skilled welder shortage. First, we manage our traditional Scholarship Programs to assist students in gaining a welding education. For the 2010–2011 school terms, the Foundation has awarded more than 400 scholarships with a value of approximately $340,000. Our challenge is that the applications received from students seeking education dollars far outnumbered the funds the Foundation has available. Since the program’s inception in 1991, we have awarded nearly 3500 scholarships totaling more than $4.9 million.

The other effort, the AWS Welder Workforce Development Program, has generated a great deal of enthusiasm and excitement. Its focus is addressing the industry shortage for welders by helping with recruitment, training for specific industry needs, assisting with curriculum development where appropriate, and working with training institutions to accomplish the training. Our initiatives have created an enormous amount of interest and involved many industry partners. You can view the welding careers Web site at www.careersinwelding.com and request copies of the various publications used to recruit new students. The welding jobs Web site, www.jobsinwelding.com, launched this past June, allows job seekers to search more than 92% of the welding jobs posted on the Internet and provides employers access to thousands of qualified applicants.

Our major funding support to date has been welding equipment/filler metal manufacturers, distributors, and individuals. Although we have received some very appreciated donations from fabricators and construction companies who employ welders, we need more support from them. We need your involvement and connections to reach others so we may have the opportunity to speak to those who understand the impact of welding professionals on their business. Our efforts have one focus: to strengthen the welding profession and prepare for future technology needs.

During these tough economic times we must reach out and engage a broader base of supporters so we may continue our efforts. There is a significant need for qualified, skilled welders to build the massive wind towers, nuclear power plants, and alternative manufacturers, distributors, and individuals. Although we have received some very appreciated donations from fabricators and construction companies who employ welders, we need more support from them. We need your involvement and connections to reach others so we may have the opportunity to speak to those who understand the impact of welding professionals on their business. Our efforts have one focus: to strengthen the welding profession and prepare for future technology needs.

Support our efforts to provide educational opportunities to those considering welding as a professional choice, to improve the image of welding, and to recruit new people into our industry. A welding career can take many roads — from entry-level welder to engineer and beyond. We need everyone’s help if we are to recruit new welders into the work force and retain those already on board. The American Welding Society and Foundation are gratified by the current evolution and position of this campaign, and more importantly, the impact our efforts have made on the welding workforce and profession. However, there is a great deal more to be done.

One way you can help, especially some of you “long-timers” like myself, is by putting the AWS Foundation into your estate plan. However, there are many other ways as well. You can contact me at guttrachi@aol.com or Foundation Executive Director, Sam Gentry at sgentry@aws.org. We would like to talk to you firsthand about what the Foundation is doing. ♦

Gerald D. Utrachi
Chair, AWS Foundation
Miller’s exclusive WELD X apparel is the NEW SOLUTION in welder protection.

A lightweight base fabric is infused with a proprietary compound producing a material with EXTREME FLAME-RESISTANT properties and the ability to repel sparks, spatter and other molten metals. It won’t burn, melt, ignite or shrink! WeldX protective apparel outperforms in the toughest environments to keep your team SAFE, COMFORTABLE and more PRODUCTIVE.

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For Info go to www.aws.org/ad-index  MillerWelds.com
Lincoln Electric Prepares Fabricators to Meet EPA Regulations and Control Air Pollutants

Lincoln has launched a National Emissions Standard for Hazardous Air Pollutants awareness campaign for metal fabricators. Shown at the top is an interactive guide available at www.lincolnweldfumecontrol.com followed by a good example of controlling welding fumes using a central system.

The Lincoln Electric Co., Cleveland, Ohio, recently introduced phase 2.0 of its “Are You Ready?” fume control regulation awareness campaign to aid fabricators in understanding the effects and requirements associated with the Environmental Protection Agency (EPA) Metal Fabrication Hazardous Air Pollutants (MFHAP) and National Emissions Standard for Hazardous Air Pollutants (NESHAP) regulation.

Scheduled to take effect July 25, 2011, the new EPA, MFHAP and NESHAP regulations will require metal fabricators to reduce air emissions of metal compounds such as chromium, lead, manganese, and nickel from nine metal fabrication and finishing source categories that affect welders and fabricators. These compounds can pose health risks to workers overexposed to fumes.

At www.lincolnweldfumecontrol.com, visitors may study resources, ask questions, and prepare their organizations for compliance. The site serves as a resource for those seeking more information on welding fume regulation issues and solutions. Links are provided to informative documents, and an interactive flow chart guides users through the welding operations portion of the EPA rule. A glossary of terms is included. Resources will continue to be added, including whitepapers, videos, user tools, and other details about weld fume control and welding safety.

In addition, the company offers an e-mail address for users to get extra information and ask a question or provide feedback. Responses to the requests will be handled by a subject matter expert from a panel of personnel. Users may contact weldfumecontrol@lincolnelectric.com. The company will present seminars on the regulations, welding fume control, welding safety, and related topics.

The Welding Safety Interactive Training Program educates arc welders about the safety hazards they may encounter and the safe practices they should follow. It provides the user with a menu of topics to learn about at their own pace. The program includes more than 120 frequently asked questions about welding safety and a safety photo hunt section. It’s offered free on a DVD from Lincoln and the company’s distributors. Request a copy at www.lincolnelectric.com/products/firerequest/.

Fast Facts on Fume Control and Safe Practices

Lincoln also contributes the following points:
• Selecting equipment to control welding fumes can be difficult for any business. Choosing the proper equipment depends on many factors from the size of your operating floor to the type of welding process.
• Employers are under pressure to comply with the hexavalent chromium standard as it applies to the welding industry. The key to determining the level of effort needed for compliance is to understand how the Occupational Safety and Health Administration has structured the standard.
• The EPA’s regulation requires certain metal fabricators to control emissions from various operations, including welding. If you own a business that does metal fabrication, you need to determine if this regulation applies to you. If it does, you need to have documents, procedures, and practices in place to control emissions from welding processes before the regulation’s compliance date next year.
• It’s essential to follow safe practices when welding, including proper clothing. Safe attire includes a long sleeve shirt and pants, safety glasses, and a welding helmet. When welding, be aware of the fumes you could inhale and take action to control your exposure by providing adequate ventilation.
• Local exhaust ventilation is routinely used to control worker exposure to fumes, but none is 100% effective, and the ability to position and reposition the hood system is important to maintain sufficient capture velocity. Understand the principles of welding fume extraction that influence hood effectiveness as well as ways to optimize the hood’s positioning.

Partnership to Provide Canadian Electrical Workers with Fire-Resistant Apparel

DRIFIRE®, Columbus, Ga., a manufacturer of fire-resistant clothing, has partnered with MWG Apparel, a Canadian workwear manufacturer based in Winnipeg, and the International Brotherhood of Electrical Workers in Canada to launch a program that gives electrical workers access to comfortable fire-
resistant apparel and educates them on potential tax savings through government programs.

An educational campaign at the center of the partnership informs Canadian electrical workers about the safety implications of wearing different garments in the event of an arc flash or exposure to flame, gives them information about tax savings and grants for which they may be eligible, and allows them to browse and order clothing through MWG Apparel at www.compliantftwear.com or directly with the company.

The garments offered include a range of base layer and outerwear garments, including women’s and men’s undergarments, T-shirts, woven pants and shirts, and fire-resistant denim jeans and jackets. All garments are made with DRIFIRE fabric, which offers permanent flame resistance and has patented comfort characteristics, including good wicking, fast drying, and antimicrobial odor control.

Safety Engineers Offer Heat-Related Illness Safety Tips

The American Society of Safety Engineers, Des Plaines, Ill., suggests employers and employees be aware of factors leading to heat stress, symptoms of heat exhaustion and heat stroke, preventing heat stress, and what can be done for heat-related illnesses.

According to the U.S. Occupational Safety and Health Administration, when one’s body is unable to cool itself by sweating, several heat-induced illnesses can occur. Factors leading to this include high temperatures; being in direct sun or heat; limited air movement; physical exertion; poor physical condition; some medicines; and inadequate tolerance for hot workplaces.

To prevent heat stress, officials suggest monitoring coworkers and yourself. Prevention efforts include blocking out direct sun or other heat sources; using cooling fans or air conditioning; and resting regularly. It’s also important to drink lots of water, about one cup every 15 min, and wear lightweight, light-colored, loose-fitting clothes. If you’re going to be in the sun, it’s recommended you avoid alcohol, caffeinated drinks, and heavy meals.

According to the National Institute of Occupational Safety and Health, heat can cause injury due to accidents related to sweaty palms, fogged up glasses, and dizziness. Sunburns are a hazard of sun and heat exposure as well. Suggested tips for employees and employers include the following:
• Use cooling pads that can be inserted into hardhats or around the neck to keep the head and neck cool. Vented hardhats or neckbands soaked in cold water minimize prolonged heat exposure and prevent the body from overheating.
• Wear protective eyewear featuring sufficient ventilation or an antifog lens coating to reduce lenses fogging from heat. Sweatbands can be used to prevent perspiration from dripping into your eyes.
• Use gloves with leather palms and cotton or denim backs allowing for an increased airflow. Choose gloves with a liner to absorb sweat preventing perspiration buildup.

For more information, go online to www.cdc.gov/niosh/blog/nsb071408_summerheat.html or www.osha.gov/OshDoc/data_HumanFacts/working_outdoors.pdf.

Taber to Supply Aluminum Extrusions for Navy’s Joint High-Speed Vessel Program

Austral USA has awarded contracts to Taber Extrusions LLC, Russellville, Ark., that will position it as the primary supplier of aluminum extruded products for the Navy’s Joint High-Speed Vessel (JHSV) program.

The first contract is for manufacturing the main and flight
Do your part for the future of resistance welding.
Give this ad to a college student.

A $2,500 annual scholarship was established in 2005 by the Resistance Welder Manufacturers’ Association for a college junior who wishes to become involved in the resistance welding industry. The hope is that the scholarship recipients will learn to appreciate the simple elegance and robustness of the process, so that they can carry the message forward to the next generation. The scholarship is awarded based on an essay, academics and recommendations.

The deadline for the 2011 fall award is February 15
For details, visit www.aws.org/foundation/scholarships/rwma.html

Taber has been chosen as the primary supplier of aluminum extruded products for the Navy’s Joint High-Speed Vessel defense program through a contract with Austal USA. Pictured is a company employee welding materials. (Photo courtesy of Taber Extrusions.)

deck extrusions for the JHSV 2 Vigilant. These assemblies consist of wide, multivoiced panel-type extrusions utilizing a diagonal truss-web design that are friction stir welded to form panels. Taber’s use of the 8600-ton extrusion press with a rectangular container configuration enables producing the sections in lengths up to 47 ft.

Additionally, the company will produce the 5083 tee extrusions for the JHSV 1, Fortitude, and JHSV 2, Vigilant. Since the initial build phase on JHSV 1, Austal has utilized friction stir welded 5083 panels. The extrusions used in the panels will be produced at Taber’s Gulfport, Miss., facility. These welded panels are used in the ship’s superstructure, decking, and bulkheads.

Austal USA has contracts to build the first three Joint High-Speed Vessels as part of a 10-vessel program valued at up to $1.63 billion. These vessels will be capable of transporting up to 300 troops and their equipment for four days.

Nozzle Rental Program Reduces Welding Costs, Provides ‘Green’ Benefits

By participating in Secoa’s Single & Tandem Annual Rental program, companies help to protect the environment and scarce resources, plus typically lower welding costs.

Secoa Technology’s Single & Tandem Annual Rental program gives qualifying companies the option to rent welding nozzles. Its recycling plan includes a “help the environment” container for storage and shipment.

All nozzles rented through the program are PerfectArcs™ self-cleaning welding nozzles suitable for virtually any manual or robotic gas metal arc welding process. They also eliminate the need for spatter release sprays and dips.

Used rental welding nozzles are returned to PerfectArcs for reuse, refurbishing, or recycling. Some are donated to local welding schools, and for each one returned, the company will make a
ThyssenKrupp Presta Terre Haute
Expands Indiana Manufacturing Facility

At the ribbon-cutting ceremony for ThyssenKrupp Presta Terre Haute’s expansion in Terre Haute, Ind., are (from left) Rick Burger, Terre Haute Chamber of Commerce; Judy Anderson, president, Vigo County Commissioners; Kathy Chalos-Miller, president, Vigo County Council; Mayor Duke Bennett, Terre Haute; Peter Allaart, president of ThyssenKrupp Presta Terre Haute; Ambassador Claudia Fritsche; Steve Witt, president, Terre Haute Economic Development Corp.; Michael Hoopingamer, architect, American StructurePoint; and Rachel Leslie, Terre Haute Chamber of Commerce.

The Terre Haute Economic Development Corp. joined ThyssenKrupp Presta Terre Haute, LLC, a manufacturer of steering systems for the automotive industry, at a ribbon cutting for the $17.5 million expansion of its Terre Haute, Ind., facility.

The investment will increase production capacity and create up to 80 new jobs, bringing the facility’s total employment to approximately 230 by 2012. These full-time jobs will consist of hourly and salaried positions. Hiring for qualified machine operators, quality inspectors, and warehouse coordinators began last December.

The expansion reflects increasing orders from original equipment manufacturers. It includes a 70,000-sq-ft addition for manufacturing and office space, completed in June. The investment also covers the purchase and installation of new laser welding and bearing assembly lines. Installation of all new equipment is scheduled to be completed by this month.

Industry Notes

• Airgas, Inc., Radnor, Pa., signed a three-year extension to its safety products supply agreement with The Boeing Co. representing $19 million of revenue in the first year of the contract.

• The Society of Manufacturing Engineers, Dearborn, Mich., and Tooling University LLC, Cleveland, Ohio, an online training provider for the manufacturing industry, signed an agreement for the society to acquire all the university’s outstanding shares.

• Thermal Spray Technologies, Sun Prairie, Wis., recently celebrated four years without one lost time accident.

• DeWalt®, Towson, Md., is participating in a promotion with Call2Recycle®. Users who recycle the company’s NiCd, NiMH, or Li-Ion power tool batteries at one of its 79 service centers will receive a $10 discount to put toward their next battery purchase.

• Spartan Light Metal Products facility in Sparta, Ill., achieved a safety milestone of working 1 million hours without an accident resulting in lost time from work.

• Welding Alloys Group’s Web site at www.welding-alloys.com features easy access to product information, a new search facility, more interactive format, and industry focus section.

• Leaders from the Aluminum Associations of Canada, Mexico, and the U.S. recently met during the Aluminum Association’s Aluminum Week and Annual Meeting in Chicago, Ill.

• A Gleeble® physical simulation system has been delivered to the Brazilian Synchrotron Light Laboratory, Campinas, Brazil. It will be used to perform advanced in-situ materials studies.

• ITW Welding North America has added MAXAL™ brand aluminum welding wire products to its portfolio.

• Panasonic Factory Solutions Co. of America moved into a new dedicated demonstration and training facility in Buffalo Grove, Ill., and offices in nearby Rolling Meadows, Ill.

• The academic partnership Dassault Systèmes has with Ohio Northern University’s Dept. of Technological Studies brought good results. During a project for auto supplier KTH to assess a robotic welding cell with two robots and a two-position turntable, the student team created a solution to reduce cycle time by 7 s.

• Robinson Steel has relaunched the company, now known as Robinson Laser. Its RPS® PriceCheck, an online, real-time price comparison of unique laser parts, is at www.robinsonlaser.com.

• Acculloy Manufacturing Solutions started operations at PerformaCoat, Inc., a new division performing advanced protective and lubricating coating services in the Gulf Coast area.

• The North American Die Casting Association, Wheeling, Ill., started a blog at www.diecasting.org/nadca featuring sites of interest to die casters, plus reposting/sharing options.
Hyundai Heavy Industries to Develop Welding Technology for Polar LNG Carriers

Hyundai Heavy Industries of Korea has announced plans to develop special equipment to weld the thick aluminum plates used for LNG tanks. The work is part of the company’s long-term strategy for the expected increase in demand for LNG carriers and LNG FPSO vessels to be used in the polar region. Interest in natural gas development in that area has been growing because it is estimated that 44 billion barrels of natural gas, or 30% of the world’s natural gas reserves, are located in the Arctic Ocean.

The goal of the project is to develop new welding machines and welding carriages that can increase weld deposition from 35 to 60 g/min. The company hopes to improve welding speed and increase welding capacity by more than 30%. Polar LNG carrier tanks are made of 50- to 70-mm-thick aluminum plates; the thick plates allow them to be used in regions where there are many ice walls.

“High-quality vessels can be built when welding is done efficiently,” said Kim Dae-soon, company vice president. “We’ll develop highly sophisticated welding technologies to meet market trends and client requests.”

Hyundai Heavy Industries has built 37 LNG carriers, completing the first one in 1994. It builds two types of LNG carriers, the spherical dome type and membrane type.

TÜV Rheinland Acquires Brazilian Engineering Company

TÜV Rheinland, Boston, Mass., recently acquired Geris Engenharia e Servicos, an engineering company based in São Paulo, Brazil. Geris offers technical engineering services for the oil and gas industry, electricity producers and suppliers, infrastructure projects, residential construction, and logistics.

Geris, founded in 1993, has more than 600 employees. Annual sales are approximately $37.7 million. The acquisition boosts the number of employees working for TÜV Rheinland in South America to 2100.

“We are expanding our commitment on this continent further because we see growing demand there for quality, safety, and sustainability concerning industrial projects,” said Friedrich Hecker, CEO of TÜV Rheinland AG.

Welder Training to Be Given to Young Adults in Rural India

VIT University, Vellore, India, recently signed a memorandum of understanding with the Indian Welding Society, BHEL Ancillary Association, Ranipet (BAAR), and BHEL Suppliers Association, related to conducting skill development programs in welding for unemployed young adults.

Unemployed people aged 18 to 25 from the rural area in and around Vellore will receive six months of welding training: the first two months at VIT and the final four at BHEL ancillary industries. The organizations that signed the memorandum will jointly develop the syllabus and course materials.

Over the next year, about 100 people are expected to receive the training. The students will receive a stipend of about $56 per month during their training.

Serimax to Provide Welding Services for Water Pipeline in Saudi Arabia

Serimax, an international full-service welding company headquartered in Paris, France, recently secured its first pipeline project in Saudi Arabia. The company will provide welding services for the Ras Az-Zawr to Riyadh water pipeline transmission system. The work will be done on behalf of contractor Mapa-Limak-MNG and end-client Saline Water Conversion Corp.

The work involves in-trench welding on two parallel 72-in. waterlines over 125 km. The company was expected to train the contractor’s welders on its Saturnax automatic welding system on-site beginning in mid-August with production scheduled to start last month.

“We have performed a number of offshore projects in Saudi Arabia, but this is our first major onshore project and is an excellent opportunity to demonstrate the value of Serimax’s full automatic welding technologies in a strategically important region,” said Cyril Tigien, the company’s vice president for Europe, Middle East, Africa, and Russia/Community of Independent States.

RathGibson to Supply Titanium Tubing for Chinese Power Plant Project

RathGibson, Lincolnshire, Ill., recently received an order for 40 tons of thin-walled titanium tubing for Nanjing Turbine & Electric Machinery Group Co., Ltd. (NTC). NTC manufactures equipment for power-generation facilities, including gas turbines, steam turbines, generators, and motors.

The tubing will be used in the assembly of two seawater condensers for a power plant project in Fujian, China. RathGibson manufactured the 25-mm OD and 0.5- and 0.7-mm wall thickness Grade 2 titanium tubing to NTC’s specifications, which are stricter than those in the ASME B338 standards.

The innovative self-contained design of the new Edge™ Series is engineered to protect all of the critical components that make up a regulator system, eliminating exposure to outside elements and ultimately, minimizing the risk of injury to the operator in the event of a tank accident.

To learn more about the SAFEST regulator on the market, go to www.victoredge.com/safety.

Get serious about safety. Get the new Edge Series Regulator from Victor. Other regulators just aren’t worth the risk.
SMAW Safety: Do You Need Control?

Relative to shielded metal arc welding (SMAW), conventional machine architecture allows for continuous power on the welding conductors whether the machine is welding or not welding. The open circuit voltage of the machine (the voltage on the conductors when not welding) can be as little as 12 V or it can be 90 V or more. The amount of open circuit voltage depends on the technology and manufacturer, and can vary depending on where you are in the world and the local standards.

Twelve volts, generally speaking, are not going to hurt you; however, even at 12 V, about 800 ohms will get you to the 15 mA danger area associated with electric currents and the human body. Obviously, the higher the voltage, the greater the risk of shock or electrocution. Remember, 5 mA (AC) is the setting on your ground-fault circuit interrupter outlets in your house, so there are variables as to what is considered “safe.”

The resistance of the human body while in a relatively “dry” state can be several thousand ohms to nearly a mega-ohm. However, under the right conditions, a dirty, sweaty person can have a resistance of less than 800 ohms — sometimes, much less. And just for information, the body’s internal resistance (like through a cut or breach in the skin) is much less than 800 ohms.

It is at this “much less than 800 ohms” point where the real danger lurks for SMA welders and their equipment. If a welder is using a machine with low open circuit voltage (OCV) or a volt-

Fig. 1 — The zRID device and instruction diagram. The green light indicates no power to the welding conductors.
the situation and the desires of the personnel operating the welding equipment — the low OCV or VRD product will switch over to full open circuit voltage. At that point, the operator had better be ready to weld.

So why are SMAW machine conductors allowed to lay around with power on them all the time? Why doesn’t the operator have control over the power coming out of the welding machine? The answer seems to be that it has always been that way. And once something has always been that way, it tends to become the norm.

Is there an incentive for shutting off the output of the welding machine when not welding? By shutting off the welding machine during nonwelding operations, the welder gains the following:

1. Control over arc initiation
2. Virtual elimination of accidental arc flash
3. Zero power on the electrode holder while changing electrodes
4. Automatic shutdown at the end of arcing operations.

zRID Pty. Ltd., Wangara, Australia, has developed a product that effectively shuts off the welding machine during nonwelding operations. In an attempt to fully ascertain if there is a need for such a device, let’s examine those four potential benefits mentioned previously one by one.

1. **Control over arc initiation.** Do you really need that amount of control? When you prepare to weld, you know when you’re ready to begin welding. You know that when you touch the electrode to the workpiece, you will get an arc. Therefore, you’re already in some control of the arc, but total control over arc initiation would have been nice on those occasions in which you weren’t ready for an arc but got one anyway. How often does that happen to you? You will have to decide if this type of control is a benefit to you.

2. **Virtual elimination of accidental arc flash.** This is related to the first benefit. By giving total control over arc initiation to the welder, you have virtually eliminated accidental arc flash. How often have you struck an arc before you were ready?

3. **Zero power on electrode holder while changing electrodes.** Have you ever been zapped while changing electrodes? Have you ever grabbed the leads unintentionally? Whether you perceive having no power to the electrode holder while changing electrodes as a benefit may depend on how often you have been rudely introduced to the effects of electricity.

4. **Automatic shut down at the end of arcing operations.** With the zRID device, after you’re done welding, the welding conductors are deenergized. Is that really necessary? If something were to happen to you while welding and you slipped or fell, is it important to you that breaking the arc renders the electrode holder harmless?

If we make the assumption that having control over the welding machine is important, can we do it without hampering productivity? The zRID device operates as follows:

1. Press remote button at electrode holder (button does not have to be held in order to weld).
2. Initiate arc within 0.5-3 s (depending on settings).
3. Perform the welding procedure.
4. Once arc is broken, machine shuts off.
5. Repeat to weld again.

Adding a button-press to a procedure, especially one that you do not have to hold, does not appear to hinder productivity. The short story of the zRID welding safety device is this: Do you want and need control over the power coming out of the welding machine? We have control over almost everything plugged into our walls: stereo, toaster, microwave, television, circular saws, and drills. Even gas metal arc welding machines have a trigger to control the output. Shielded metal arc welding machines are different, and it has always been that way; the electrode holder sits there with voltage on it all the time. However, is that safe, smart, and is it the best we can do now? Keep in mind that technology is now available that can virtually eliminate electrical accidents related to the output of shielded metal arc welding machines.

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**Fig. 2 —** Solter is the first company to integrate the zRID safety technology into a product off the shelf. Shown is the ICON 1750 zRID SMAW machine. The red light indicates the welding conductors are active.

**JOHN WILLIS** (anchor-controls@cox.net) is vice president, Anchor Controls & Engineering, Virginia Beach, Va. Anchor Controls & Engineering is a representative for the zRID device in the United States.
Q: Why are those little copper tubes installed in the resistance spot welding electrode holders we purchase? They’re fragile and our spot welding machine operators often throw them away when they get bent.

A: Problems commonly observed during our company’s service calls at customers’ plants indicate that the proper use of water tubes in resistance welding electrodes is not well understood.

Although small and seemingly insignificant, those little tubes serve an important role in making good-quality resistance welds. Copper resistance welding electrodes, although alloyed with chrome and other materials for added strength, must be kept as cool as possible because excessive heat allows the nose to soften and mushroom, leading to a significant drop in weld quality.

As the face of an electrode gradually mushrooms, the welding current is spread over a larger area and the current at any one point is decreased. Therefore, if the welding machine’s heat and weld time settings are not adjusted, or the tips are not dressed or replaced, welding quality degrades over time.

However, a properly installed water tube forces cooling all the way to the bottom of the cavity drilled inside the tip and removes heat faster from the tip of the electrode. This reduces copper softening and helps maintain electrode contact diameter. In this way, weld quality and electrode life are maximized.

Water tubes come in two basic styles: sliding and spring loaded. An adjustable sliding tube with the end cut on a 45-deg angle is the most common type of water tube used in resistance welding applications. Its diameter is sized to fit in or on a stationary tube threaded inside the electrode holder.

As a new spot welding tip is installed, make sure to extend the sliding tube all the way out prior to seating the tip into the tip holder. By using this method, the sliding tube will self-adjust inside the tip as it is installed, ensuring that the tube reaches all the way to the bottom of the tip’s water cooling cavity.

The 45-deg angle cut on the end of the tube is designed to allow water to flow back out of the cavity after striking the hottest part of the tip first. If the water tube does not reach all the way to the bottom of the cavity, a steam pocket may form and cooling water may not reach the end of the tip where it is needed — Fig. 1. If the tube is not long enough, insert a proper one to match the electrode being used.

A spring-loaded water tube self-adjusts and seats automatically, but electrode holders with spring-loaded tubes are not well suited for use with offset tips equipped with sliding water tubes installed by the manufacturer.

Using water tubes properly will pay big dividends in weld quality and electrode life. Don’t throw them away.

Why Water Tubes Are Important

• Steel melts at about 2500°F and a typical spot weld is formed at about 2400°F at the interface of the two pieces of metal being welded.
• Electrodes made from copper alloy serve the dual purpose of conducting the high welding current to the weld area and applying forging force.
• Contact surfaces of electrodes can reach 1900°F during the welding process.
• Copper electrodes cannot withstand such high temperatures without deforming.
• Copper’s conductivity degrades and the weld face mushrooms as it heats up.
• Therefore, most resistance welding electrodes are water cooled, or should be.
• Small-diameter water tubes typically made of brass or copper force the flow of cooling water down inside an electrode’s internal cooling passage to the point closest to the weld.
• Weld quality and electrode life will degrade rapidly if water tubes are not used.

Things to Watch for

• Don’t discard water tubes; they’re furnished for a reason.
• If tubes must be replaced, make sure the end is cut on a 45-deg angle to allow for proper water flow — Fig. 2.
• Water should be circulated as close as possible to the weld, so make sure the water tube reaches all the way down inside the tip.
• If the tube is not properly positioned, an internal steam pocket may form in the area closest to the weld and cooling water will not circulate all the way to the end of the water hole cavity.
• For improved cooling, use straight electrode tips whenever possible, rather than offsets.
• When using offset electrodes, select one that incorporates an internal water tube.
• If weld access is a problem, use offset tip holders and straight tips rather than offset tips in straight holders.

Following are results from a research project done by Roger Hirsch of Unitrol Electronics titled “Influence of Water Temperature and Flow on Electrode Life.” The entire paper can be downloaded at www.unitrol-electronics.com from the downloads section.

Positioning the adjustable cooling tube 1 in. back from the end of the inside water hole of the electrode had a major influence on tensile strength, weld nugget diameter, and electrode face diameter. Compared to a test run on a 0.050-in. cold-rolled steel with a properly positioned sliding tube and operated at the same water flow and temperature, the mechanical change over the 8000 weld run was as follows:

1. Tensile strength decreased 27.6%.
2. Weld nugget diameter decreased by 18.2%.
3. Electrode face diameter increased by 42.0%.

TOM SNOW is chief executive officer, T. J. Snow Co., Inc., Chattanooga, Tenn. He is a member of the Resistance Welding Manufacturing Association (RWMA). Send your comments/questions to him at tomsnow@tjsnow.com, or to Tom Snow, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.
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Q: We produce agricultural sprayers of 304L stainless. They are made of two dished heads and a rolled and welded cylinder. The sprayers are used for herbicides and insecticides, as well as for liquid fertilizer. Some have been returned to us because of leaking. When we examined the leaks, we found that the leakage was due to a number of pits, mainly in the welds and beside the welds joining the top head to the cylinder. Should we change to a more expensive base metal like 316L?

A: Figure 1 shows an example of the inside surface of a leaking sprayer tank. A number of pits are readily apparent, some in the weld and some in the cylinder just below the weld joining it to the head. It can be seen that the weld is a partial penetration weld, made from the outside of the cylinder, which is a major part of the pitting problem. The lack of complete penetration provides a crevice, and 304L stainless steel is susceptible to crevice corrosion. Pitting actually starts in the root of this crevice. Rust stains are apparent, trickling out of the crevice.

A second noteworthy point about the weld area is that there is clear evidence of heat tint on the base metal surface beside the weld. This indicates that there was no backing gas on the inside of the tank when the outside was welded. The heat tint is oxidized metal that is more susceptible to pitting than is the clean base metal. The pitting beside the weld is almost entirely within the heat tint area. Much of that pitting is also within the rust stains coming out of the crevice provided by the partial penetration weld. Corrosion engineers describe rust on stainless steel as “auto-catalytic.” This means that rust on the surface of the stainless promotes corrosion wherever the rust deposits. The rust trickling from the initial pits in the crevice clings to the heat tint beside the weld, which makes for particular susceptibility to pitting corrosion in that area. It should be noted that there are no pits in the heat tint on the head side of the joint, most likely because the rust trickling out of the crevice falls downward along the cylinder wall, not upward to the head surface.

Given these observations, I don’t think that changing to 316L will solve the pitting problem. Under the present fabrication conditions, there will still be a crevice and heat tint, and 316L is also susceptible to crevice corrosion which, I believe, triggers the pitting both in the root of the partial penetration weld and in the heat tint area.

Rather, the first step in preventing the pitting is to eliminate the crevice. Change to a complete penetration weld, or apply a seal weld to the inside of the tank to cover the crevice produced by the partial penetration weld. Complete penetration can be achieved by GTAW, by GMAW with a modern power source that senses the arc conditions and adjusts the power supply output to prevent melting through, or by keyhole plasma arc welding (PAW). There are a number of manufacturers of GTAW torches that can operate through a small opening in such a tank to make a seal weld from the inside, with or without filler metal addition.

If you eliminate the crevice, you may eliminate the pitting problem. However, that is not a sure bet. The heat tint on the surface exposed to the various corrosive chemicals in the sprayers may still render the steel susceptible to pitting in those environments. It may just take longer to initiate the pitting in the heat tint area if rust trickling from the crevice is eliminated by eliminating the crevice. The heat tint can be prevented by purging the inside of the tank, or at least the inside surface in the weld area, before welding. The purge gas can be argon or nitrogen. These gases are equally effective for this purpose, although it is advisable, with nitrogen purging, to use a tight root and reduce the nitrogen purge flow rate during welding to prevent nitrogen from getting into the arc on the outside of the tank. See the July 2000 Stainless Q&A column for a more complete discussion of nitrogen as a purging gas.

Alternatively, if you do not want to provide a backing or purge gas to the inside of the tank, or consider it impractical in your manufacturing operation, you should consider removing the heat tint by pickling the inside of the tank. A typical pickling solution is a mixture of 20% nitric acid, 2% hydrofluoric acid, in water (see ASTM A380). About 30 min exposure to this solution will dissolve a superficial layer of stainless steel under the heat tint so that the oxides comprising the heat tint are released from the surface of the steel. These oxides will then be carried away by the pickling bath and/or by the following water rinse. The downside to pickling the inside of the tank is that it is eventually necessary to dispose of the spent pickling solution in an environmentally acceptable manner, which may be costly. If you consider this approach, you should check with the local environmental agency to determine what is required.

Another possibility for removal of the heat tint is to introduce an abrasive grit to the inside of the tank and roll the tank for a period of time. This will require some experimentation to determine the most effective abrasion procedure. And, typically, abrasion is not as effective as pickling in terms of maximizing pitting resistance of the weld area.

A word of caution: Removing, or preventing formation of, the heat tint, without eliminating the crevice, will probably not improve the pitting resistance. The crevice, formed by the partial penetration weld root, is by far the most important factor that needs to be addressed.
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National Scholarship Program

Congratulations to Dale David, recipient of the D. Fred and Marian L. Bovis Technical Scholarship

“I am very thankful for being selected for the second year as a winner of the D. Fred and Marian L. Bovis Technical Scholarship. I appreciate and thank Mr. and Mrs. Bovis as well as the AWS Foundation for awarding me this scholarship. I am also very thankful for their support and faith they have in me as a welder. This scholarship will help me continue my education and become a more skilled welder.”
North Dakota State College of Science – Welding Technology

Congratulations to Brady Orth, recipient of the ESAB Welding and Cutting Endowed Scholarship

“This is a huge honor to be the recipient of the 2010-2011 ESAB Welding and Cutting Scholarship. The American Welding Society and scholarships like these make it possible for students to excel. I would like to thank my instructors at Florence-Darlington Technical College. They have great experience and knowledge and have only helped enhance my abilities. The only way to become a good welder is to stay under the hood, and with this scholarship I will be able to do so.”
Florence-Darlington Technical College – Welding

Congratulations to Kathryn P. Cook, recipient of the Hypertherm International HyTech Leadership Scholarship

“I am honored to be selected as the recipient of the 2010-2011 Hypertherm International HyTech Leadership Scholarship. I would like to thank the members of the AWS Foundation as well as Hypertherm for their generous support in helping me continue my education and prepare for a leadership role within the engineering community. I look forward to representing both the AWS Foundation and Hypertherm over the next year as they scholarship recipient and contributing to the materials engineering and welding communities.”
University of California at Berkeley – Masters in Materials Science Engineering and Engineering Management

Section Named Scholarship Program

Congratulations to Ricardo Cerua, recipient of the George Kampfshaler – Houston Section Named Scholarship

“I am thankful and honored to be the recipient of the George Kampfshaler Scholarship. I would like to thank the American Welding Society Foundation and everyone involved in helping me further my education and achieving my goal. Thank you for supporting my future career in the welding industry and for motivating me to have a positive and successful outcome in my future.”
San Jacinto College – Welding Technology

Congratulations to Jana Valigura, recipient of the Dr. Daryl Morgan – Houston Section Named Scholarship

Sam Houston State University – Animal Science with a minor in Secondary Education

Congratulations to Danny Castro, recipient of the Ronald S. Theiss – Houston Section Named Scholarship

“By the grace of God, I am a welder.”
Lone Star College – Welding Technology

Congratulations to Joe Stavinaaho, recipient of the Paul O’Leary Memorial – Idaho/Montana Section Named Scholarship

“I am truly honored to be the proud recipient of the 2010-2011 AWS Paul O’Leary Memorial Scholarship. Because of the generous contributions from the O’Leary family, I am able to continue my education at Montana Tech of the University of Montana in the General Engineering program with the Welding Engineering Option. I would like to extend my sincere thanks to those involved in selecting me as this year’s scholarship award winner.”
Montana Tech of the University of Montana – Masters in General Engineering – Welding Engineering Option

Congratulations to Kelvin Dewalt, recipient of the Lehigh Valley Professor Robert D. Stout Named Scholarship

“I am honored to receive the Professor Robert D. Stout Scholarship. This scholarship will assist me as I further my education in the welding field as I work towards my career goal of being a pipeline welder. I want to thank the Lehigh Valley Section of AWS for funding this scholarship and promoting education in the welding field.”
Pennsylvania College of Technology – Welding Technology

Section Named Scholarship Program

Scholarships sponsored by AWS Sections to support students in their communities.

Congratulations to Nicholas Musery, recipient of the Amos and Marilyn Winsand – Detroit Section Named Scholarship

“It is an honor to be selected for this scholarship. As a former chapter secretary and recent award recipient, it is readily apparent that any time and energy put into this organization is consistently returned many-fold. I look forward to helping grow the organization for future members.”
Ferris State University – Welding Engineering Technology

Congratulations to Joseph LaTour, recipient of the Bob and Mary Jane Anderson – Wisconsin Section Named Scholarship

“Thank you for your support in my welding career.”
University of Wisconsin – Madison – Welding Technology

Congratulations to Sean Kuenzel, recipient of the Ransom – Texas Section Named Scholarship

“Thank you for making a difference in my life.”
Texas Tech University – Welding Technology

Congratulations to Ryan Allen, recipient of the Idaho Power Company – Idaho Section Named Scholarship

“I am thankful to the Ida Power Scholarship Committee for awarding me this scholarship and recognizing my dedication towards the welding field. I will use this scholarship to further my education and pursue my welding career.”
Boise State University – Welding Engineering Technology

Congratulations to Dylan Lounsbery, recipient of the Southern California Gas Company – California Section Named Scholarship

“The Southern California Gas Company Scholarship gave me the opportunity to continue my education in the welding industry. It has allowed me to further my welding career.”
Orange Coast College – Welding Technology
Section Named Scholarship Program

Congratulations to Kelly Wilson, recipient of the Ronald C. and Joyce Pierce – Mobile Section Named Scholarship

"I feel honored to receive the Ronald C. and Joyce Pierce – Mobile Section Named Scholarship. The financial assistance provided by the Pierce family and the AWS Foundation help make my education possible, and being chosen for such an honor inspires and encourages me towards my goals and dreams. I would like to thank the Pierce family and all who contribute to this and similar scholarships for their generosity."

University of Alabama
Materials and Metallurgical Engineering

Congratulations to Levent Alptunaer, recipient of the Shelton Ritter – New Orleans Section Named Scholarship

Southern Louisiana Community College

Congratulations to Nicholas Schley, recipient of the Northwest Section Named Scholarship

"I am very thankful for the grant from the American Welding Society Northwest Section Named Scholarship. This financial assistance will help a great deal with my future in the welding industry. Someday I would like to own my own weld shop, and I know how important a quality education is for my career, and it would not be possible without your generous support. I look forward to a continuing relationship with the AWS for many years to come."

Lake Area Technical Institute – Welding Technology

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This award is sponsored by Tri-Tool and the Sacramento Section, and was awarded to students in District 22 as part of their District Scholarships

Louis DeFreitas – Santa Clara Valley Section Named Scholarship

This award is sponsored the Santa Clara Valley Section in recognition of Louis DeFreitas, and was awarded to students in District 22 as part of their District Scholarships

District Named Scholarship Program

Scholarships sponsored by AWS Districts and local companies to support students in their communities.

Congratulations to Clinton Jenny, recipient of the Ed Cable-BUG-O District 7 Named Scholarship

Pennsylvania College of Technology – Welding and Fabrication Engineering Technology

Congratulations to David Crawford, recipient of the AWS-Detroit Section, District 11 Fred Ellicott Scholarship for Arc Welding

"It is a privilege to have received a scholarship from AWS. This scholarship will help me continue my education in Welding and Fabrication Engineering. I would like to thank the American Welding Society for their continued support of students in the Welding industry across the nation."

Ferris State University
Welding Engineering Technology

Congratulations to Bradley Opperman, recipient of the AWS-Detroit Section, District 11 Dietrich Roth Scholarship for Resistance Welding

"I would like to thank the American Welding Society for awarding me this Scholarship. This foundation has helped me throughout the years with the costs associated with my education. I am very grateful for all of the support that the AWS has provided me as well as many other welding students across the country."

Ferris State University
Welding Engineering Technology

AWS International Scholarship

Congratulations to Matthew B. Grove, recipient of the Donald and Jean Cleveland – Willamette Valley Section Named Scholarship

"I greatly appreciate the financial assistance that AWS has provided me with through the Willamette Valley Section Scholarship. This scholarship will help me as I further my education in the engineering field. Thank you AWS for honoring me with this award."

Linn Benton Community College
Welding and Machine Tool

Congratulations to Vahid Firouzdar, recipient of the AWS International Scholarship

"I would like to extremely express my appreciation to the AWS Foundation and its supporting companies for awarding me the AWS International Scholarship. It is a great honor and a big encouragement for me to continue my research in Welding."

University of Wisconsin – Madison
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Complying with OSHA’s Cr(VI) Regulations

Hexavalent chromium, also known as Cr(VI), poses serious threats to health and safety. Therefore, on Feb. 28, 2006, the Occupational Safety & Health Administration (OSHA) issued a new standard relating to occupational exposure to hexavalent chromium. The new standard lowered the permissible exposure limit (PEL) of hexavalent chromium from 52 to 5 micrograms.

The OSHA decision to lower the exposure limit was based on a finding that employees exposed to Cr(VI) face an increased risk of significant health effects like lung cancer, asthma, nasal septum ulcerations and perforations, skin ulcerations (“chrome holes”), and allergic and irritant contact dermatitis.

OSHA’s 2006 regulation for employee exposure to hexavalent chromium also includes provisions relating to preferred methods for controlling exposure, respiratory protection, protective work clothing and equipment, hygiene, medical surveillance, hazard communication, and record keeping. This rule applies to all manufacturing processes where hexavalent chromium is present.

The following are industries most likely to be affected by the regulation:
• Electroplating — hard chrome electroplating
• Thermal spraying
• Welding — all types could be affected, but the highest concentration is in stainless steel welding
• Steel mills — rolling mills and forging operations
• Metal cutting — all types including laser, plasma, and oxyacetylene.

Capturing the Fumes

What are the best ways to capture welding fumes containing hexavalent chromium and keeping them out of the breathing zone?

There are normally two different ways of maintaining air quality:
• Fume extraction directly on the welding gun or torch — Fig. 1
• Source capture using a dust or fume collection device and exhaust arms with hoods — Fig. 2.

SUWANA SMITH (suwana.smith@nederman.com) is with Marketing Department, Nederman USA, Westland, Mich.
Choosing the right solution depends on the type and quantity of contaminant generated.

It has been proven that extraction at source is the most effective and efficient method of capturing and removing welding and similar fumes. Using this method, the risk of the welder or operator being subjected to hazardous fumes is minimized.

Welding torches and guns with integrated extraction (on-torch extraction) is a form of extraction at source that allows the welder to work over large areas as well as inside constructions. Extraction efficiency ranges from 70 to 98% depending on the welding method, type of shielding gas, material being welded, and the welder’s skills. On-torch extraction is especially suitable for robotic welding. On-torch extraction lowers the volume of air that is extracted from the workshop. This makes it cost effective as it reduces the amount of heated/cooled air extracted from the premises.

Robotic welding operations using automated welding equipment require careful monitoring. Operators and service personnel need to be protected in a similar way to manual welding procedures. Solutions for robotic welding include both on-torch extraction and extraction systems with hoods.

Central vacuum/filtering systems provide overall vacuum power for capturing of welding fumes; extraction of dust from grinding, sanding, and cutting; collection of scraps from process lines; and for general housekeeping. The filtered air can, under certain conditions, be discharged to the outdoors. However, any business that is a source of air pollution is subject to air permitting requirements.

There is a variety of safety precautions one should take when welding, as the equipment and material involved in welding can cause serious injury or death. Heat, sparks, dangerous gases, and ultraviolet light are all part of the welding environment. Whether you are completing a small welding project in your garage or are part of a team of welders on a big construction job, safety should be the first priority. 

Fig. 2 — An example of extraction at the source, which is an effective and efficient method of capturing welding fumes.
What Can Your Welding Salesperson Do for You?

Six experienced welding sales reps discuss the expertise they offer their customers

BY HOWARD M. WOODWARD, KRISTIN CAMPBELL, AND MARY RUTH JOHNSEN

Purchasing welding equipment, consumables, and accessories is a whole lot different from walking into a shoe store to buy a pair of shoes. For the most part, self-serve doesn’t work with welding. Every weldment is different. Every time the base metal changes, it can mean a change in filler metal or shielding gas. There are questions related to whether it should be a manual, semiautomatic, or automatic welding process. With so many variables involved with welding, it’s a big help if you can find a knowledgeable salesperson, someone who can do much more than just bring out all the size tens and have you try them on until you find a fit.

But what can a welding salesperson really do for you? The Welding Journal editors spoke with six experienced welding sales reps — all of whom have become American Welding Society (AWS) Certified Welding Sales Representatives (CWSR) — to find out. Here’s what they had to say about their jobs.

Terry Byrd

After working in the welding industry for more than 40 years, Terry Byrd now serves as the national welding product manager for Airgas, Inc., Radnor, Pa. — Fig. 1.

Byrd learned about welding through working on a farm and with his father, an ironworker. He graduated from Montgomery County Joint Vocational School, Clayton, Ohio, where he later taught adult education.

At Hobart Brothers Co. and the Hobart Institute of Welding Technology, Troy, Ohio, Byrd worked as a test welder, manager, and instructor for AWS certification tests and nondestructive examination course. Also, he helped start the arc welding division of Thermal Arc, a Thermadyne brand, and introduced it to their sales force.

Byrd has been with Airgas for nine years. According to the company’s Web site at www.airgas.com, Airgas, through its subsidiaries, is the largest U.S. distributor of industrial, medical, and specialty gases and related hardgoods; a leading United States distributor of safety products; the largest liquid CO2 producer in the Southeast; has built the largest national distribution network in the packaged gas industry; and features approximately 1100 locations.

“I’m constantly selling,” Byrd said. This includes the following: welding products, including machines for spot, resistance, and submerged arc processes along with accessories, filler metals, and welding support equipment; industrial application and specialty gases; safety products like clothing and gloves, plus head, eye, and face protection; specialty and welding gas equipment; and cutting tools, abrasives, and industrial brushes.

It’s important to know how materials perform in various work environments. Byrd brings a different set of eyes to evaluate situations and provide solutions. He could take as little as a minute to recommend a product or process. This response comes from experience, which allows him to answer technical questions from many viewpoints, and working on projects from start to finish.

“I talk to customers every single day,” Byrd added. He stressed that listening, paying attention, asking the right ques-
tions, and understanding are key skills a salesperson must have.

In addition, he mentioned the objective in any sales call is to satisfy the customer's needs by listening and finding out the problem. Observe what's happening to resolve issues, Byrd advised. For example, if a process requires a lot of grinding work that could mean the wrong gas combination or equipment is being used. Also, make sure the welding process is operating efficiently. If a higher deposition rate is desired, changing to a flux cored wire may be best, or if overwelding occurs that can be fixed.

"By relying on a qualified salesperson for more up-to-date information, a customer doesn't have to worry and can focus on their company's production," Byrd said.

Traveling is another big part of the job. Byrd manages business relations with filler metal and equipment suppliers; audits the company's nuclear program for filler metals; visits the company's 12 regional organizations; and attends sales meetings. The job has allowed him to go all over the United States, and he has been to every continent but Antarctica.

"I enjoy helping people," Byrd said, adding there's pleasure in doing a good service for others and fixing problems.

He likes that his work combines engineering, research and development, welding, sales, and marketing. Keeping up with new code and specification requirements along with current alloys is challenging, but making time for this is necessary to be on top of current trends.

"It’s never boring. There's a different challenge all the time," Byrd said.

He was part of the beta test group for the AWS Certified Welding Sales Representative program as well. He said the certification does not offer sales techniques, but educates you on various welding processes. He thinks companies will benefit by using the certification as a qualifying tool to advance the positions of employees and track training.

Mike Billington

Mike Billington is a salesman for ILMO Products Company, headquartered in Jacksonville, Ill. — Fig. 2. His company, founded in 1913, provides welding equipment, gases, retail sales, and rental and supply services for customers in Illinois and Missouri.

Billington considers his most valuable asset as a salesman is his ability to offer each customer professional assistance specific to their operations from a "higher level of experience and expertise, and discipline." He adds, "My Certified Welding Sales Representative (CWSR) certification has greatly enhanced each of these traits, and my customers value it as well." He said he makes each customer's concern his personal problem to solve. "Product and process knowledge," he said, "is instrumental in the long-term success of a salesperson in the welding industry, and consequently, for his or her customers. My ability to advise a customer and fit the best equipment or process transforms me from just another salesperson coming in the door into a partner in the process."

Billington said his suggestions to the customer may be to simply change a type of rod or wire, upgrade to a more appropriate power supply, utilize a bulk gas system vs. high-pressure cylinders, or to introduce a higher-capacity technology such as a robotic or laser system.

He contends, "The guiding tenet for any advice the salesperson offers should be, 'Does this save or improve the customer's resources?' Whether the resource is time, capital, or manpower, savings in these areas will result in more efficient production and greater productivity, often paying for the new equipment or process in a relatively short time."

As an example, Billington explained that he is currently working on converting a customer's operation from a double-end air-cooled gas metal arc welding (GMAW) system to a submerged arc system (SAW). He decided this change was the best way to go after studying the customer's needs. The extended time required for the GMAW multipass welds created a "pinch-point" in the fabrication process. He said, "The change to a SAW system will increase the efficiency of this production line and alleviate the production backlog. Labor cost savings and the increased production efficiency should make the payoff for the new SAW system in about 18 months.

"I am also currently examining the installation of a bulk gas system for a large plasma arc cutting machine for another customer, and adding a seam-tracker to an existing robot for the better use of an underutilized asset."

Billington said ILMO Products has recently offered consulting services provided by its staff of Certified Welding Inspectors (CWI), Educators (CWE), Supervisors (CWS), and Welding Sales Representatives (CWSR). Billington said these are valuable credentials because customers trust the AWS certification platform and they expect to receive efficiency improvements.

"My company has a long history of promoting employee attendance to both on-premise and off-premise seminars and certifications to ensure the expansion of staff's knowledge in all divisions, including ISO 17025 Certification of its Specialty Gases Laboratory. I find the AWS certification program has been and continues to be beneficial in my continued education of welding processes. I currently hold the CWS and CWSR certifications and plan to eventually earn the CWI and possibly..."
Certified Radiographic Interpreter. Many of my associates hold CWI, CWE, and CWS certifications. The CWSR certification would be especially valuable for less-experienced salespeople and would be a great starting certification to build further certifications upon.

“As a customer,” Billington advised, “it would always be prudent to determine the extent of expertise and experience that your welding sales representative can offer. Welding processes can be complex and erroneous advice can be costly. AWS certifications would be a simple indication of expertise to evaluate, and these certifications reflect a consistent knowledge platform. Proper use of salespersons with these certifications should also reflect in increasing your bottom line as a customer by reducing costs in material, labor, and time.”

**Greg Pierce**

You might say Greg Pierce was born into the welding profession. His father, Ron Pierce (a past AWS president and chair emeritus of the AWS Foundation) and his partner, Leo Veal, started WESCO Gas and Welding Supply, Inc., in the early 1960s in Prichard, Ala. Ron Pierce bought out his partner in 1974, and today, the company’s eight offices supply the Gulf Coast region from the Florida Panhandle to New Orleans with welding supplies, industrial and safety supplies, and medical, industrial, and specialty gases. Greg Pierce and his siblings all work for the company. “We always have built our reputation on a very simple philosophy,” Pierce said, “premium customer service. We feel we provide the best welding products at a competitive price combined with superior technical service.

“Being part of a family distributorship, I get involved in many different aspects through the company, but my main focus is on outside shipyard development,” Pierce said. Much of his time is spent working with BAE Systems Southeast Shipyard Alabama, in Mobile, Ala., and Northrop Grumman Shipbuilding in Pascagoula, Miss. In preparation for his position, Pierce attended a two-year welding program at Pensacola Jr. College; took a variety of technical training seminars on efficient selling, welding processes and power sources, and advanced processes; and worked in every department at WESCO.

“I have learned in my 27 years in the welding industry that the price of a product is not as significant as the value-added services that I have provided,” he said. “I constantly strive to improve our service that we can offer over our present competition.”

Manufacturers offer a basic equipment package, Pierce explained, then “it is up to the distributor to modify the product to increase productivity. We do a lot of R&D to look at different ways to modify equipment, to help our customers increase productivity.” The company is an AWS Accredited Test Facility, so it performs qualification tests of welders for its customers, and it has a 15,000-sq-ft, air-conditioned service department. Pierce stressed that a successful welding distributor needs to service the customer before and after sales.

“Not only can we do a cost analysis vs. one process to another, but we also have the capability of doing and developing the welding procedure specifications for those processes. Also, we have the capability of taking standard equipment from a manufacturer and adapting it to the end user’s applications for a semi- or fully automatic process.”

Pierce participated in the beta group for the CWSR seminar and test. Two other members of the WESCO team are now also AWS Certified Welding Sales Representatives. He and the company participated in the programs for several reasons, he said. First of all, it’s a big supporter of AWS and its programs, and second, the company budgets for educational programs for its employees and stresses proper training. “We strongly believe that a pool of extraordinary talent gives WESCO and our customers a great strategy advantage,” he said. “And we fully believe continuous education is a valuable resource and an investment to better serve our customers.”

In his conversations with the other WESCO employees who went through the CWSR program, Pierce said, “They thought it was one of the toughest courses, but fair, that they’ve been involved with.” He also said he hopes the program will become an online offering at some point to make it more accessible to potential users.

“I have attended several different certification and training programs throughout my career,” Pierce said, “and it is always refreshing to look at programs that can enhance my ability for continuous education. The AWS Certified Welding Sales Representative Program has provided another value-added service for my internal and external customers. If I can’t overcome the commodity perception, then price becomes the major determining factor (for customers) in buying their products. With this new AWS program, I was able to strengthen my welding knowledge to help identify our real value positioning in today’s market.”

**Jim Appiedorn**

Currently, Jim Appiedorn serves as the U.S. distributor sales manager for The Lincoln Electric Co., Cleveland, Ohio—Fig. 3. He was hired into the company’s sales training program after graduating from Michigan State University with engineering and communication degrees.

“The engineering side of my job requires an understanding of the technical nature of our products, welding processes, and customer applications,” Appiedorn said. “The communication side of my job requires the ability to interact with people, both socially and in a formal business context.”

Appiedorn spent many years as a Lincoln Electric sales representative and sales manager throughout the United States. He said a typical Lincoln salesperson brings his or her product and process knowledge to the end user to help them weld better, safer, and more efficiently.

Its Web site at www.lincolnelectric.com states the company has 39 manufacturing...
locations, including operations and joint ventures in 19 countries and a worldwide network of distributors and sales offices covering more than 160 countries.

Appledorn has been active in AWS. He served as chairman of the Spokane, Salt Lake City, and Houston Sections, plus the District 18 director position.

Today, Appledorn spends most of his time assisting distributors. He interacts with several dozen each month, offering special programs and sales policies that reward those for doing the best job. Also, he works with them to resolve issues and discuss new ways to grow sales. He represents all products manufactured by Lincoln Electric.

“The most important skill, beyond that of product and process knowledge, is to be a good listener,” Appledorn said. “A successful salesperson in this industry needs to nurture long-term relationships with their end-user customers. That can only be done by clearly understanding the needs of the customer and introducing solutions that effectively address those needs. Through this process, salespeople develop credibility and ultimately become a trusted resource.”

He mentioned most end users know a great deal about what they manufacture. It would be difficult for a welding salesperson to presume they knew more about making a certain item, like underground storage tanks, than a company whose job it is to make tanks. On the other hand, sales representatives have welding knowledge that can facilitate the tank manufacturing process. Their awareness of new technologies in welding, positioning, joint preparation, and gas delivery systems represents tremendous value.

Most of the company’s salespeople make five or six sales calls a day to distributors and consumers, unless they are involved in a large job or special assignment. Also, distributor and manufacturer salespeople can work as an effective team; the distributor salesperson is a “generalist” with a basic understanding of a variety of products, and the manufacturer salesperson is the “specialist” with a deeper understanding of a focused set of products.

Appledorn stated the amount of traveling varies per salesperson. For example, it might be rare for an outside salesperson for a distributor, but many supplier representatives travel extensively.

“In this business, I believe there is still a critical need to visit the customer,” he said. Meeting in person, seeing the application up close, and experiencing the manufacturing environment is worthwhile.

In addition, it’s exciting to close a big order, but in the long term, Appledorn thinks the most rewarding part of sales comes from seeing the products and services meet their intended purpose. This ensures future business and loyal customers.

“No two days are alike,” Appledorn said about the job. He enjoys the range of people, unique distributor issues, and varied customer applications. It’s tough going through periodic soft business cycles, but that’s bound to happen over a long career. Salespeople just have to treat these times as opportunities to think creatively.

Appledorn took the CWSR exam to gauge how useful it might be to incorporate into Lincoln Electric’s own sales training. He thinks it’s more useful for measuring a distributor salesperson’s knowledge, because knowing a broad range of welding-related topics is needed, so the exam suits them. The credential could be utilized as a hiring criterion for distributors looking at new salespeople and serve as an advertising tool if all their salespeople earned it.

Rob Koczur

Prior to joining Maine Oxy, Rob Koczur had little welding knowledge. “I knew that in order to succeed, and move up within our company, I would need to learn all that I could — and fast,” he recalled. “I took advantage of every opportunity available to me that provided more knowledge. I have taken approximately 15 accredited welding classes, asked questions of experienced coworkers and customers, and read, a lot.”

Maine Oxy is a family-managed industrial gases and welding hardgoods supplier with 11 locations throughout New England. Koczur joined the company nearly ten years ago as a truck driver and inside salesperson. “I had to fill in for the store manager while he was deployed to Iraq for 18 months, and got the chance to prove myself to management,” he recalled. “That opened the door to being offered a position in outside sales.”

Today he is a technical outside salesperson covering central and northern New Hampshire — Fig. 4. His responsibilities include bringing in new accounts, growing sales within the company’s current customer base, and maintaining and servicing those customers. His clients cover a wide range of industries from small job shops to huge power plants.

Koczur believes one of the keys to his success is “I try to treat people how I want to be treated. I try to treat everyone the same way whether it’s the guy sweeping the floor or the president of the company. I speak and treat everyone the same because, in ten years, the janitor could become the president of the company.”

Increasing his welding knowledge is another key. “I actually took welding classes, so I can run a bead. I take online and distributor training on new products and new processes that I can share with my customers. If I don’t do that, I’m just like all the other guys.”

Koczur wouldn’t presume to tell a company that has successfully made a specific product for a long time how to do its job, but he can put a fresh eye to a company’s operations. “Sometimes even with longtime welders, they’re doing certain things incorrectly and don’t realize it. I try to tell them in a nice way what’s going on. I don’t say, ‘You’re doing it wrong.’” He gave an example of something he’d seen recently in which a company was having a problem with a stainless steel application. He noticed welders were using a steel brush, thereby introducing contamination into the weldment.

Koczur was also part of the beta test
John Bray

John Bray is a veteran salesman with Affiliated Machinery, Inc., Pearland, Tex. — Fig. 5. His company specializes in selling, renting, and buying welding and positioning equipment, and advising customers on the best solutions to their current challenges.

Bray mused, “I think the oldest profession is sales.” He contends that “Everyone has some sales experience. For example, when you were a child, didn’t you try to sell your parents or grandparents on what you would do for them if they would buy you that new toy?”

“However,” Bray said, “in the welding sales representative profession, it takes more than just some sales experience to be at the top of the field. The true professional has to be more than an ‘order taker’ over the phone or at the counter.”

Bray noted that he has been greatly influenced by meeting many sales personnel from all over the country. “My company,” he noted, “works with distributors coast to coast. It amazes me how many sales personnel do not have the tools to take them to the next level.”

He believes that sales personnel should participate in continuing education to keep them on top of their field. Bray recently completed the AWS Certified Welding Sales Representative course. “After taking the course,” he said, “I realized just how diversified a welding salesperson should be. Many experienced personnel are not completely versed in the entire welding sales process. It was really an eye opener to see just how many areas a competent welding salesperson needs to understand.”

Bray wanted his company’s management to understand that even with more than 42 years of experience in the field of welding repair and sales of equipment, a salesperson could benefit from more knowledge. “The CWSR program made me become aware of not only my strong points but what I may be missing completely to become a true ‘Welding Sales Representative Problem Solver’ for my customers.”

Bray recalled, “One of the most rewarding experiences for me was when one of my distributors pointed to me and said to the customer, ‘This is the guy you need to talk to.’

“When a customer comes into our shop to inquire about a machine, I see it as an opportunity to make sure they get not only what they asked for, but to be sure what...
they get will do the job for them. Many very experienced welders do not always know what is the best equipment to do their job. The sales process of asking questions and listening to the customer’s needs can be the most critical part of solving their problem. If I just listen to their request and not (ask them questions to) fully understand their problem, I would miss the most important part of the whole sales process.”

Bray, who serves as AWS District 18 director, is well known for his enthusiasm for working with others. He attributes his skills for working with people from what he learned from the Dale Carnegie Sales Course he took many years ago. An important lesson, he recalled, was urging sales representatives to listen first before they spoke. “I believe that is one of the keys a lot of salespeople overlook.”

Bray said, in conclusion, “I find the welding sales profession to be an ongoing learning and developing experience. When I think I know it all is when I’m often in the most trouble. I keenly listen to each customer’s needs, then do my absolute best to give them the best advice. I want all of my customers to point to me and say, ‘He’s the guy we need to talk to.’”

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Fig. 5 — John Bray (far left), District 18 director, chats with Greg Sanford (center), owner of Technical Alloy & Industrial Gas, Inc., Houston, Tex., in the company showroom. Company salesman Shannon McDonald (far right) is also a graduate of the first Certified Welding Sales Representative course.

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Maintaining a safe welding environment does a lot more than just offer companies the practical benefits of reduced worker compensation claims and production interruptions. A safe workplace also improves job satisfaction and employee retention.

However, achieving a safer welding environment isn’t just a “do it once and you’re done” type of activity. It must be a continuous practice with buy-in from all levels of the organization.

To best understand how to establish a safer environment, it helps to understand the potential hazards common to most welding applications and the options available for ensuring that employees avoid those hazards.

**Heat Stress**

One of the under-recognized dangers in welding applications is heat stress. The area immediately surrounding a welding operation can be more than 15°F hotter than the ambient temperature. This presents a number of potential dangers to the welding operator and his or her cowork-
Ideas are presented to make your welding environment not only safer, but a source for greater job satisfaction for your employees

BY BILL GARDNER

Heat stress can have a range of impacts on the welder, varying from mild discomforts like muscle cramps or a heat rash to heat stroke, where the body's core temperature exceeds 105°F and immediate medical attention is critical. Beyond these obvious physical dangers, heat stress can also reduce the welder's ability to recognize and respond to other hazards in the workplace, which can put both the welder and others in the area in jeopardy.

Heat stress results from the combination of high ambient temperatures, a lack of air flow in the weld cell (challenging when procedures require shielding gas), and the diminished ability of the body's natural cooling mechanisms. The body's two primary ways of cooling itself, sweating and diverting blood toward the skin surface, are impeded by the use of the welder's protective clothing. Taken together, these two factors require vigilance from welders and supervisors.

While providing regular water breaks is one of the most common ways for companies to encourage heat stress safety among their employees, products designed to combat heat stress can also help protect employees without imposing any downtime.

Among the products that employers might consider are under-helmet cooling systems that direct air over the welder's head and face to augment the body's natural cooling defenses. These products use fans mounted to the welder's helmet or belt that can reduce the under-helmet temperature up to 17°F.

Another option for reducing the potential for heat-induced injuries is select-
ing flame-resistant protective apparel that is breathable and lightweight. Flame-resistant cotton provides better breathability and is about one-quarter the weight of most leather garments, but it doesn’t always provide the level of protection required by some applications. WeldX™ is a new nonflammable synthetic fabric that features oxidized acrylic fibers with a proprietary coating that repels sparks and spatter. It provides a level of protection similar to leather but at the weight of traditional cotton fabrics, making it ideal for garments worn in warm environments.

**Welding Fumes**

The issue of welding fumes has been surrounded by controversy over the past decade, but there are a few indisputable factors that employers should bear in mind. The Occupational Health and Safety Administration (OSHA) maintains permissible exposure limits for some of the compounds found in welding fumes, including hexavalent chromium and manganese.

Whether or not your company’s welding operations fall under governmental regulations, many shop owners have found that providing protection from welding fumes improves employee job satisfaction and overall morale — two factors that help them attract and retain talented welders.

Choosing the right fume-control method requires a careful analysis of the welding application. These include the materials being welded, welding process, facility layout, nearby employees, etc., and the types of control methods available.

There are three common types of fume control methods: engineering controls, source-capture devices, and personal respirators. Each method works well when implemented within the welding applications for which it was designed.

**Engineering Controls**

Engineering controls involve employing a heating, ventilation, air-conditioning (HVAC) technician or other qualified professional to design and install a fume-removal/air-replacement system using ductwork, high-powered air circulators, filters, and the required electrical infrastructure. These systems work well to protect all of the employees in a facility, but are often very costly to install.

**Source-Capture Devices**

Source-capture devices are often far less expensive than engineering controls, but operate similarly in that they remove welding fume at the source, thereby protecting all of the employees in a facility —
Source-capture units vary greatly in terms of their fume-filtration capabilities, air-displacement ratings, maintenance requirements, and portability, so it is important to consider these and other factors when evaluating a source-capture unit.

Because the particles in welding fumes are 0.3 to 1 micron in size (much smaller than the particles for which standard air filters are designed), companies should look to a source-capture fume extractor that uses a filter specifically designed for capturing welding-size particles.

Another consideration is whether the fume extractor uses a disposable filter or has a self-cleaning mechanism to clean the filters. A self-cleaning unit is typically more expensive to purchase, but in many high-fume applications, those costs can be offset quickly by the savings in replacement filter costs.

Another factor to keep in mind when selecting a source-capture fume extractor is how it will fit into the layout of a welding facility. Compact, portable units are available that weigh less than 50 lb and can be easily carried up stairs or slid under a welding table. Larger mobile extractors fit well in flexible work cells with varying weld conditions. Likewise, a wall-mounted unit can help companies avoid cluttering up their shop floor and still protect their employees from fume exposure.

Personal Respirators

For some applications, neither a source-capture device nor engineering controls provides a practical solution for fume protection. In these cases, personal respirators offer the advantage of being the most portable and least expensive option for fume protection. Personal respirators can be either powered, in which filtered clean air is blown into the welding helmet, or passive, in which a filtration mask fits over the welder's nose and mouth.

Sparks, Spatter, and UV Light

Sparks, spatter, and ultraviolet (UV) light all present potential hazards that demand head-to-toe personal protection. A number of factors, including the welding process, shielding gas, welding wire, and base material, will impact the levels of these hazards, so choosing the right personal protective equipment should be based on the application.

It might sound like a good idea to simply purchase the most-protective apparel available, regardless of the application, but doing this can result in welder fatigue, lack of necessary dexterity, and excessive heat stress. Instead, try to choose the protective apparel that balances the needed protection with the physical demands and the welding environment.

At a minimum, a welder should wear leather boots (steel toes are ideal), cuffless pants made from natural fibers, a flame-resistant welding jacket or other chest and arm protection, leather gloves with wrist and forearm coverage, safety glasses, an approved welding helmet with a skull cap or other protection for the top of the head. The accessories mentioned above will provide a base level of protection from sparks, spatter, and UV light, but many welders achieve significant gains in productivity, comfort, and overall satisfaction by upgrading to protective equipment such as autodarkening helmets, purpose-designed welding gloves, high-quality apparel, and underhood cooling systems.

Although this article does not cover every potential hazard that welders face in their daily job duties, the topics covered address the most common hazards faced by all welders. Following the recommended safety protocols and using the right protective equipment can help ensure a long and satisfying career in welding.
Establishing a Gas Safety Program

Outlined are the elements you need to set up your safety program

In spite of the risk of serious injury to their employees and stiff fines for violations from the Occupational Safety and Health Administration (OSHA) or other regulatory agencies, many firms do not have a welding gas safety program and/or gas safety equipment. Safety around welding and other compressed gases is the responsibility of both the employee and employer. The absence of gas safety procedures or inattention around welding and compressed gases can lead to serious accidents.

A grinder in Pennsylvania blew dust from his clothing using oxygen. Minutes later he was engulfed in flames when his oxygen-impregnated clothing caught fire. The grinder died from third-degree burns over 60% of his body.

A common error is the belief that welding/industrial oxygen is ordinary room air. Air is made up of nearly 80% nitrogen and 20% oxygen, while welding/industrial oxygen consists of 99.7% or greater pure oxygen. Any concentration of oxygen above 23.5% lowers the ignition point of most materials (materials like oil-stained fabrics may ignite as low as 30°F) and increases the speed and temperature of combustion. Some materials burst into searing flames with explosive-like force.

Employees who spray off their clothing and work areas with oxygen are setting themselves and their employers up for devastating accidents — Fig. 1.

Oxygen is the most hazardous of welding and industrial gases because of the common misunderstanding that oxygen is ordinary air. Oxygen is not air (Refs. 1, 2).

In Indiana, a welder using oxy-propane gas was killed when leaking gas exploded in his confined workspace. The welder may have been aware of the small amount of leaking oxy-propane, but just didn’t realize the enormous amount of energy present in flammable gases.

All the common welding and industrial gases found in the workplace are hazardous when safety procedures and equipment are not used or are ignored. Welding and industrial gas safety requires training and equipment that is readily available from gas and welding equipment suppliers (Ref. 3). You can find videos containing some of this information at www.oxyfuelsafety.com/data/files/superflash_safety_video.wmv.

In the southwest, a welder was killed when a flashback occurred that ignited mixed gases in a homemade shop gas manifold. The employer was found to be grossly negligent and fined $113,000 by OSHA. This case is currently pending in the courts for punitive costs and fines.

Setting up a Gas Safety Program

• A gas safety program (Ref. 4) starts with, and requires, regular self auditing. Knowing the status of a gas safety program is critical before an accident or violation occurs. Free self-audit checklists are available from your gas and welding equipment supplier or in the

By David J. Marquard

David J. Marquard (dmarquard@applied-inc.com) is president/owner of Superflash Compressed Gas Equipment, IBEDA Inc., Westlake, Ohio, and owner/partner of IBEDA GmbH & Co., KG, Neustadt-Wied, Germany.
Fig. 2 — Regular welding gas safety training as is shown here should be included in every safety program.


A comprehensive gas safety program includes regular gas safety training for any employee who uses welding or industrial gases, or who requisitions, completes paperwork, or supervises areas where gases are used, stored, or transported — Fig. 2.

Next, gas safety devices like flashback arrestors should be installed on all welding guns/torches and regulators, gas filters should be installed on pipelines, and individual regulators should be installed on line stations or tapping points. In addition, personal protection equipment should always be used. Gas manifolds and piping must be manufactured by competent and qualified suppliers, and installations must be inspected and certified prior to being put into service.

It is never too late to start or update a gas safety program. Don’t wait until a devastating accident involving welding or compressed gas occurs.

References

Operators get an added level of safety thanks to key design elements, including reverse-flow check valves, flashback arrestors, particle traps, and gauge guards

BY BOB BOYER

It doesn’t matter whether you’re an oxyfuel novice welding your first plate of steel, or a seasoned veteran cutting a 12-in. I-beam, accidents with oxyfuel equipment and pressurized gas cylinders can happen and have devastating consequences. The inherent dangers can cause loss of sight from arc rays and sparks, damage to lungs from fume inhalation, burns, fires, and even explosions.

Mitigating risks requires that you follow proper procedures when using oxyfuel equipment, but it’s also critically important to use equipment you know has safety features that can minimize dangers on the job site.

Manufacturers of cutting and welding equipment make safety considerations the center of their product designs. Victor®, the Thermadyne brand that produces gas cutting and welding equipment and accessories, was founded in 1913 by L. W. Stettner, a welder who suffered the loss of an eye from a welding accident. His injury spurred him to design and build better, safer welding products, a tradition that continues at the company today.

Setting aside welding gloves, eye protection, and other safety gear you should always be using, there are a few key design elements critical to the equipment itself that should be looked for in the products you use. Following are some of these design elements and why they’re important, including a few new advancements in gas equipment technology that can help you work safer.

Pay Attention to Flashback Protection

Reverse flow in an oxyfuel gas system is when either oxygen enters the fuel side or fuel enters the oxygen side of the system. This can occur when there is a gas supply restriction or imbalance of pressure, which can be caused by things such as a clogged or blocked cutting tip, or allowing one of the supply cylinders to run out of gas. Reverse-flow check valves are designed to help prevent this from happening by closing off the supply stream when gas flow reverses direction. This is important, because if a reverse flow condition is allowed to exist, flashback can occur.

Flashback is the return of a flame through the torch, into the hose, and even into the regulators. It could also reach the cylinder itself. This condition could potentially cause an explosion anywhere within the system. Flashback arrestors prevent the flame from traveling beyond the point of the arrestor. This is done by means of a sintered filter within the arrestor, carefully designed and configured to extinguish the flame as it attempts to pass through.

Because of the serious risks associated with reverse flow and flashback, it is recommended that both reverse-flow check valves and flashback arrestors be fitted at the rear of any oxyfuel torch. Look for built-in safety features no matter what brand you use, or use add-on arrestors and check valves when built-in versions are not present.

Be Aware of Oxygen and Contaminants

When working with high-pressure compressed gases, the pressure regulator chosen can play a huge role in maintaining safety on the job site. If we focus on oxygen, there are two primary factors that can have a big impact on the safety of your regulator and gas system. One factor is the inherent hazard of oxygen incompatibility with hydrocarbon materials and other contaminants. Oxygen promotes rapid burning, and hydrocarbons like to burn, so this creates a dangerous mix. The second factor is the heat of compression (also called adiabatic compression), which is the heat generated when gas is compressed, usually into a confined space (such as within a regulator, when opening a cylinder valve).

Exposed to these factors, high-pressure oxygen has the potential to cause a volatile energy release. Contaminants, even minor...
ones like dust from the regulator being stored under a workbench, can combine with oxygen and the heat of compression to form an explosive combination. In the presence of a pure oxygen fire, most materials, even metals, will burn violently. This can turn a gas pressure regulator into a ball of fire, which can rapidly propagate downstream, or into anything around it.

It’s not always easy to keep equipment perfectly clean, as tools get dirty, especially when out on a job site. And sure, we all know we’re supposed to open a cylinder valve slowly. But was it slow enough? Did this cylinder valve have a stuck seat that suddenly popped open, or a coarse adjustment that still allowed for high heat of compression to occur? You can never be too careful.

In an effort to minimize these risks and move regulator safety to a higher level, Victor has introduced a new line of regulators called the Edge™ Series, which include a patent pending, particle trap feature that essentially robs incoming contaminants of their explosive energy by both trapping the particles and diffusing their energy as they enter the regulator — Fig. 1. This prevents dangerous levels of ignited particle energy from ever reaching the regulator internals, which helps prevent an oxygen ignition source from turning into a serious explosion.

But how do you know for sure if a regulator is safe with oxygen, or if it minimizes the effects of harmful contamination? The first thing you can do is to pay attention to the industry standards to which the regulator complies.

In the United States, gas equipment is governed primarily by the Compressed Gas Association (CGA), Underwriters Laboratories® (UL), and in small ways, depending on product, some American Society for Testing and Materials (ASTM) and American National Standards Institute (ANSI) standards. These standards exist to establish minimum levels of safety, performance, and reliability in compressed gases, gas equipment, and gas accessories.

Regardless of what brand is chosen, make sure the products you’re using meet applicable standards. Victor Professional regulators, including the Edge Series, meet or exceed CGA E-4, Standard for Gas Pressure Regulators, and UL 252, Standard for Safety, Compressed Gas Regulators, both of which should be considered mandatory requirements for any gas pressure regulator you’re using.

The Edge Series regulator also passes the ASTM G175, Standard Test Method for Evaluating the Ignition Sensitivity and Fault Tolerance of Oxygen Regulators Used for Medical and Emergency Applications.

Fig. 1 — Victor’s Edge Series helps prevent what is shown here, as it’s designed to offer resistance to oxygen combustive contamination. It passes the promoted ignition test according to ASTM G175, Standard Test Method for Evaluating the Ignition Sensitivity and Fault Tolerance of Oxygen Regulators Used for Medical and Emergency Applications.

In addition, does this without negatively affecting performance or function, allowing it to meet high flow demands. There are no extra baffles, narrow passages, or small orifices inside the regulator needed to quench a fire, which also hurt performance. It’s the difference between trying to contain an oxygen explosion vs. simply robbing the energy from the incoming material so it never gets the chance to turn into one.

Secure High-Pressure Gas Cylinders

If you’re fortunate, you will never experience what happens when a high-
pressure gas cylinder is knocked over by a forklift, or is bumped and falls over because it wasn’t properly secured — while the cylinder is in use with a regulator attached. This is one of the most dangerous accidents. Even just the force of gravity, combined with the weight of a gas cylinder tipping over, can cause a regulator to smash and break — inlet connection snapping off, gauges crushing, outlet connection snapping off, and possibly even the mass of the regulator causing the cylinder valve to shear off the cylinder.

The regulator is the device that’s essentially the protection between you and the high-pressure contents of the cylinder, so if any of these things accidentally happen, you’ve got an extremely dangerous situation on your hands. You can never be too careful — check, double check, and triple check to make sure that all your gas cylinders are properly secured.

If an accident does happen, and a regulator smashes into the ground with the weight of a cylinder behind it, parts can be thrown violently, the cylinder can be completely opened to the atmosphere, gas can engulf an enclosed space in a matter of seconds, and the force of the rapidly exiting gas has the potential to turn the cylinder into a rocket, shooting it violently across the room or even out the building through concrete walls. The effects of any one of these can be devastating.

Many cylinders now have built-in protection devices to prevent them from turning into projectiles, but it’s unlikely that this alone could prevent a cylinder accident from turning dangerous. It is hoped none of us will ever see this happen in person, but since accidents can happen even in the safest environments, the possibility cannot be ignored.

The Edge Series regulator was designed to not only consider safety on the inside, but also safety in the work environment around the regulator, including accidents involving cylinders falling over. The regulator contains patent pending shock limitation and absorption mechanism (SLAM™) technology built directly into the knob of the regulator — Fig. 2. It involves multilayer shock zones designed to slow the velocity of impact in the event it’s struck (from any angle) as a result of the cylinder falling over, the easily replaceable knob becoming the sacrificial device to help the system maintain integrity. No regulator can guarantee your system will survive an accident, but SLAM is designed to help protect the regulator and the cylinder valve itself by absorbing more than 5000 lb-force of impact energy, which could help prevent a cylinder accident from turning into a devastating situation.

Take Care of Regulator Appendages

It doesn’t make much sense that the most sensitive part of a pressure regulator — the gauges — is part of the regulator most exposed to damage. However, this is indeed the case with most regulators. Usually poking out the top of a regulator, these large discs filled with sensitive components are in the perfect position to be smacked by tools, wrenches, or work materials. In fact, every appendage on a regulator that protrudes outward becomes a target for damage, and in many cases, that can be dangerous. No matter how durable a regulator is designed to be, it’s only really as durable as the components that get attached to it.

To keep your gauges safe, gauge guards are available in many different forms for most every brand of regulator, so you should always consider using them. It’s an easy and inexpensive way to protect your gauges. You should never use a regulator with damaged or inoperable gauges. Not only will you be unable to optimize pressures for your cutting or welding job, which can waste gas, but you’ll be unable to see supply pressure problems or see creep in your delivery pressure. Lack of visibility to these kinds of things can mask a potential safety problem until it becomes big enough to turn into something serious.

There’s no much you can do about the location of the regulator outlet, but you can make sure that what you’re attaching to it is in good working condition. Inspect your hoses often, especially at the end connections, to look for cracks, breaks, tears, or any other signs of fatigue or damage that could cause hose failure. Never use a hose if you doubt its integrity. Additionally, always give a quick look at the regulator outlet connection before attaching a hose. If it’s got damaged threads, for example, from being accidentally hit with a wrench, it may lack the strength to ensure a secure connection that won’t blow off. Replace it if ever in doubt.

It can be a big challenge to be careful, especially when you’ve got something constantly being handled like a regulator that gets tossed around, thrown into job boxes with other equipment piled on top, always hanging out in the open when in use, in constant line of fire for getting hit by something. However, a regulator is an industrial tool that needs to take abuse, so it really needs to be as indestructible as possible.

The Edge regulator offers a unique approach to a common hazard, the work environment. Its shape and general configuration was created with the work environment in mind. Rather than appendages sticking out in all directions, it tucks all these in to minimize potential impact points, thereby minimizing potential damage. The dual, built-in gauges are recessed into the body and protected by an integral gauge guard, the relief valve is located in the least likely position to be struck by something, and the outlet is tucked in and pointing rearward, away from the user, to help protect from acci-
dental hose connection failure while making pressure adjustments.

**Know Your Regulator, and Keep Things Visible**

Do you have the right regulator for your job? Are you sure? It’s not uncommon to occasionally see a regulator with a cylinder adaptor on the inlet, to adapt it from one CGA connection to another. You should be cautious of ever doing this as it can be a dangerous practice.

Not all regulators are designed the same. Different gases sometimes require different materials inside to ensure optimum performance and reliability. Regulators are also often configured in other ways, such as the delivery pressure spring or seat orifice size, based on the gases and pressures for which they are to be used. Plus, the regulator you’re using may have already been used on another gas, which can result in extremely dangerous mixtures occurring inside the regulator if you switch to a different gas.

Always verify that the regulator model number, gas service, and maximum delivery pressure match what you plan on using it for. All three of these pieces of information should be marked on every regulator. If you can’t find this, or are in doubt, don’t use the regulator until you can be sure you’ve got the right one for your job.

So you know you’ve got the right regulator, but can you tell what it’s doing? Damaged or inoperable gauges were already mentioned, but a working gauge is just as worthless if it’s too dirty to read. Gauge lenses can get broken or severely scratched; they can yellow over time, and can completely lose their transparency if accidentally exposed to chemicals like acetone or paint thinner. They can also usually be easily replaced, and most manufacturers offer them as replacement parts for their products. If you can’t see through the lens, or if the lens isn’t protecting the gauge internals, get it replaced.

Gauges can also corrode and wear on the inside, especially when frequently exposed to outdoor weather. Moisture can get inside and cause rust or corrosion to the dial face itself, making it impossible to read the scale. Even if a gauge still appears to be functioning properly, don’t use it if you can’t read the scale, and get it replaced.

**What More Can We Do?**

The welding and cutting industry has made tremendous progress through the years in promoting safe practices on the jobsite, but there is always room for improvements.

Equipment users must never forget that proper care and maintenance is necessary to protect the integrity of the powerful equipment they are using. Also, manufacturers must never forget to keep safety a top priority, and continue to invest resources into the research and design of new innovations that make their equipment safer. Helping to decrease accidents and injuries should be part of all of our job functions.

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Selecting Filter Lens Shades

Welding helmets with filter lenses are intended to protect users from arc rays and from sparks and spatter that impinge directly against the helmet. They are not intended to protect against slag chips, grinding fragments, wire wheel bristles, and similar hazards. Spectacles with side shields or goggles should also be worn to protect against these hazards.

The spectacles or goggles may have either clear or filtered lenses, depending upon the amount of exposure to adjacent welding or cutting radiation (Table 1). Others in the immediate area should wear similar eye protection. Keep in mind that welding helmets will not protect against the severe impact of fragmenting grinding wheels, abrasive discs, or explosive devices. It is also recommended that eye protection include side shields (Table 1).

Table 1 — Guide for Shade Numbers (from AWS F2.2, Lens Shade Selector). Shade numbers are given as a guide only and may be varied to suit individual needs.

<table>
<thead>
<tr>
<th>Process</th>
<th>Electrode Size</th>
<th>Arc Current (Amp)</th>
<th>Minimum Protective Shade</th>
<th>Suggested* Shade No. (Comfort)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shielded Metal Arc Welding (SMAW)</td>
<td>Less than $\frac{3}{8}$ (2.4)</td>
<td>Less than 60</td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>$\frac{3}{8}$ to $\frac{3}{4}$ (2.4-4.0)</td>
<td>60-160</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>$\frac{3}{4}$ to $\frac{7}{8}$ (4.0-6.4)</td>
<td>160-250</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>More than $\frac{7}{8}$ (6.4)</td>
<td>250-550</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Gas Metal Arc Welding (GMAW) and Flux Cored Arc Welding (FCAW)</td>
<td>Less than 60</td>
<td></td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>60-160</td>
<td>10</td>
<td>11</td>
<td></td>
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<td></td>
<td>160-250</td>
<td>10</td>
<td>12</td>
<td></td>
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<tr>
<td></td>
<td>250-500</td>
<td>10</td>
<td>14</td>
<td></td>
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<tr>
<td>Gas Tungsten Arc Welding (GTAW)</td>
<td>Less than 50</td>
<td></td>
<td>8</td>
<td>10</td>
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<td></td>
<td>50-150</td>
<td>8</td>
<td>12</td>
<td></td>
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<tr>
<td></td>
<td>150-500</td>
<td>10</td>
<td>14</td>
<td></td>
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<tr>
<td>Air Carbon Arc Cutting (CAC-A)</td>
<td>(Light)</td>
<td>Less than 500</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(Heavy)</td>
<td>500-1000</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Plasma Arc Welding (PAW)</td>
<td>Less than 20</td>
<td></td>
<td>6</td>
<td>6 to 8</td>
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<td></td>
<td>20-100</td>
<td>8</td>
<td>10</td>
<td></td>
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<td></td>
<td>100-400</td>
<td>10</td>
<td>12</td>
<td></td>
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<td></td>
<td>400-800</td>
<td>11</td>
<td>14</td>
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<td>Plasma Arc Cutting (PAC)</td>
<td>Less than 20</td>
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<td>4</td>
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<td></td>
<td>20-40</td>
<td>5</td>
<td>5</td>
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<td></td>
<td>40-60</td>
<td>6</td>
<td>6</td>
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<td></td>
<td>60-80</td>
<td>8</td>
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<td>80-300</td>
<td>8</td>
<td>9</td>
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<td>300-400</td>
<td>9</td>
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<td></td>
<td>400-800</td>
<td>10</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Torch Brazing (TB)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3 or 4</td>
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<td>Torch Soldering (TS)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2</td>
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<tr>
<td>Carbon Arc Welding (CAW)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>14</td>
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<table>
<thead>
<tr>
<th>Plate Thickness</th>
<th>Suggested* Shade No. (Comfort)</th>
</tr>
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<tbody>
<tr>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
<td>Oxyfuel Gas Welding (OFW)</td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>Under ½</td>
</tr>
<tr>
<td>Medium</td>
<td>½ to ¾</td>
</tr>
<tr>
<td>Heavy</td>
<td>Over ¾</td>
</tr>
<tr>
<td>Oxygen cutting (OC)</td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>Under 1</td>
</tr>
<tr>
<td>Medium</td>
<td>1 to 6</td>
</tr>
<tr>
<td>Heavy</td>
<td>Over 6</td>
</tr>
</tbody>
</table>

*As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade that gives sufficient view of the weld zone without going below the minimum. In oxyfuel gas welding, cutting, or brazing where the torch and/or the flux produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line of the visible light spectrum.

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(701) 373-0658  (701) 751-4256
www.learntoweld.com

For info go to www.aws.org/ad-index


♦ JOM-16, 16th Int’l Conf. on the Joining of Materials and ICEW-7, 7th Int’l Conf. on Education in Welding. May 10–13. Roskilde Conference and Hotel, Helsingør, Denmark. Contact JOM Institute, Gilleleje, Denmark. Phone +45 48 35 54 58; jom_aws@post10.tele.dk.


♦ FABTECH. Nov. 13–16, 2011. McCormick Place, Chicago, Ill. This exhibition is the largest event in North America dedicated to showcasing the full spectrum of metal forming, fabricating, tube and pipe, welding equipment, and myriad manufacturing technologies. Contact American Welding Society, (800/305) 443-9353, ext. 264; or visit www.fabtechexpo.com or www.aws.org.

♦ Fray Int’l Symposium on Metals and Materials Processing in a...

Educational Opportunities

Art Using Welding Technology Classes and Workshops. Miami, Fla. With artist and sculptor Sandra Garcia-Pardo. Meet the artist at www.sandragarciaart.com; or call (786) 547-8681.


Certified Welding Supervisor Preparation with Exam. Two-week-long classes beginning March 21, Sept. 1, 2011. Hobart Institute of Welding Technology, Troy, Ohio. Call (800) 332-9448; visit www.welding.org; e-mail hiwt@welding.org.


ASM Int’l Courses. Numerous classes on welding, corrosion, failure analysis, metallography, heat treating, etc., presented in Materials Park, Ohio, online, webinars, on-site, videos and DVDs. Visit www.asminternational.org, search for “courses.”


Basics of Nonferrous Surface Preparation. Online course, six hours includes exam. Offered on the 15th of every month during 2010 by The Society for Protective Coatings. Register online at www.sspc.org/training.

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WELDING RECEPTACLES

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✓ Ensures protection from arc flash
✓ Meets requirements for local disconnect

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WELD TRAINING

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Prep for AWS Certified Welding Supervisor Exam

Prep for AWS Welding Inspector/Educator Exam

Visual Inspection

Welding for the Non Welder

Arc Welding Inspection & Quality Control

Weldability of Metals, Ferrous & Nonferrous

Liquid Penetrant & Magnetic Particle Inspection

Visit www.welding.org
for course dates or call
1-800-332-9448
for more information.

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St. of OH Reg. #70-12-0064HT

For info go to www.aws.org/ad-index
Introducing Hypertherm’s new Powermax65® and Powermax85®. Do more than ever before with the world’s most advanced air plasma cutting and gouging systems. Whether it’s mild steel, stainless steel or aluminum, in the factory or in the field, the new Powermax65 and Powermax85 will cut or gouge faster, thicker and easier. The new Duramax™ series torches give you the right tool for more types of jobs. And Smart Sense™ technology boosts efficiency by automatically adjusting gas pressure to the cutting mode and torch length. Check out the newest Powermax systems at www.powerfulplasma.com.
### 2011 AWS Certification Schedule

**Certification Seminars, Code Clinics, and Examinations**

Application deadlines are six weeks before the scheduled seminar or exam. Late applications will be assessed a $250 Fast Track fee.

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresno, CA</td>
<td>Jan. 9–14</td>
<td>Jan. 15</td>
</tr>
<tr>
<td>Beaumont, TX</td>
<td>Jan. 9–14</td>
<td>Jan. 15</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Jan. 23–28</td>
<td>Jan. 29</td>
</tr>
<tr>
<td>Albuquerque, NM</td>
<td>Jan. 30–Feb. 4</td>
<td>Feb. 5</td>
</tr>
<tr>
<td>Pittsburgh, PA</td>
<td>Jan. 30–Feb. 4</td>
<td>Feb. 5</td>
</tr>
<tr>
<td>Birmingham, AL</td>
<td>Jan. 30–Feb. 4</td>
<td>Feb. 5</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>Jan. 30–Feb. 4</td>
<td>Feb. 5</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>Jan. 30–Feb. 4</td>
<td>Feb. 5</td>
</tr>
<tr>
<td>Long Beach, CA</td>
<td>Feb. 6–11</td>
<td>Feb. 12</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Exam only</td>
<td>Feb. 17</td>
</tr>
<tr>
<td>Corpus Christi, TX</td>
<td>Exam only</td>
<td>Feb. 19</td>
</tr>
<tr>
<td>Milwaukee, WI</td>
<td>Feb. 27–Mar. 4</td>
<td>Mar. 5</td>
</tr>
<tr>
<td>Atlanta, GA</td>
<td>Feb. 27–Mar. 4</td>
<td>Mar. 5</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>Feb. 27–Mar. 4</td>
<td>Mar. 5</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Feb. 27–Mar. 4</td>
<td>Mar. 5</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Mar. 6–11</td>
<td>Mar. 12</td>
</tr>
<tr>
<td>Norfolk, VA</td>
<td>Mar. 6–11</td>
<td>Mar. 12</td>
</tr>
<tr>
<td>Indianapolis, IN</td>
<td>Mar. 13–18</td>
<td>Mar. 19</td>
</tr>
<tr>
<td>Portland, OR</td>
<td>Mar. 13–18</td>
<td>Mar. 19</td>
</tr>
<tr>
<td>Perrysburg, OH</td>
<td>Exam only</td>
<td>March 12</td>
</tr>
<tr>
<td>Mobile, AL</td>
<td>Exam only</td>
<td>March 19</td>
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<tr>
<td>Rochester, NY</td>
<td>Exam only</td>
<td>March 19</td>
</tr>
<tr>
<td>Boston, MA</td>
<td>Mar. 20–25</td>
<td>Mar. 26</td>
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<tr>
<td>Phoenix, AZ</td>
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<td>Mar. 26</td>
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<tr>
<td>Anchorage, AK</td>
<td>Mar. 20–25</td>
<td>Mar. 26</td>
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<tr>
<td>Chicago, IL</td>
<td>Mar. 20–25</td>
<td>Mar. 26</td>
</tr>
<tr>
<td>York, PA</td>
<td>Exam only</td>
<td>March 26</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Mar. 27–Apr. 1</td>
<td>Apr. 2</td>
</tr>
<tr>
<td>Dallas, TX</td>
<td>Apr. 3–8</td>
<td>Apr. 9</td>
</tr>
<tr>
<td>Springfield, MO</td>
<td>Apr. 3–8</td>
<td>Apr. 9</td>
</tr>
<tr>
<td>Portland, ME</td>
<td>Apr. 3–8</td>
<td>Apr. 9</td>
</tr>
<tr>
<td>Las Vegas, NV</td>
<td>Apr. 3–8</td>
<td>Apr. 9</td>
</tr>
<tr>
<td>Knoxville, TN</td>
<td>Exam only</td>
<td>April 16</td>
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<tr>
<td>Corpus Christi, TX</td>
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<td>April 23</td>
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<tr>
<td>St. Louis, MO</td>
<td>Exam only</td>
<td>April 23</td>
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<tr>
<td>Baton Rouge, LA</td>
<td>May 1–6</td>
<td>May 7</td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>May 1–6</td>
<td>May 7</td>
</tr>
<tr>
<td>Waco, TX</td>
<td>Exam only</td>
<td>May 7</td>
</tr>
<tr>
<td>Nashville, TN</td>
<td>May 8–13</td>
<td>May 14</td>
</tr>
<tr>
<td>Jacksonville, FL</td>
<td>May 8–13</td>
<td>May 14</td>
</tr>
<tr>
<td>Baltimore, MD</td>
<td>May 8–13</td>
<td>May 14</td>
</tr>
</tbody>
</table>

### 9–Year Recertification Seminar for CWI/SCWI

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Orleans, LA</td>
<td>Jan. 10–15</td>
<td>NO EXAM</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>Feb. 7–12</td>
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<tr>
<td>Dallas, TX</td>
<td>Mar. 14–19</td>
<td>NO EXAM</td>
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<tr>
<td>Miami, FL</td>
<td>Apr. 11–16</td>
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<tr>
<td>Sacramento, CA</td>
<td>May 9–14</td>
<td>NO EXAM</td>
</tr>
<tr>
<td>Pittsburgh, PA</td>
<td>June 6–10</td>
<td>NO EXAM</td>
</tr>
</tbody>
</table>

### Advanced Visual Inspection Welding (AVIW)

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaumont, TX</td>
<td>Jan. 14</td>
<td>Jan. 15</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Jan. 28</td>
<td>Jan. 29</td>
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<tr>
<td>Pittsburgh, PA</td>
<td>Feb. 4</td>
<td>Feb. 5</td>
</tr>
<tr>
<td>Birmingham, AL</td>
<td>Feb. 4</td>
<td>Feb. 5</td>
</tr>
<tr>
<td>Milwaukee, WI</td>
<td>Mar. 4</td>
<td>Mar. 5</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Mar. 11</td>
<td>Mar. 12</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>Mar. 25</td>
<td>Mar. 26</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Apr. 1</td>
<td>Apr. 2</td>
</tr>
</tbody>
</table>

### Certified Welding Supervisor (CWS)

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta, GA</td>
<td>Jan. 24–28</td>
<td>Jan. 29</td>
</tr>
<tr>
<td>New Orleans, LA</td>
<td>Apr. 4–8</td>
<td>Apr. 9</td>
</tr>
</tbody>
</table>

CWS exams are also given at all CWI exam sites.

### Certified Radiographic Interpreter (CRI)

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami, FL</td>
<td>Feb. 7–11</td>
<td>Feb. 12</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>Mar. 7–11</td>
<td>Mar. 12</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Apr. 4–8</td>
<td>Apr. 9</td>
</tr>
<tr>
<td>Las Vegas, NV</td>
<td>May 16–20</td>
<td>May 21</td>
</tr>
</tbody>
</table>

Radiographic Interpreter certification can be a stand-alone credential or can exempt you from your next 9-Year Recertification.

### Certified Welding Sales Representative (CWSR)

<table>
<thead>
<tr>
<th>Location</th>
<th>Seminar Dates</th>
<th>Exam Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles, CA</td>
<td>Jan. 26–28</td>
<td>Jan. 28</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Feb. 23–25</td>
<td>Feb. 25</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Mar. 23–25</td>
<td>Mar. 25</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>May 4–6</td>
<td>May 6</td>
</tr>
</tbody>
</table>

CWSR exams will be also given at CWI exam sites.

### 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 first two days).

### Senior Certified Welding Inspector (SCWI)

Exam can be taken at any site listed under Certified Welding Inspector. No preparatory seminar is offered.

### Certified Robotic Arc Welding (CRAW)

<table>
<thead>
<tr>
<th>Week of</th>
<th>Location</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 17</td>
<td>Wolf Robotics, Ft. Collins, CO</td>
<td>(970)225–7736</td>
</tr>
<tr>
<td>Feb. 7</td>
<td>ABB, Inc., Auburn Hills, MI</td>
<td>(248) 391–8421</td>
</tr>
<tr>
<td>Feb. 14</td>
<td>Genesis–Systems, Davenport, IA</td>
<td>(563) 445–5688</td>
</tr>
<tr>
<td>Feb. 28</td>
<td>Lincoln Electric Co., Cleveland, OH</td>
<td>(216) 383–8542</td>
</tr>
<tr>
<td>Mar. 7</td>
<td>Wolf Robotics, Ft. Collins, CO</td>
<td>(970) 225–7736</td>
</tr>
<tr>
<td>Apr. 25</td>
<td>Wolf Robotics, Ft. Collins, CO</td>
<td>(970) 225–7736</td>
</tr>
<tr>
<td>May 2</td>
<td>ABB, Inc., Auburn Hills, MI</td>
<td>(248) 391–8421</td>
</tr>
<tr>
<td>May 23</td>
<td>Genesis–Systems, Davenport, IA</td>
<td>(563) 445–5688</td>
</tr>
</tbody>
</table>

### International CWI Courses and Exams

Please visit [www.aws.org/certification/inter_contact.html](http://www.aws.org/certification/inter_contact.html)

---

**Important:** This schedule is subject to change without notice. Please verify your event dates with the Certification Dept. and confirm your course status before making your travel plans. For information, visit [www.aws.org/certification](http://www.aws.org/certification), or call (800/305) 443-9353, ext. 273, for Certification; or ext. 455 for Seminars. Apply early to avoid paying the Fast Track fee.
Our world class manufacturing plant in Florence, Kentucky is a showplace for producing the highest quality welding materials in North America.

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Our products are sold through one of our fine distributors in your area. Call our office for one near you.
AWS understands that the certification of individuals in robotic arc welding is important to the industry, and has developed a program, based on the AWS QC19 standard and AWS D16.4 specification, that defines the requirements for personnel to be considered qualified to test for certification.

Depending on the level of experience, individuals who pass a written exam and performance test can be certified as either Robotic Arc Welding Technicians or Operators.

For more information regarding this program, including how to become an AWS Approved Test Center, visit our website today at www.aws.org/certification/CRAW or call (800) 443-9353 ext. 211 (email flopez@aws.org).

To schedule training and testing to become certified in robotic arc welding, contact one of these AWS Approved Test Centers.

**Colorado** // Wolf Robotics // 4600 Innovation Drive // Fort Collins, CO 80525 // (970) 225-7736

**Iowa** // Genesis-Systems Group // 6900 Hamson Street // Davenport, IA 52806 // (563) 445-5688

**Michigan** // ABB, Inc. // 1250 Brown Road // Auburn Hills, MI 48326 // (248) 391-8421

**Ohio** // The Lincoln Electric Co. // 22221 St. Clair Ave. // Cleveland, OH 44117 // (216) 383-8542

**Wisconsin** // Milwaukee Area Technical College // 1200 South 71st Street // West Allis, WI 53214 // (414) 297-6996

**SEMINAR / EXAM SCHEDULE**

<table>
<thead>
<tr>
<th>Week of:</th>
<th>AWS Approved Test Center</th>
<th>Week of:</th>
<th>AWS Approved Test Center</th>
</tr>
</thead>
</table>

On request: Milwaukee Area Technical College, Milwaukee, Wis.

**To schedule training and testing to become certified in robotic arc welding, contact one of these AWS Approved Test Centers.**
The American Welding Society presented arc welding training at the National Centennial Boy Scouts of America (BSA) Jamboree held July 26 to Aug. 4 at Fort A. P. Hill, Va.

Staggering in scope, the Jamboree drew about 45,000 scouts, 5000 staffers, and 2000 security personnel, with more than 17,000 tents covering an area of 3000 acres. The jamboree arena show attendance was 70,000. The jamboree theme was 100 Years of Scouting, Celebrating the Adventure; Continuing the Journey.

This was the first time the Society has participated at a BSA jamboree. The welding exhibit colocated with the popular Engineering Merit Badge tent, where AWS received thousands of visitors and hundreds experienced hands-on welder training using the VRTEX™ 360 virtual reality arc welding simulator technology provided by The Lincoln Electric Co.

Jack Compton, a retired welding instructor and a past AWS District 22 director, worked tirelessly to demonstrate the virtual welding machine, discuss welding careers with visitors, train the scouts, and distribute literature. In addition, many military personnel stopped by the AWS exhibit to test their arc welding skills.

Compton said, “By the end of the last day of the jamboree I had demonstrated the virtual welding machine to over 1200 people and handed out all of the literature AWS, Lincoln Electric, and Miller Electric Mfg. Co. had given me. The Engineering Merit Badge team had completed training for 2443 Boy Scouts — more than double any other merit badge team at the event.”

Overwhelmed with work, the long hours, record summer heat and high humidity, Compton added, “Fortunately, I was able to recruit several scouts, engineers, and Merit Badge Midway volunteers to work with me by handing out literature while I supervised attendees on the virtual welding machine.”

Thousands of welding-related texts and souvenirs were distributed to the crowds. The hottest items included the Iron Man comic book; Your Career in Welding; Hot Bikes, Fast Cars, Cool Careers; In-Demand Careers in Welding; AWS stickers; AWS Student Membership fliers; and welding equipment pamphlets.

The AWS welding event was deemed a complete success judging from the enthusiastic public response and the cooperation of many people, including Jeremy Hedegore, Dick Seif, Kate Eidam, and Carl Peters of Lincoln, and jamboree contacts Mark Maris and Chris Jones.

Compton said he and wife, Connie, drove to the Jamboree from Piru, Calif. Inspired by his experiences, Compton said he is looking forward to representing the American Welding Society and promoting interest in the welding industry at the next National BSA Jamboree, to be held in 2013 at a new high-adventure base to be constructed in Fayette County, W.Va.
Amendment Notice

The following Amendment has been made and incorporated into the current editions of the above documents.

Amendment No: AMD1
Subject: Summary of Supporting PQRs
1. Page 1 — Correct list of Supporting PQR Numbers by replacing “500506, 500510” with “500505, 500519”:

Supporting PQR Numbers: 200726, 200748, 500500, 500504, 500505, 500506, 500509, 500510, 500515, 500520, 500529, and 500550.
2. Delete Footnote 1 and renumber subsequent footnotes accordingly.

New Standard Project
Development work has begun on the following revised standard. Affected individuals are invited to contribute to its development. To participate, contact the staff secretary listed with the document. Participation on AWS Technical Committees and Subcommittees is open to all persons.

A2.4:20XX, Standard Symbols for Welding, Brazing, and Nondestructive Examination. This standard establishes a method for specifying certain welding, brazing, and nondestructive examination information by means of symbols. Detailed information and examples are provided for the construction and interpretation of these symbols. This system provides a means of specifying welding or brazing operations as well as nondestructive examination, including the examination method, frequency, and extent. Stakeholders: Designers, fabrication, and inspection personnel. A. Alonso, ext. 299.

Standards Approved by ANSI
D1.5M/D1.5:2010, Bridge Welding Code. Revision approved 8/18/10.

Amendment Standards Approved by ANSI
B2.1-1/8-227:2002—AMD1, Standard Welding Procedure Specification (SWPS) for Gas Tungsten Arc Welding of Carbon Steel (M-1/IP-I, Groups 1 or 2) to Austenitic Stainless Steel (M-8/P-8, Group 1), 7/8 through 1 1/2 Inch Thick, ER309(L), As-Welded Condition, Primarily Pipe Applications. Approved 9/8/10.
B2.1-1/8-229:2002—AMD1, Standard Welding Procedure Specification (SWPS) for Gas Tungsten Arc Welding followed by Shielded Metal Arc Welding of Carbon Steel (M-1/IP-I, Groups 1 or 2) to Austenitic Stainless Steel (M-8/P-8, Group 1), 7/8 through 1 1/2 Inch Thick, ER309(L) and ER309(L)-15, -16, or -17, As-Welded Condition, Primarily Pipe Applications. Approved 9/8/10.
B2.1-1/8-230:2002—AMD1, Standard Welding Procedure Specification (SWPS) for Gas Tungsten Arc Welding with Consumable Insert Root of Carbon Steel (M-1/IP-I, Groups 1 or 2) to Austenitic Stainless Steel (M-8/P-8, Group 1), 7/8 through 1 1/2 Inch Thick, IN309 and ER309(L), As-Welded Condition, Primarily Pipe Applications. Approved 9/8/10.

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. Contact Rosalinda O’Neill, roowell@aws.org; (800/305) 443-9353, ext. 451, to obtain a draft copy.

ISO Draft Standard for Public Review
Copies of ISO/DIS 15615 are available for review through your national standards body, which in the United States is ANSI, 25 W. 43rd St., Fourth Fl., New York, NY, 10036; (212) 642-4900. If you wish to participate in the development of International Standards for welding, contact Andrew Davis, adavis@aws.org; (800/305) 443-9353, ext. 466.

Technical Committee Meetings
To attend a meeting, call the staff member listed at (800/305) 443-9353.

The November meetings will be held during FABTECH in Atlanta, Ga.
Nov. 1, C7 Committee on High Energy Beam Welding and Cutting. M. Rubin, ext. 215.
Nov. 2, ASK Subcommittee on Titanium and Zirconium Filler Metals. S. Borrero, ext. 334.
Nov. 2, B5Q Subcommittee on Thermal Spray Operators. J. Gayler, ext. 472.
Nov. 2, C2 Committee on Thermal Spraying. J. Gayler, ext. 472.
Nov. 2, C5 Committee on Arc Welding and Cutting. M. Rubin, ext. 215.
Nov. 2, C6 Committee on Friction Welding. J. Gayler, ext. 472.
Nov. 2, D15C Subcommittee on Track Welding. S. Borrero, ext. 334.
Nov. 2, D16 Committee on Robotic and Automatic Welding. M. Rubin, ext. 215.
Nov. 2, G2D Subcommittee on Reactive Alloys. S. Borrero, ext. 334.
Nov. 3, B1 Committee on Methods of Inspection. B. McGrath, ext. 311.
Nov. 3, B1B Subcommittee on Visual Examination of Welds. B. McGrath, ext. 311.
Nov. 3, D9 Committee on the Welding, Brazing, and Soldering of Sheet Metal. A. Alonso, ext. 299.
Nov. 3, D14 Committee on Machinery and Equipment. M. Rubin, ext. 215.
Nov. 3, D15 Committee on Railroad Welding. S. Borrero, ext. 334.
Nov. 3, D17K Committee on Resistance Welding. M. Rubin, ext. 215.
Nov. 4, ASH Subcommittee on Filler Metals and Fluxes for Brazing. S. Borrero, ext. 334.
Nov. 4, C5, C3 Committee and Subcommittees on Brazing and Soldering. S. Borrero, ext. 334.
Nov. 4, D17 Committee on Welding in the Aircraft and Aerospace Industries. M. Rubin, ext. 215.
Dec. 1, 2, Safety and Health Committee. Miami, Fla. Contact: S. Hedrick, ext. 305.
Contribute Your Knowledge to These Technical Committees

Marine Construction

The D3 Committee for Welding in Marine Construction to contribute to the development of D3.5, Guide for Steel Hull Welding; D3.6, Specification for Underwater Welding; D3.7, Guide for Aluminum Hull Welding; and D3.9, Specification for Classification of Weld-Through Paint Primers. Contact B. McGrath, bmcgrath@aws.org, ext. 311.

Mechanical Testing of Welds

The B4 Committee for Mechanical Testing of Welds to contribute to B4.0, Standard Methods for Mechanical testing of Welds. Contact B. McGrath, bmcgrath@aws.org, ext. 311.

Surfacing Industrial Mill Rolls


Magnesium Alloy Filler Metals

A5L Subcommittee on Magnesium Alloy Filler Metals to assist in the updating of AWS A5.19-92 (R2006), Specification for Magnesium Alloy Welding Electrodes and Rods. Contact R. Gupta, gupta@aws.org, ext. 301.

Robotic and Automatic Welding


Thermal Spraying


Labeling and Safe Practices

SH14 Subcommittee on Labeling and Safe Practices to update AWS F2.2, Lens Shade Selector; AWS F4.1, Safe Practices for the Preparation of Containers and Piping for Welding and Cutting; and the AWS Safety and Health Fact Sheets. S. Hedrick, steveh@aws.org, ext. 305.

Nominations Sought for the M.I.T. Award

November 2, 2011, is the deadline for submitting nominations for the 2012 Prof. Koichi Masubuchi Award, sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology (M.I.T.).

This award, including an honorarium of $5000, is presented each year to one person, 40 years old or younger, who has made significant contributions to the advancement of materials joining through research and development.

Member-Get-A-Member Campaign

Listed are the members participating in the 2010–2011 Member-Get-A-Member (MGM) campaign effective 9/18/2010. For campaign rules and the prize list, see page 65 in this Welding Journal or visit the AWS campaign Web site www.aws.org/mgm.

Call the AWS Membership Dept. (800/305) 443-9353, ext. 480, for information on your member-proposer point status.

Winner’s Circle

Sponsored 20+ new members per year since 6/1/1999. The superscript indicates the number of years the member has achieved this status.

J. Compton, San Fernando Valley7 E. Ezell, Mobile7 J. Merzthal, Peru2 G. Taylor, Pascagoula2 B. Chin, Auburn-Opelika1 S. Esders, Detroit1 M. Haggard, Inland Empire1 M. Karagoulis, Detroit1 S. McGill, NE Tennessee1 B. Mikeska, Houston1 W. Shreve, Fox Valley1 T. Weaver, Johnstown-Altoona1 G. Woomer, Johnstown-Altoona1 R. Wray, Nebraska1

President’s Club

Sponsored 3–8 new members


President’s Honor Roll

Sponsored 2 new members

M. Allen, Charlotte R. Fuller, Florida W. Coast J. Hill, Nebraska J. Hope, Puget Sound A. Laabs, Lakeshore M. Pelegrino, Chicago W. Wall, Auburn D. Wright, Kansas City

Student Member Sponsors

Sponsored 3 or more members

M. Pelegrino, Chicago — 69


WELDING JOURNAL 57
New AWS Supporters

**Brake Supply Co., Inc.**
5501 Foundation Blvd.
Evansville, IN 47725
Representative: Scott Francis
www.blake.com

Brake Supply is a certified company offering new and remanufactured replacement products for original equipment manufacturers, including Caterpillar, Euclid/VME, Wabco/Dresser, Komatsu, Terex, Unit Rig, and others. Its specialties include wet and dry brakes, clutches, drivelines, pneumatics, and hydraulic products.

**Indian Hills Community College**
525 Grandview Ave.
Ottumwa, IA 52501
Representative: John D. Hopwood
www.indianhills.edu

The Indian Hills C. C. welding technology program prepares students for a variety of industrial settings, providing them with the best opportunity for success. The program uses the latest technology in welding equipment with highly skilled instructors. The college has been successfully training welding students for more than 40 years.

**New Sustaining Companies**

**Cives Steel Co.**
825 Old Alabama Rd., Ste. 200
Roswell, GA 30076
Representative: Patrick J. Fortney
www.cives.com

For 58 years, Cives Steel Co. has used its precision, capacity, and expertise to make engineering services and project support the cornerstone of its business. The company ensures that each assignment, no matter how large or complex, is fabricated to the customers’ specifications and tolerances.

**New AW Supporters**

**Brake Supply Co., Inc.**
5501 Foundation Blvd.
Evansville, IN 47725
Representative: Scott Francis
www.blake.com

Brake Supply is a certified company offering new and remanufactured replacement products for original equipment manufacturers, including Caterpillar, Euclid/VME, Wabco/Dresser, Komatsu, Terex, Unit Rig, and others. Its specialties include wet and dry brakes, clutches, drivelines, pneumatics, and hydraulic products.

**R-V Industries, Inc.**
584 Poplar Rd.
Honey Brook, PA 19344

**Supporting Company**
Poly-Matrix, Inc.
700 Cherry St.
Blanchester, OH 45107

**Educational Institutions**

**Champlain Valley Educational Services**
Plattsburgh Satellite Campus
518 Rugar St., Plattsburgh, NY 12901

**Educational Institutions**

**Northumberland County C.T.C.**
1700 W. Montgomery St.
Coal Township, PA 17866

**Rabiiya Industrial Training Institute**
Masjid Rd., Ashrafi Complex (Opposite Canara Bank) Golmuri, Jamshedpur, Jharkhand 831003, India

**San Benito High School-Ag Mechanics**
450 S. Williams Rd.
San Benito, TX 78586

**Woodson Center for Excellence**
342 Cockerell Dr., Abilene, TX 79601

**Honorary Meritorious Awards**

The Honorary Meritorious Awards Committee makes recommendations for the nominees received to the Honorary Membership, National Meritorious Certificate, William Irrgang Memorial, and the George E. Willis Awards. These honors are presented during FABTECH each fall. The deadline for submissions is December 31 prior to the year of the awards presentations. Send candidate materials to Wendy Sue Reeve, secretary, wreeve@aws.org; 550 NW LeJeune Rd., Miami, FL 33126. Descriptions of these awards follow.

**William Irrgang Memorial Award**

Sponsored by The Lincoln Electric Co. in honor of William Irrgang, the award, administered by AWS, is given each year to the individual who has done the most over the past five years to enhance the Society’s goal of advancing the science and technology of welding. It includes a $2500 honorarium and a certificate.

**National Meritorious Certificate Award**

This certificate award recognizes the recipient’s counsel, loyalty, and dedication to AWS affairs, assistance in promoting cordial relations with industry and other organizations, and for contributions of time and effort on behalf of the Society.

**George E. Willis Award**

Sponsored by The Lincoln Electric Co. in honor of George E. Willis, the award, administered by AWS, is given each year to an individual who promoted the advancement of welding inter-

nationally by fostering cooperative participation in technology transfer, standards rationalization, and promotion of industrial goodwill. It includes a $2500 honorarium and a certificate.

**Honorary Membership Award**

The honor is presented to a person of acknowledged eminence in the welding profession, or to one who is credited with exceptional accomplishments in the development of the welding art, upon whom the Society deems fit to confer an honorary distinction. Honorary Members have full rights of membership.

**International Meritorious Certificate Award**

This honor recognizes recipients’ significant contributions to the welding industry for service to the international welding community in the broadest terms. The awardee is not required to be an AWS member. Multiple awards may be given. The award consists of a certificate and a one-year AWS membership.
Shown working on the welding truck are Long Island Section members (from left) Sal Spallino, Ray O’Leary, Chair Brian Cassidy, Deputy Director Harland Thompson, Barry McQuillen, and Tom Gartland.

District 1
Thomas Ferri, director
(508) 527-1884
thomas_ferri@thermadyne.com

GREEN & WHITE MOUNTAINS
SEPTEMBER 16
Speakers: Burt Riendeau, David Schaffer
Affiliation: Airgas
Topic: Shielding gases for GMAW
Activity: The program was held at River Valley Tech School in Springfield, Vt. Following the talks, the Section members, welding students, and guests participated in a hands-on tour of the school’s welding laboratory. Mike Hakey, last year’s Vermont SkillsUSA winner, gave a presentation about his experiences during the Kansas City competition.

District 2
Kenneth R. Stockton, director
(908) 412-7099
kenneth.stockton@pseg.com

LONG ISLAND
SEPTEMBER 16
Activity: Several Section members joined their talents to build a welding business vehicle. The participants were Sal Spallino; Ray O’Leary; Brian Cassidy, chairman; Harland Thompson, deputy District 2 director; Barry McQuillen; and Tom Gartland.
Shown during the Lancaster Section tour of The Warrell Corp. are (from left) Terry Gross, Brian Gross, Justin Heistand, Mike Sebergandio, David Watson, and Jerry Cross.

Speaker Frank York (right) is shown with Bill Strate, North Florida Section treasurer.

Lancaster Section Chairman Mike Sebergandio (right) thanks Terry Gross for sharing some of his candy-making secrets.

Shown at the North Florida Section program are (from left) District 5 Director Steve Mattson, AWS Vice President Nancy Cole, and speaker Frank York.

District 4
Roy C. Lanier, director
(252) 321-4285
rlanier@email.pittcc.edu

District 5
Steve Mattson, director
(904) 260-6040
steve.mattson@yahoo.com

NORTH FLORIDA
SEPTEMBER 9
Speaker: Frank York
Affiliation: Advanced Automated Welding
Topic: Orbital GTA welding processes
Activity: Thirty-two members and guests attended the program, including AWS Vice President Nancy Cole and Steve Mattson, District 5 director. The program was held in Jacksonville, Fla.

District 3
Michael Wiswesser, director
(610) 820-9551
mike@welderinstitute.com

LANCASTER
AUGUST 25
Activity: The Section members donned hair nets and lab coats to tour The Warrell Corp. candy-making plant in Camp Hill, Pa. Terry Gross, product development manager, and Eric Murray conducted the program, explained the numerous processes and some of the science behind dry roasting nuts, pulling taffy, and making chocolate-covered pretzels and other tasty snacks. Participating were Chair Mike Sebergandio, Justin Heistand, David Watson, Jerry Cross, Janelle Sebergandio, and Brian Gross.

District 6
Kenneth Phy, director
(315) 218-5297
KAPhyInc@gmail.com

NIAGARA FRONTIER
AUGUST 11
Activity: Section members, including Jess Bedard, Tom Matecki, Harry Carlson, Ken Jozwick, and Matt Hezel, manned a booth during a well-attended Cruise Night at Lancaster Speedway to introduce automobile enthusiasts to welding opportunities and American Welding Society offerings. The AWS booth was sponsored by Quality Technical Training Institute, Depew,
N.Y., an accredited AWS welding school. The Section members estimated they discussed welding with at least 1000 visitors, and distributed 200 Jay Leno DVDs and 300 copies of Your Career in Welding brochures. On display were examples of welding solutions for building and repairing auto parts including a redesigned Ford rear-end housing, custom-modified oil pan, pro stock car aluminum head with extensive rework, and various repaired tanks and bottles.

**District 7**

Don Howard, director  
(814) 269-2895  
howard@ctc.com

**COLUMBUS**

**November Meeting Notice**  
The November meeting sponsor will be ASME. For date, time, and topic, visit www.awssection.org/columbus, click on the “Calendar” tab, or contact Chair Bryan Lyons at bryan@osu1.net; or call (614) 418-7520.

**District 8**

Joe Livesay, director  
(931) 484-7502, ext. 143  
joe.livesay@ttcc.edu

**GREATER HUNTSVILLE**

**August 19**  
Activity: The Section met at Marshall Technical School in Guntersville, Ala., to discuss arrangements for members to attend the upcoming FABTECH show in Atlanta, and discuss plans for a student welding contest.

**District 9**

George D. Fairbanks Jr., director  
(225) 473-6362  
ffts@bellsouth.net

**BIRMINGHAM**

May 11

Activity: The Section members, students, and guests toured the Gardendale High School welding department facilities in Gardendale, Ala. Welding instructor Tim Turner conducted the tour and discussed the welding curriculum. District 9 Director George Fairbanks presented Roy Ledford the Section Educator Award and the Section Meritorious Award to Jim Cooley.
AWS President John Bruskotter (far right) is shown with the scholarship winners at the Sept. 9 Detroit Section students’ night program.

Shown at the Detroit Section students’ night program are Lapeer County welding students (from left) Sean Murray, Joe Dzieszkowski, Amanda Rhein, instructor Tony Major, Mark Wells, and Andrez Klos.

Lakeshore Section members toured Kewaunee Fabrications. Shown are guides (from left) Jack Delleman, Jim Peot, John Robillard, Mike Urban, and John Zielonka, Section vice chair.

Mike Palko, Detroit Section membership chair, manned a booth at the Battery Joining and Manufacturing Symposium.

**District 10**
Richard A. Harris, director
(440) 338-5921
richaharris@windstream.net

**District 11**
Eftihios Siradakis, director
(989) 894-4101
ft.siradakis@airgas.com
DETROIT
SEPTEMBER 8
Activity: The Section participated in the Battery Joining and Manufacturing Symposium along with Edison Welding Institute; Society of Automotive Engineers, Detroit chapter; and The Ohio State University Center for Automotive Research. The focus of this event was to address technologies associated with electric vehicle manufacturing. An area of emphasis was the joining processes used to manufacture stored energy devices.

SEPTEMBER 9
Speaker: John Bruskotter, AWS president Affiliation: Bruskotter Consulting Services Topic: AWS Energizes the World Activity: The Detroit Section hosted its annual students’ night program at Macomb Community College in Warren, Mich., for 89 attendees. Scholarships totaling $33,250 were awarded to 29 students representing the Wayne County Community College District and Ferris State University. Also attending were students from the Lapeer County Intermediate School District who attended the 2010 SkillsUSA National Conference in Kansas City, including Sean Murray who took third place in the overall welding individual category competition. Following the presentations, attendees toured the college’s welding lab.

LAKE SHORE
SEPTEMBER 9
Activity: The Section members and guests toured Kewaunee Fabrications LLC in Kewaunee, Wis. Section Vice Chair John Zielonka presented a history of the company beginning in 1941 with production of Navy vessels. Jack Dellemen, Jim Peot, John Robillard, Mike Urban, and John Zielonka led the tour including the Burn Shop featuring online beveling and stamping operations, and the production areas for manufacturing fire truck ladders and associated aerial device fabrications, armor-plated truck sections, frames for Caterpillar road reclaimers, Oshkosh Co. products including snow trucks, Pierce pump tanker fire engines, and Striker 1500 airport fire-suppression and emergency response vehicles. The Section recognized Andrew Miller, age 19, on becoming the youngest AWS CAWI. The Section provided financial support for Miller to complete his studies at Hobart Welding Institute. The dinner was held at Port O’Call Restaurant in Kewaunee, Wis.
District 15 Conference
JUNE 12
Activity: The District 15 conference was held at University of Saskatchewan, Saskatoon, Canada, hosted by Mace Harris, District 15 director. Attending were representatives from the Northwest, Saskatoon, Northern Plains, and Arrowhead Sections, including Jay Gerdin, Ike Oguocha, Bob Renner, Joel Ziegler, and Tom Baldwin. The staff representative was Jeff Weber, senior deputy executive director.

District 16
David Landon, director
(641) 621-7476
dandon@vermeermfg.com

KANSAS
SEPTEMBER 9
Activity: The Section members met at Wichita Area Technical College National Center for Aviation Training in Wichita, Kan., to tour the new facilities. Sheree Utash, senior vice president of academic affairs, learner services, conducted a tour of the welding center and lab and the other training facilities.

KANSAS CITY
SEPTEMBER 9
Speaker: Brian Garrett
Affiliation: Iron Workers Local 10
Topic: Details of the Iron Workers apprenticeship program.
Win Great Prizes in the 2010-2011 AWS Member-Get-A-Member Campaign*

ABOUT: AWS is looking for individuals to become part of an exclusive group of AWS Members who get involved and win. Give back to your profession, strengthen AWS and win great limited-edition prizes by participating in the 2010-2011 Member-Get-A-Member Campaign. By recruiting new members to AWS, you’re adding to the resources necessary to expand your benefits as an AWS Member. Year round, you’ll have the opportunity to recruit new members and be eligible to win special contests and prizes. Referrals are our most successful member recruitment tool. Our Members know first-hand how useful AWS Membership is, and with your help, AWS will continue to be the leading organization in the materials joining industry.

To recruit new Members, use the application on the reverse, or visit www.aws.org/mgm

PRIZE CATEGORIES

**President's Honor Roll:** Recruit 1-2 new Individual Members and receive an AWS Sportpack bag.

**President's Club:** Recruit 3-8 new Individual Members and receive an AWS hat and an AWS Sportpack bag.

**President’s Roundtable:** Recruit 9-19 new Individual Members and receive an AWS polo or denim shirt, hat and an AWS Sportpack bag.

**President’s Guild:** Recruit 20 or more new Individual Members and receive an AWS Messenger Bag, an AWS polo or denim shirt, a one-year free AWS Membership, the "Shelton Ritter Member Proposer Award" Certificate and membership in the Winner’s Circle.

**Winner's Circle:** All members who recruit 20 or more new Individual Members will receive annual recognition in the Welding Journal and will be honored at the FABTECH Show.

**SPECIAL PRIZES**

Participants will also be eligible to win prizes in specialized categories. Prizes will be awarded at the close of the campaign (June 2011).

**Sponsor of the Year:** The individual who sponsors the greatest number of new Individual Members during the campaign will receive a plaque, a trip to the 2011 FABTECH Show, and recognition at the AWS Awards Luncheon at the Show.

**Student Sponsor Prize:** AWS Members who sponsor two or more Student Members will receive an AWS Sportpack bag.

**International Sponsor Prize:** Any member residing outside the United States, Canada and Mexico who sponsors the most new Individual Members will receive a complimentary AWS Membership renewal.

**LUCK OF THE DRAW**

For every new member you sponsor, your name is entered into a quarterly drawing. The more new members you sponsor, the greater your chances of winning. Prizes will be awarded in November 2010, as well as in February and June 2011.

**Prizes Include:**
- Complimentary AWS Membership renewal
- AWS t-shirt
- AWS hat

**SUPER SECTION CHALLENGE**

The AWS Section in each District that achieves the highest net percentage increase in new Individual Members before the June 2011 deadline will receive special recognition in the Welding Journal.

The AWS Sections with the highest numerical increase and greatest net percentage increase in new Individual Members will each receive the Neitzel Membership Award.

*The 2010-2011 MGM Campaign runs from June 1, 2010 to May 31, 2011. Prizes are awarded at the close of the campaign.
AWS MEMBERSHIP APPLICATION

4 Easy Ways to Join or Renew:
- Mail this form, along with your payment, to AWS
- Call the Membership Department at (800) 443-9353, ext. 480
- Fax this completed form to (305) 443-5647
- Join or renew on our website <www.aws.org/membership>

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

Last Name
First Name
Title

Were you ever an AWS Member? ☐ YES ☐ NO If “YES,” give year__ and Member # __

Primary Phone ( ) Secondary Phone ( )

FAX ( )

E-Mail

Did you learn of the Society through an AWS Member? ☐ YES ☐ NO

If “YES,” Member’s name: __ Member’s # (if known):

From time to time, AWS sends out informational emails about programs we offer, new Member benefits, savings opportunities and changes to our website. If you would prefer not to receive these emails, please check here ☐

ADDRESS

Note: This address will be used for all Society mail.

Company (if applicable)
Address
Address Con’t

City___ State/Province___ Zip/Postal Code___ Country___

PROFILE DATA

Note: This data will be used to develop programs and services to serve you better.

☐ Who pays your dues?: ☐ Company ☐ Self-paid

☐ Sex: ☐ Male ☐ Female

☐ Education level: ☐ High school diploma ☐ Associate’s ☐ Bachelor’s ☐ Master’s ☐ Doctoral

PAYMENT INFORMATION (Required)

ONE-YEAR AWS INDIVIDUAL MEMBERSHIP $80
TWO-YEAR AWS INDIVIDUAL MEMBERSHIP $160 $135 (New Members Only)

If yes, add one-time initiation fee of $12...

International Members add $90 for optional hard copy of Welding Journal (note: digital delivery of $7 is standard)...

Domestic Members add $25 for book selection ($192 value), and save up to 87%...

International Members add $75 for book selection (note: $50 is for international shipping)...

(Note: Book Selection applies to new Individual Members only – Book selections on upper-right corner)

TOTAL PAYMENT $...

AWS STUDENT MEMBERSHIP ☐ Domestic (Canada & Mexico incl.) $15
☐ International $50

TOTAL PAYMENT $...

NOTE: Dues include $18.70 for Welding Journal subscription and $4.00 for the AWS Foundation.

BOOK/CD-ROM SELECTION

Pay Only $25... up to a $192 value

Note: Only New Individual Members are eligible for this selection. Be sure to add $25 to your total payment.

ONLY ONE SELECTION PLEASE.

☐ Jefferson’s Welding Encyclopedia (CD-ROM only)
☐ Design and Planning Manual for
Cost-Effective Welding
☐ Welding Metallurgy
☐ Welding Handbook (9th Ed., Vol. 3)
☐ Welding Handbook (9th Ed., Vol. 2)
☐ Welding Handbook (9th Ed., Vol. 1)

For more book choices visit www.aws.org/membership

Learn more about each publication at www.awspubs.com

☐ New Member ☐ Renewal

A free local Section Membership is included with all AWS Memberships. Section Affiliation Preference (if known):

Type of Business (Check One only):

☐ Contract construction
☐ Chemicals & allied products
☐ Petroleum & coal industries
☐ Primary metal industries
☐ Fabricated metal products
☐ Machinery except elect. (incl. gas welding)
☐ Electrical equip., supplies, electrodes
☐ Transportation equip. — air, aerospace
☐ Transportation equip. — rail, ships
☐ Transportation equip. — railroad
☐ Utilities
☐ Welding distributors & retail trade
☐ Misc. repair services (incl. welding shops)
☐ Educational Services (univ., libraries, schools)
☐ Engineering & architectural services (incl. assocs.)
☐ Misc. business services (incl. commercial labs)
☐ Government (federal, state, local)
☐ Other

Job Classification (Check One only):

☐ President, owner, partner, officer
☐ Manager, director, superintendent (or assistant)
☐ Sales
☐ Purchasing
☐ Engineer — welding
☐ Engineer — design
☐ Engineer — manufacturing
☐ Engineer — other
☐ Architect designer
☐ Metallurgist
☐ Research & development
☐ Quality control
☐ Inspector, tester
☐ Supervisor, foreman
☐ Technician
☐ Welder, welding or cutting operator
☐ Consultant
☐ Educator
☐ Librarian
☐ Student
☐ Customer Service
☐ Other

Technical Interests (Check all that apply):

☐ Ferrous metals
☐ Aluminum
☐ Nonferrous metals except aluminum
☐ Advanced materials/Intermetallics
☐ Ceramics
☐ High energy beam processes
☐ Arc welding
☐ Brazing and soldering
☐ Resistance welding
☐ Thermal spray
☐ Cutting
☐ LND
☐ Safety and health
☐ Bending and shearing
☐ Roll forming
☐ Stamping and punching
☐ Aerospace
☐ Automotive
☐ Machinery
☐ Marine
☐ Piping and tubing
☐ Pressure vessels and tanks
☐ Sheet metal
☐ Structures
☐ Other
☐ Automation
☐ Robotics
☐ Computation of Welding
Activity: Grant Von Lunen, welding instructor at Kansas City, Kan., Community College Technical Education Center, was presented the Section Educator of the Year Award.

District 17
J. Jones, director
(940) 368-3130
jjones@thermadyne.com

District 18
John Bray, director
(281) 997-7273
sales@affiliatedmachinery.com

HOUSTON
SEPTEMBER 13
Activity: The Section members participated in a welding contest at Wharton County Jr. College in Wharton, Tex. Roy Jones, Welding Department head, and John Bray, District 18 director, supervised the event.

SAN ANTONIO
SEPTEMBER 14
Speaker: Rene Hernandez
Topic: PipeWorx welding system and ASME Section 9 update
Activity: The first meeting of the season, hosted by Chair Steve Sigler, included 53 students representing the Alamo and Floresville Student Chapters. The program was held at St. Joseph’s Hall in San Antonio, Tex. John Mendoza, AWS vice president, attended the event.

District 19
Neil Shannon, director
(503) 419-4546
neilshnn@msn.com

PUGET SOUND
SEPTEMBER 7
Activity: The Section hosted the West Coast Pipe Design & Welding Symposium in Seattle, Wash. Eight speakers presented papers and four scholarships were presented during the all-day event. The presenters included Barbara Henon; Steve Carter with Precore; Ed Hansen and John Brinkley from ESAB; Pete Theriot with Mathey Dearman; Brent Keil with N.W. Pipe Co.; Blain Maki with Metal Test, Inc.; and Chris Sunberg from CH2M Hill, Inc.

District 20
William A. Komlos, director
(801) 560-2353
bkoz@arctechllc.com

COLORADO
SEPTEMBER 9
Speaker: Richard Roen
Topic: The ultimate welding robot
Activity: Speaker Roen was recognized for his long career in welding and nondestructive testing. He has served 18 years in space programs, eight years in offshore work, and 25 years in research and process and equipment development. Presently, he is introducing automation into the Canadian oil field tank production operations. The event was held at Las Brisas Restaurant in Englewood, Colo.
Shown at the Colorado School of Mines Student Chapter program are (from left) Steve Duren, Dave Fullen, Advisor Stephen Liu, Kin-Ling Sham, Caleb Roepke, Collin Trickel, Scott Mitzner, Scott Gordon, Erik Lord, Pavel Campos, and Juan Carlos Madeni.

Shown are San Francisco Section past chairs (from left) Dale Phillips, Richard Hashimoto, Andy Ochoa, Liisa Pine, Andre Lopez, Sharon Jones, Joe Meyer, and Tom Smeltzer.

Liisa Pine chats with cryogenics specialist Mark Miller at the San Francisco Section program in September.

**Colorado School of Mines Student Chapter**

**AUGUST 2**

Activity: **David Fullen** of Lincoln Electric and **Steven Duren** of General Air visited the school in Golden, Colo., to tour its Center for Welding, Joining, and Coatings Research facilities, conducted by **Stephen Liu**, Student Chapter advisor and professor at the center. Fullen and Duren held a special ceremony to honor the graduating class, featuring the presentation of bright red lab coats. The graduates included **Kin-Ling Sham**, Caleb Roepke, Collin Trickel, Scott Mitzner, Scott Gordon, Erik Lord, Pavel Campos, Juan Carlos Madeni, Karem Tello, Hamad Al-mostaneer, Tariq Al-Ghamdi, Richard Derrien, Christine Hillier, Dan Baker, Kamalu Koenig, Damian Illing, and Michael Liu.

**District 21**

**Nanette Samanich, director**

(702) 429-5017

Nan07@aol.com

**District 22**

**Dale Flood, director**

(916) 288-6100, ext. 172

flashflood@email.com

**SAN FRANCISCO**

**SEPTEMBER 1**

Speaker: **Mark Miller**

Affiliation: Airgas, construction specialist

Topic: Some fun and technical facts about cryogenics

Activity: The Section celebrated its past chairs at Spenger’s Restaurant in Berkeley, Calif. Past chairs attending included Dale Phillips, Richard Hashimoto, Andres Ochoa, Liisa Pine, Andre Lopez, Sharon Jones, Tom Smeltzer, and current Chair Joe Meyer. Tom Smeltzer received the Distinguished Service Award, and Andres Ochoa and David Nourot received District Educator Awards. Forty-nine members and guests plus 15 student members attended the program, featuring Miller’s spectacular demonstrations of what cryogenic fluids can do.
Guide to AWS Services

550 NW LeJeune Rd., Miami, FL 33126; (800/305) 443-9353; FAX (305) 443-7599; www.aws.org

Staff extensions are shown in parentheses.

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jbruskotter@epweb.com

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Corporate Director, Exhibition Sales
Joe Kral...jkrall@aws.org .................(297)

Organizes annual AWS welding show, convention, space assignments, and other expo activities.

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NEW EDITION! D1.1/D1.1M:2010, Structural Welding Code—Steel
For everyone involved in any phase of welding steel structures—engineers, detailers, fabricators, erectors, inspectors, etc.—the new D1.1 spells out the requirements for design, procedures, qualification, fabrication, inspection, and repair of pipe, plate, and structural shapes that are subject to either static or cyclical stresses. U.S. Customary and SI units of measurement. 570 pages, 21 annexes, 171 figures, 78 tables, (2010).
D1.1 $496/$372

D1.1-SWJ-WC:2008, Welded Joint Details for Structural Applications Wall Chart
D1.1-SWJ-WC $40/$30

D1.1-BI, The Official Book of D1.1 Interpretations
A collection of responses to formal inquiries about the requirements of AWS D1.1 from 1976 to 2006. An excellent reference for AWS D1.1 users. 54 pages, 6 figures. (2008).
D1.1-BI $64/$43

D1.2/D1.2M:2008, Structural Welding Code—Aluminum
Covers welding requirements for any type of structure made from aluminum structural alloys, except aluminum pressure vessels and fluid-carrying pipelines. Includes sections on design of welded connections, procedure and performance qualification, fabrication, inspection, study welding, and strengthening and repair of existing structures. A commentary offers guidance on interpreting and applying the code. 226 pages, 59 figures, 24 tables, (2008).
D1.2 $164/$123

Covers welding of structural sheet/strip steels, including cold formed members, equal to or less than 3/16 in. (0.188 in./4.8 mm) nominal thickness and having a minimum specified yield point no greater than 80,000 psi (550 MPa). Applicable to welding of commonly used structural quality low-carbon hot rolled and cold rolled sheet and strip steel, with or without zinc coating (galvanized), to other structural sheet steels or to supporting structural steel members. Three weld types unique to sheet steel—arc spot, arc seam, and arc plug welds—are included. Includes sections on design, procedure and performance qualification, fabrication, inspection and stud welding as well as a commentary. 98 pages, 7 annexes, 44 figures, 11 tables, 3 forms (2008).
D1.3 $120/$90

Covers welding of reinforcing steel in most reinforced concrete applications. Includes sections on allowable stresses, structural details, workmanship requirements, technique, procedure and performance qualification, and inspection. Figures clearly illustrate important welding considerations: unacceptable weld profiles, effective weld sizes, details of joints of anchorages, base plates, and inserts. New in this edition: A comprehensive approach to radiographic testing of reinforcing steel welds; a section on weld cleaning, welder qualification requirements and testing for fillet welds, and updated forms for welding, testing, and inspection. 80 pages, 7 chapters, 5 annexes, 18 figures, 10 tables, (2005).
D1.4 $92/$69

NEW EDITION! D1.5M/D1.5:2010, Bridge Welding Code
Get the facts and code requirements for bridge building with carbon and low-alloy construction steels. Covers welding requirements of the American Association of State Highway and Transportation Officials (AASHTO) for welded highway bridges made from carbon and low-alloy construction steels. Chapters cover design of welded connections, workmanship, technique, procedure and performance qualification, inspection, and study welding. Features the latest AASHTO revisions and nondestructive examination requirements, as well as a section providing a “Fracture Control Plan for Nonredundant Bridge Members.” Revisions include:
• Revised procedure, personnel, and test equipment inspection requirements
• New materials and hybrid joint provisions
• New guidance on electro slag and narrow-gap ESW
Approx. 456 pages, 17 annexes, 90 figures, 43 tables, 9 forms, commentary (2010).
D1.5 $254/$198

D1.6/D1.6M:2007, Structural Welding Code—Stainless Steel
Covers requirements for welding stainless steel structural assemblies/components (excluding pressure vessels or pressure piping) using gas metal arc welding, shielded metal arc welding, flux cored arc welding, submerged arc welding, and stud welding. Allows prequalified Welding Procedure Specifications for the austenitic stainless steels based on considerable experience with the most widely used stainless steels. Sections include design, procedure and performance qualification, fabrication, inspection, and stud welding. 292 pages, 14 annexes, 80 figures, 29 tables, (2007).
D1.6 $160/$120

D1.7/D1.7M:2010, Guide for Strengthening and Repairing Existing Structures
Provides engineers and contractors with general direction and guidance on weld repairs, weld strengthening, and other procedures to correct problematic issues with existing structures made of steel (minimum yield strength of 100 ksi and minimum thickness of 1/8 inch), cast iron, and wrought iron. 52 pages, 4 tables, (2009).
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D1.8/D1.8M:2009, Structural Welding Code—Seismic Supplement
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Over 600 pages of comprehensive information on solid-state and other welding and cutting processes. The book includes chapters on resistance spot and seam welding, projection welding, flash and upset welding and high-frequency welding. In addition to a chapter on friction welding, a new chapter introduces friction stir welding. The most recent developments in beam technology are discussed in the greatly expanded chapters on laser beam welding and cutting and electron beam welding. A diverse array of processes are presented in chapters on the ultrasonic welding of metals, explosion welding, diffusion welding and diffusion brazing, adhesive bonding and thermal and cold spraying. The last chapter covers various other welding and cutting processes, including modernized water jet cutting, 669 pages, 15 chapters, 3 appendices, 438 illustrations, 59 tables; hardbound, 8” x 10”, (2007).
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A2.4 $148/$111

NEW EDITION! A3.0M/A3.0:2010, Standard Welding Terminology
Alphabetical glossary of over 1,400 standard terms and definitions for welding, brazing, soldering, resistance welding, etc., as well as hybrid processes. Each term has one clearly applicable definition, accurately reflecting the term's use in the joining world. Includes figures to illustrate the use of terms. For completeness, nonstandard terms are also included. Contains a Master Chart of Welding and Allied Processes, and the Joining Method Chart. 150 pages, 62 figures, 5 tables (2010).
A3.0 $148/$111

Addresses which examination method—visual, liquid penetrant, magnetic particle, radiographic, ultrasonic, electromagnetic (eddy current), or leak testing—best detects various types of discontinuities. Note: Does not address acceptance criteria. 64 pages, 30 figures, 4 tables, (2009), fourth edition.
B1.1M/B1.1 $104/$78

B1.11:2000, Guide for the Visual Examination of Welds
Provides guidance on visual examination of welds, including sections on prerequisites, fundamentals, surface conditions, and equipment. Sketches and color photographs illustrate common weld discontinuities. 48 pages, 3 annexes, 48 figures, (2000).
B1.11 $104/$78

Specifies all fusion welding processes and an exhaustive array of materials used in metal fabrication. Specifies requirements for the qualification of welding procedures, and for performance qualification of welders and welding operators for manual, semiautomatic, mechanized, and automatic welding. 290 pages, 43 figures, 25 tables, 5 forms (2009).
B2.1/B2.1M $176/$132

B4.0:2007, Standard Methods for Mechanical Testing of Welds
Describes the most common mechanical test methods applicable to welds and welded joints. Each test method gives details concerning specimen preparation, test parameters, testing procedures, and suggested report forms. Acceptance criteria are not included. Three new weldability tests (WLC, toughness, and GROD) and resistance weld tests have been included in this new edition. (Note: Joint tests for brazements are covered in AWS C3.2/M/C3.2.) U.S. Customary Units. 152 pages, 97 figures, (2007).
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NEW EDITION! C7.2:2010, Recommended Practices for Laser Beam Welding, Cutting, and Allied Processes
Covers common applications of the process, including drilling and transformational hardening, definitions, safe practices, general process requirements, and inspection criteria. 142 pages, 88 figures, 15 tables, (2010).
C7.2 $100/$75

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Covers the requirements for the underwater welding of structures or components in wet and dry environments at one-atmosphere and ambient atmospheres. Includes qualification and inspection requirements.

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Covers arc and braze welding requirements for nonstructural sheet metal fabrics using commonly weldable metals available in sheet form up to and including 3 gauge, or 0.350 in. Applications of the code include heating, ventilating, and air conditioning systems, food processing equipment, architectural sheet metal, and other nonstructural sheet metal applications. Sections include procedure and performance qualification, workmanship, and inspection. Nonmandatory annexes provide useful information on materials and processes. Not applicable when negative or positive pressure exceeds 30 kPa (5 psi). 70 pages, 29 figures, 10 tables, (2006).
D9.1M/D9.1 $72/$54

Covers welding processes applicable to the welding of all principal structural weldments and all primary welds used to manufacture cranes for industrial, mill, powerhouse, and nuclear facilities. Includes sections on design of welded connections, performance requirements, acceptance. Additional requirements cover repair welding of existing structures and nonflight hardware acceptance. Includes sections on design of welded connections, personnel and procedure qualification, fabrication, inspection, repair of existing structures and nonflight hardware acceptance. Includes sections on design of welded connections, personnel and procedure qualification, fabrication, inspection, repair of existing structures and nonflight hardware acceptance. Includes sections on design of welded connections, personnel and procedure qualification, fabrication, inspection, repair of existing structures and nonflight hardware acceptance.

D14.1/D14.1M $104/$78

D17.1:2001, Specification for Fusion Welding for Aerospace Applications
Specifies general welding requirements for welding aircraft and space hardware. Includes fusion welding of aluminum-based, nickel-based, iron-based, cobalt-based, magnesium-based, and titanium-based alloys using arc and high energy beam welding processes. Includes sections on design of welded connections, personnel and procedure qualification, fabrication, inspection, repair of existing structures and nonflight hardware acceptance. Includes sections on design of welded connections, personnel and procedure qualification, fabrication, inspection, repair of existing structures and nonflight hardware acceptance. Includes sections on design of welded connections, personnel and procedure qualification, fabrication, inspection, repair of existing structures and nonflight hardware acceptance.

D17.1 $160/$120

This invaluable training reference helps inspectors, engineers, and welders evaluate the difference between discontinuities and rejectable defects. 254 pages, 18 chapters, index, 106 figures, 16 tables, 61/2” x 9”, (2000), third edition.
WI $76/$57

WIT-T:2008, Welding Inspection Technology
For al-h ore-study course, this official reference textbook for the three-day AWS core seminar for CWI exam preparation is readable, informative, and comprehensive. 329 pages, 10 chapters, 379 figures and photographs, (2008).
WIT-T $272/$204

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A comprehensive, organized survey of the basics of brazing, processes, and applications. Addresses the fundamentals of brazing, brazing design, brazing filler metals and fluxes, safety and health, and many other topics. Includes new chapters on induction brazing and diamond brazing. A must-have for all brazers, brazing engineers, and students. 780 pages, 36 chapters, 3 appendices, 308 figures, 116 reference tables, fifth edition, (2007).
B10 $136/$102

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What is the main emphasis of this paper? Process Oriented ☐ Materials Oriented ☐ Modeling ☐
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Abstract:
Introduction (100 words max.) – Describe the subject of the presentation, problem/issue being addressed and its practical implications for the welding industry. Describe the basic value to the welding community with reference to specific communities or industry sectors.

Technical Approach, for technical papers only (100 words max.) – Explain the technical approach, experimental methods and the reasons why this approach was taken.

Results/Discussion (300 words max.) – For technical papers, summarize the results with emphasis on why the results are new or original, why the results are of value to further advance the welding science, engineering and applications. For applied technology and education papers, elaborate on why this paper is of value to the welding community, describe key aspects of the work developed and how this work benefits the welding industry and education.

Conclusions (100 words max.) – Summarize the conclusions and how they could be put to use – how and by whom.

NOTE: Abstract must not exceed one page and must not exceed the recommended word limit given above

Note: The Technical Program is not the venue for commercial promotions of a company or a product. All presentations should avoid the use of product trade names. The Welding Show provides ample opportunities for companies to showcase and advertise their processes and products.

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A recently released 24-page, full-color catalog features the company’s full line of equipment and accessories for bench top and free-standing wet and dry abrasive cut-off and mitre saws for both steel and nonferrous materials, and saw arm assemblies. Included is a wide assortment of belt Sanders, disc Sanders, combination belt and disc Sanders, belt grinders, dust collectors, vibratory finishers, accessories, stands, index fixtures, 5C collet-holding fixtures, abrasive belts, discs, and wheels. The catalog No. K09 may be ordered by phone or downloaded from the Web site.

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Thermal Spray Process Detailed in Brochure

Just released, the four-page, full-color, well-illustrated brochure, *Powder Application Made Easy*, details the company’s Spraywelder™ thermal spray system including a detailed five-step application process describing proper surface preparation, preheating, spraying, fusing, and finishing. Twenty-four nickel-chromium-boron, tungsten, cobalt, and composite hardfacing alloys are listed in a chart comparing Rockwell hardinesses and fusing temperatures in °F and °C. Described are spray rates, nozzles and spray patterns, coating density, and safety features. Visit the Web site or call to request data sheet SW-100.

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A new 56-page, full-color catalog illustrates and describes the company’s complete line of Arcair® brand air-carbon arc products for wide-ranging gouging and exothermic cutting needs encountered in many industries, including fabrication plants, shipyards, railroads, and farms. Included are product information for manual and automated gouging equipment,
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Welding Magnesium Alloys
Text Published

Released last month, Welding and Joining of Magnesium Alloys provides an in-depth review of both established and new techniques for welding magnesium (Mg) alloys, welding these reactive metals to other metals, and the necessary surface treatments. The 422-page, hardcover text discusses in Part 1 various topics including Mg welding metallurgy, preparation for welding, joining of Mg alloys to aluminum alloys, joining Mg to steel, and protection of Mg joints from corrosion. Part 2 details brazing and soldering of Mg alloys, mechanical joining methods, adhesive bonding, gas tungsten arc welding, variable-polarity pulsed-arc welding, hybrid laser welding, friction stir welding, resistance spot welding, and electromagnetic welding of Mg alloys. The text is described as a comprehensive reference for producers of primary Mg; users of Mg alloys in the welding, automotive, and similar industries; and academicians involved in metallurgy and materials science research.

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Virtual Welding Training Technology Described

An eight-page, full-color brochure illustrates and describes the features and advantages of using the VRTEX™ 360 virtual reality (VR) arc welding equipment and FirstPass™ welding curriculum. The system trains welders faster using an interactive VR experience combined with state-of-the-art instructor resources to teach many arc welding procedures using a wide variety of weld joint configurations. Visual cues provide real-time welding technique feedback similar to a video game. The student is immersed in a virtual welding booth, construction site, or desert environment enhanced by a combination of realistic weld pool simulations and arc welding sounds, coordinated to the welder’s movements, to provide an effective, 3-D, hands-on training experience. Described are the instructor tools to integrate the VR training into traditional welding training programs and student reports that document each student’s progress. Additional advantages for the technology are listed, including reduced material waste, energy savings, and savings in shielding gas, consumable parts, and cost of waste disposal.

www.lincolnelectric.com/vrtex360/literature.asp
(888) 935-3878

Grinder Safety Training on CD-ROM

A new safety training series on CD-ROM is described as an interactive training experience using a multimedia presentation. The CD is focused on personal protection for pedestal and bench grinders. The topics covered include personal protective equipment, grinder and grinding wheel rev/min compatibility, performing ring tests, grinding wheel installation, guard adjustments, and aluminum oxide grinding wheels. The CD is formatted for PCs running Windows® Vista, XP, and 2000. For information on this and other safety-related and OSHA books, CDs, and DVDs, visit the Web site or call.

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Air-Pollution Control Products Pictured

A product overview brochure illustrates and lists the major features of a cross section of the company’s product lines. Shown are dust collectors, Zephyr® portable units, packaged systems, fan motors, controllers, FarrVac, GS-Mini™ portable dust collectors, GSB booths, Cyclone separators, and Hemiplat® and DuraPleat® filters. The product sheet can be downloaded from the Web site listed.

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“We’d like to see our sales guys be Certified Welding Inspectors, and this is a real nice stepping stone.” — Larry Burnett, S. J. Smith Co.

“Knowledgeable inside and outside sales people can answer any question when customers call us or walk into our stores. We believe that kind of service adds value to what we sell.” — Bill Pagliaro, ABCO Welding Supply

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Los Angeles: Jan. 26-28
Miami: Feb. 23-25
Houston: Mar. 23-25
Miami: May 4-6
Atlanta: Jun. 8-10

www.aws.org/CWSR
Airgas Appoints Chair

Airgas, Inc., Radnor, Pa., has appointed John C. van Roden Jr. chairman of its board of directors. Van Roden has served as a director since 2006, and has 20 years of experience in leadership positions at P. H. Glatfelter, Conectiv, and Lukens.

GH Induction Names Sales Director

GH Induction Atmospheres, based in Rochester, N.Y., has appointed E. J. (Chip) Laskowski director of sales. Laskowski has more than ten years of experience in the induction heating industry. He most recently served as national sales manager for Ameritherm, Inc., an upstate New York manufacturer of induction heating power supplies.

Kaman Names a President

Kaman Corp., Bloomfield, Conn., has named Steven J. Smidler president of its subsidiary, Kaman Industrial Technologies Corp. He succeeds T. Jack Cahill who has retired. Smidler has more than ten years of experience in the welding and welding equipment business, and managed numerous crises facing the industry. New members named to the board of directors include Matthew Dionne, Bill Emberson, Garney Scott III, William Toler, and David Youngblood. Dionne is president of Extrusion North America, Hydro. Emberson is manager of business development at RMT, Inc. Scott is president of Scepter, Inc. Toler is president and CEO of Smelter Service Corp.; and Youngblood is president and COO of Basic Resources, Inc.

Aluminum Association Annual Meeting Actions

The Aluminum Association, Rosemont, Ill., at its annual meeting held Sept. 22, presented Russ Wisor, Alcoa’s vice president, government affairs, its Marlan Boultlinghouse Award. Wisor was cited for his 30 years in the industry where he promoted aluminum across multiple markets, and managed numerous crises facing the industry. New members named to the board of directors include Matthew Dionne, Bill Emberson, Garney Scott III, William Toler, and David Youngblood. Dionne is president of Extrusion North America, Hydro. Emberson is manager of business development at RMT, Inc. Scott is president of Scepter, Inc. Toler is president and CEO of Smelter Service Corp.; and Youngblood is president and COO of Basic Resources, Inc.

ITW Names VP and Board Members

Illinois Tool Works, Inc. (ITW), Glenview, Ill., has elected Sundaram Nagarajan executive vice president, with responsibility for the company’s global welding businesses. Kevin M. Warren and Anir D. Williams have been elected to the ITW board of directors. With ITW for 19 years, Nagarajan has held a series of engineering and management roles within the company’s welding businesses. Most recently, he served as group president, welding international. Warren is president of the U.S. Solutions Group for Xerox Corp., and a vice president of the corporation. Williams is president of Global Commercial Card for American Express.

Kimberly-Clark Fills Key Safety Posts

Kimberly-Clark Professional, Roswell, Ga., has appointed Gil Madrid vice president, global safety; and David St-Hilaire senior director, North American safety. Madrid, with the company for 18 years, most recently served as Europe, Middle East, and Africa vice president, based in Europe. St-Hilaire, with the company since 1980, most recently held the post of director of channel development.

Member Milestone

Ebert Honored by OSU College of Engineering

Harry W. Ebert, a professional engineer licensed in Ohio and New Jersey, was honored by The Ohio State University (OSU) College of Engineering with the Distinguished Alumni Award. Gregory N. Washington, interim dean, College of Engineering, presented the award Sept. 10 during the 13th Annual Excellence in Engineering and Architecture Alumni Awards Luncheon. The Distinguished Alumni award was established to recognize distinguished achievement on the part of alumni in the field of engineering or architecture by reason of significant inventions, important research or design, administrative leadership, or genius in production.

An AWS Life Member, Ebert was elected an AWS Fellow in 1995, served as an AWS District director, and received the National Meritorious Award in “recognition of his good counsel, and promoting cordial relations with industry and other organizations.”

Ebert has volunteered his talents to the AWS Technical Activities Committee, and the A5 Committee on Filler Metals and Allied Materials and its subcommittees for many years, and chaired the D10 Piping and Tubing Committee. He currently serves as an advisor for the Committee on Piping and Tubing and its subcommittees on welding practices, welding chromium-molybdenum steel piping, heat treating of pipework, purging and root pass welding, and low-carbon steel pipe.

Ebert was a member of OSU’s first graduating class of welding engineers in 1948, then earned his master’s degree at Newark College of Engineering. He worked part-time at Marietta College teaching physics, engineering drawing, and shop math. He is a former member of the OSU-IWSC Faculty Advisory Committee and Edison Welding Institute’s Industry Advisory Board. He retired from the U.S. Army with the rank of colonel. Ebert retired in 2000 from Exxon Engineering where he served as principal welding engineer. With Exxon’s financial support, he established a Welding Engineering Scholarship Fund. Currently, Ebert serves as a part-time welding consultant.
Machine Shop Manager Named at Wall Colmonoy

Wall Colmonoy Aerobraze, Cincinnati, Ohio, has appointed Cory Lowe machine shop manager. Lowe, with 20 years of machining and engineering experience, will strengthen the company’s existing partnership with Rolls Royce, as well as grow the business.

Controls Manager Named at Applied Manufacturing

Applied Manufacturing Technologies, Orion, Mich., has appointed Edward Turley manager of its Controls Engineering Dept. His duties include management of its hardware and software design, and field support operations. Prior to joining the factory automation design, engineering, and process consulting services company, Turley held key management positions at Esys Corp.

Woodlawn Mfg. Names Plant Manager

Woodlawn Mfg. Ltd., Marshall, Tex., a high-volume, precision manufacturer of metal parts and assemblies, has named Cory R. Mayo plant manager. Previously, Mayo served as director of operations for two Stoneridge plants, a manufacturer of electronic systems for the automotive and agricultural markets.

SME Elects Board and Council Members

The Society of Manufacturing Engineers (SME), Dearborn, Mich., has elected four new members to its member council and six new members to its board of directors for the 2011-2012 term, plus one member, James W. Schlusemann, elected for a one-year term from Jan. 1 through Dec. 2011. The international directors include Warren R. DeVries, Wayne E. Frost, LaRoux K. Gillespie, Thomas R. Kurfess, Mark L. Michalski, and George E. West Jr. The new council members are Timothy D. Bond, Helen Greathouse, Brock T. Strunz, and Robert L. Wolff. The officers will be installed Nov. 13 during the SME fall board meeting in Dearborn, Mich. Their terms will begin Jan. 1, 2011.

Obituaries

Dennis Bileca

Dennis (Dionisie) Bileca, 71, died Sept. 23 at his home in Miami, Fla. He served on the AWS headquarters staff from 1984 to 2004, where he held several key positions, including manager, Certification Dept.; sales director, Convention Dept.; and purchasing director, Administration Dept. Born in Frasari, Romania, he immigrated to the United States at the age of ten. He served in the U.S. Navy for a number of years then completed college and graduate school. Bileca served as a professor at New York University and Rutgers University. He was also a small business owner, and an educational director. Donations may be made in his memory to the Division of Liver Diseases, University of Miami, 1500 NW 12th Ave., #1101E, Miami, FL 33136. Bileca is survived by his wife, Miriam, four children, and eleven grandchildren.

Kenneth L. Brown

Kenneth Leonard Brown, 79, died Sept. 20 in Cleveland, Ohio. He received his bachelor of science degree in chemistry from Western Reserve University in 1953, then worked for Union Carbide before joining the The Lincoln Electric Co. as a project research manager. At Lincoln, he served for more than 50 years before retiring in 2007. A member of the American Welding Society since 1975, he received the R. D. Thomas Memorial Award in 1998 and the AWS Safety and Health Award in 2000. Brown was a member and past chair of the AWS Safety and Health Committee, AWS Fumes and Gases Committee, Labeling and Safe Practices Committee, and served as the U.S. delegate to Commission VIII, Safety & Health, of the International Institute of Welding. Brown also chaired ISO/TC 44 SC9. At the National Electrical Manufacturers Association, he served on the Precautionary Labeling Committee and the Ask Group on Electromagnetic Fields. Brown held memberships in the American Chemical Society, ASM International, American Industrial Hygiene Association, American Ceramic Society, and the American Conference of Governmental Industrial Hygienists. Donations may be made to the Kenneth L. Brown Memorial Scholarship Fund, c/o Huntington National Bank. Brown is survived by his wife of 57 years, Nancy Elizabeth, seven children, and eleven grandchildren.

William A. Milek

William A. Milek, 92, died Sept. 3 in Glen Ellyn, Ill. He was a long-time member of the AWS D1 Committee on Structural Welding. After graduating from the University of Nebraska in 1941, he served as a second lieutenant combat engineer in the WWII South Pacific Theater building roads and ports often while invasions were in progress. His first duty was at Pearl Harbor, Hawaii, where he survived the December 7th attack. Promoted to captain, he was awarded two battle stars for his service during the invasions of Kwajabain Atoll in the Marshall Islands and Saipan in the Mariannas. He continued his military service in the Army National Guard until 1977 when he retired with the rank of lieutenant colonel. Milek joined the American Institute of Steel Construction (AISC) in 1955 as a district engineer based in Omaha, Neb. He served as a research engineer from 1961 to 1967 at AISC headquarters in New York City. He became director of engineering and research in 1968, and later served as vice president of engineering until his retirement in 1983. In 2000, Milek received the AISC Lifetime Achievement Award in honor of his many contributions to the institute and the structural steel industry. Milek is survived by three sons, a daughter, two brothers, two grandchildren, and a great-grandson.
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Annual FABTECH International & AWS Welding Show  
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**Submission Deadline: April 22, 2011**  
(Complete a separate submittal for each poster.)

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**Poster Title (max. 50 characters):**

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**Poster Requirements and Selection Criteria:**

- Only those abstracts submitted on this form will be considered. Follow the guidelines and word limits indicated.
  - Complete this form using MSWord. Submit electronically via email to mventura@aws.org or print and mail.
- Any technical topic relevant to the welding industry is acceptable (e.g., welding processes & controls, welding procedures, welding design, structural integrity related to welding, weld inspection, welding metallurgy, etc.).
- Submittals that are incomplete and that do not satisfy these basic guidelines will not be considered for competition.

Posters accepted for competition will be judged based on technical content, clarity of communication, novelty/relevance of the subject & ideas conveyed and overall aesthetic impression.

Criteria by category as follows:

**A) Student**
- Students enrolled in 2yr. college and/or certificate programs at time of submittal.
- Presentation need not represent actual experimental work. Rather, emphasis is placed on demonstrating a clear understanding of technical concepts and subject matter.
- Practical application is important and should be demonstrated.

**B) Student**
- For students enrolled in baccalaureate engineering or engineering technology programs at the time of submittal.
- Poster should represent the student's own experimental work. Emphasis is place on demonstrating a clear understanding of technical concepts and subject matter.
- Practical application and/or potential relevance to the welding industry is important and should be demonstrated.

**C) Student**
- For students enrolled in graduate degree programs in engineering or engineering technology at time of submittal.
- Poster should represent the student's own experimental work. Poster must demonstrate technical or scientific concepts. Emphasis is placed on originality and novelty of ideas presented.
- Potential relevance to the welding industry is important and should be demonstrated.

**D) Professional**
- For anyone working in the welding industry or related field.
- Poster must demonstrate technical or scientific concepts. Emphasis is placed on original contributions and the novelty of the presentation.
- Potential relevance to the welding industry is important and should be demonstrated.

**E) High School**
- Junior or Senior high school students enrolled in a welding concentration at the time of submittal.
- Presentation should represent technical concepts and application to the welding industry.
- Practical application and creativity are important and should be demonstrated.
Check the category that applies:

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☐ (D) Professional
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Abstract:

Introduction (100 words) – Describe the subject of the poster, problem/issue being addressed and its practical implications for the welding industry.

Technical Approach & Results (200 words) – Explain the technical approach. Summarize the work that was done as it relates to the subject of the poster.

Conclusions (100 words) – Summarize the conclusions and how they could be used in a welding application.

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A Control System for Keyhole Plasma Arc Welding of Stainless Steel Plates with Medium Thickness

BY C. S. WU, C. B. JIA, AND M. A. CHEN

ABSTRACT

Keyhole plasma arc welding (PAW) has the potential to achieve deep, narrow penetration with low cost and high tolerance of joint preparation. However, the narrow parameter window associated with the keyhole condition limits its wide application, especially for welding thicker plates. To reach its full potential, a control system for keyhole PAW is developed. The efflux plasma voltage signal is detected in real-time to characterize the keyhole size and dimension. The welding current waveform with two slow dropping substages and variable slopes is designed to improve the controllability of keyhole dynamics via reducing both heat input and arc force when a keyhole transforms from its opening status to the closure status. The keyhole PAW experiments are conducted to examine the control effectiveness of the system. The developed system operates in the mode of “one keyhole per pulse” reliably. Closed-loop control tests of varied-thickness plates show that even if the plate thickness changes as much as 50% (from 8 to 4 mm), the developed system adjusts the peak current and its dropping slopes automatically to keep both weld width and penetration consistent.

Introduction

The keyhole mode of welding is the primary attribute of high-power-density welding processes (plasma arc welding, laser beam welding, and electron beam welding) that can penetrate thicker workpieces with a single pass and produce welds with a high aspect ratio. Compared to laser beam welding and electron beam welding, keyhole plasma arc welding (PAW) is more cost effective and more tolerant of joint preparation (Refs. 1, 2). Thus, keyhole PAW has found wide application in industry (Refs. 3–8). However, the keyhole dynamics, i.e., the establishment, sustenance, and closure of the keyhole during the PAW process, is a critical issue in applying PAW (Ref. 9). In keyhole PAW, the quality of the weld depends on the keyhole stability, which itself depends on a large number of factors, especially the physical characteristics of the material to be welded and the welding parameters to be used (Ref. 10). In normal keyhole PAW, the keyhole is maintained open and stable to ensure weld quality. To this end, the welding process parameters, especially the welding current, have to be within a narrow range. If the welding current is a little bit lower, the keyhole may be closed, but if the welding current is a little bit higher, the keyhole expands too large and there is a tendency for the molten metal to be blown away from the weld pool, causing melt-through or cutting instead of joining. To solve this problem, Zhang et al. proposed a novel approach to operate keyhole PAW through employing pulsed current and to switch the current from the high peak current to the low base current after the keyhole is established (Ref. 11). In this way, while the establishment of the keyhole ensures the desired complete penetration, the base current allows the melted metal to solidify and the keyhole to close so that melt-through is prevented. After a specified period of base current, the peak current is applied again to reestablish the keyhole, beginning a new pulse cycle. As a result, the process is not maintained in the keyhole mode as it is classically defined, but in a mode of “one keyhole per pulse,” and the square waveform of the welding current is usually used (Refs. 11, 12). However, this square waveform is associated with quick step change of welding current from the peak level to the base level, which causes the keyhole condition to vary in a nonsmooth way, i.e., a rapid closure of the keyhole occurs. Furthermore, such a current waveform is just suitable in welding of thin sheets (Ref. 13). To avoid this problem, Zhang and Liu proposed another kind of current waveform with two declining substages when the welding current changes from the peak level to the base level (Ref. 14), but the first substage is with a fixed slope, and the welded workpiece thickness is still limited. Thus, it is necessary to investigate further for improving the flexibility of adjusting the keyhole condition for thicker plates.

Another critical issue for realizing automatic control of keyhole PAW with a wider parameter window is how to monitor and sense the keyhole dynamics. Once the feedback signals of the keyhole condition are sensed, the welding process parameters can be adjusted synchronistically to control the keyhole’s stability. Various methods have been used to monitor the keyhole condition, such as efflux plasma voltage, optical sensors, sound signal sensors, and plasma cloud charge sensors (Refs. 15–22). Each sensing method has some limitations. For example, optical sensors need a long time to

KEYWORDS

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Efflux Plasma Voltage
Stainless Steel Plates
Medium Thickness

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transfer and process video signals and cost a lot, and sound signal sensors are not accurate enough. The efflux plasma charge sensor measures the electrical potential resulting from the plasma efflux on the backside of the workpiece when the keyhole is established (Refs. 20-22). Although such a sensing approach has some disadvantages, i.e., the detection plate has to be mounted on the backside of the workpiece, its cost is low, its structure is simple, and its reliability is high.

In this study, a control system for the keyhole PAW process is developed to widen its parameter window. The efflux plasma voltage signal is used to characterize the keyhole size and weld dimension. The peak current and its duration, as well as its dropping slopes, are employed as the controlling variables. The ideal one keyhole per pulse condition is attempted for stainless steel plates with medium thickness. The flexibility of adjusting the keyhole condition is expected to improve further.

### Experimental System

Figure 1 shows the developed control system for the keyhole PAW process. It consists of the computer, PAW machine, data-acquisition unit, welding current sensor, and efflux plasma voltage sensor. The computer is the central unit of the system. On one hand, it can adjust welding current in real time and output any current waveforms as user defined (Ref. 23). On the other hand, it samples the transient signals of welding current and efflux plasma voltage, and adjusts the output current waveform parameters automatically to respond to any changes in the keyhole signal.

As shown in Fig. 1, the keyhole sensor is developed through measuring the efflux plasma voltage. The measuring bar is a piece of mild steel sheet mounted underneath the workpiece. It is kept insulated electrically. The distance between the workpiece and the measuring bar is fixed at about 6 mm. If the keyhole is established, the plasma jet must exit through the keyhole. The efflux plasma will establish an electrical potential between the workpiece and the measuring bar due to the phenomenon of plasma space charge (Refs. 11, 24). If the keyhole is not established, there will be no efflux plasma between the workpiece and the measuring bar, and thus, no electrical potential exists. A simple sensor consisting of a resistor and a capacitor is used to detect the electrical potential or the voltage between the workpiece and the measuring bar. The larger the keyhole size, the higher the intensity of the efflux plasma, thus, the larger the efflux plasma voltage. There is a correlation of the keyhole diameter at the backside with the measured efflux plasma voltage signal (Ref. 25).

### Control Strategy

Figure 2 shows the specially designed welding current waveform and keyhole signal. As the welding current drops from the peak level to the base level, two sub-stages of decreasing current with different slopes of \( K_1 \) and \( K_2 \) are added. At instant
At time $t_f$, the peak current $I_p$ is applied, and the system keeps detecting the signal from the efflux sensor. The signal of the efflux plasma voltage is around zero before the keyhole is established. At instant $t_2$, the keyhole is established and the efflux plasma voltage exceeds a certain value. To avoid the keyhole size from expanding too much, the current starts to decrease with a dropping slope $K_1$. Because of thermal inertia, the remaining keyhole volume expands slowly even though both heat input and arc force associated with the welding current start to drop during this stage. At instant $t_3$, when the keyhole size reaches the preset value to meet the desired practical requirements of weld quality, the current decreases at a steeper slope $K_2$ ($|K_2| > |K_1|$), so that the keyhole stops expanding but starts to close. At instant $t_4$, the keyhole is completely closed, and the efflux plasma voltage is zero. The current is switched to base level $I_B$ at instant $t_f$. After $I_B$ is applied for a preselected period $T_B = t_6 - t_5$, the current is switched to the peak level again to begin a new cycle. In this way, it can ensure keyhole establishment and complete penetration but avoid melt-through defects.

To characterize the keyhole size and weld bead width at the backside of the workpiece, the average value $(\langle V_{EP} \rangle)$ of efflux plasma voltage from $t_2$ to $t_3$ in each cycle is used as the feedback signal because it has been validated that the measured $V_{EP}$ is well correlated with the weld bead width at the backside of the workpiece (Ref. 25). Take the average value of efflux plasma voltage $(\langle V_{EP} \rangle)$ as the controlled variable. Take the pulse current value $(I_p)$ and its two dropping slopes $(K_1$ and $K_2)$ as the controlling variables. By adjusting $I_p$, $K_1$, and $K_2$, the $V_{EP}$ is kept within the preselected range so that the weld penetration and weld bead width are controlled. Figure 3 shows the schematic diagram of the closed-loop control system. The PI (proportional and integral) controller is used to adjust $I_p$, $K_1$, and $K_2$ according to the difference between the measured $V_{EP}$ and setpoint $V_{EP}$. The expression of discrete PI control algorithm may be written as

$$ u(k) = K_p e(k) + K_i \sum_{i=0}^{k} e(i) $$

where $u(k)$ is the output of PI controller, $e(k) = V_{EP}(k) - V_{EP}$ is the error (input of PI controller), $K_p$ and $K_i$ are coefficients, and $k$ is the cycle number.

As shown in Fig. 4, the base current $I_B$ is fixed, while $I_{K1}$ and $I_{K2}$ are correlated to the peak level $I_p$ in the following way,

$$ I_{K1} = I_B + 70\% \times (I_p - I_B) = 0.7I_p + 0.3I_B $$

$$ I_{K2} = I_B + 30\% \times (I_p - I_B) = 0.3I_p + 0.7I_B $$

(3)  \hspace{1cm} (4)

Referring to Fig. 4, the dropping current slopes $K_1$ and $K_2$ may be written as

$$ K_1 = -(I_p-I_{K1})/T_1 = -0.3(I_p-I_B)/T_1 $$

$$ K_2 = -(I_{K1}-I_{K2})/T_2 = -0.4(I_p-I_B)/T_2 $$

(5)

where $T_1$ and $T_2$ are defined in Fig. 2. Therefore, just through adjusting the peak level, the dropping current slopes $K_1$ and $K_2$ for two substages can be changed correspondingly, so that the waveform pa-
parameters can be set more easily but the characteristics of the controlled pulse current remain. Figure 5 is the control process flowchart of the system.

Control Experiment with 8-mm-Thick Workpiece

The developed control system was used to conduct closed-loop control experiments. The experiments used stainless steel (Type 304) for the workpiece. The thickness of the workpiece was 8 mm, and its dimensions were 200 mm in length and 80 mm in width. Bead-on-plate PAW was carried out. The test conditions were as follows: the distance from the nozzle to the workpiece surface was 6 mm; the shielding gas and the plasma gas were argon with respective flow rates of 20 L/min and 3 L/min; the welding speed was 120 mm/min. Other process parameters were set as follows: $I_B = 60$ A, $T_B = 50$ ms, $T_1 = 50$ ms, $T_2 = 50$ ms. As the controlling parameter, the pulse current $I_p$ was adjusted in-process, and other parameters such as $I_{K1}$, $I_{K2}$, $K_1$, and $K_2$ were determined by Equations 2–5. The setpoint for the desired value of the efflux plasma voltage $V_{EP}$ was preset as 1000 mV.

Figure 6 shows the weld appearance at both top and back sides. The weld bead width at both sides looks consistent. During the welding process, the experimental system captured the transient signals of welding current and efflux plasma voltage.
which are shown in Fig. 7. $V_E$ is the transient value of measured efflux plasma voltage, while $V_{EP}$ is the average value of $V_E$ in each cycle.

To demonstrate the response of the pulse current with respect to the efflux plasma voltage more clearly, the signals during the period from 53 to 60.5 s in Fig. 7 are magnified in the time scale. As shown in Fig. 8, one keyhole was established for every pulse. For each cycle, the keyhole formed and closed as the peak current changed. Because of thermal inertia, there was a delay between the current change and the keyhole signal. But the mode of one keyhole per pulse was achieved reliably. Figure 8A also illustrates the computer output (preset) and the measured current waveforms. It is validated that both are in good agreement, and the pulse current has a quick response to the efflux plasma voltage signal.

As shown in Fig. 8, although the workpiece thickness was not varied but kept at 8 mm, there may have been other disturbances during the welding process, so that the peak current $I_p$ of the five cycles were 213, 213, 218, 208, and 206 A, respectively. Due to the control action, the peak current, its duration and dropping slopes at two substages are not the same in each cycle, but are adjusted automatically based on the measured signal of efflux plasma voltage.

Figure 9 is the measured average values of the efflux plasma voltage and the peak current $I_p$. It seems that the average value of the measured efflux plasma voltage in each cycle always fluctuates around the setpoint $V_{EP}$ within an acceptable limit. The pulse current makes a relevant adjustment based on the measured $V_{EP}$. It can be seen that the pulse current $I_p$ varies with the signal of efflux plasma voltage in real-time so that the value of $V_{EP}$ in each cycle is within a narrow range around the setpoint $V_{EP}$. The response speed and accuracy are satisfactory. It shows marked control effectiveness in welding of a 8-mm thick plate.

**Control Test on Plate with Varied Thickness**

To test the control effectiveness of the developed system further, a test plate with varied thickness was used, as shown in Fig. 10. Bead-on-plate welding was conducted on such a workpiece from left (thickness 8 mm) to right (thickness 4 mm). The process parameters were set as follows: $I_B = 60$ A, $T_{11} = 60$ ms, $T_1 = 60$ ms, and $T_2 = 60$ ms. Other parameters were selected as aforementioned. The pulse current $I_p$ was adjusted in-process, and current waveform parameters such as $I_{K1}$, $I_{K2}$, $K_1$, and $K_2$ were calculated by Equations 2–5. The setpoint for the desired value of the efflux plasma voltage $V_{EP}$ was preset as 1000 mV. Because the plate thickness was gradually varied from 8 to 4 mm, the welding process could not maintain consistency if no appropriate control action was applied. Using the developed system, the peak current, along with its duration and dropping slopes, made a suitable adjustment based on the measured efflux plasma voltage signal as the thickness varies along the welding direction. Figure 11 shows the weld appearance at both topside and backside. It appears the weld formation and penetration were controlled very well, even with the change in plate thickness.

Figure 12 shows the measured transient welding current and efflux plasma voltage signals in the control test of a plate with varied thickness. Figure 13 illustrates the control action for the varied plate thickness. During the welding process, as the plate thickness continuously decreased, the welding current waveform parameters made a suitable response, especially the peak current was lowered, so that the keyhole size was kept almost constant. The measured average value of $V_{EP}$ of efflux plasma voltage fluctuates around the set...
point $V_{EP}$ within the allowable range.

To observe the response of welding current to the efflux plasma voltage more clearly, three time intervals of the transient signals in Fig. 12 are magnified in time-scale, i.e., the signals within three time intervals $30-35.5$ s, $38.5-44$ s, and $68-73$ s. These three time intervals correspond to the segments on the workpiece, as shown in Fig. 14. The magnified results for three segments are shown in Figs. 15-17, respectively. For segment 1, the plate thickness was not varied, but kept at $8$ mm. The peak current was constant ($220$ A), and the measured efflux plasma voltage agrees with the setpoint. Segment 2 located at the middle part of the workpiece, and the thickness changed continuously. Thus, the peak current was gradually decreased from $220$ to $200$ A to keep the keyhole size nearly constant. The six pulses in Fig. 16A are with values of peak current $220, 220, 215, 210, 205$, and $200$ A, respectively. For segment 3, the workpiece thickness became thinner. Thus, the peak current was lowered further. It changed gradually from $153$ to $143$ A to adapt to the thinner thickness. The five pulses in Fig. 17A are with values of peak current $153, 154, 145, 144$, and $143$ A, respectively. Therefore, the experimental results show that even if the plate thickness changes as much as $50\%$ (from $8$ to $4$ mm), the developed system is capable of adjusting the peak current and its dropping slopes automatically so that the keyhole size stays almost constant. Therefore, both weld width and penetration are consistent, and control action responds reliably and smoothly.

**Conclusions**

1) A control system for keyhole plasma arc welding was developed for application on thin sheet to thick plate. The efflux plasma voltage was measured in real-time to characterize the keyhole size and weld dimension. The peak current and its duration, as well as its dropping slopes, are employed as the controlling variables.

2) The specially designed pulse current waveform, including two slow dropping substages with both variable slopes, is used to transform the welding current from its peak level to base level. The keyhole condition can smoothly transform from the opening status to the closure status under the action of such current waveform.

3) The experimental results showed that the sampled efflux plasma voltage signal responded to the variation in the controlled pulse current waveform very well. The developed system operates in the mode of “one keyhole per pulse” reliably for welding of thick materials.

4) The varied thickness plates were used to conduct the control experiments. The test results showed that even when the plate thickness changed as much as $50\%$ (from $8$ to $4$ mm), the developed system was capable of adjusting the peak current and its dropping slopes automatically so that the keyhole size keeps almost constant, and both weld width and penetration are consistent.

**Acknowledgment**

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**References**

Fig. 16 — Segment 2 for time interval 38.5–44 s. A — The measured welding current; B — efflux plasma voltage.

Fig. 17 — Segment 3 for time interval 68–73 s. A — The measured welding current; B — efflux plasma voltage.

Effect of Welding Parameters and Electrode Condition on Alloying Enrichment of Weld Metal Deposited with Coated Cellulosic Electrodes

The effect of welding parameters and dried condition of cellulosic electrodes on C, Si, and Mn enrichment as well as increased cracking susceptibility of deposited weld metals were evaluated

BY J. E. RAMIREZ AND M. JOHNSON

ABSTRACT

Manual welding with cellulosic electrodes is widely used. However, unexpectedly high weld metal alloy contents have been associated with weld metal hydrogen-assisted cracking. Lot-to-lot consumable variation may not always be the primary factor responsible for unexpected cases of highly alloyed weld metals. Therefore, the effect of welding parameters (arc length, welding current, and weld length) and conditions of the cellulosic electrode (as-received and dried) on alloying enrichment of deposited weld metals were evaluated. Arc length, weld length, and “dried” condition of the electrode have a primary effect on the chemical composition of deposited weld metals. Welding current has a secondary effect. Decreasing the arc length resulted in an increase of carbon level in the weld metal. A large increase in manganese and silicon in the weld metal resulted with increasing distance from the weld start point or the use of cellulosic electrodes in the “dried” condition. Alloying enrichment of the weld metals, as indicated by the carbon level and carbon equivalent, results in an increase in susceptibility of the weld metal to cracking.

Introduction

Despite advances in mechanized welding technology, development of low-hydrogen self-shielded flux cored arc welding (FCAW-S) consumables, and substantial improvement of basic low-hydrogen downhill shielded metal arc welding (SMAW) electrodes, manual welding with cellulosic electrodes is still widely utilized throughout the world. Cellulosic-coated SMAW electrodes (AWS EXX10, EXX11) are traditionally used for “stovepipe” welding of pipelines because they are well suited for deposition of pipeline girth welds and are capable of high deposition rates when welding downhill.

Cellulosic electrode coverings typically contain silicate binders, 30 to 45% cellulosic (C₆H₁₀O₇)ₓ, 15 to 20% rutile (TiO₂), extrusion aides, and ferro-alloy additions (Refs. 1–3). During production, these electrodes are typically “dried” (70° to 150°C [158° to 300°F]), not baked, after extrusion. During welding, decomposition of the cellulose and water generate carbon monoxide (CO) and hydrogen gas that shield the weld pool, surrounding the weld pool with reducing conditions. Hydrogen gas causes the resistance of the arc opening to increase, which results in a higher arc voltage and a more penetrating arc (Ref. 3). However, the resulting diffusible hydrogen level in weld metal deposits produced using cellulosic electrodes is high (30 to 60 mL H₂/100 g deposited weld metal), which restricts the use of cellulosic electrodes on high-strength steels or when welding thick sections with high restraint.

Three sets of experiments were conducted to evaluate the potential alloying enrichment of the weld metal as a result of lot-to-lot consumable variation, welding parameter variation (arc voltage, welding

KEYWORDS

Cellulosic Electrodes
Hydrogen-Assisted Cracking
Arc Length
Welding Current
Weld Length
As-Received and “Dried” Conditions

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Experimental Approach

Due to the high hydrogen levels, there is a potential for hydrogen-assisted cracking (HAC). HAC remains one of the most important technical issues associated with manual girth welding of pipelines when using cellulosic electrodes. Some reviews provide examples of HAC, which has occurred in pipeline girth welds and the economic impact associated with HAC (Refs. 4, 5). In one case, cracking was attributed mainly to rich weld metal (0.19 wt-% C, 0.5 wt-% Mo) deposited using E7010-G electrodes and hard regions that formed due to undissolved molybdenum particles originating from the electrode covering. In another case, cracking was attributed to on-site modification of the weld procedure allowing deposition of thin, low-heat-input stringer passes with low interpass temperature, and the use of higher carbon equivalent welding consumables.

However, in other reported cases of HAC (Ref. 6), even though established welding procedures were used, it was clear that richer than expected weld metals were deposited and played a critical role in the resulting observed cracking. Several factors that can contribute to rich weld metal compositions include dilution from the base metal, lot-to-lot consumable variation, welding parameters (arc length, current) within the operating window, and factors that influence weld metal transfer mode such as covering moisture and perhaps power supply characteristics.

This experimental work evaluated possible effects of lot-to-lot consumable variation, welding procedure variation, and covering moisture on alloying enrichment of weld metals deposited with cellulosic-coated electrodes.

Three sets of experiments were conducted to evaluate the potential alloying enrichment of the weld metal as a result of lot-to-lot consumable variation, welding parameter variation (arc voltage, welding.
current, and weld length), and covering moisture.

**Failure Analysis of Cracked Welds**

Welds representing three cases, identified as A, B, and C, where cracking was observed in the field, were obtained from industry and used for analysis. In all three cases, significant transverse cracking was observed, and the same type of consumable (AWS E8010-G) from different lot numbers from the same manufacturer was used (Ref. 6).

The chemical composition of the weld metals and pipe materials representing the cracked joints from the three different cases was determined. Additionally, unconsumed electrodes from the lot used to deposit the cracked welds in case C were returned to the manufacturer for evaluation. Nominal weld metal composition data from the certificate of conformance tests corresponding to the time interval for the production of consumables used in case C were obtained as well.

Finally, a small number of electrodes with identical production codes to those used to produce the cracked girth welds in case C were used for evaluation. Chemical analysis test pads were produced following instructions prescribed in AWS A5.5/A5.5M:2006, Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding (Ref. 7). Duplicates of the chemical analysis test pads were conducted at the consumable manufacturer. The weld pads for chemical analysis were produced using welding currents of 120 to 130 A, 23 V for the 4.0-mm- (5/32-in.-) diameter electrodes, and 160 to 170 A, 24 V for the 4.8-mm- (3/32-in.-) diameter electrodes. The results from this failure investigation established the basis for additional testing as described below using a separate lot of commercially procured E8010-G electrodes from the same manufacturer.

**Welding Parameter Variation**

In order to evaluate the effect of welding parameter variation (arc voltage, welding current, and weld length), standard AWS A5.5/A5.5M:2006 instructions and groove weld test assembly were utilized. A 0.75-in.-thick carbon steel plate was used as the base material. A 4.8-mm- (5/32-in.-) diameter E8010-G electrode was used to deposit the experimental welds in the flat position with short (1 mm), medium (2–3 mm), and long (5 mm) arc lengths and a range of welding currents. An inverter power supply and a single lot of electrodes were used. The summary of the welding conditions used is listed in Table 1.

**Covering Moisture**

One key observation in the failure analysis mentioned above was that all cracked welds were produced in field conditions where high temperatures were present, and covering moisture was observed.
Failure Analysis of Field Welds

The composition and carbon equivalent (Ref. 9) of the weld metal and pipe material representing the cracked joints from cases A, B, and C are listed in Tables 3 and 4. The carbon and carbon equivalent measured in welds containing cracks and the pipe materials are plotted in a map of carbon content vs. carbon equivalent (Ref. 9) shown in Fig. 2. Weld metals from cases B and C show the highest alloying levels as described by the carbon and carbon equivalent. The weld metal B had a carbon concentration of 0.17 wt-%, manganese concentration of 1.40 wt-%, and a carbon equivalent of 0.52 wt-%. Exceptionally high manganese (1.9 wt-%) and carbon (0.19 wt-%) concentrations were measured in the cracked girth weld metal C, resulting in a carbon equivalent of 0.66 wt-%.

The consumable manufacturer reported that the retested electrodes representing the electrodes used in case C deposited weld metals were within....
established manufacturing ranges. Nominal weld metal compositions from certificate of conformance tests corresponding to the time interval for the production of the consumables used in case C is summarized in Table 5. As indicated in Tables 3 and 4, AWS 5.5/A5.5M:2006 specification does not include limits for carbon levels in all-weld metal deposited with E8010-G electrodes. Compared to the weld metal composition reported in the certificate of conformance test welds, the manganese concentration in the C welds was substantially higher. Silicon was slightly higher than the typical conformance test welds while other elements such as nickel and molybdenum were representative of the weld metal composition expected from electrodes produced during that time period.

The compositions of the chemical analysis weld pads produced in-house and weld pads duplicated by the consumable manufacturer, representing the consumable used in case C, are included in Table 4. The composition measured in the weld pads was close to the values reported in the certificate of conformance test results. Slightly richer composition was measured in the weld pads produced with the 4.8-mm- (0.19-in.-) diameter electrodes. Although the chemical analysis pad welds were relatively rich, the high manganese (1.9 wt-%) and high silicon (0.29 wt-%) concentrations measured in the field girth welds from case C, and the resulting high carbon equivalent were not duplicated, as shown in Fig. 2.

The level of lot-to-lot variation is an open question and an area of continuous improvement for all electrode manufacturers. Many electrode manufacturers have developed elaborate controls to ensure that a consistent product is produced. For example, specifications are often placed to control core wire composition, flux composition (this is usually analyzed in each lot), and covering thickness.

As a summary, the weld metal compositions measured in the E8010-G welds, which exhibited cracking in the field, indicate that a relatively rich composition was present in all three cases, most notably in cases B and C. However, direct comparison of results from electrode retesting, certificate of conformance testing, and from analyses of weld pads representing consumables used in case C with the composition of the cracked girth welds does not substantiate the high manganese and silicon concentrations. Additionally, as presented in following sections, the chemical composition of E8010-G welds deposited with a separate lot of commercially procured E8010-G electrodes from the same manufacturer and using standard welding parameter conditions and/or electrodes in the as-received condition was much leaner than those of the failed welds from case B or C.

Table 3 — Composition of Weld Metal and Steel Pipe from Cases A and B (wt-%)

<table>
<thead>
<tr>
<th></th>
<th>EXX10-G A5.5 Req.</th>
<th>Case A Weld</th>
<th>Case A Pipe</th>
<th>Case B Weld</th>
<th>Case B Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>NS</td>
<td>0.14</td>
<td>0.10</td>
<td>0.17</td>
<td>0.077</td>
</tr>
<tr>
<td>Mn</td>
<td>1.00&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>1.15</td>
<td>1.51</td>
<td>1.40</td>
<td>1.37</td>
</tr>
<tr>
<td>P</td>
<td>NS</td>
<td>0.021</td>
<td>0.008</td>
<td>0.011</td>
<td>0.016</td>
</tr>
<tr>
<td>S</td>
<td>NS</td>
<td>0.004</td>
<td>&lt;0.001</td>
<td>0.008</td>
<td>0.004</td>
</tr>
<tr>
<td>Si</td>
<td>0.80&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>0.17</td>
<td>0.29</td>
<td>0.22</td>
<td>0.27</td>
</tr>
<tr>
<td>Ni</td>
<td>0.59&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>0.47</td>
<td>&lt;0.10</td>
<td>0.57</td>
<td>0.02</td>
</tr>
<tr>
<td>Cr</td>
<td>0.30&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>0.12</td>
<td>0.02</td>
<td>0.12</td>
<td>0.02</td>
</tr>
<tr>
<td>Mo</td>
<td>0.20&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>0.06</td>
<td>&lt;0.05</td>
<td>0.075</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Cu</td>
<td>NS</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>0.01</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>V</td>
<td>0.19&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>0.012</td>
<td>0.042</td>
<td>0.012</td>
<td>0.033</td>
</tr>
<tr>
<td>Al</td>
<td>NS</td>
<td>&lt;0.01</td>
<td>0.035</td>
<td>&lt;0.01</td>
<td>0.023</td>
</tr>
<tr>
<td>Ti</td>
<td>NS</td>
<td>0.01</td>
<td>&lt;0.01</td>
<td>0.014</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Nb</td>
<td>NS</td>
<td>&lt;0.005</td>
<td>0.035</td>
<td>0.007</td>
<td>0.029</td>
</tr>
<tr>
<td>Zr</td>
<td>NS</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>B</td>
<td>NS</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>CE&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>NS</td>
<td>0.43</td>
<td>0.41</td>
<td>0.52</td>
<td>0.41</td>
</tr>
</tbody>
</table>

(a) For AWS “G” classification only one of the elements designated with “a” must exceed values shown in the table.
(b) CE = C + (Mn + Si)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 (Ref. 9).
Based on the chemical composition of the steel pipe used in the failed welds (Table 4 and Fig. 2), the expected effect of weld metal dilution by the base metal would have been to decrease the carbon and carbon equivalent of weld metal, which is opposite to the high carbon and carbon equivalent observed in welds from case C.

Therefore, these experimental results essentially eliminate lot-to-lot variation in electrode composition as the primary factor responsible for the rich composition measured in these specific cracked weld metals, especially those representing case C, and indicate that other factors must have contributed to the alloying enrichment measured in these specific cracked girth welds.

**Welding Parameter Variation**

The results of chemical composition analyses of the weld metal deposited with different welding parameters are listed in Table 6. The base plate chemical composition is also reported in Table 6. Figures 3-5 show the weld metal nitrogen, carbon, and manganese concentration, respectively, as function of welding current and arc length. Important considerations regarding the characteristics of the arc column and weld metal transfer during SMAW with cellulose electrodes are needed for the explanation of the observed changes in weld metal chemical composition.

**General Characteristic of Arc Column and Weld Metal Transfer with Cellulosic Electrodes**

During SMAW with cellulosic electrodes, decomposition of the cellulose and water generate carbon monoxide (CO) and hydrogen gas that shield the weld pool, surrounding the weld pool with reducing conditions (Ref. 2). The reducing conditions are created by the excess of hydrogen and carbon from the cellulose and water vapor generated during the welding process.

---

**Table 4 — Summary of Chemical Composition Measured in Weld Metals from Case C and Results of Chemical Analysis in Welds Pads (wt-%)**

<table>
<thead>
<tr>
<th></th>
<th>EXX10-G</th>
<th>Field Weld</th>
<th>Chemical Analysis Pad</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A5.5 Req.</td>
<td>Weld</td>
<td>Pipe</td>
</tr>
<tr>
<td>C</td>
<td>NS</td>
<td>0.19</td>
<td>0.097</td>
</tr>
<tr>
<td>Mn</td>
<td>1.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.93</td>
<td>1.35</td>
</tr>
<tr>
<td>P</td>
<td>NS</td>
<td>0.004</td>
<td>0.008</td>
</tr>
<tr>
<td>S</td>
<td>NS</td>
<td>0.007</td>
<td>0.01</td>
</tr>
<tr>
<td>Si</td>
<td>0.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.29</td>
<td>0.26</td>
</tr>
<tr>
<td>Ni</td>
<td>0.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.64</td>
<td>0.04</td>
</tr>
<tr>
<td>Cr</td>
<td>0.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.16</td>
<td>0.04</td>
</tr>
<tr>
<td>Mo</td>
<td>0.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.08</td>
<td>0.01</td>
</tr>
<tr>
<td>Cu</td>
<td>NS</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>V</td>
<td>0.1&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.002</td>
<td>0.006</td>
</tr>
<tr>
<td>Al</td>
<td>NS</td>
<td>&lt;0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Ti</td>
<td>NS</td>
<td>0.01</td>
<td>0.007</td>
</tr>
<tr>
<td>Nb</td>
<td>NS</td>
<td>&lt;0.005</td>
<td>0.01</td>
</tr>
<tr>
<td>Zr</td>
<td>NS</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>B</td>
<td>NS</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>CE&lt;sup&gt;e&lt;/sup&gt;</td>
<td>NS</td>
<td>0.66</td>
<td>0.38</td>
</tr>
</tbody>
</table>

(a) For AWS “G” classification only one of the elements designated with “a” must exceed values shown in the table.

(b) CE = C + (Mn + Si)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15.
hydrogen from the water. Cellulose has a chemical composition described by the formula \((C_6H_{10}O_5)_n\) with a molar ratio of oxygen to carbon and hydrogen equal to 1:1.2:2.0. The reducing atmosphere of the arc facilitates and increases the efficiency of transfer to the weld metal of not only carbon but manganese and silicon as well (Refs. 10, 11).

The carbon generated during the dissociation of the cellulose may interact with the molten slag during metal transfer and support the silicon-reduction process. This result in the transfer of silicon into the weld metal even if ferrosilicon (FeSi) is not present in the electrode covering. Additionally, due to higher temperature, larger surface area, and nonequilibrium conditions, the rate of oxidation is faster during drop metal transfer than in the weld pool. At the high-temperature condition of the arc (above 2000°C), during weld metal transfer carbon is preferentially oxidized as compare to other elements, which results in a higher transfer of alloying elements to the weld metal.

The potential gradient along the arc length depends on the nature of the covering and its chemical composition (Ref. 12). Hydrogen gas is a poor electrical conductor and has a high ionization potential that causes the resistance of the arc opening to increase and the electron emission to decrease, which result in a higher arc voltage and a more penetrative discharge.

### Table 5 — Summary of Composition Measured in Conformance Welds Deposited during Time Interval when Consumables for Case C Welds Were Produced (wt-%)

<table>
<thead>
<tr>
<th>Element</th>
<th>3.2 mm (¼ in.)</th>
<th>4.0 mm (⅜ in.)</th>
<th>4.8 mm (⅝ in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>0.91</td>
<td>1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>Si</td>
<td>0.25</td>
<td>0.25</td>
<td>0.17</td>
</tr>
<tr>
<td>Ni</td>
<td>0.86</td>
<td>0.72</td>
<td>0.70</td>
</tr>
<tr>
<td>Cr</td>
<td>0.02</td>
<td>0.11</td>
<td>0.14</td>
</tr>
<tr>
<td>Mo</td>
<td>0.08</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>V</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cu</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>
The weld metal transfer across the arc in gas metal arc welding (GMAW) and SMAW is normally described as short-circuit, globular, and spray mode (Refs. 14, 15). In most cases, droplets of various sizes are transferred in the arc, but the type of covering determines the predominant mode of transfer (Refs. 15, 16). The weld metal transfer of cellulosic electrodes has been described as a combination of spray, short-circuit, and explosive transfer (Ref. 17). When welding in the downhill direction, the spray transfer is present all the time, but the metal drops grow periodically and globular transfer became the dominant mode. In general, gravitation, pinch effect, Lorentz force, and plasma action are less important in SMAW than in welding by other methods unless very high welding currents are used. Forces having a significant effect on SMAW metal transfer include surface tension and viscosity, and metallurgical effects (Ref. 13).

When arc melting killed steel wires in air, oxygen forms an oxide film on the surface of the droplet, oxygen combines with silicon, and this limits the possibility of CO formation, which affects its surface tension rather than causing metal to effervesce. This is characteristic of welding with basic electrodes, surface tension, and viscosity can determine the metal transfer mode.

During welding with cellulosic electrodes, metal from the melting electrode is usually supersaturated with hydrogen and frequently with CO, which results in its becoming disturbed and effervescent. This affects the melting mode more than surface tension and viscosity do. Additionally, cellulosic electrode coverings contain large amounts of moisture. Electrode coverings usually melt faster than they de-gas. Therefore, large quantities of gas evolve from melting the cellulosic covering, which makes the melting slag effervesce and boil.

### Table 6 — Weld Metal Chemical Composition (wt-%) as Function of Welding Parameters

<table>
<thead>
<tr>
<th>Arc Length</th>
<th>Heat Input (kJ/mm)</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Carbon</th>
<th>Mn</th>
<th>Si</th>
<th>Ni</th>
<th>Cr</th>
<th>N</th>
<th>O</th>
<th>CE (AWS) (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>1.1 to 1.8</td>
<td>26.5</td>
<td>145</td>
<td>0.16</td>
<td>0.92</td>
<td>0.10</td>
<td>0.74</td>
<td>0.14</td>
<td>0.06</td>
<td>0.056</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>26.0</td>
<td>145</td>
<td>0.16</td>
<td>0.88</td>
<td>0.08</td>
<td>0.79</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>0.040</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>27.0</td>
<td>165</td>
<td>0.16</td>
<td>0.78</td>
<td>0.06</td>
<td>0.68</td>
<td>0.12</td>
<td>0.09</td>
<td>0.060</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27.5</td>
<td>172</td>
<td>0.17</td>
<td>0.86</td>
<td>0.07</td>
<td>0.75</td>
<td>0.13</td>
<td>0.08</td>
<td>0.057</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.0</td>
<td>200</td>
<td>0.18</td>
<td>0.88</td>
<td>0.07</td>
<td>0.76</td>
<td>0.13</td>
<td>0.012</td>
<td>0.060</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.0</td>
<td>200</td>
<td>0.16(^{15})</td>
<td>0.85</td>
<td>0.07</td>
<td>0.76</td>
<td>0.13</td>
<td>0.015</td>
<td>0.060</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.0</td>
<td>200</td>
<td>0.18(^{16})</td>
<td>1.18</td>
<td>0.14</td>
<td>0.76</td>
<td>0.14</td>
<td>0.010</td>
<td>0.044</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>1.5 to 2.3</td>
<td>31.5</td>
<td>171</td>
<td>0.15</td>
<td>0.80</td>
<td>0.07</td>
<td>0.73</td>
<td>0.13</td>
<td>0.036</td>
<td>0.060</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>35.0</td>
<td>199</td>
<td>0.17(^{17})</td>
<td>1.05</td>
<td>0.11</td>
<td>0.73</td>
<td>0.14</td>
<td>0.033</td>
<td>0.039</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35.0</td>
<td>199</td>
<td>0.13(^{18})</td>
<td>0.79</td>
<td>0.07</td>
<td>0.71</td>
<td>0.13</td>
<td>0.030</td>
<td>0.056</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>38.0</td>
<td>172</td>
<td>0.10(^{19})</td>
<td>0.81</td>
<td>0.06</td>
<td>0.74</td>
<td>0.13</td>
<td>0.087</td>
<td>0.045</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>1.7 to 2.5</td>
<td>38.0</td>
<td>172</td>
<td>0.10(^{20})</td>
<td>0.81</td>
<td>0.06</td>
<td>0.74</td>
<td>0.13</td>
<td>0.087</td>
<td>0.045</td>
<td>0.32</td>
</tr>
<tr>
<td>Base Metal</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.22</td>
<td>1.10</td>
<td>0.18</td>
<td>0.01</td>
<td>0.04</td>
<td>0.004</td>
<td>&lt;0.003</td>
<td>0.44</td>
</tr>
<tr>
<td>E8010(^{21})</td>
<td>—</td>
<td>28-30 (c)</td>
<td>163-170</td>
<td>0.11</td>
<td>0.66</td>
<td>0.10</td>
<td>0.71</td>
<td>0.02</td>
<td>0.021</td>
<td>0.065</td>
<td>0.32</td>
</tr>
</tbody>
</table>

(a) Measured at about 5.0 in. (127.0 mm) from start of weld.
(b) Measured at about 5.0 in. (127.0 mm) from start of weld.
(c) CE = C + (Mn+Si)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 (Ref. 9).
(d) Standard welding condition.
(e) Arc length of about 2.5 mm.
and facilitates the transfer of liquid during welding and may promote spray-type metal transfer (Ref. 13).

**Effect of Arc Length and Welding Current**

As shown in Fig. 3, the weld metal nitrogen content increases from about 100 to about 700 ppm as the arc length is increased. In general, the nitrogen level in the weld metal was not affected by welding current. It may be considered that in addition to affecting the welding metal transfer across the arc column, the effervescence and boiling that results from metallurgical and gas reactions in the melting metal and flux coverings may also act as waves of disturbance that may temporarily disrupt the reducing arc column and its protection to the weld metal from oxygen and nitrogen in the air. The longer the arc length, the higher the degree of disturbance induced in the arc column, which results in a higher probability of mixing with air and in a higher level of nitrogen in the weld metal.

Carbon content in the weld metal increases from about 0.08 to about 0.16 wt-% as the arc length was decreased, as shown in Fig. 4. This represents about a 100% increase in the weld metal carbon content. Increase of carbon in the weld metal with shorter arc length may result from a more stable reaction between the molten weld metal and the reducing or carburizing arc column atmosphere. Even though a longer arc length may represent a longer time for the molten metal-column reaction, the reducing/carburizing potential of the arc column atmosphere may be decreased by a higher degree of disturbance experienced by a long arc column. These disturbances may even, locally or temporarily, create an oxidizing condition in the arc column atmosphere.

As shown in Fig. 4, at a given arc length, there was a slight increase of carbon content in the weld metal as the welding current was increased. This experimental observation may result from an increase in the rate of weld metal transfer across the arc column due to higher melting rates of the electrodes with higher welding currents (Ref. 18). A higher current causes a higher droplet transfer rate, and consequently, more molten surface area flowing across the arc column per unit of time, which may result in a higher degree of carburization of the weld metal due to reaction with the reducing arc atmosphere.

A similar trend to carbon content in the weld metal, but to a much lower degree, was observed in the manganese content in the weld metal as function of arc length, as shown in Fig. 5. The manganese content in the weld metal changes from about 0.7 to 0.9 wt-%, an increase of about 25%, as the arc length was decreased. With a short arc length, the disturbances of the arc column and the presence of oxidizing species in the column atmosphere are minimized. Therefore, most of the manganese present as ferromanganese in the flux is recovered in the weld metal. As the arc length increases, the disturbance of the arc column increases, and some of the manganese is consumed in oxidizing/deoxidizing reactions that take place in the arc column or weld metal pool. In general, a similar trend to that observed for manganese in the weld metal was observed for silicon content in the weld metal as a function of the arc length.

**Table 7 — Summary of Weld Metal Composition Measured in the EWI Multipass Mockup Welds Made with As-Received (AR) and Dried Consumables**

<table>
<thead>
<tr>
<th></th>
<th>12 mm (0.5 in.)</th>
<th>19 mm (¾ in.)</th>
<th>12 mm (0.5 in.)</th>
<th>19 mm (¾ in.)</th>
<th>12 mm (0.5 in.)</th>
<th>19 mm (¾ in.)</th>
<th>12 mm (0.5 in.)</th>
<th>19 mm (¾ in.)</th>
<th>Base Metal</th>
<th>Base Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8010-AR</td>
<td>8010-Dried</td>
<td>8010-AR</td>
<td>8010-Dried</td>
<td>8010-AR</td>
<td>8010-Dried</td>
<td>8010-AR</td>
<td>8010-Dried</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.11</td>
<td>0.14</td>
<td>0.14</td>
<td>0.13</td>
<td>0.14</td>
<td>0.13</td>
<td>0.14</td>
<td>0.14</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Mn</td>
<td>0.95</td>
<td>1.32</td>
<td>1.00</td>
<td>1.31</td>
<td>1.48</td>
<td>1.60</td>
<td>1.60</td>
<td>1.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.006</td>
<td>0.003</td>
<td>0.007</td>
<td>0.010</td>
<td>0.007</td>
<td>0.011</td>
<td>0.010</td>
<td>0.003</td>
<td>&lt;0.003</td>
<td></td>
</tr>
<tr>
<td>Si</td>
<td>0.008</td>
<td>0.009</td>
<td>0.010</td>
<td>0.011</td>
<td>0.010</td>
<td>0.011</td>
<td>0.010</td>
<td>0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>0.12</td>
<td>0.28</td>
<td>0.10</td>
<td>0.28</td>
<td>0.33</td>
<td>0.30</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>0.12</td>
<td>0.14</td>
<td>0.13</td>
<td>0.14</td>
<td>0.13</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mo</td>
<td>0.07</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>0.007</td>
<td>0.010</td>
<td>0.007</td>
<td>0.010</td>
<td>0.007</td>
<td>0.060</td>
<td>0.070</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Al</td>
<td>0.02</td>
<td>&lt;0.01</td>
<td>0.02</td>
<td>&lt;0.01</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ti</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nb</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zr</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE</td>
<td>0.37</td>
<td>0.49</td>
<td>0.41</td>
<td>0.48</td>
<td>0.53</td>
<td>0.41</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CE = C+ (Mn + Si)/6+ (Cr + Mo + V)/5+ (Ni + Cu)/15
Table 8 — Relative Effect of Arc Length, Welding Current, Distance from the Start of the Weld (Weld Length), and Condition of the Consumable on the Chemical Composition of the Deposited Weld Metals

<table>
<thead>
<tr>
<th>Element</th>
<th>Decreasing Arc Length</th>
<th>Increasing Welding Current</th>
<th>Increasing Distance from Start of Weld</th>
<th>“Dried” Electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>(+++++)</td>
<td>(+)</td>
<td>(+)</td>
<td>(++)</td>
</tr>
<tr>
<td>M</td>
<td>(+)</td>
<td>−</td>
<td>(+++)©</td>
<td>(++++)</td>
</tr>
<tr>
<td>S</td>
<td>(+)</td>
<td>−</td>
<td>(++++)©</td>
<td>(+++++)</td>
</tr>
<tr>
<td>O</td>
<td>−</td>
<td>−</td>
<td>(−−)</td>
<td>NA</td>
</tr>
<tr>
<td>N</td>
<td>(………………)</td>
<td>−</td>
<td>~</td>
<td>NA</td>
</tr>
</tbody>
</table>

(+)= Relative increase in the concentration
(-)= Relative decrease in concentration
−= No effect or definitive trend
(a)= Specially with high welding current
NA= Data not available

Table 9 — Summary of Carbon Content and Carbon Equivalent Measured in the Weld Metals as a Function of Arc Length, Weld Length, and Electrode Condition

<table>
<thead>
<tr>
<th>Welding Conditions</th>
<th>Carbon (wt-%)</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arc Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Chemical analysis</td>
<td>0.16</td>
<td>0.41</td>
</tr>
<tr>
<td>measured at 3.0 in.</td>
<td>0.16</td>
<td>0.40</td>
</tr>
<tr>
<td>[76.2 mm from start</td>
<td>0.16</td>
<td>0.37</td>
</tr>
<tr>
<td>Weld Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 in.</td>
<td>0.16</td>
<td>0.39</td>
</tr>
<tr>
<td>(38.1 mm)</td>
<td>0.13</td>
<td>0.35</td>
</tr>
<tr>
<td>3.0 in.</td>
<td>0.18</td>
<td>0.42</td>
</tr>
<tr>
<td>(76.2 mm)</td>
<td>0.18</td>
<td>0.48</td>
</tr>
<tr>
<td>5.0 in.</td>
<td>0.17</td>
<td>0.44</td>
</tr>
<tr>
<td>(127.0 mm)</td>
<td>0.10</td>
<td>0.32</td>
</tr>
<tr>
<td>Standard Condition (about 2.5 mm arc length)</td>
<td>0.11</td>
<td>0.32</td>
</tr>
<tr>
<td>Electrode Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>As-Received</td>
<td>0.11</td>
<td>0.37</td>
</tr>
<tr>
<td>Dried</td>
<td>0.14</td>
<td>0.41</td>
</tr>
</tbody>
</table>

arc length. Even though cellulosic coverings may not contain ferrosilicon, the weld metal may contain some silicon that is reduced from silicates in the covering.

Effect of Weld Length and Welding Current

The observed changes in the concentration of carbon, manganese, silicon, and oxygen in the weld metal as a function of distance from the start of the weld (welding time) and arc length are shown in Figs. 6-9.

As shown in Fig. 6, only small changes in carbon content were observed as a function of distance from the start of the weld. At short arc length, the carbon content increased from about 0.16 to 0.18 wt-% from a location corresponding to 1.5 in. (38.1 mm) to a location corresponding to 5.0 in. (127.0 mm) from the start of the weld. This represents an increase of about only 10%.

The observed changes in manganese and silicon levels were observed as a function of distance from the start of the weld or welding time as shown in Figs. 7 and 8. The increase in manganese and silicon contents was more pronounced in conditions of short and medium arc length where a higher welding current, 200 A, was used. At short arc length and 200 A, manganese and silicon increased from about 0.85 to 1.2 and from 0.07 to 0.14 wt-%, respectively, as a function of distance from the start of the weld. These changes represent an increase of about 50% and 100% of manganese and silicon, respectively.

Previous research work indicates that preheating of the SMAW electrode during welding causes a change in the size distribution of the droplets transferred across the arc column (Ref. 15). Welding involves a considerable heating of the electrode due to the Joule effect. The higher the welding current, the higher the temperature of the electrode is as a function of weld length or welding time (Ref. 12). At the beginning of welding, the electrode is not heated as much and small size droplets predominate. As electrode preheating becomes more intense (induced mainly by the increase in resistivity with temperature of the metal core of the electrode) with increase in the weld length, globular transfer with large droplets replaces some of the small droplets (Ref. 15).

An increase in the fraction of large droplets, with a small surface area-to-volume ratio, results in an increase of recovery of manganese and silicon with welding time due to less oxidation reactions in the arc column, as shown in Figs. 7 and 8. This is confirmed by the observed decrease of oxygen along the weld deposits, as shown in Fig. 9.

Effect of Covering Moisture

The results of chemical composition analysis of the weld metal deposited with as-received and dried E8010-G electrodes are listed in Table 7. Pipe chemistry is also listed in Table 7. Minor changes in weld metal carbon content were observed with changes in the condition of the electrode. On the other hand, manganese and silicon concentrations were observed to increase significantly when dried electrodes were used. The average manganese and silicon content in the weld metals increased from about 0.97 to 1.37 wt-% and from 0.11 to 0.30 wt-%, respectively, when the condition of the electrode changed from as-received to dried. These changes represent an increase of 41 and 270% in the manganese and silicon content in the weld metal, respectively. It is clear from these data that electrode drying can have a significant impact on the weld metal manganese and silicon concentrations.

Figure 10A and B show the effect of electrode drying on droplet size and arc characteristics. Drying the electrodes had two effects. First, the droplet size increased during welding with the dried electrodes, and second, the droplet transfer rate decreased.

The observed changes in weld metal transfer behavior could be explained based on changes in arc characteristics due to the dried condition of cellulosic electrodes. Baking cellulosic electrodes leads to a reduction of gas-forming components in the covering and to the loss of hydrogen gas in the arc atmosphere, resulting in changes in the arc characteristics (Ref. 2). Different coverings ionize in the arc to different degrees. With decreasing amounts of gas evolving from the cellu-
Practical Implications

The relative effect of arc length, welding current, distance from the start of the weld (weld length), and “dried” condition of the electrode on the chemical composition of the weld metal is summarized in Table 8. Arc length, weld length, and “dried” condition of the electrode have a primary effect on the chemical composition of weld metal deposited with cellulosic electrodes. Welding current has a secondary effect in the resulting chemical composition of the weld metal.

The main effect of decreasing the arc length is to increase the carbon level in the weld metal, as indicated in Table 8, as a result of the carburizing effect of the reducing arc column atmosphere. Short arc length welding conditions result in a slight increase of manganese and silicon in the weld metal due to an increase in the recovery of these alloying elements.

As shown in Table 8, a large increase in manganese and silicon, and a decrease in oxygen in the weld metal, resulted with weld length or distance from the start of the weld. From a practical standpoint, this result suggests that higher enrichment of cellulosic weld metals could occur in normal fabrication where the use of longer beads is expected as compared to weld repair. For weld repair, short as possible weld beads are recommended to minimize weld metal composition enrichment and susceptibility to cracking. Removal and repair of defects with cellulosic electrodes often involves the combination of high restraint and high hydrogen. Therefore, if a rich weld composition can occur, it would increase the risk of cracking.

Use of cellulosic electrodes in the “dried” condition resulted in a large increase in manganese and silicon content in the weld metal, as listed in Table 8. Fabricators may store cellulosic and basic electrodes (as-received condition) to minimize potential enrichment of the deposited weld metals. Proper quality assurance and training/instruction of the welder is required, as control of these variables may be difficult to carry out in the field. In welding with electrodes of a given diameter and covering thickness, the main control parameter is the magnitude of the current, while the voltage and arc length depend on the type of covering and the welder. They are not adjustable as in semiautomatic arc welding processes. Additionally, extremely dry electrodes are typically expected to not react very well and corresponding completed welds are expected to contain significant quantities of porosity. However, electrode formulations have evolved through the years to improve operator appeal, and it is possible that specific formulations have improved to the point where acceptable operation continues even with a dry covering. During the deposition of the experimental welds, no drastic change in performance was observed when using the dried E8010-G electrode. Additionally, welds deposited using electrodes in the dried condition were subjected to X-ray inspection to ver-
ify weld soundness, and no substantial increase in weld porosity was observed in the E8010-G deposits either. Therefore, it may be difficult in the field to determine the condition of the electrodes based on their performance during welding.

Conclusions

Based on the experimental observations and discussions, the following conclusions are presented:

- Factors other than lot-to-lot variation in electrode composition are primarily responsible for rich compositions measured in the specific evaluated welds that experienced hydrogen-assisted cracking.
- Arc length, weld length (welding time), and "dried" condition of the electrode have a primary effect on the chemical composition of weld metal deposited with cellulose electrodes. Welding current has a secondary effect in the resulting chemical composition of the weld metal.
- The main effect of decreasing the arc length was a 100% increase in carbon level in the experimental weld metals, from about 0.08 to about 0.16 wt-%. The weld metal nitrogen content decreased from about 0.7 to 0.1 ppm, and the manganese content in the weld metal changed from about 0.7 to 0.9 wt-%, about a 25% increment, as the arc length was decreased.
- A large increase in manganese and silicon, and decrease in oxygen in the weld metal resulted with weld length or distance from the start of the weld, especially when welding current from the start of the weld. Only small changes, about 10%, of carbon content were observed as a function of distance from the start of the weld.
- Use of cellulose electrodes in "dried" conditions has a significant impact on the weld metal manganese and silicon concentrations. Average manganese and silicon content in the weld metals increased from about 0.97 to 1.37 wt-% (41% increase) and from 0.11 to 0.30 wt-% (270% increase), respectively, when the condition of the electrode changed from as-received to dried. Only minor changes in weld metal carbon content were observed with a change in the condition of the electrode. The weld metal transfer along the arc column of a "dried" cellulosic electrode was characterized by an increased fraction of larger droplets and decreased droplet transfer rate as compared to that of an as-received electrode.
- The alloying enrichment of weld metals, as represented by changes in carbon and carbon equivalent (CE), initiated by modifications in welding conditions (AWC; CE ranges from 0.26 to 0.46) or changes in condition of the cellulosic electrodes (AEC; CE ranges from 0.39 to 0.50) or by a combined effect result in an increase in susceptibility of the weld metal to hydrogen assisted cracking.
- During welding with coated cellulosic electrodes, it would be a good practice to avoid too short arc length, use low welding current as practical and within the range recommended by the manufacturer, and to use the electrodes immediately after being removed from the package (as-received condition) to minimize potential enrichment of deposited weld metals. Proper quality assurance and training/instruction of welders is recommended as well.

References

6. EWI internal communication.
7. AWS A5.5/A5.5M:2006, Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding.
Comparison of Control Algorithms for Ultrasonic Welding of Aluminum

The weld strength variance for ultrasonic welds made with the time mode was smaller than that for welds made in the height and energy modes

BY M. BABOI AND D. GREWELL

ABSTRACT

Ultrasonic metal welding has many advantages including speed, weld quality consistency, and efficiency compared to other joining methods. In order to further improve the process, this work focused on enhancing process consistency. A comparison between three control modes: energy, height (post height), and time was conducted and the results were analyzed. Thus, the main objective of this study was to characterize and compare the weld consistencies of the various control modes. In this study, 60 welds made with optimum welding parameters with each mode were made, and the average weld strength and variance of the population were statistically compared. It was determined by analyzing the data with an F-test with a probability $\alpha = 0.05$ that there was a slight improvement in weld strength consistency for the time mode compared to the other two modes (energy and post height). No significant difference in the average weld strength was seen for the three modes, only in the consistency of the welds. It is believed that in the energy and post height modes, while the average weld strengths were similar to the time mode, these modes were affected by sample fixture loading and sample variations.

Introduction and Background

Ultrasonic metal welding, which was invented more than 50 years ago, is a process that consists of joining two metals by applying ultrasonic vibrations under moderate pressure. The high-frequency vibrations locally soften the overlap zone between the parts to be welded forming a solid-state weld through progressive shearing and plastic deformation. The oxides and contaminants are removed by the high-frequency motion (scrubbing) producing a pure metal/metal contact between the parts allowing the metallic bonds to form. Beyer stated, “Ultrasonic welding of metals consist of interrelated, complex processes such as plastic deformation, work hardening, breaking of contaminant films, fatigue crack formation and propagation, fracture, generation of heat by friction and plastic deformation, recrystallization, and interdiffusion” (Ref. 1). Also, it is worth noting that “the dominating mechanism for ultrasonic welding is solid-state bonding, and it is accomplished by two different processes: Slip and plastic deformation” (Refs. 2–6).

During welding, the machine controller is usually set to a particular mode. For example, in the energy mode, the power supply monitors and integrates the power as a function of time. Once a preset amount of energy is dissipated, the power supply discontinues the ultrasonic energy, independent of the time. In contrast, in the time mode the sonics remain on for a present length of time, independent of the energy. In the last mode, post height, the power supply monitors an encoder on the actuator and continues to apply ultrasonic energy to the parts until the preset amount of displacement occurs. The post height is defined as the gap between the final position of the horn and anvil as detailed in Fig. 1.

It is important to note that it is industry standard to use an energy mode for process control, and post height is a relatively new technology for the industry.

Objective

The objective of this study was to characterize and compare the weld consistencies of the various control modes. Because weld strength variation is a major dependent parameter related to ultrasonic metal welding, determining which control mode would increase weld consistency, reduce waste, and improve productivity in industry is important.

Experimental Procedure

Experimental Design

To determine the optimum welding conditions for the various modes: energy, post height, and time, the energy mode was initially studied because it represents the mode most commonly used in industry. Ten samples were welded with each energy level varying from 2000 to 5500 J with increments of 500 J. The energy value that resulted in the highest weld strength while using the energy control mode was selected as the optimum weld energy. The corresponding average weld time (1.0 s) and average post height (4.6 mm) from this optimum weld energy value were used as initial welding parameters for the other modes (time and post height). For example, in order to identify the optimum time and post height values, additional welds were made with a range in times between 0.6 and 2 s and range in post height between 4.3 and 5.5 mm. For each condition, ten welds were made and tested. Based on these results, the optimum welding parameters for each mode were selected and 60 welds were made with each mode for a total of 180 welds.

To compare the weld consistency between the various modes, a statistical F-test was used. In order to replicate industry practice, the welds were not randomized.

Based on screening experiments and previous studies (Ref. 7), the weld amplitudes that were studied ranged from 40 to 60 $\mu$m, and the weld force was set to a constant value of approximately 3400 N. Addi-
The material used in this study was aluminum 5754 coupons of two different thicknesses: 2 and 3 mm. The pretreated and prelubricated AA5754-H111 aluminum alloy was used in an as-received condition. The pretreatment is a silicate coating and the lubricant is a dry-film lubricant. The aluminum was purchased from Novelis, Inc. The weld samples consisted of two 25.4 × 100 mm in an overlap configuration, with a 25.4-mm (1-in.) overlap, and the weld centered on the overlap.

Equipment

The weld amplitude was varied using a WPC-1 controller. The controller has the ability to vary the amplitude profiling at two separate values (A and B) with various switchover modes (Ref. 8). The switchover mode is the parameter that defines when the amplitude is switched from value A (typically 60 μm) to B (typically 43 μm). For example, the mode can be set to time, energy, and peak power. In this work, only time was evaluated for amplitude profiling as this is the simplest mode to visualize and decouple from other welding parameters. In screening experiments, various amplitudes (50 and 58 μm) were studied, but the resulting weld strength and consistency were lower (~3000 N) than the ones described in this paper.

The welding system was manufactured by Branson Ultrasonic Corp. The horn was a standard knurled tip as shown in Fig. 2. The anvil was a standard “flex” anvil with a knurled tip as detailed in Fig. 3. The weld force was held constant at 3360 N. A squeeze time of 0.2 s was used to allow the force to fully develop prior to activation of the sonics. The actuator was a specially designed pneumatic linear system that had a linear rail to reduce rotation of the stack assembly during welding.

Characterization

All welds (ten samples for every energy level) were tested in tension at a crosshead speed of 10 mm/min. The maximum sustained load was used to calculate the ultimate strength. It is seen that shims were not used in the grips with the sample and thus bending stresses were not minimized.

Results and Discussion

Energy Mode Optimization

Using the energy control mode, Fig. 4 shows weld strength as a function of energy with constant amplitude and amplitude profile. It is seen that the welds made with amplitude profiling of 60 to 43 μm had a relatively lower range of variation of the weld strength compared to those welds made with constant amplitude of 43 μm. The maximum weld strength for the welds made with amplitude profiling was approximately 8 kN, while in contrast the maximum weld strength made with a constant amplitude was only approximately 5.5 kN. It is important to note that the weld cycle time was extended when amplitude profiling was used. The average time was 1.1 s and the average post height was 4.6 mm. Because it is expected that these conditions (time and post height values) would correspond to the near optimum parameters for the corresponding modes, they were used as starting values for optimizing the other modes.

Post Height Mode Optimization

Based on previous results, welds were made in the post height mode at various post height settings using a constant and profiled amplitude. As seen in Fig. 5 (weld strength as a function of post height), welds made with amplitude profiling again
appear to be stronger. It is important to note that a constant higher amplitude (60 μm_{pp}) was not included in this study because a constant higher amplitude promotes shearing of the weld and reduces weld strength.

Again referring to Fig. 5, by using amplitude profiling (60 to 43 μm_{pp}) the optimum post height value was selected as 4.7 mm, which produced a maximum weld strength of more than 6.5 kN. In contrast, welds made with a constant amplitude produced a maximum weld strength value of only 4.5 kN at a post height of 4.9 mm.

In order to gain insight into the welding process, two samples, one at the optimum welding post height (4.7 mm) and one at the minimum welding post height (4.3 mm), were selected for optical microscopy. One sample from beach population was cross-section cut, mounted, ground, polished, and etched. Figure 6 shows the micrographs of the sample welded with a post height of 4.3 mm (overwelded sample). It is seen that the interface (faying surface) has multiple cracks and defects between the coupons caused by a relatively large amount of penetration beyond the optimum conditions.

Figure 7 shows a higher magnification at the interface for the sample welded with a post height of 4.3 mm. As can be seen, there appear to be voids (emphasized by the blue ovals) and evidence of fracture of the faying surfaces. It is believed that these fractures are due to overwelding and shearing of the weld even though amplitude profiling was used. This results in a nonuniform microstructure and therefore a relatively low weld strength sample.

Figure 8 shows the micrographs of the sample welded with a post height of 4.75 mm (optimum weld strength). At a magnification of 1000×. Again, it is seen that the microstructure is uniform with little evidence of pores/voids compared to the microstructure of the weld made with a post height value of 4.3 mm. The fusion appears to be more pronounced being emphasized in the red oval.

**Time Mode Optimization**

Figure 10 shows weld strength as a function of welding time with and without amplitude profiling. Again, a constant amplitude at the higher level (60 μm_{pp}) was excluded from this study because it has already been shown to produce relatively low weld strengths. It is seen that amplitude profiling produced relatively higher weld strengths, compared to constant amplitude.

Figure 10 suggests that by using amplitude profiling, the standard deviation is relatively low over the time range studied compared to the standard deviation of the constant amplitude case. It is important to note that in this study, the population size was 10 and thus this is only a general observation. The optimum weld strength when using the amplitude profiling was ~8 kN with a weld time of 1.2 s and the optimum weld strength value for the constant amplitude was ~6 kN reached with a weld time of 1.7 s.

**Statistical Comparison**

Table 1 details the optimum welding parameters used to weld 60 samples with each mode. Because a constant amplitude did not produce welds with the highest strength, only those condition using amplitude profiling was considered.

In comparing the three control algorithms, it is important to note that the average weld strengths for all: energy, post height, and time were very similar and fell within the standard deviations of each other, as seen in Fig. 11. In more detail, this graph shows the average weld strength
(bar height) for the 60 welds made with each mode, and the standard deviation is detailed by the corresponding error bars. The overall average for all three modes (180 welds) is highlighted with the black horizontal line. In order to confirm that the average weld strengths were not significantly different, a standard F-test was conducted. Table 2 details the results of the test comparing the F-test values for the average weld strengths comparing the three modes. For example, in comparing the energy and post height modes, the F-test value is 0.2405, which corresponds to a 66% (100–24.05%) confidence level that there is a difference between the two average values. Because this confidence level is relatively low, there is no significant evidence that there is a difference between the two modes: energy and post height. In addition, when comparing the

| Table 3 — Statistical Analysis of the Comparison between Energy and Post Height Mode |
|---------------------------------|------------------|------------------|
| Energy                        | 7546             | 7327             |
| Post Height                   | 1228052          | 1259047          |
| Mean (N)                      | 60               | 60               |
| Variance                      | 60               | 60               |
| df                            | 59               | 59               |
| F                             | 0.975            | 1.025            |
| P(F<α) one-tail               | 0.462            | 0.154            |

| Table 4 — Statistical Analysis of the Comparison between Energy and Time Modes |
|---------------------------------|------------------|------------------|
| Energy                        | 7546             | 7464             |
| Time                           | 1228052          | 636453           |
| Mean (N)                      | 60               | 60               |
| Variance                      | 59               | 59               |
| df                            | 1.930            |                  |
| P(F<α) one-tail               | 0.006            |                  |
| F Critical one-tail           | 1.540            |                  |

| Table 5 — Statistical Analysis of the Comparison between Post Height and Time Modes |
|---------------------------------|------------------|------------------|
| Post Height                    | 7327             | 7464             |
| Time                           | 1259047          | 636453           |
| Mean (N)                      | 60               | 60               |
| Variance                      | 59               | 59               |
| df                            | 1.978            |                  |
| P(F<α) one-tail               | 0.005            |                  |
| F Critical one-tail           | 1.540            |                  |
other modes — post height with time and energy with time — it is seen that the F-test values are higher, 0.6587 and 0.4631 respectively, thus the confidence level that there is any difference between any of these two populations is less. Thus, it is proven that there is no significant difference between the average weld strengths of any of the three populations.

As previously noted, in order to compare weld strength variance, Table 3 shows the statistical analysis of the data for the comparison between the post height and energy mode. The energy mode was considered the baseline mode as it is the mode most commonly used by industry (Ref. 9). This analysis is intended to prove whether the difference in the variance of the two populations (energy, post height) is significant. This approach is commonly used when the standard deviation of two populations is being compared. For such a sample size (i.e., 60), if $F > 2.354$ then it is possible to state that it has been proven with $\alpha = 0.05$ and $\beta = 0.05$ that there is a significant difference between the variances of the two populations compared.

For example, as seen in Table 3 the post height mode variance (1259047) compared to the energy mode variance (1228052) has an $F_{calc}$ value of 1.025, thus because $F_{calc} < 1.54$ there is no significant difference between the two modes in terms of variance.

Table 4 details the statistical analysis of the data for the comparison between the energy and time modes. The energy mode variance (1228052) vs. the time mode variance (636453) has an $F_{calc}$ value of 1.930. Because $F_{calc} = 1.54 < 1.93$, there is a significant difference between the variances of the two populations compared: energy and time.

Table 5 details the statistical data of the comparison between the post height and time mode. The post height mode variance (1259047) vs. time mode variance (636453) has an $F_{calc}$ value of 1.978, thus because $F_{calc} = 1.54 < 1.98$, there is a significant difference between the two populations compared: post height and time.

Therefore, for a population size of 60, the time mode resulted in weld strength values that were more consistent. That is to say, the weld strength variance for those welds made with the time mode was smaller than that for the welds made in the height and energy mode. While there is no direct evidence for this observation, it is believed that the energy and post height modes are affected by variations such as sample fixture loading, material consistency, and interfacial consistencies. For example, variations in interfacial contaminations (such as oil) or coupling variations to the fixture due to fixture loading variation would affect the power dissipation resulting in variation and the duration of the weld in the energy mode.
In this study, it was statistically proven that the weld strength variance for those welds made with the time mode was smaller than that for the welds made in the height and energy mode. In addition, when each mode is optimized, they produced comparable average weld strength.

In addition, it was seen that overwelding in post height mode resulted in large voids at the faying surface.

Thus, in summary:
- The weld strength variance for the time mode is smaller compared to the other two modes.
- When each mode is optimized, it produces comparable average weld strength.
- The micrographs showed that overwelding in post height mode resulted in large voids at the faying surface.

Acknowledgements

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References

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