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- K Ti
- Fe Mo
- Fluorspar
- MC FeMn
- LC Si Mn
- Fe Si Zr
- Sod Ti
- Fe V
- Cr Metal
- Carbonates

and many more.

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See Us at FABTECH booth #6172
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On the cover: McCormick Place Entrance
McCormick Place offers the most exhibit space of any convention center in North America. With 2.2 million square feet of exhibit space, 114 meeting rooms, four theaters, and assembly seating for 10,000 people, McCormick Place has the capacity to suit the needs of both large conventions and trade shows and smaller meetings and exhibits. (Photo credit — Chicago Convention and Tourism Bureau.)
The World of Welding . . . and More

You have probably already started making your plans to attend North America’s greatest annual event devoted to welding and metal fabricating: FABTECH. This year’s giant FABTECH exposition is set for November 14–17 at McCormick Place in Chicago, Ill., which has proven to be such a premier destination for the show that we return there every other year. Chicago’s popularity with both show attendees and exhibitors is easy to understand, considering the area’s huge manufacturing and construction base, its central location, travel convenience, and the city’s broad appeal and hospitality to visitors.

A big part of what makes FABTECH successful is the wide spectrum of technologies it embraces. A quick look at its cosponsors makes this evident: the American Welding Society (AWS), the Society of Manufacturing Engineers (SME), the Fabricators & Manufacturers Association, International (FMA), the Precision Metalforming Association (PMA), and the Chemical Coaters Association International (CCAI). These well-known and respected organizations ensure a strong audience interest from proven products and structures.

After hosting its own AWS Welding Show for more than 50 years, the American Welding Society knew it was a strong value-added move back in 2005 to form an alliance with the FABTECH event. What we have seen since is true synergy that benefits both exhibitors and show attendees. Overall exhibit space this year will be greater than ever, topping 500,000 net square feet, and more than 30,000 visitors are expected to attend.

Successful exhibitions in any field involve a precise mix of worthwhile displays and information, education, and demonstrations that will naturally bring forth intelligent decisions on how to move ahead successfully. The ultimate value added in a show like ours is having a large number of motivated attendees seeking solutions from the exhibitors. Done right, this mixture of ideas and technologies benefits everyone involved.

In addition to the exhibits, here are some of the unique features of this year’s show that are bound to grab your interest and sharpen your competitive edge:

• A talk by Congressman Don Manzullo on strengthening U.S. manufacturing and creating jobs.
• A keynote presentation on “Growing Your Business through Innovation” by internationally recognized authority Robert Tucker.
• A state-of-the-industry executive outlook by industry experts.
• A look at the total cost of sending business offshore.
• New product presentations in the Solutions Showcase Theater.
• The Professional Welders’ Open Competition.
• A Buyer Appreciation Day, offering many Exhibitor Show Specials.
• The AWS Professional Program, featuring cutting-edge welding research.
• The RWMA Resistance Welding School.
• The AWS Awards Luncheon, and the AWS Image of Welding Awards at the Section Appreciation Luncheon.
• The National Welding Education Conference, and the 8th Conference on Weld Cracking.
• The brand-new AWS Foundation trailer, where the public can try virtual welding and learn more about the tremendous opportunities offered by careers in welding.
• AWS conferences and seminars on topics ranging from power source innovations to thermal spray technology, and much more.

This is just a sampling of what you can accomplish at this year’s FABTECH exposition. The whole event is tailored to solving your manufacturing and construction problems, and providing a competitive advantage to your company and to you, personally. We hope you’ll join us again this November in Chicago for what is bound to be the most valuable FABTECH event you have ever experienced.

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NIST Selects First Chief Manufacturing Officer

The National Institute of Standards and Technology (NIST) has appointed Michael F. Molnar its first chief manufacturing officer. Molnar is a licensed professional engineer and certified manufacturing engineer who once served as a federal fellow in the White House Office of Science and Technology Policy. Most recently, he was director of environmental policy and sustainable development at Cummins, Inc., a company that designs and manufactures commercial engines and power-generation systems.

As chief manufacturing officer, Molnar will be responsible for planning and coordination of NIST’s broad array of manufacturing research and services programs and will serve as NIST’s central point of contact with the White House, the Department of Commerce, and other agencies on technical and policy issues related to manufacturing.

House Subcommittee Holds Field Hearing on Job Growth

The House Education and Workforce Subcommittee on Higher Education and Workforce Training held a field hearing in August titled, “Reviving Our Economy: The Role of Higher Education in Job Growth and Development.” The hearing featured two panel discussions, one on the economy and job opportunities, and the second on the ability of higher education institutions to successfully prepare graduates to join the workforce.

More information, including copies of witness’ testimony, is available at www.edworkforce.house.gov/hearings.

OSHA Enhances Whistleblower Protection Program

In response to a Government Accountability Office audit that found “significant deficiencies” in the whistleblower protection role of the Occupational Safety and Health Administration, OSHA has announced significant enhancements, including in the areas of personnel training and internal systems. OSHA is presently charged with enforcing 21 federal whistleblower statutes in the areas of labor, environment, and consumer protection. These laws generally prohibit employers from retaliating against employees who raise various protected concerns or provide protected information to the employer or to the government.

U.S. Signs Antitrust Pact with China

The U.S. Department of Justice and Federal Trade Commission have signed a memorandum of understanding (MOU) with corresponding enforcement agencies in China regarding cooperation in antitrust matters. The MOU essentially creates a long-term framework for joint activity, through information exchanges, training programs, and workshops. Whether this will lead to China becoming more helpful in specific antitrust investigations involving Chinese companies remains to be seen.

New Export Definition of ‘Defense Services’ Proposed

The U.S. Department of State proposes to ease export restrictions under the International Traffic in Arms Act (ITAR) by changing the definition of “defense services.” The State Department believes the current definition is overly broad, capturing certain forms of assistance or services that do not warrant ITAR control. The proposed change narrows the focus of services to furnishing of assistance (including training) using “other than public domain data,” integrating items into defense articles, or training of foreign forces in the employment of defense articles. As a result, services based solely upon the use of public domain data would not constitute defense services and, therefore, would not require a license, technical assistance agreement, or manufacturing license agreement to provide to a foreign person.

The proposed rule also provides that a license is not required when foreign companies hire U.S. citizens if no technical data would be transferred by the U.S. citizen to the foreign employer.

Labor Suspends Prevailing Wage Determinations in Green Card Certifications

In response to a federal court order, the Department of Labor has temporarily suspended prevailing wage determinations, as well as redeterminations, until further notice. This is being done to allow Labor, as mandated by the order of the court, to recalculate prevailing wages for the H-2B temporary nonagricultural worker program. This will directly affect the labor certification program for green card cases, since an employer cannot file a certification for a foreign national employee without a valid prevailing wage determination issued by the Department of Labor.

Agency Scientific Integrity Policies Largely on Schedule

Federal departments and agencies are making significant progress in the development of scientific integrity policies, as called for by White House Office of Science and Technology Policy. These policies are intended to promote the integrity of scientific activities each agency undertakes and to ensure that such scientific integrity informs management and policy decisions. Among other measures, it is expected that each agency policy will provide for independent peer review of data and research used to support policy decisions, as well as inclusion of explanations of underlying assumptions and descriptions of probabilities associated with both optimistic and pessimistic projections, including best-case and worst-case scenarios.

HIPAA Audits Imminent

The U.S. Department of Health and Human Services has announced that it has retained a contractor to begin doing random audits for compliance with the Health Insurance Portability and Accountability Act (HIPAA). The audits are presently scheduled to commence prior to the end of 2011, with the first audit phase scheduled to end by December 31, 2012. Among areas that may be the focus of these audits are incident detection and response; access log review; up-to-date software; and secure wireless network.

It is unclear whether entities that are “business associates” under HIPAA will be included in these audits. ✻
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See Us at FABTECH booth #6749
The National Center for Welding Education and Training has recently been awarded a $2.9 million funding grant from the National Science Foundation (NSF).

This center, known as Weld-Ed and housed on the campus of Lorain County Community College, Elyria, Ohio, will use the three-year continuing grant to strengthen its efforts to advance educational curricula and instructor professional development in an ongoing effort to increase the number of certified welding technicians to meet workforce demands around the country.

According to the National State of the Welding Industry Report, published by Weld-Ed, the welding industry is currently scrambling to meet the hiring needs of at least 30,000 additional welding professionals annually, in an effort to produce 238,000 new and replacement workers through 2019.

To do that, the industry must acclimate to changing technology and increasingly specialized fields, according to Duncan Estep, center director and coprincipal investigator of Weld-Ed. Monica Pfarr of the American Welding Society Foundation serves as principal investigator on the grant.

The award will enable Weld-Ed to pursue several objectives the center has outlined, including developing a national welding educators’ certificate program; expanding professional development for welding faculty in new technologies; expanding and increasing the effectiveness of the center and its Regional Partners Network to address market-driven needs and the use of distance learning applications in sharing curricula between institutions and in delivering coursework; and developing and implementing a strategy to deliver technical assistance and consulting services to community and technical colleges, universities, K-12 school districts, and the welding industry.

FABTECH Canada to Debut in March 2012

FABTECH Canada 2012 will be held for the first time March 20–22, 2012, at the Toronto Congress Centre, Toronto, Ont., Canada. The event, sponsored by the American Welding Society, Society of Manufacturing Engineers, and the Fabricators & Manufacturers Association, International®, will showcase the latest technologies geared toward the needs of Canada’s 1.5 million employees in the automotive, construction, and energy industries. Visit www.fabtechcanada.com for additional information. Show updates will be posted on Twitter and LinkedIn.

Colfax Offers to Acquire Charter Int’l for $2.4 Billion

Colfax Corp., Fulton, Md., a global supplier of fluid-handling products, and Charter International plc, Dublin, Ireland, the owner of welding and cutting company ESAB, have reached an agreement on the terms of a recommended offer by Colfax to acquire Charter for 910 pence (approximately $14.45) per Charter share, comprised of 730 pence in cash and a fixed ratio of 0.1241 Colfax common shares per Charter share. The stock portion of the consideration is valued at 180 pence.

The acquisition, unanimously recommended by Charter’s board of directors, is expected to enable the combined company to benefit from secular growth drivers; provide an extra growth platform in the welding and cutting industry; and deliver earnings growth as well as double digit returns on invested capital within three to five years.

The transaction will be financed by Colfax with a combination of balance sheet cash, new bank debt that will be arranged by Deutsche Bank and HSBC, from which it has received $2.1 billion in firm commitments, and new equity of $805 million to be provided by certain existing investors.

GAWDA to Break $1 Million in Charitable Contributions

The Gases and Welding Distributors Association (GAWDA), Miami, Fla., is about to break the $1 million mark in charitable contributions through its GAWDA Gives Back campaign. Over the past 12 years, $975,053 has been donated to help charities in the host cities of its annual convention. This year, New York City will host its event.

For this year’s recipients of its charitable contributions, GAWDA has selected the FDNY Fire Family Transport Foundation, dedicated to the well-being of the fire department family, and the Pencil Fellows Program, which provides career-minded juniors and seniors in New York City public high schools learning experiences through full-time paid summer internship positions.

The 2011 Annual GAWDA Convention will take place Oct. 9–11 at the Times Square Marriott Marquis.
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Joplin Welding Program Reopens in Temporary Location Following Devastating Tornado

On May 22, an EF5 multiple-vortex tornado — the deadliest tornado to hit the United States since 1947 — devastated Joplin, Mo. Among the many buildings destroyed were Joplin High School and the Iowa Street campus of Franklin Technology Center (FTC). However, after only 60 days of construction, FTC students started the first day of school August 17 in a 50,000-sq-ft temporary facility at 420 Grand Ave. in Joplin.

The new space, dedicated to technical/vocational education, picks up all of the center’s half-day and evening programs. It offers 13 areas of study, including welding technology; assists seven sending schools; has community education classes; and serves 300 high school students as well as 65 adult students.

“Franklin Technology Center will be celebrating its 75th year of existence in 2012,” Dave Rockers, the center’s director, said in an announcement. He added that working together with partners, the center will do its part to rebuild the city.

R. E. Smith Construction Co., Joplin, served as the project’s general contractor. The renovation included adding a welding shop with 18 welding and 6 oxyfuel cutting booths, all with ventilation systems; remodeling existing offices; a culinary arts kitchen; an auto collision classroom/area; an auto tech division; classrooms for medical/nursing and labs, computer science, computer drafting, HVAC, and construction tech; a commons area for team building efforts in anticipation of SkillsUSA events; and a student store.

“We are pleased with it and happy to be here,” said Steve Reed, the center’s assistant director.

David Noah and Chuck Sexson teach welding technology, a 720-h certificate program. Currently, Noah instructs 36 high school students during the day, and Sexson trains 11 adult students at night. The semester is expected to end in May 2012.

Study areas include basic safety in the welding lab; interpreting blueprints; operating welding and cutting processes; oxyfuel cutting; shielded metal arc, gas metal arc, and gas tungsten arc welding; theory of heat treating metals; testing/inspecting welds; and plasma CAM processes.

Students receive a combination of classroom lectures with demonstrations and lab instruction including hands-on exercises. They also test according to the American Welding Society D1.1, Structural Welding Code — Steel, along with the American Society of Mechanical Engineers Welder Performance Qualifications exam.

The new lab contains 18 welding machines along with electrodes, autodarkening helmets, jackets, and gloves donated by The Lincoln Electric Co., Cleveland, Ohio, and Miller Electric Mfg. Co., Appleton, Wis.

In addition, the lab features a Victor® travel torch, pipe beveling machine, Edwards Mfg. Co. 75-ton ironworking system, and numerous hand tools. Extra cutting machines are on order.

“Our school was hit hard by the tornado on May 22nd. When I saw the devastation, I was overwhelmed and saddened by the destruction. I’ve had the opportunity to train more than 600 entry-level welders in my 20 years here at FTC, and at that moment, I wasn’t sure I would get to do that again,” said Noah. “I have been humbled by the generosity of our local community as well as the business and industry professionals related to the welding field. I never would have imagined so many people coming together to make sure our temporary facilities were of the best quality, so that my students’ training would not be interrupted, and for that I am thankful.”

To learn more about Franklin Technology Center, visit ftcjoplin.org.
Web Site Is a Virtual Welding and Cutting Industry Marketplace

BUG-O Systems, Canonsburg, Pa., is introducing Weld.com, a new resource for the welding and cutting industry to address all aspects of the field. It’s expected to be live by Oct. 1. “Weld.com provides more than just a company profile and some contact information,” said Chip Cable, its founder.

The Web site will give users the opportunity to engage with industry leaders, see full line cards and product reviews without leaving the site, and find what they need through multiple search features. It’s geared toward being an all-encompassing marketplace for the welding industry. Users can also find information on manufacturers, distributors, manufacturer’s representatives, consultants, schools, job postings, and more. It will present up-to-date news on new product applications to getting help with your own applications.

For a limited time, companies can be registered for a free listing. Contact Todd Clouser, tclouser@weld.com, for more information.

Owens C. C. Unveils $1.1 Million Welding Design Center

Owens Community College recently unveiled its new $1.1 million, 14,512-sq-ft Welding Design Center at the Toledo-area campus. It features up-to-date technological and academic resources...
specific to welding for several degree and certificate programs.

“The need for highly skilled welding professionals is greater than ever before,” said Jim Gilmore, the college’s chair of manufacturing and industrial operations.

Two large classrooms house 60 welding booths, 12 cutting booths, and eight grinding stations with technology for students to receive hands-on training for the shielded metal, gas metal, and gas tungsten arc welding processes. Thirty-six booths offer argon and carbon dioxide for welding purposes, while oxygen and acetylene are provided in 12 cutting booths. The center also includes a 1813-sq-ft storage complex for welding materials.

In addition, 68 workstations feature a welding fume extraction system with technology designed to extract metalworking particulate.

The center is utilized by students pursuing an associate’s degree in welding as well as gas metal arc, gas tungsten arc, and shielded metal arc welding, plus welding precertification certificates. It was designed by the firms Stough and Stough Architects of Sylvania and MDA Engineering, Inc., in Maumee, Ohio. Midwest Contracting, Inc., Holland, Ohio, served as general contractor.

**ExxonMobil Grants License to Nippon Steel for Field Welding Technology**

ExxonMobil Corp. has granted Nippon Steel Corp. a license to use its patented field welding technology to construct high-pressure pipelines made with X120 ultrahigh-strength steel.

ExxonMobil pursued an X120 development program to ensure its field welding technology would meet X120 strength requirements and be compatible with conventional pipeline construction practices. The technology uses the pulsed gas metal arc welding process with a proprietary solid welding wire and argon-based shielding gas. Welding is performed using standard automated and semiautomated welding tools.

Also, the technology includes the right to manufacture the proprietary welding wire. It is believed signing of the license agreement makes Nippon Steel the world’s first and sole pipe manufacturer having available both a mill to manufacture X120...
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CDA Approves Change for Zirconium Copper C15000

Cadi Co., Inc., Naugatuck, Conn., recently requested the Copper Development Association (CDA) to consider the composition listing revision of Zirconium Copper C15000 to complement international standards.

The association’s UNS listings for composition requirements of the alloy does not make a provision for impurities other than the footnote for Cu + Zr minimum, particularly when the Zr content is at or near the top of the limit. In addition, copper determination in the industry for this alloy is typically determined by difference, as spectrographic methods do not yield the required precision for a requirement of 99.80% minimum.

The CDA’s Technical Service and Standards Advisory Committee approved this request at its June 2011 meeting. The adjustment will be added to the SAE ASTM Metals & Alloys in the Unified Numbering System. Also, an alloy composition revision is being requested to the American Welding Society’s J1 Committee on Resistance Welding Equipment.

Details of the current composition for C15000 can be found at www.copper.org or www.cadicompany.com.
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Q: We silver-brazed what we thought was a so-called “oxygen-free” grade of copper (C10200) in our hydrogen brazing furnace at 1500°F (815°C), using BAg-8 filler metal, and the parts did not braze well at all. The parts came out of the furnace with blisters and cracks on their surfaces. When we analyzed the now-ruined copper, we found it actually to be Copper-110 (UNS C11000), i.e., tough-pitch copper, rather than an oxygen-free grade. The parts came with a certification stating it was C10200. Why does this blistering/cracking occur with C110, and what can we do to prevent it from happening again? What about the certification?

A: Copper-110 (also specified as C110, or UNS C11000), and known as electrolytic tough pitch (ETP) copper, has about 0.02-0.06% oxygen in its matrix as cuprous-oxide, primarily along the grain boundaries. Because hydrogen atoms are so small, they can easily penetrate deeply into any metal matrix when that metal is heated in a hydrogen-containing atmosphere.

In your case, you heated the parts to 1500°F (about 815°C) and the hydrogen atoms penetrated deep into the C110 matrix, reacting with the oxygen encountered, to form H₂O molecules, which under the high heat of your brazing process, then formed steam. The expanding steam can form blisters on the metal and crack the grain boundaries, etc. This is a nonreversible reaction, and is a good example of what we call “hydrogen embrittlement” of the metal.

To prevent this problem, C110 (ETP) copper should never be brazed in hydrogen, but only in a nonreactive gas such as argon or nitrogen. It can also be brazed in a vacuum atmosphere (if precautions are taken to perhaps use a partial pressure of argon in the furnace to prevent any outgassing of the copper itself). In fact, it’s probably wise to braze ALL copper parts in such nonreactive atmospheres, just to be on the safe side, since there is usually some tiny amount of oxygen present in all grades of copper.

Now, as far as the certification you received with the copper sent to you for brazing, please understand that such mistakes are rare. The vast majority of certs sent to folks are good, and accurate representations of what you have received. However, having said that, there are occasions (though rare) when the certification does not match the material. Someone at the company who sent the material to you grabbed the wrong material by mistake, and for whatever reason, failed to see that he/she was sending the incorrect material with the certification. Again, this is rare. But, if this happens, then that certification suddenly takes on new value, since it is a legal document. You can now use that to go back to your supplier to seek restitution for the mistake they made.

A word of caution about such restitution — in this litigious society, I personally recommend some compassion. Everyone makes mistakes. May I suggest that you follow the motto, “Do unto others as you would have them do to you.” If you had made that mistake of sending out the wrong material, how would you want your customer to respond to you?

This column is written sequentially by TIM P. HIRTHE, ALEXANDER E. SHAPIRO, and DAN KAY. Hirthe and Shapiro are members of and Kay is an advisor to the C3 Committee on Brazing and Soldering. All three have contributed to the 5th edition of AWS Brazing Handbook.

Hirthe (timhirthe@aol.com) currently serves as a BSMC vice chair and owns his own consulting business.

Shapiro (ashapiro@titanium-brazing.com) is brazing products manager at Titanium Brazing, Inc., Columbus, Ohio.

Kay (Dan@kaybrazing.com), with 40 years of experience in the industry, operates his own brazing training and consulting business.

Readers are requested to post their questions for use in this column on the Brazing Forum section of the BSMC Web site www.brazingandsoldering.com.

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Recently, I came across an alloy called Weldalite® Alloy 2195. Apparently, this material is an aluminum-lithium alloy. Why is lithium added to aluminum, where are these alloys used, and can they be welded?

A: Why lithium is added to aluminum.

One method for lowering the density of an aluminum alloy is to add an element that has lower atomic weight. Lithium is the most effective metallic addition for lowering the density of aluminum. For each 1% of lithium added to aluminum (up to the 4.2% lithium solubility limit), there will be a reduction of density of about 3%; this is accompanied by an increase in modulus of around 5%. Furthermore, a small addition of lithium promotes the precipitation strengthening of these alloys through the formation of a homogeneous distribution of coherent, spherical AlLi precipitates that form during heat treatment. The combined density-reducing effect and the precipitation-strengthening characteristic of lithium are the primary reasons for its selection as the alloying element used for the development of low-density, high-strength aluminum-based alloys.

Where These Alloys Are Used

Most aluminum-lithium alloys were developed for aircraft and aerospace applications where welding of high-strength aluminum alloys was not the preferred joining technique. An exception to this is Al-5Mg-2.2Li-0.14Zr Alloy 1420, which was developed in the 1960s in the Soviet Union for welded applications. In the early to middle 1980s, the potential to reduce the weight of welded launch systems by using aluminum-lithium alloys was recognized. Studies were initiated to assess the weldability of the recently developed Al-Cu-Li-(Mg)-Zr alloys, such as 2090, 2091, and 8090. Other studies were designed specifically to develop aluminum-lithium alloys with weldability as a design property. These latter alloys were trademarked Weldalite® alloys and include registered variants 2094 and 2195, as well as others. Their compositions are shown in Table 1. Lithium is an effective addition to aluminum alloys because it reduces alloy density and increases stiffness. Aluminum-lithium alloys often contain copper or magnesium, or both, as the primary alloying elements for increased strength. Most commercial aluminum-lithium alloys also contain zirconium, because of its ability to refine grains and inhibit recrystallization.

Table 1 — Typical Compositions of Aluminum-Lithium Alloys

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Cu</th>
<th>Li</th>
<th>Mg</th>
<th>Ag</th>
<th>Zr</th>
</tr>
</thead>
<tbody>
<tr>
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<td>2.7</td>
<td>2.2</td>
<td>5.0</td>
<td>0.4</td>
<td>0.14</td>
</tr>
<tr>
<td>2090</td>
<td>2.0</td>
<td>1.9</td>
<td>1.3</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>2091</td>
<td>4.5</td>
<td>1.25</td>
<td>0.4</td>
<td>0.4</td>
<td>0.14</td>
</tr>
<tr>
<td>2195</td>
<td>4.0</td>
<td>1.0</td>
<td>0.4</td>
<td>0.4</td>
<td>0.14</td>
</tr>
</tbody>
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*Variants of 1420 exist also with chromium, manganese, or both.
Weldability Of Aluminum-Lithium Alloys

With the correct composition, aluminum-lithium alloys can be strong and weldable. Weldability of aluminum alloys is generally defined as resistance to hot cracking. Aluminum-lithium alloys can be weldable; however, hot cracking has been reported for some alloys. A particular problem in welding Al-Li alloys is their propensity for weld-zone porosity, which results from the reactivity of lithium. Nevertheless, low-porosity weldments can be fabricated by use of proper preweld preparation, which includes chemically or mechanically milling the surfaces to be joined, coupled with the use of an inert gas cover during welding.

By considering the known hot-cracking susceptibility of binary and ternary model alloys as a starting point for alloy design, Al-Cu-Li Weldalite® alloys were specifically designed to be weldable. The first such alloy was designed to be above the solid solubility limit where hot-cracking resistance is often very good because of the ability of the solute-rich eutectic liquid to heal weld cracks by a backfilling mechanism during the final stages of solidification. Initial heats contained 6.3% copper, the level in conventional Alloy 2219, whose excellent weldability is in part responsible for its use as the main structural alloy on the Space Shuttle external tank.

Welding trials based on the function of copper content showed that the Alloy AlXCu-1.3Li-0.4Ag-0.4Mg-0.14Zr could be readily welded with no discernible hot cracking at copper levels down to 4.5% and possibly lower. Because all of the alloy compositions in this study were above the solid solubility limit, decreasing the copper level did not reduce strength in this composition range. As expected, fracture toughness and ductility increased with decreasing copper level, so the nominal 4.5% level was selected, and the alloy was registered as 2094.

As the properties of commercial lots of 2094 plate became available, trade studies revealed that greater weight savings could be achieved at higher toughness levels even with a slight decrease in strength. This gave rise to Alloy 2195 with the nominal composition Al-4.0Cu-1.0Li-0.4Ag-0.4Mg-0.14Zr. Commercially available filler Alloy 2319, with a high copper level of 6.3%, was selected to ensure hot-cracking resistance via base-filler mixing.

Two major obstacles to obtaining sound, X-ray-clear welds in any Al-Li alloy are the fairly thick surface oxide layer, which must be removed prior to welding, and the high reactivity of lithium with oxygen and hydrogen, necessitating additional inert gas shielding requirements.
A study was performed to compare the as-welded weldment properties of 2195/2319 with those of 2219/2319 using VPPAW. Long transverse tensile properties and weldment toughness, as measured by fracture strength of surface-cracked toughness panels, were measured for each alloy weldment as a function of temperature. Surface cracks were introduced at the weld centerline or the weld interface on selected specimens.

Neither 2195 nor 2219 displayed any hot-cracking problems. The weldment tensile strength of 2195/2319 was significantly greater than that of 2219/2319 at both ambient and cryogenic temperatures — Fig. 1. The mean 70°F (21°C) tensile strength of the 2195 VPPA weldments was 56.6 ksi (390 MPa), significantly higher than that of 2219 and higher than that of any known aluminum alloy VPPA weldments at that time. As can be seen, the weldment toughness of 2195/2319 is also superior to that of 2219/2319 at both ambient and cryogenic temperatures — Fig. 2.

Conclusions

Lithium is added to aluminum to create low-density, high-strength alloys primarily used in the aerospace and aircraft industries. Some of the aluminum-lithium alloys can be difficult to weld and exhibit hot-cracking tendencies. However, there are other aluminum-lithium alloys that have been developed to have good weldability. Provided the appropriate base material is selected and suitable precleaning and welding procedures are used, there are aluminum-lithium alloys that can and are welded very successfully.

Acknowledgment


Tony Anderson is director of aluminum technology, ITW Global Welding Technology Center. He is a Fellow of the British Welding Institute (TWI), a Registered Chartered Engineer with the British Engineering Council, and holds numerous positions on AWS technical committees. He is chairman of the Aluminum Association Technical Advisory Committee for Welding and author of the book Welding Aluminum Questions and Answers currently available from the AWS. Questions may be sent to Mr. Anderson c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126, or via e-mail at tony.anderson@millerwelds.com.
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New Materials and Torch Shapes Increase Range of Plasma Cutting Applications

Every new technology, from automobiles to televisions, goes through an evolutionary period where the design develops from the early, rudimentary concept to modern, refined, and user focused. If you think back to your first computer or cell phone, it bore little resemblance to the advanced tablets and smart phones of today.

The torches found on today’s plasma arc cutting systems are no different. The first torches were squared-off, clunky hunks of plastic that looked more like a child’s toy hammer than high-tech cutting equipment. These torches did the trick when plasma arc cutting was in its infancy, but as plasma arc cutting and gouging evolved, it became clear the torches needed to change to withstand harsher conditions and meet a wider variety of needs.

Many people think the torch is only important as a holder for the consumables. After all, it is the consumables in the torch that make a plasma system work: the electrode carries the charge necessary to create the plasma from the power supply; the swirl ring forces the flow of the resulting plasma into a vortex; and a nozzle constrains and directs the plasma until it is focused enough for cutting. Indeed, most of the early technology development centered around improving consumable design for increased ease of use and efficiency. For example, in the late 1980s, the introduction of blowback torch technology eliminated the need for high-frequency starts and the advent of shielded nozzles enabled the operator to drag the torch directly on the metal being cut.

Operators saw immediate benefits from these technological improvements. Contact-start systems eliminated interference with shop equipment, while drag cutting resulted in smoother, easier cuts that allowed users to follow a straight edge or template. Other improvements focused on safety, like the addition of a safety trigger to eliminate accidental torch firing and a “parts-in-place” circuit to ensure consumables were properly installed before firing the torch. The addition of quick-disconnects gave operators the ability to quickly swap torches or to remove the torch when transporting the power supply. But even after all these improvements, the shape and bulk of plasma torches remained the same, limiting their use to certain applications.

Making radical changes to this traditional design would require a whole new engineering approach, and a group of plasma engineers at Hypertherm was determined to rethink torch design. They knew the best way to understand the challenges their customers faced was to visit them and watch them work. Over a period of a year, engineers and product managers logged hundreds of hours on the road, talking to numerous customers during visits to scrapyards, shipyards, and other high-use cutting environments. Their goal was to find out how well current plasma torches performed in tough conditions and to see firsthand what operators wanted to do with plasma but couldn’t because of design limitations.

What they heard and observed is that plasma torches, especially hand torches, take a lot of abuse. It wasn’t uncommon to see torches accidentally falling off scaffolding, getting banged against metals, or seared by the heat of cutting and gouging. The engineers also learned there were many jobs operators couldn’t do with a standard 90-deg plasma hand torch or full-length mechanized torch.

The engineers focused on three areas: creating a robust torch, improving handle ergonomics while also improving gouging and cutting access for tight locations, and developing a shorter torch for robotic and pipe cutting applications. Everything was up for review, and the engineers spent two years prototyping torches, then conducting heat, impact, and cut tests. Once testing was completed, efforts turned to finding the right material for the torch body.

They knew they wanted to use plastic because it is light and easily molded, but they weren’t sure exactly which plastic to use. With hundreds of different brands and compositions to choose from, the task of narrowing down the choices wasn’t easy. One thing that helped was the decision to turn to quantifiable measures, like the standards set by the American Society for Testing and Materials for heat deflection, impact resistance, and environmental friendliness. Based on that, the team was able to zero in on several different plastics that had the best balance of properties. Those choices were then evaluated on actual performance before a winning plastic was selected.

“The challenge with designing plasma torches is that we are cutting metal with a plastic object,” said Jesse Roberts, one of the project engineers. “Ideally, the torch handle should be made of brick and rubber at the same time. A brick to take the heat and rubber to take the day-to-day abuse.”

The next challenge was to create a torch better shaped for gouging and cutting in tight places. Oxyfuel users have long had an array of torch angles and lengths available to them with plasma, though, the shape has traditionally been limited by the need for an internal plunger to bring the electrode in contact with the nozzle and to start the arc. The plunger, and wires attached to it, needed room to move within the torch shell, restricting the choice of shapes and angles available, and limiting plasma’s usefulness for certain applications.

The solution was to work from the inside out. The engineers knew they had to figure out how to remove the plunger before they could think about making a meaningful change to the torch’s shape. More months of work followed until the team agreed upon a solution: a new consumable design that replaced the plunger in the torch with a blowback spring in the electrode. This technology, dubbed Spring Start™, enabled the engineers to design a nearly straight torch that angles down just 15 deg at the tip — Fig. 1. Additionally, this allowed narrowing of the neck of the standard hand torch for greater visibility and to change the shape so that it could be held at either a 75- or 90-deg angle to the plate.

The team finally turned its attention to the third objective: developing a shorter torch for robotic and pipe- cutting applications. During end-user visits, they had noticed the standard length mechanized torch was often cumbersome for pipe-cutting and robotic applications. The solution was to replace the one-piece mechanized barrel with a modular design that could easily and quickly convert from a long torch to a short one — Fig. 2. Users could either work with the standard 15-in. torch or remove a section from the barrel to create a 6-in. mini torch, better suited for...
For pipe-cutting and robotic applications, the decision was made to replace the one-piece mechanized barrel with a modular design that could easily and quickly convert from a long torch to a short one.

robotic applications, pipe saddles, track burners, and other applications where the extra barrel length was a problem.

The new torches arrived on the market late in 2010. Users report the straighter profile of the 15-deg torch makes cuts in corners, overhead, and in tight spots much easier. For plasma arc gouging, it provides the user with more visibility and better control of the arc while keeping the operator’s hand away from the high heat generated by the gouging process.

These changes are just a few steps in the evolutionary process. As operators find new uses for plasma arc cutting and gouging, plasma engineers will keep innovating right along with them.

PAULA FLANDERS (Paula.Flanders@hypertherm.com) is marketing specialist/technical writing team leader, Hypertherm, Inc., Hanover, N.H.
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The opportunities and challenges facing the South African welding industry are examined

Hosting the 2010 FIFA Soccer World Cup enhanced South Africa’s profile internationally, attracted investment, and improved the local people’s sense of pride and unity regarding their country. Hosting the biggest sports show on earth also required significant infrastructure improvement. Although fewer new stadiums were constructed than originally intended, all existing match venues underwent major upgrades to increase capacity and to ensure that all FIFA’s requirements were met (Ref. 1). To accommodate the people traveling to South Africa to attend the event, commuter rail infrastructure was refurbished and upgraded, and the Airports Company of South Africa spent $0.7 billion to improve existing airport facilities, particularly in Johannesburg and Cape Town (Ref. 2).

To the South African engineering and fabrication industry, however, 2010 had significance for reasons other than soccer. Last year was the peak of an unprecedented infrastructure spending cycle that saw much more than transportation and sports facilities arise. To realize its plans to stimulate economic growth, reduce unemployment, and halve poverty by 2014, the South African government put forward a set of economic proposals in 2005 called the Accelerated and Shared Growth Initiative of South Africa, underpinned by unprecedented public investment in infrastructure (Ref. 3). Although the global economic crisis has severely curtailed the country’s expected economic growth, public infrastructure spending limited the negative impact of the economic meltdown and sustained the South African fabrication and engineering sectors through difficult times. Economic growth has improved substantially from −1.8% in 2009 to 2.8% in 2010. The National Treasury expects the growth rate to increase further to 3.4% this year and 4.5% up to 2014.

Although the World Cup is now behind us, public and private infrastructure spending will continue to have a major impact on the South African welding industry. To highlight the extent of the opportunities being offered to South African fabrication and engineering companies, a number of the public infrastructure development projects expected to come to fruition in the next few years follow. Several private infrastructure development and capital expansion projects, especially in the petrochemical sector, will further boost the economy and create opportunities in the welding sector.

Opportunities

In November 2005, Alec Erwin, then public enterprises minister, announced the public sector would invest more than $52 billion in the five years leading up to 2011, South Africa’s largest public investment program ever (Ref. 4). In addition to a host of smaller provincial projects, these programs were to focus on expanding the infrastructure of South Africa’s state-owned enterprises, including Eskom, the country’s state-owned power utility, and Transnet, the state-owned transport utility. Further investment from both the public and private sectors will continue to fund expansion in these areas beyond 2011.

Power Generation

Eskom is responsible for 95% of the country’s supply of electricity, which equals about 45% of the electricity generated on the African continent. Eskom currently operates 26 power stations (coal-fired and nuclear), with a total network of more than 186,400 miles of power lines and a nominal capacity in excess of 40,000 MW (Ref. 5).

To meet the rising demand for electricity in southern Africa, Eskom embarked on a massive expansion program totaling approximately $4 billion for the period 2005 to 2013. Since the expansion program began, additional capacity of 4454 MW has been commissioned. The aim is to deliver an additional 16,304 MW in power station capacity by 2017, with Eskom ultimately doubling its capacity to 80,000 MW by 2026. To satisfy the grow-
ing demand for electricity on the African continent, the following projects are currently underway:

- Construction started in August 2007 on the first new coal-fired power station in South Africa in more than 20 years. Medupi power station is a dry-cooled, coal-fired generating plant, comprised of six units with 4788-MW installed capacity. The supercritical boilers will operate at higher temperatures and pressures than older boilers ensuring greater efficiency.

- In February 2008, Eskom awarded contracts worth about $4.4 billion for its Kusile project, a coal-fired power station. Expected to be completed by late 2011, the first unit should be online in 2013. This station will consist of six units each rated at approximately 800-MW installed capacity. Once completed, it will be one of the largest coal-fired power stations in the world, and will be the first power station in South Africa to have flue gas desulfurization technology installed to remove oxides of sulfur from the exhaust flue gas.

- Work is also progressing well on Ingula, a pumped-storage scheme near Ladysmith, KwaZulu-Natal, with a planned capacity of 1352 MW. The scheme consists of an upper and a lower dam; both with approximately 72.2 million ft³ water capacity. Underground waterways and an underground powerhouse that will house four 333-MW pump turbines will connect the dams, which are 2.9 miles apart. During times of peak energy consumption, water will be released from the upper dam through the pump turbines to the lower dam to generate electricity. During times of low energy demand, the pump turbines will pump water from the lower dam back up to the upper dam.

- As part of its “return-to-service” initiative, Eskom is demothballing three coal-fired power stations, an initiative expected to contribute an additional 3600 MW of power by the end of this year.

- To satisfy the need for new peaking capacity with a short lead time to commercial operation, Eskom commissioned two open-cycle gas-turbine power stations, fired by liquid fuel, in April 2007, valued in excess of $0.5 billion. Both these stations have subsequently been expanded.

- Eskom is also investing heavily in renewable energy. Its Klipheuwel wind farm has a total capacity of 3.16 MW.

Transport Infrastructure

Transnet operates and controls South Africa’s major transportation infrastructure, and has been expected to spend $10.9 billion from 2005 to 2011 on a range of rail, port, pipeline, and other infrastructure projects. The plan aims to deal with the backlog in maintenance and upgrading that developed in earlier years, and to expand its asset base to meet the capacity demands of its customers (Ref. 6).

Key projects include the following:

- Expansion of the iron ore export channel from Sishen in the Northern Cape to Saldanha in the Western Cape. Capacity has been 29 million tons (Mt) per year. The expansion will increase the overall capacity of the rail corridor to 47 Mt/yr by 2011, with a further expansion project to 60 Mt/yr already underway.

- Increasing the capacity of the coal export channel by upgrading the coal link line to Richards Bay in KwaZulu-Natal to 86 Mt/yr, and by capacity expansion of the Richards Bay harbor.

- A new container terminal to increase capacity from 1.98 to 2.9 million units per year, and increased capacity at the car terminal for the Port of Durban in KwaZulu-Natal.

- Widening, deepening, and upgrading of the Cape Town container terminal to increase capacity from 600,000 to 900,000 units per year.

- Refurbishment and renewal of general rolling stock to increase freight capacity.

- Continued development of the Port of Ngqura, with provision for a full-service container terminal with two berths in the first phase to provide capacity of 750,000 units per year.

- Construction of a new 342-mile-long, 24-in. trunkline multipurpose fuel pipeline between Durban and Johannesburg to address the increased demand for fuel in Gauteng province and its surrounding areas.

Challenges

These projects hold enormous potential for South African engineering and fabrication companies, and for the welding industry in particular. The South African Institute of Steel Construction estimates roughly 180,000 tons of steel work will be required for power generation alone in the next few years, excluding distribution (Ref. 7). Estimates of skills level requirements for major projects over the next three years indicate large numbers of highly skilled welders will be required for the Eskom new-build projects, new petrochemical projects, and major shutdowns.

The local welding industry needs to take advantage of the opportunities being offered by current and future capital expansion programs. To remain competitive, the local welding industry needs to successfully overcome a number of challenges, some of which follow.

Technology Issues

Increased competition in global markets makes it imperative for the South African welding industry to remain current with recent developments in welding technology, processes, and materials. Improved control, lower defect levels, better energy efficiency, improved integration of welding with other manufacturing processes, and lower welding costs are critical factors that need to be addressed. Since local fabricators compete with fabricators abroad who can often supply products at very low prices, maintaining high quality levels in fabrication has become critical to ensuring competitiveness of local companies. Company certification schemes, such as ISO 3834, immediately confirm a fabricator’s competency level to end users, project managers, and design houses, and demonstrate the fabricator’s quality capabilities are competitive with similarly accredited companies from abroad.

Due to increasing competition between suppliers and the entry of many international welding equipment suppliers into the country in recent years, the local welding industry is faced with an excellent opportunity for investment in new technology and modern equipment. Local industry is conservative and there is a need to provide information and to sensitize industry to new developments and technologies in the field of welding. A number of key technology needs for the coming years have been identified by the American Welding Society, and are listed in Table 1 (Ref. 8). These technologies need to be introduced and promoted in South Africa. Technology centers at the Southern African Institute of Welding and the University of Pretoria (among others) need to be expanded to facilitate knowledge transfer and support local industry with respect to the introduction and application of advanced technologies.

Skills Shortage

During the 1980s and 1990s, South Africa lost numerous engineering, project management, and artisan skills. This brain drain can be attributed to a number of factors, including the turbulent political climate, the high crime rate, and lucrative positions and packages offered by international companies. The HIV/AIDS pandemic has also severely hit sectors such as mining, manufacturing, and trans-
portation, leading to high labor turnover rates and a loss of experience and vital skills. In the 1990s and early 2000s, the demand for welding skills was at a fairly low level in South Africa, and companies tended to downsize in terms of equipment and staff. South Africa’s good reputation with regard to education and skills training and the relatively low cost of labor made it an attractive recruiting ground for international companies. South Africa was an exporter of welders in the 1990s. Despite efforts by government and the private sector in recent years, South Africa’s skills pool is still severely depleted.

It is widely accepted that South Africa’s artisan shortage is a chronic problem (Ref. 9). According to the Department of Labor, specialist steel welding has been identified as a skill that is in short supply in both the private and public sectors, and welders and boilermakers have been included in the Manufacturing, Engineering and Related Services Sector Education and Training Authority (MERSETA) critical skills list. Although artisan development remains a key priority with government, there is still a major backlog to be dealt with. Figures compiled by the Steel and Engineering Industry Federation of South Africa for the metal trade sector indicate that at the end of the 1980s there were approximately 14,000 registered apprentices. This figure fell as low as 2000 early in the new millennium, but has since recovered somewhat, with more than 5930 apprentices registered at the end of 2009. Most of this growth is attributed to the accelerated artisan training program, which has allowed companies to take on more people with improved support and grants from MERSETA. This program attempts to accelerate artisan training by selecting only those trainees who already have the education and qualifications normally incorporated as part of the traditional apprenticeship route (Ref. 9).

MERSETA reports favorable growth and projects an upward trend in the number of trained artisans in the metals industry. It is reported that since 2003, the artisan apprentice intake has almost tripled, a trend that has continued. Many large South African companies have committed to injecting large amounts of money into accelerating artisan training. The lack of structured workplace experience is, however, still a major constraint.

Despite these programs and a number of smaller initiatives, South Africa still does not have sufficient numbers of suitably qualified and skilled welders and welding personnel. The following is a summary of a number of the challenges facing the South African welding industry with respect to skills shortages:

- It is still difficult to attract suitable people to welding-related careers as the industry’s image tends to discourage talented people. Many user companies have shed their welding workforce, forcing many welders in South Africa to lead itinerant lives to remain employed, moving from shutdown to shutdown. A government study showed that, when it comes to paying skilled workers, South African wages are at the bottom, but when it comes to paying managers, it is at the top, resulting in an imbalance between managers, professional, skilled, and semi-skilled workers. Although the rates paid to welders have increased between 50 and 200% in the seven-year period leading up to 2010, current rates are still not high enough to attract talented young people (Refs. 10, 11).
- Qualified and skilled welders, welding inspectors, supervisors, nondestructive examination technicians, welding technologists, and engineers are still in short supply. Skilled workers are imported on a regular basis for large capital expansion and construction projects.
- Skills levels are still low and high levels of rework are increasingly common on major projects and shutdowns (Refs. 10–12). Since many user companies do not permanently employ welders any more, welders are sourced through labor brokers. As a result of low skills levels and the poor credibility of welder certification and experience records, rejection levels are high. In addition, the training instructors and supervisory staff often lack practical and theoretical competence to support welders (Refs. 10, 11). Reject rates on welds made by imported Thai welders were reported to be less than half that of local welders during a recent major petrochemical shutdown.
- Workers who do the actual welding usually learned their skills on the job, rather than through apprenticeships or formal welder training. This move from qualified artisans progressing to code-certified welders (a process that takes three to four years), to fast tracking/coaching of welders through construction code certification requirements (a process that takes about three months) without the benefit of the background artisanship does not work and is probably a major contributing factor to high defect rates (Refs. 10–12).
- The government has introduced a number of initiatives to encourage skills development. In 2004, President Mbeki announced a new National Skills Development Strategy for the period 2005–2010. Approximately $3.1 billion over five years was allocated to fund this strategy, which aimed at improved cooperation between the Sector Education and Training Authorities on one hand, and the Further Education and Training (FET) colleges and institutions of higher education on the other (Ref. 13). Despite the good intentions of these programs, students progressing to FET colleges and acquiring qualifications have a credibility challenge because indus-

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**Table 1 — Key Technology Needs Identified by the American Welding Society (Ref. 8)**

**Automotive**
- Real-time sensing and adaptive control
- Resistance spot welding process control, electrode wear, and equipment design
- Joining of lightweight metallics, particularly aluminum
- Joining of high-strength coated steels
- Joining of dissimilar materials
- Polymer joining
- Laser processes/tailor-welded blanks
- Structural adhesive technology
- Welding design and process management tools
- Microelectronics: process development and reliability
- Modeling

**Energy and chemical**
- Joining of high-strength steels (linepipe)
- Inspection, reliability, and risk assessment
- Welding of corrosion-resistant alloys
- Repair technology (in-service repairs, repairs without postweld heat treatment)
- Improved fitness-for-service assessment methods

**Others**
- Laser processing
- Improved fatigue performance and design rules
- Modeling
- Real-time process control
- Optimized robotic and mechanized welding systems
- Welding of high-strength steels
- Welding of new Al, Ti, and Ni alloys for aerospace applications
- Solid-state joining and brazing processes (with emphasis on friction stir welding)
- Polymer and composite joining
- Nondestructive examination
Welding personnel will increase the profession in the welding field had little training in the practical aspects of welding. Promoting the use of internationally recognized training programs for welding is also a major concern. The government and private sector should create and fund a national training scheme for welders. Knowledgeable trainers should train all welders and welding personnel according to a credible program that delivers the high skills levels industry requires. This can easily be addressed in South Africa by adopting the International Institute of Welding programs, which are recognized internationally and are widely accepted by local industry.

Little research is currently being carried out in welding-related fields in South Africa. This severely restricts the ability of academic and research institutions to support local industry with specialized technical knowledge. The University of Pretoria’s research program in welding metallurgy and the friction stir processing program at Nelson Mandela Metropolitan University are currently the only sustained long-term welding research programs at South African tertiary education institutions. The availability of postgraduate research students is also a major concern.

A number of possible solutions to these problems have been proposed by industry (Ref. 14), the American Welding Society (Ref. 8), academia, and the Southern African Institute of Welding (Ref. 10):

- Suitable South Africans can be targeted by increasing the attractiveness of welding as a vocation. The prestige and promise of welding as a career will grow as welders are certified to guarantee their capabilities, and engineers gain greater appreciation for the potential uses of welding. Promoting the use of internationally recognized training programs for welding personnel will increase the prestige of welding as a career and ensure that successful candidates receive greater recognition and status. The Southern African Institute of Welding’s Young Welder of the Year competition has also been instrumental in raising awareness and increasing the profile of young welders in this country.

- Relevant professionals should be targeted as the present skills demand is not a transient requirement. More students should be attracted to welding-related fields through bursaries, scholarships, and learnerships. At the same time, the welding-related course material in the curriculum of materials scientists, metallurgical engineers, mechanical engineers, civil engineers, and architects should be increased, and students should be educated on the role of welding in the total fabrication process.

- Cooperative welding research programs should be encouraged between government, industry, and academia, with sharing of costs and resources. Government already has several programs in place to fund research, but industry should support these programs by providing funding for welding-related projects, sponsoring students, and encouraging suitable employees to study toward higher degrees.

- Greater reliance on mechanism, automation, and robotic welding, and sourcing international skills outside the borders of South Africa in the short and medium term should be the last resort. The primary focus should be on transferring and developing skills among South Africans.

Conclusions

South Africa is enjoying a period of unprecedented public and private infrastructure development and capital expansion. To take advantage of these developments, the local welding and fabrication industry needs to position itself in such a way that it is globally competitive. This will involve keeping abreast of new developments in welding technology, processes, and materials, and solving the threatening skills shortage in the field. By addressing these potential threats now, local industry can ensure less money leaks out of the economy in the form of foreign contracts.

Acknowledgments

The author would like to acknowledge the contributions of Jim Guild and the Southern African Institute of Welding.

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Through Steel and Glass, Artist Seems to Defy Gravity

As everyone learns to weld, we all start to think about the possibilities of what we can do beyond fillet welds and T-joints. Many welding schools host art competitions as an extracurricular event, but what happens when you take your skills as a fabricator and designer, match that with unbound creativity, and take it to the next level? Meet Stretch.

Jeff Rumaner (aka Stretch) is an entrepreneur, restaurateur, TV personality, fabricator, and designer living in Kansas City, Mo., where he’s an integral part of the city’s art community — Fig. 1.

He runs a gallery known as ZONE, as well as two restaurants called Grinders and Grinders West. The restaurants, filled with custom Stretch creations, accompany a sculpture park turned live music venue, CrossroadsKC @ Grinders, which promotes artists, musicians, and benefits for nonprofit organizations.

Stretch has been a juror for the SkillsUSA sculpture contest and served on the board of directors for the International Sculpture Center. He’s also crisscrossed the nation as a guest on Extreme Home Makeover, Monster House, and Guy Fieri’s Roadshow Tour.

In addition, he will be headlining his own pilot on SPIKE TV this fall, Hungry Men at Work.

Above all, he is a sculptor. His choice of materials — glass and steel — is not just a personal preference. He believes that glass and steel work against each other, “causing tension while maintaining a high level of dialogue.” The dialogue is meant to educate and trigger insight, as well as create a “better understanding of concepts and ideals the work embodies.”

Stretch has worked with many renowned artists on public commissions for airports, college campuses, and city sculpture parks around the world. He has been welding for more than 25 years and building large-scale sculptures for more than 15 years.

John Swartz is a product manager for Miller Electric Mfg. Co. (www.millerwelds.com), Appleton, Wis.

For more information about Jeff Rumaner (aka Stretch), visit www.stretchsculpture.com, twitter.com/StretchArtist, or www.grinderspizza.com.
Welding as a Key Tool in the Artist’s Repertoire

First Interest in the Trade

Stretch’s career as an artist goes back to his 7th grade metal shop class. He found that by practicing good technique, he had a talent for creating things with his hands. As a junior in high school, he began taking college art courses at the Philadelphia College of Art, where he excelled. Stretch then attended the Kansas City Art Institute.

“I came to the Art Institute to design toys,” he said. “I was taking design classes, designing electric cord caddies and vegetable brushes. I looked across campus, and the sculptors were welding steel and kicking up 20-ft rooster tails with these grinders. I picked up my stuff, cruised over to sculpture, and never went back.”

He saw scaffolding, metal, huge ice blocks, and light refracting through it all to create giant prisms. He asked what it was, and when he was told it was a sculpture, he said, “No, sculptures are these ground down, stainless steel cube-like pieces. That was my eye opener, and that was about 25, 30 years ago.”

Current Techniques and Machines Used

Today, he employs a variety of bolting/joining methods, as well as gas metal arc welding (GMAW), gas tungsten arc welding (GTAW), and plasma cutting processes to achieve each sculpture's unique design — Figs. 2, 3.

His welding and cutting fleet includes the following: a 180-A, AC/DC GTAW machine (Miller’s Diversion™ 180) for working with thin materials and more difficult alloys such as aluminum, titanium, and stainless steel; a 210-A all-in-one GMAW machine (the Millermatic® 211 with Auto-Set) for welding on steel up to 3/8 in. thick; and a plasma cutting machine (Miller’s Spectrum® 375 X-TREME™) for simplicity and portability in cutting various shapes and designs out of materials up to 3/8 in. thick.

Unique Works of Art Made from Stainless Steel, Glass

Much of his work, like Heartland Shuffle—a stainless steel and cast glass orbital structure that stands watch outside the H&R Block world headquarters in Kansas City, Mo.—seems to defy gravity while complementing the architecture around it — Fig. 4.

Guardian, a steel and stacked glass installation that seems to join the earth with the sky, is a centerpiece of the Crossroads—
Standing outside the H&R Block world headquarters in Kansas City — Fig. 5A, B.

Other installations, such as the Sabine Pass Fire House #4 Fountain in Sabine Pass, Tex., mix stainless steel with fire and water to truly tie in the structure with the environment and elements — Fig. 6.

Transporting Large Sculptures Takes a Toll

However, his pieces weren’t always as large. While living in New York, he attended sculpture art shows, where, among other things, he could determine the size of an artist’s studio by the size and how many pieces their sculptures were in.

“If it was in 50 pieces, the sculptor lived on the eighth floor with no warehouse elevator. They had to carry it down in a little tiny elevator and then assemble the whole thing together,” he said.

For Stretch, welding allowed the freedom to get from point A to B in the smoothest, fastest, and safest way possible.

“Old welding allowed the freedom to get from point A to B in the smoothest, fastest, and safest way possible.

“Fig. 3 — Stretch relies on GTAW for welding thinner materials, and more sensitive alloys such as aluminum and titanium.

“Fig. 4 — Standing outside the H&R Block world headquarters in Kansas City, Mo., Heartland Shuffle is an orbital combination of stainless steel and cast glass.

“If I could weld just one section and carry it, great,” he said. “If not, I would have to make it in several pieces connected by a variety of weld and bolt mechanical connections. You become a Rolodex of information on connections. Welding is a necessary and functional way to facilitate my ideas and get them to the next level.”

“I started welding everything together,” he continued. “I would weld manhole covers, aluminum hub caps, and try to weld steel to bronze. I didn’t know the difference between the different metals, but I learned whether the welds would crack or hold. And little by little, by welding everything under the sun together, I learned how to weld and create sculptures.”

Learning to Work with Different Types of Materials

A major component of the artist’s work involves finding ways to connect a variety of disparate elements, including metal,
This sculpture of steel and stacked glass anchors Stretch’s own music and arts venue, CrossroadsKC; B — close-up view of the artwork.

“Gravity works. It’s one of those amazing things that you can’t always fight, so I have to find a way to get my objects in the air and keep them there,” he said. “One thing I’ve learned is that there are eight-million different kinds of connections. You might have a welding machine that can only weld a certain thickness, but you can drill to make bolt and mechanical connections so that the separate pieces will fit in your truck.”

Aside from functionality, it’s that marriage of different elements and materials that make Stretch’s work stand out.

“You have a yin-yang thing working between two elements, and when you add glass, wood, plastic, and stone, and do it all with structural integrity.

Fig. 6 — The Sabine Pass Fire House #4 Fountain in Sabine Pass, Tex., mixes stainless steel with fire and water to tie in the structure with the environment and elements.
another element, it becomes incredibly dynamic,” he said.

“I take plate glass, stack it, and chip the edge. It becomes very seductive, like an icicle. It wants to suck you in. And then you have this hard edge of steel that sandwiches it together or holds it delicately like a diamond ring,” Stretch said. “So, you have this incredible balance between two materials that are completely malleable but hard as steel. That’s powerful.”

**Fabricator’s Skill and Creative Mind Set, Business Acumen**

What has made him as successful as he is today is a tireless work ethic matched with a talent for creating art that people want. Many of his sculptures serve as installations in public places, and that honor has allowed him the freedom to explore new and different ways of using materials.

“Being an artist isn’t easy,” he said. “It’s glamorous, and it’s romantic, but it’s a heck of a lot of work. With my imagery and choice of materials, I am lucky. They’re architectural, referential, and work well with people’s houses and the environment.”

Stretch credits much of his success to working jobs that allowed him to hone his skills as a metalworker while keeping his creative edge.

“Much of my training was as a fabricator,” he said. “I had set schedules and had to be places at certain times. I have carried that with me as an artist. I don’t miss deadlines, and I am on or under budget. I’ve had great mentors in the business world that helped to focus my attention. I work seven days a week and have for years and years. Many artists don’t like that kind of lifestyle.”

**Giving Guidance to Prospective Artists**

What advice does he have for future sculpture artists out there, whether you’re just learning to weld or strike an arc every day in your day job?

“Art isn’t about direct representation,” he said. “As long as you have a cell phone camera, you can document whatever you want and then reproduce it in a drawing. With metal sculpting, you don’t need to sit and sketch something out and reproduce it in welded steel. You want to take it to the next level by abstracting it, looking at it, and dissecting what you want to get out of it. You want to capture the essence of an object; art is not about duplicating or making things exact.”

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Jim Farley, Project Manager

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How to Assure Quality in Outsourced Welded Products

The OEM must be actively involved with its outsourcing suppliers to verify they are properly staffed, trained, and equipped to provide compliant production on a consistent basis

BY WILLIAM C. LAPIANTE

Global welding supplier development is a business reality and is the result of outsourcing of welding and metal fabrication products by United States-based original equipment manufacturer (OEM) organizations (e.g., aerospace primes) for commercial, industrial, and military project applications. Outsourcing activities are driven by such criteria as reducing supply chain costs, decreasing internal production risks, increasing production flexibility, a lack of internal manufacturing capabilities, as well as foreign sales contract obligations. However, in an effort to optimize profit margins, to meet scheduled delivery dates, and to achieve technical success in the manufacturing and marketing of high-integrity welded products, there exists a requirement for welding supplier development.

Outsourcing Requirements

For businesses engaged in the manufacturing of welded products, outsourcing and welding supplier development represent an integral part of a business strategy. From this point, the terms “supplier” and “fabricator” shall be considered synonymous. Manufacturing today is extremely competitive. Thus, OEMs who cannot meet increasing costs, quality, and delivery performance requirements of their customers jeopardize their competitive edge and the loss of their customers. Within the global industry, there are OEM companies that have a supplier development program in place. Unfortunately, many of these programs are simply in word only. That is, many of these programs encompass nothing more than some type of a “Welding Supplier Quality Award” in which a sub-tier welding supplier receives an award for achieving a certain degree of product quality in conjunction with on-time delivery performance. Performing sub-tier welding supplier audits on a one-, two-, or three-year cycle does not accomplish the principal aspects of a welding supplier development program that is in the development of a competent, capable, and credible supplier. This technique is simply “welding supplier checking and verification” as opposed to “welding supplier development.” This is evident when products received from external suppliers fail to pass the incoming OEM weld inspection, or the product fails in the field, or the customer complains about shoddy workmanship, poor performance, and/or unsatisfactory durability.

The Three Most Costly Problems

Based upon my experience, the three biggest and most costly problems associated with the outsourcing of welded products are:

1) Shoddy workmanship and the subsequent lack of an effective visual weld inspection program to identify discrepancies, defects, and nonconformances as they occur on a daily basis during the fabrication process. That is, is there a diligent, in-process weld inspection activity taking place? For example, during production, are welds 100% visually inspected on an inch-by-inch basis employing a Weld Map where the results are then documented daily?

2) The failure to identify weld discrepancies, defects, and nonconformances as they occur during production results in costly weld rework, lost productivity and material, and possibly scrapping product;

3) The lack of adherence to weld code criteria results in the accelerated degradation of weldment performance, durability, and robustness, and;

Supplier development represents a collaborative effort by an OEM to work with its sub-tier suppliers to continuously evaluate and improve product quality, manufacturing capabilities and competencies, and cost-performance criteria.

Supplier development commences after the auditing process and the supplier selection process have been completed, where the strengths and weaknesses of the sub-tier supplier have been clearly identified. From the OEM’s perspective, the logistical and resource commitment for welding supplier development is all-encompassing with respect to coordinating and providing the welding subject matter experts (SMEs), including welding engineers (e.g., CWEngs), welding inspectors (e.g., CWIs), and weld-
Working with Foreign Suppliers

Table 1 illustrates sample areas of responsibilities for U.S.-based, OEM welding SMEs relative to providing job-site support at global supplier locations.

The foundation for achieving welding supplier development and qualification success lies in the degree of preproduction preparation and planning efforts prior to the commencement of the “arc-and-sparks.” A further layer of complexity to the supplier-support process depends on the country where the manufacturing will be conducted. In addition to possible language and communication problems, many foreign welding suppliers have no experience with U.S.-based weld code requirements for weldment design criteria, welding inspector qualifications, welding documentation such as procedure qualification records (PQRs) and welding procedure specifications (WPSs), as well as the welder qualification process. Extensive efforts with respect to engineering instruction and personnel training and qualification are required for foreign suppliers to become competent in their understanding and compliance with U.S.-based weld code criteria in an effort to meet OEM drawing and contract requirements.

Welding Supplier Development — The Critical Welding Audit Process

Selecting the right supplier is critical. Prior to awarding a contract, a comprehensive welding operations audit should be conducted in which the supplier is given a detailed and thorough evaluation. The supplier’s production readiness to manufacture the OEM’s product must be accurately determined. Thus, the audit’s purpose is to clearly identify each supplier’s strengths and weaknesses:

1. Determine the supplier’s competencies and capabilities as related to the compliance criteria required to manufacture the intended product. Bottom line: Is the supplier capable of manufacturing a quality product in a cost- and time-efficient and effective manner that is comm-
pliant to the drawing on a consistent basis?

2. Determine the level of OEM resource commitment needed for supplier development. That is, funding, time, personnel, equipment, travel, etc.

3. Determine the supplier’s attitude, motivation, and responsiveness to the contract requirements.

The final supplier selection should be based upon objective evidence that demonstrates the above and the supplier’s commitment to meeting all the OEM’s specified product contract requirements.

Table 2 illustrates sample weld audit questions that a U.S.-based, OEM welding operations auditor may present to a sub-tier supplier relative to welding operation attributes.

Correlate Audit Results to Product Welding Requirements

The welding operations audit results should be evaluated carefully and correlated to the fabrication requirements of the pending and future contracts. Audit questions should be direct, with weaknesses. Careful attention should also be made to document the supplier’s attitude, motivation, and responsiveness as well. Audit questions should be direct with the focus upon achieving only specific answers, no ambiguities. No general questions or responses are acceptable. Based upon the audit results, all objective evidence should be compiled from each supplier such that the strengths and weaknesses are weighed and correlated to the product contract fabrication requirements. Let the facts speak for themselves relative to the characterization of the supplier. From the OEM perspective, welding supplier development represents an enormous commitment and undertaking in terms of cost, time, and resources. Thus, the OEM must be critical and objective in the welding supplier selection process.

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<tr>
<th>Table 3 — U.S.-Based, OEM Welding Supplier Development Lessons Learned</th>
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<tr>
<td>1. Welding SMEs must “lead by example” — “can do, will do, did.” Welding SMEs must provide job-site technical leadership by providing hands-on shop floor and classroom instruction to develop the supplier’s competency and capability.</td>
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<td>2. Select a supplier that has a professional quality infrastructure with qualified inspectors, QA engineers, inspection procedures, calibrated inspection tools, and measuring equipment, up-to-date code books and specifications, etc.</td>
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<td>3. OEM lessons learned. If you are not willing to make corrections based upon past mistakes, then you should be willing to pay the price for negative supplier development and performance consequences.</td>
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<td>4. During the supplier auditing, development, and support process, be professional, objective, and listen actively to the supplier.</td>
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<td>5. Carefully evaluate the supplier’s production control infrastructure. A production control department is critical to initiate and maintain shop floor production discipline and organization.</td>
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<td>6. Ensure international travel security conditions for electronic assets (computers, smartphones, etc.), ITAR (International Traffic in Arms Regulations Export Administration Regulations) and fabrication drawings and contract protection and controls are being met.</td>
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<tr>
<td>7. Do not select a welding supplier solely based upon a low cost quote. Any perceived savings may quickly evaporate due to job-site support/resource requirements and shoddy workmanship and quality issues.</td>
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<td>8. Make regular visits to the job sites to verify the product weld inspection activities and to address and resolve any production problems and concerns. The in-person time is far more effective than phone discussions and e-mails.</td>
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<tr>
<td>9. Employ only competent and experienced personnel to conduct welding operation audits.</td>
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<td>10. Recognize the importance of welding drawing notes. “Boiler plate” the notes from one drawing to another can have drastic manufacturing and cost consequences if the notes indicated are not pertinent to the respective product. Comprehensive drawing welding notes must be added by the OEM to eliminate supplier manufacturing confusion and problems misinterpreting the drawings.</td>
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<tr>
<td>11. Implement design for manufacturability, assembly, and weldability principles (DFMA-W). Make sure the product can be fabricated! Work with the supplier to develop full-size weld-joint mock-ups as required, verifying welding process and NDE method accessibility.</td>
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<td>12. Incorporate a nondisclosure and noncompeting stipulation clause within all sub-tier welding supplier contracts.</td>
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<td>13. Verification and validation. For the FAV process, the measurement methodology process to verify and validate the dimensional integrity of a weldment during fabrication needs to be established prior to production. The fabrication measurement methodology employed must be aligned with the same level of precision as with the FAV measurement method.</td>
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<td>14. Minimize the number of personnel directly involved with the sub-tier supplier. Nonqualified personnel may provide conflicting opinions and the dissemination of misinformation.</td>
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<td>15. Provide welder training/qualification and develop all PQRs and WPSs for the project prior to production. Also, take the time to train/qualify welding inspectors, and develop weld inspection procedures, Weld Maps, FOD/FOE procedures, etc.</td>
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<tr>
<td>16. Verify all measuring tools, fixtures, and tooling employed for production are calibrated to ensure weldment dimensional integrity accuracy.</td>
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<td>17. Communicate honestly, openly, and timely. Employ translators as required. Sub-tier suppliers need to become extensions of OEMs — their customers. If there is no effective or efficient communication, expect the worst.</td>
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<tr>
<td>18. Travel to the sub-tier supplier to perform a comprehensive job-site audit of the facility as opposed to performing a “desk top audit” or relying solely upon a certificate from a certifying authority. Assess the true capabilities and competency of the supplier based upon a first-hand visit of the facility.</td>
</tr>
<tr>
<td>19. Sub-tier suppliers must take the leadership position and notify the OEM company relative to recommended product changes or warnings if there is a product design flaw, potential operational or safety problem, or anything that could impact the cost, delivery schedule, or quality of the product. All parties must be proactive and not reactive.</td>
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<tr>
<td>20. Build the supplier’s confidence and earn the supplier’s respect and trust. Welding SMEs, inspectors, and educators must develop a trusting rapport with the workforce.</td>
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<td>21. The instilling of process discipline and workmanship quality pride within the workforce is critical. Shoddy product workmanship quality and the lack of adherence to weld code, specification, and weld inspection acceptance criteria results in product degradation.</td>
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Table 3 — Continued

22. Welding SMEs, inspectors, and educators represent the OEM as ambassadors and thus should be professional, organized, and well prepared for job-site work activities.

23. Conduct pre-kick-off project team meetings with welders, welding operators, process engineers, quality and manufacturing personnel, etc., to discuss fabrication criteria, workmanship quality standards, OEM expectations, and any areas of concern.

24. Carry extra weld code/reference books for suppliers, especially for international suppliers.

25. Purchase the right welding equipment and welding wire for the application. Know and fully understand the respective base materials you are welding, forming, and cutting.

26. When supporting suppliers internationally, abide by the cultural customs and social dos and don’ts.

27. It is critical for the OEM to conduct visual weld inspection awareness classes on an annual basis for its sub-tier supplier base. Classes must be conducted to calibrate sub-tier welding inspectors to the OEM’s weld inspection criteria.

28. EHS criteria are critical considerations in fabrication and manufacturing. When welder comfort increases and the workplace is a safe, controlled, and orderly environment, the productivity, morale, and workmanship quality increases.

29. Obtain professional and accredited materials testing laboratory support for base and weld metal mechanical and metallurgical testing, failure analysis, and investigation criteria.

30. Sub-tier suppliers need to provide a Manufacturing Data Package (MDP) to the OEM company for it describes and details how the product is to be manufactured.

31. If you are not going to weld the product the right way, do not attempt to weld the product.

32. Obtain experienced and expert advice to develop accurate and realistic product welding and fabrication timeline estimates.

33. The OEM organization benefits by funding and promoting sub-tier supplier comradery using bonus awards, dinner functions, etc.

34. The supplier must submit drawing changes as required during the life of the project. That is, if there are drawing discrepancies, the suppliers must red-line the drawing and submit drawing change notices (CN) to the OEM.

35. For suppliers engaged in the manufacturing and fabrication of welded products, the need to address weld code interpretation, deviation, or clarification criteria may arise. The relevant weld code should be contacted in the event there is an urgent need for alternative rules concerning materials, fabrication, or in-service inspection activities not covered by the respective weld code.

36. Employ Six Sigma and Lean principles at supplier locations. The OEM needs to provide training in the application of Lean, Six Sigma, and quality tools. Requesting that suppliers decrease their costs without giving them the “know-how” to lower their costs is not sustainable in the long term. This may force suppliers out of business, which is contrary to the ethics and principle of welding supplier development.

37. Unless the supplier has demonstrated fluency and command of the English language, it is recommended that drawing notes be written in the indigenous language of the respective sub-tier supplier as well as in English.

38. In an endeavor for the OEM to better control, manage, and develop existing sub-tier suppliers, it is recommended to minimize the total number of ASL sub-tier suppliers as opposed to expanding the supplier base.

39. It is encouraged that an increased effort be made by U.S.-based, professional engineering organizations such as the AWS, ASME, and API to incorporate and cross-polllinate, highly reputable international welding specifications such as ISO EN 3834 within U.S.-based weld codes, specifications, and standards.

40. Develop and distribute a pre-weld checklist to production welders and welding operators in an effort to eliminate rework or lost product due to human error.

41. Where applicable, especially for international applications, a weld code “gap analysis” should be performed to determine if a non-U.S.-based weld code can be employed for a U.S. product manufacturing application in another country in lieu of the respective U.S. weld code. A “gap analysis” is a comparison process and illustrates the differences between weld codes.

42. Establish an E-room to hold all pertinent product-related documentation such that information can be accessed globally by all sub-tier suppliers.

43. Welding documentation such as welder qualifications, PQRs, and WPSs should be in electronic format.

44. The global welding and metal fabrication industry needs more professionally minded and competent welding engineers, inspectors, educators, metallurgists, welders, etc., to support high integrity welding, fabrication, and manufacturing engineering applications. The AWS supports this effort by offering an array of training and certification programs.

Welding Supplier Development — Providing Job-Site Supplier Supervision and Support

The goal of welding supplier development is the qualification of the sub-tier supplier and the placement of the sub-tier supplier on the OEM’s approved supplier list (ASL). Placement of the sub-tier supplier on the ASL represents an official OEM recognition and approval for the supplier to manufacture product. Once the OEM auditing and supplier selection process has concluded, job-site support can commence to assist in the correction of all audit findings in an effort to start production activities as soon as possible.

Typically, as the level of OEM support increases, the timeline for closing out all corrective action findings decreases. It should be noted that welding supplier development also encompasses ongoing product production support efforts after all corrective actions have been closed. For many suppliers, the audit process represents their first exposure to U.S.-based weld code criteria. Thus, continuous production support efforts can be anticipated due to the fact the supplier may be inexperienced in weld code criteria and weld inspection and acceptance requirements.
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For welding suppliers, the American Welding Society (AWS) offers a Certified Welding Fabricator program (CWF) detailed in AWS QC17, Specification for AWS Accreditation of Certified Welding Fabricators, and AWS B5.17, Specification for the Qualification of Welding Fabricators. Also, AWS offers Certified Welding Engineer (AWS B5.16), Certified Welding Supervisor (AWS B5.9, QC13), Certified Welding Inspector (AWS B5.1, QC1), Certified Welding Educator (AWS B5.5, QC5), Radiographic Interpreter Certification (AWS B5.15), and Certified Welder (AWS QC7) programs to further educate professional personnel engaged in metal fabrication activities. Visit the AWS Web site (www.aws.org) for more information.

Welding Supplier Development — OEM Welding Supplier Development Lessons Learned

Table 3 presents the lessons learned over years of working in an engineering and quality capacity (i.e., WE, CWI, CWE, auditor) at domestic and international job-site sub-tier supplier locations to support various U.S.-based, OEM supply chain and program initiatives.

Conclusions

Global welding supplier development is an ongoing effort by top-tier U.S.-based, OEM organizations to support their network of sub-tier suppliers. Even after the sub-tier supplier has been added to the authorized supplier list, its manufactured products must be continuously inspected and evaluated by qualified personnel in an effort to ensure welding code, workmanship quality, drawing, and the contract compliance requirements are being met. Continuous improvement initiatives are required to provide sub-tier suppliers the training, experience, and confidence to meet product contract requirements in a cost- and time-effective manner consistently, such that the OEM organization is able to optimize profit margins, meet scheduled delivery dates, and to achieve technical success in the manufacturing and marketing of a high-integrity welded product.

Iron Man Comic Book, Welding Career DVDs Available for Free

Copies of four unique resource materials, including the Careers In Welding magazine, Iron Man comic book, and Hot Bikes, Fast Cars, Cool Careers and Careers In Welding DVDs, may be requested for free.

Just visit www.CareersInWelding.com, click on the welding publications link, and fill out the form specifying the quantity you need of each item.

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4 Sessions, 14 Speakers • 9:00 AM - 5:00 PM
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Ceramic Backing Enhances One-Sided Welding

BY SONG TONGZHAN, DENG HUAN, XU ZHIMIN, NIU XILIN, AND YAO JIANCHENG

Production efficiency was improved in the fabrication of a steel bridge structure by using a ceramic backing and CO₂-shielded flux cored arc welding

Fig. 1—The Xinxiang Wei River bridge.

One-side welding with back formation is an efficient welding technology. It has been applied in the fabrication of watercraft, pressure vessels, bridges, and many kinds of large steel structures and equipment. It can improve production efficiency significantly, reduce the labor intensity, and improve the working environment and weld quality. This article describes how this technology was used in the fabrication of heavy box girders for bridge construction.

In the factory, during fabrication of box girders, there are many overhead, horizontal, and vertical welds with strictly regulated quality. The welding is difficult and labor intensive. In a project to construct a bridge to span the Xinxiang Wei river, steel box girders were fabricated using ceramic backing and flux cored arc welding with CO₂ shielding (FCAW-G) for one-sided welding.

The steel box girders for the bridge are designed to be 70 m long. The main girder is 1.3 m high, the box width is 7 m, and the cantilever length is 1.5 m. The bridge has a tower constructed of 1000-mm-diameter x 14-mm-long steel tube, which extends 30 m above the bridge. The tower rotates and tilts outward in a shape of an oval — Fig. 1. The steel material for the bridge is Q345D. The steel sections of the bridge tie into a concrete structure on both sides.

The steel box girders were designed to be assembled at the jobsite. The prefabricated girders have 6 configurations with 16 sections on each side that are joined in the middle for a total of 32 sections. The maximum length of the girder is 5 m. There are draglines on both sides. See Table 1 for the material and section quantity for one side of the bridge. The bridge tower is elliptical and tilted after a 60-deg rotation around the long axis of a 21.2 m radius. The short axis is 10 m.

Characteristics of the Ceramic Backing and FCAW CO₂ Welding

The weight-percent for each component used in the ceramic backing are: SiO₂ 40%~60%; Al₂O₃ 30%~45%; Fe₂O₃ 0 ~1.2%; MgO and/or CaO 3%~18%; Na₂O and/or K₂O 1.5%~5%, and the hole rate is less than 5%. The material has waterproof and damp-proof characteristics. The weld formation on the back is smooth without any gas holes for both horizontal and vertical welding. The weld formed had the required quality. The need for back grinding, overhead welding, and turning over the workpiece was eliminated. With the need to perform difficult and laborious carbon arc gouging eliminated, the time-consuming cleaning of the root is also eliminated. The problem of poor weld toughness associated with the back gouging is no longer a concern.

The FCAW-G process with CO₂ shielding addressed the problem of incomplete fusion sometimes associated with a solid welding wire process. At the same time, the FCAW process increased the deposition rate, improving efficiency. The process performed well, producing low spatter and good weld appearance. It also saved material, power, space, workload, and shortened the construction period.

Improvement on the Design of Bridge Box Girders

The steel bridge box girder has a large cross section — Fig. 2. The flange plate and web are thin, but the required per-
formance level of the material is high. There are requirements for camber (2.5% P-wave bridge design, the centerline in the vertical curve). Weld quality is inspected with the ultrasonic (UT) process. Because the internal space in the box structure is small, with ribs and segmented design, automatic welding could not be used. Only a semiautomatic process or manual welding were available. It is difficult to guarantee quality when a manual arc welding electrode is used and the efficiency is low. According to the construction site conditions, in order to meet the schedule, adapt to the construction conditions at the site and improve the production rate of the plant, it was decided to modify the bridge sections as shown in Table 2. It was segmented into 7 sections from 16 segments, and the on-site welds were modified to 6 from 15, which not only reduced the workload of welding at the site, but also lowered the difficulty of the construction. A V-groove joint design was used with a ceramic liner bridging the root opening. The semiautomatic FCAW-G process improved efficiency and shortened the construction period.

Welding Process Test

Test Method

In the welding process test, the actual welding material and plate thickness were used, and the construction site environ-
ment was simulated. The test piece assembly is shown in Fig. 3. The dimensions of the test board are 300 × 200 × 12 mm, and the bevel of the joint was formed through machining. Before welding, the edges of the groove were polished to metallic luster with an angle grinder, making sure there was no oil, rust, and moisture. Both sides of the test plate were fixed through spot welding to ensure a root opening of 6~8 mm, and deformation of only 4 ~5 deg. The ceramic backing was attached and fluxed cored arc welding with CO₂ gas shielding was used to fill the groove. The ambient temperature for the test was 25°C. There was no need to preheat test plate, and the interpass temperature was ≤150°C.

The test plate was subject to air cooling for 24 hours after welding, then the appearance was visually inspected and the weld was ultrasonically (UT) tested. The test piece was also mechanically tested (tensile, bend, impact), and the joint structure after the tests was observed with a metallographic microscope. See Fig. 4 for the appearance of a flat butt joint weld.

**Test Material**

The base metal used in the test is low-alloy steel Q345D plate with the thickness of 12 mm. Its chemical components and properties are shown in Table 3. The ceramic backing for the test is shown in Fig. 5. The ceramic backing composition is shown in Table 4. The width of the forming groove in the ceramic segment is 10 mm, and the depth is 0.8~1.0 mm. The ceramic backing at the bottom of the central area is marked with a red line, which makes it easy to attach and align with the welds. Some small holes scatter in the direction of the length of the pad on the aluminum foil at both sides of the ceramic block in order to exhaust gases when welding. Before use, it was baked for 1~1.5 h at a temperature of around 150°C.

**Welding Equipment, Welding Materials, and Technical Parameters**

See Table 5 for welding equipment, welding materials, and process parameters. The welding machine was produced by Shandong Aotai Electric Co., Ltd., and the selection of welding wire was based on process performance and material matching. In this project, Jinzhou Jintai TWE-711 CO₂ gas flux cored welding wire with the diameter of 1.2 mm was selected.

**Mechanical Properties and Inspection of Welds**

The chemical composition and the mechanical properties of welds are shown in Table 6. All the technical indicators met the code requirements. Ultrasonic (UT) inspection was done after a 24-h cooling of the welds to ensure that the weld quality met the design requirements.

**Quality Control**

Quality control was conducted throughout the manufacturing process. The assembly of segments of the steel box girder bridge is shown in Fig. 6. On-site construction was mainly controlled in the following aspects.
The establishment of welding procedure specifications (WPS) was made in accordance with the data collected from the welding process tests and the test environment conditions. Welders performed in strict accordance with the process procedure under the watchful eye of supervisors.

Measures were taken to configure appropriate equipment for wind and moisture prevention on the site. Within 50 mm on both sides of the butt joint, rust was removed and the surface was cleaned with a steel wire wheel to meet code requirements. After the joints were cleaned, welding was generally completed within 24 h to prevent the joints from becoming rusted or contaminated again.

When the butt joint was set up, efforts were made to maintain the root opening to avoid weld flaws. Figure 7 shows the method used for the adjustment and positioning of the butt joint root opening of the box girder at the horizontal position.

When ceramic backing was attached, the area of attachment was cleaned, and the liner was closely mated to the plate. The ceramic pads were aligned with each other to prevent uneven filling, incomplete welding at the root, and a bamboo-shaped bump on welds at the liner connection location.

**Conclusions**

The use of one-sided welding with FCAW-G, CO₂ shielding, with ceramic backing makes weld formation compact and smooth with little spatter. Overhead position welding is not required, which reduces the labor intensity and eliminates the need for carbon arc gouging and grinding. These benefits save energy and electricity, and reduce the harmful effects of welding fume and dust. It was proven that CO₂ flux cored welding with ceramic backing is a good welding technology for on-site butt joint welding for bridge construction as well as other applications.

**Works Consulted**

FABTECH

General Attendance Information

FABTECH Heads to Chicago

North America’s largest metal forming, fabricating, welding and finishing event heads to McCormick Place, Chicago, Illinois, November 14–17, 2011. This annual event anticipates 30,000 visitors and over 1200 exhibiting companies covering more than 410,000 net square feet of floor space.

FABTECH gives you all the tools you need to improve productivity, increase profits, and find new ways to survive in today’s competitive business environment, making it the ONE trade show to meet all your needs. For more information on attending or exhibiting, go online at www.fabtechexpo.com.

Location

McCormick Place
2301 S. Lake Shore Dr.
Chicago, IL 60616
(312) 791-7000
www.mccormickplace.com

Show Dates and Hours

Monday, November 14 — 10:00 a.m. – 6:00 p.m.
Tuesday, November 15 — 9:00 a.m. – 5:00 p.m.
Wednesday, November 16 — 9:00 a.m. – 5:00 p.m.
Thursday, November 17 — 9:00 a.m. – 3:00 p.m.

Technology Pavilions

To guide attendees to products and services easily, the show floor is organized in Pavilions that are geared toward specific industries and technologies. FABTECH will encompass both North and South Halls at McCormick Place. The South Hall houses Pavilions dedicated to Forming & Fabricating, Laser, Metalforming, Tool/Die, Tube & Pipe, and Finishing. The North Hall houses Pavilions dedicated to Welding and Thermal Spray.

How to Register

Visitors must register to receive a show badge to attend the event. Advance registration is free of charge, on-site registration is $50. No one under 16 years of age admitted. Register online at fabtechexpo.com, download a printer-friendly registration form from the Web site and fax to (508) 743-9696, or use the form on pg. 76.

For the first-time ever, AWS will be offering a D1.5 Bridge Code Clinic, D15.1 Railroad Code Clinic, and ASME Section IX Code Clinic. Take your exam to certify as a CWI, CWE, CWS, CWSR, SCWI, CWEng, or test for endorsements. Advance application through AWS is required for qualification to take the exam(s). Call 1-800-443-9353 ext. 273, or go to www.aws.org/certification for details on the certification and registration requirements.

CANCELLATION POLICY: Cancellations must be made in writing and faxed to Attn: FABTECH Conference Cancellation at (313) 425-3407 no later than October 28, 2011, to receive a full refund minus a $50 administrative fee. Cancellations received after this date are nonrefundable.

Transportation

Shuttle Bus service is provided to and from McCormick Place from the official FABTECH hotels.

Taxicabs regularly travel around Chicago; cab fare in Chicago starts at $2.25 (once the cab begins driving) and increases $0.20 for each 1/9th of a mile. Taxicabs also travel through O’Hare International Airport and Midway International Airport. The fare to drive from the airport to downtown Chicago is approximately $35–$40.

Chicago Transit Authority (CTA) offers bus and train service from O’Hare International Airport, Midway International, and throughout Chicago. Fares are $1.50 per ride.

Metra Rail runs throughout Chicago and neighboring towns and cities. It is one of the fastest ways to travel outside of Chicago.

O’Hare International Airport and Midway International Airport offer great access to the city from all over the world. Find airport maps, flight information and more at www.flychicago.com.

FABTECH Parking

McCormick Place offers on-site parking. There are three main McCormick Place lots. A, B, and C. Lots A and C are $19 and Lot B is $14. FABTECH is located in the North and South buildings, and lots A and B are the closest to the event.

All lots are $10 after 6 p.m. Parking fees can be paid by cash or credit card. Parking lots are open throughout event hours. Overnight parking is not available, and there are no in-and-out-privileges. More information on McCormick Place parking can be found at www.mccormickplace.com. Click to view printable directions for McCormick Place parking lots A, B, and C.

Hotel Accommodations & Travel

The best hotel options and rates are currently available through Travel Planners, the official housing provider. Free shuttle bus service is available to and from McCormick Place and designated hotels in the FABTECH block. Book your discounted hotel rooms now at fabtechexpo.com/hotels or call 800-221-3531 or 212-532-1600 from 9:00 a.m. to 7:00 p.m. ET. These rates are only available when you book through Travel Planners. Lock in the lowest rates at the best hotels in Chicago.

For local travel information and resources to plan your trip to Chicago, go to choosechicago.com/fabtech.
### Official FABTECH Hotels

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<td>3.5 Miles</td>
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<tr>
<td>Embassy Suites Chicago Downtown</td>
<td>3.0 Miles</td>
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<tr>
<td>Embassy Suites Chicago Lakefront (CCAI HQ Hotel)</td>
<td>4.0 Miles</td>
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<tr>
<td>Fairfield Inn and Suites Downtown</td>
<td>5.0 Miles</td>
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<tr>
<td>Four Points by Sheraton Magnificent Mile</td>
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<tr>
<td>Hilton Chicago (AWS HQ Hotel)</td>
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<tr>
<td>Hilton Garden Inn Magnificent Mile</td>
<td>3.0 Miles</td>
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<tr>
<td>Hotel 71 (AWS Overflow)</td>
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<tr>
<td>Hyatt Regency Chicago (FMA HQ Hotel)</td>
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<tr>
<td>Hyatt Regency McCormick Place</td>
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<tr>
<td>Intercontinental Chicago</td>
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<tr>
<td>Palmer House Hilton (PMA HQ Hotel)</td>
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<tr>
<td>Sheraton Chicago Hotel and Towers (SME HQ Hotel)</td>
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<tr>
<td>TheWit, a member of the Hilton Family</td>
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<tr>
<td>Westin Chicago River North</td>
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<td>Westin Michigan Avenue Chicago</td>
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### Shuttle Schedule* Routes 1-4

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<tr>
<th>Inbound to McCormick S from Hotels Every 15 – 20 Minutes</th>
<th>Return to Hotels from McCormick S Every 30 Minutes</th>
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<tr>
<td>Tuesday 7:00 a.m. – 10:30 a.m.</td>
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<tr>
<td>Wednesday 7:00 a.m. – 10:30 a.m.</td>
<td>2:30 p.m. – 5:30 p.m.</td>
</tr>
<tr>
<td>Thursday 7:00 a.m. – 10:30 a.m.</td>
<td>2:00 p.m. – 4:30 p.m.</td>
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### Boarding Points

- **Route 1**
  - Hilton Chicago & Towers
  - Palmer House Hilton
  - 8TH Street Entrance
  - Wabash Entrance

- **Route 2**
  - Hotel 71
  - Hyatt Regency
  - The Wit Hotel
  - Front Entrance, Curbside on Wacker
  - Front Entrance, Curbside on Wacker
  - Front Entrance

- **Route 3**
  - Embassy Suites Downtown
  - Four Points by Sheraton
  - Hilton Garden Inn
  - InterContinental
  - Marriott
  - Westin River North
  - At Hilton Garden Inn, Front Entrance
  - NW Corner of Grand & Rush
  - Front Entrance
  - Illinois Street Entrance
  - NW Corner of Grand & Rush
  - NW Corner of Clark & Carroll

- **Route 4**
  - Courtyard Chicago Downtown
  - Embassy Suites Lakeshore
  - At Sheraton, NW Corner of Columbus & N Waters (NBC Tower)
  - SE Corner of St. Clair & Erie
  - No service required

### Walking Distance

- Hyatt McCormick Place
- No service required

*Please be advised that pickup times and locations listed above are subject to change. Please consult the event Web site or signage in your hotel lobby for up-to-date schedule and boarding point information.*
FABTECH Show Offers Attendees an Interactive Experience with the AWS Smartphone App

The American Welding Society recently launched a new smartphone mobile app aimed at revolutionizing the FABTECH 2011 show experience. The app, called “AWS Events at FABTECH,” provides easy-to-use interactive capabilities that allow attendees to make the most of their time at the show by having the most up-to-date AWS Education Program information in the palm of their hand.

The mobile app features include the following: interactive speaker list, e-brochures available for download, floor plan maps, complete listing of events, interactive show schedule, real-time show alerts via text messaging, and social media interaction with built-in Twitter feed.

The app is available for iPhone, Blackberry, and Android phones, but there is also a Web-based version for all other smartphone devices.

To download the app for the iPhone, iPod Touch, or iPad, access the iTunes store and search for “AWS FABTECH” then download. To download the app for Android devices, access the Android Market and search for “AWS FABTECH” then download.

To download it for all other phone types, including Blackberry and all other Web browser-enabled phones, point your mobile browser to http://m.core-apps.com/awsfabtech11.

SPECIAL EVENTS/FREE SEMINARS

Monday, November 14
9:00 a.m. – 12:00 noon Room N228

AWS Opening Session and Annual Business Meeting

During the AWS Opening Session and the 91st Annual Business Meeting, 2011 AWS President John Mendoza will give the Presidential Report and Bill Rice will be inducted as the AWS President for 2012. Following the induction, the 2011 Class of AWS Counselors and Fellows will also be introduced. This meeting is open to all AWS Members and show registrants.

Monday, November 14 – Thursday, November 17

Show Hours Show Floor North Hall

Professional Welders Competition

Watch professional welders compete on the show floor for a grand prize of $2,500 by making a 3/4-in. fillet weld using 7018 electrode on low-carbon steel in five minutes or less. The contest will be judged by a team of AWS Certified Welding Inspectors. For a $15 entry fee, welders get a chance to walk away with the title of “Best Welder in America.”

Awards Ceremony will take place at 11:00 a.m. on Thursday, November 17. For more information on the competition and to register for the event, contact the American Welding Society at (800) 443-9355, ext. 237.

10:30 a.m. – 11:30 a.m. Room N228

Comfort A. Adams Lecture — Recent Advances in Solid State Joining of Aluminium

Øystein Grong

This year’s presentation will be made by Øystein Grong, who received his PhD degree from the Norwegian University of Science and Technology in 1983. He has worked as a Research Scientist at the Norwegian Defence Research Establishment, Kjeller, Norway, and as a Visiting Research Professor at Colorado School of Mines, Golden, Colorado, and National Institute of Standards and Technology, Boulder, Colorado. He was appointed Professor of Metallurgy at the Norwegian University of Science and Technology by the King of Norway and the Prime Minister in 1987. Professor Grong has a broad interest and research experience in materials in general and microstructural modeling in particular. A significant part of this work is related to welding and thermomechanical processing of metals and alloys. He has educated 57 MSc and 21 PhD students and written 261 publications, including 92 major scientific papers in refereed international journals. He is also the author of the well-reputed textbook Metallurgical Modelling of Welding, which formerly was ranked among the top ten books (best sellers) from the Institute of Materials in London. In addition, he holds four patents and has received five prestigious awards for his scientific contributions.

11:30 a.m. – 1:00 p.m. Room N137

IIW and the 2012 Annual Assembly Session

All you wanted to know about the International Institute of Welding (IIW) and more. Founded in 1948 by the welding institutes/societies of 13 countries, including AWS, the IIW makes rapid scientific and technical progress possible on a global level. The IIW is the international vehicle by which innovation and best joining practices are promoted, while providing an international platform for the exchange and dissemination of evolving welding technologies and applications. You are encouraged to attend a session focusing on the role of the American Council of the IIW, how individual members can participate in IIW activities, and more. Various speakers will describe the value of involvement in the IIW and highlight some of the activities of the various IIW commissions and working groups. The session will discuss why you should consider participation in the IIW, not only from your company’s perspective but also for technical and career advancement. This session will also cover the unique opportunity to attend the next IIW Annual Assembly, scheduled for July 8–13, 2012, in Denver, Colo. Light lunch/refreshments will be provided.

Free Sample Sessions

AWS is offering sample sessions of our seminars for FREE. Each session is led by expert instructors, covering various hot topics related to welding sales, supervision, inspection, and radiographic interpretation. This is your opportunity to experience AWS’s...
globally recognized programs, while gaining valuable industry knowledge. Upon completion of the sample session, participants will receive a certificate of participation with professional development hours and sample course material.

1:00 p.m. – 2:00 p.m. Room 138
**Certified Welding Sales Representative**
*Free Registration Code: W41*

2:00 p.m. – 3:00 p.m. Room 138
**Certified Welding Inspector**
*Free Registration Code: W42*

4:00 p.m. – 6:00 p.m.
**Happy Hour**
Mix and mingle with other attendees and exhibitors during our new Happy Hour. Held on the exhibit floor for the last two hours of the show, Happy Hour is a great way to network with peers in a relaxed, entertaining environment while perusing the technology in exhibitor booths. Complimentary drink ticket included with your badge.

6:30 p.m.
**Hilton Chicago (Grand Ballroom)**
**AWS Officers/Presidents/Counterparts Reception**
This reception is held annually during the show and is open to all registrants. Take advantage of this opportunity to meet the AWS officers, network with members and prospects. A complimentary hors d’oeuvres buffet is included, along with a cash bar. Evening business attire, please.

**Monday, November 14**

8:00 a.m. – 9:00 a.m. Room N138
**Weld-Ed’s Professional Development Offerings for Welding Educators Session**
*FREE * Registration Code: W46
**Duncan Estep, Weld-Ed**
Presented by the National Center for Welding Education and Training (Weld-Ed), this free session is designed to inform attendees of available Professional Development for welding instructors.

**Tuesday, November 15**

Free Sample Sessions
8:00 a.m. – 9:00 a.m. Room N228
**Certified Welding Supervisor**
*FREE Registration Code: W43*

9:00 a.m. – 10:00 a.m. Room N228
**Certified Radiographic Interpreter**
*FREE Registration Code: W44*

12:00 noon – 2:00 p.m.
**AWS Awards/AWS Foundation Luncheon**
*Price: $30 * Registration Code: W39
AWS and the industry it serves have grown, so has the need to recognize outstanding scientists, engineers, educators, and researchers. Join an assembly of distinguished award presenters, recipients, and guests for a well-paced ceremony and a delicious lunch. The cost for attending the ceremony is $30 and is open to all registrants. Tickets will also be available at the door.

1:00 p.m. – 5:00 p.m. Room N137
**Thermal Spray Basics: Putting Coatings To Work**
*FREE * Registration Code: W45
This basic introduction to thermal spray benefits will cover four major areas: processes, equipment, applications, and industry usage.
- Processes covered will include molten metal flame spraying, powder flame spraying, wire flame spraying, ceramic rod flame spraying, ceramic rod flame spraying, detonation flame spraying, high-velocity oxyfuel spraying (HVOF), cold spraying, plasma spraying, electric arc spraying, and RF plasma spraying.
- Equipment will be on display. Several spray guns will be available for attendees to handle and discuss throughout the class. Other larger items such as complex systems and spray booths will be illustrated and discussed.
- Application examples will be presented for a variety of requirements from several different industries.
- Industry usage charts will be reviewed listing several processes and coating applications used by various industries.

2:00 p.m. – 3:00 p.m. Room N135
**AWS National Nominating Committee — Open Meeting**
AWS Members are requested to submit their recommendations for National Officers to serve during 2013. Nominations must be accompanied by 16 copies of biographical material on each candidate, including a written statement by the candidate as to his/her willingness and ability to serve if nominated and elected.

**Wednesday, November 16**

7:00 a.m. – 8:30 a.m.
**Prayer Breakfast: Helping the Poor**
*Price: $10 * Registration Code: W47
Come join us for an open prayer breakfast and speaker Ken Isaacs, vice president of Projects at Samaritan’s Purse. Learn how to help the poor with the skills you have.
10:00 a.m. – 10:30 a.m.  
**American Council of IIW**  
Meeting of the U.S. member body of the International Institute of Welding.

12:00 noon - 2:00 p.m.  
**Image of Welding Awards Ceremony**  
The best and brightest stars in the welding industry will be honored for their outstanding industry achievements at the 9th Annual Image of Welding Awards. Presented by the AWS and WEMCO, a standing committee of AWS, the Image of Welding Award is the industry’s top honor saluting the year’s most outstanding public initiatives and programs that promote the image of welding. By invitation only. This year the Image of Welding Awards Ceremony will be held in conjunction with the Section Appreciation Lunch.

**Thursday, November 17**

**Buyer Appreciation Day**  
The last day of the show has been designated Buyer Appreciation Day. This is a great day to visit the show and take advantage of exhibitor show specials. You can also WIN great prizes and products given away by participating exhibitors and by show management.

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**EDUCATION ANNUAL PROGRAM**

**Monday, November 14**

8:00 a.m. – 9:00 a.m.  
**FREE • Registration Code: W40**  
Valuable free programs for educators and trainers are held every day of the show. Sponsored by AWS, sessions highlight the latest developments in welding education and training programs.

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**Topics in Welding Education**  
The Topics in Welding Education session will feature presentations on metallurgical lessons and AWS standard symbols.

**8:00 a.m. – 9:00 a.m.**

**Using Practical Welding Metallurgy Object Lessons**  
*Larry Zirker, Idaho National Laboratory*

**9:00 a.m. – 10:00 a.m.**

**Common Errors in Applying ANSI/AWS A2.4 Welding Symbols**  
*J. P. Christein, Huntington Ingalls Industries*

**Career Counselor and Welding Educator Workshop**  
This workshop will provide career counselors and welding educators with a general overview of AWS and its role in supporting the welding industry. Representatives from AWS, the welding industry and trade unions will make short presentations on career paths, scholarships, and job outlook. A walking tour of exhibits on the show floor will highlight high-tech topics in welding including welding robots, friction stir welding, and laser welding and cutting. Career counselors and welding educators will receive free registration to the workshop and exhibit floor. Participants will also receive a certificate from AWS for 4 (four) Professional Development Hours (PDH) for attending the workshop.

**10:00 a.m. – 10:35 a.m.**

**Introduction**  
*T. J. Lienert, Los Alamos National Laboratory*

**10:35 a.m. – 11:15 a.m.**

**Presentation on AWS**  
*T. J. Lienert, Los Alamos National Laboratory*

**11:15 a.m. – 11:30 a.m.**

**AWS Foundation and Weld-Ed**  
*Monica Pfarr, American Welding Society*

**11:30 a.m. – 12:00 noon**

**Career Paths in Welding**  
*Ernest Levert, Lockheed-Martin Co.; Richard Seif, Lincoln Electric (Retired); Ed Abbott, Ironworkers International; Rick Polanin, Illinois Central College; Pierrette Gorman, Sandia National Laboratories; Ronny Vanscoy, International Boilermakers; Bruce Albrecht, Miller Electric; Jerry Utrachi, WA Technology, LLC*  
Representatives from the welding industry and trade unions will make short presentations on career paths and job opportunities.

**1:00 p.m. – 1:15 p.m.**

**Q & A / Panel Discussion**
Tuesday, November 15

10:30 a.m. – 12:00 noon

Plummer Memorial Education Lecture Award
“Welding Education: Changing Lives and Building a 21st Century Workforce.” (Part of Education Annual Program)

FREE Registration Code: W40
Timothy Lawrence, SkillsUSA

This award has been established by the American Welding Society to recognize an outstanding individual who has made significant contributions to welding education and training, and to recognize Fred L. Plummer’s service to the Society as President from 1952 to 1954 and Executive Director from 1957 to 1969. This year’s recipient is Timothy Lawrence, SkillsUSA. Having been involved with SkillsUSA for most of his life, Lawrence firmly believes that getting involved in technical education and joining SkillsUSA in high school set his course for a successful future. He worked in both labor and management positions in the manufacturing industry for nine years while continuing his education, and received his teaching credentials from Virginia Tech and his degree in Administration and Training from James Madison University. He became a teacher in Virginia in 1978 and was named the National Trade and Industrial Education Teacher of the Year in 1983. In January 2001, Lawrence became the chief executive officer of SkillsUSA, one of our nation’s largest individual membership organizations.

1:30 p.m. – 2:30 p.m.

Adams Memorial Membership Award Lecture

This award, established by the American Welding Society, is given as a means of recognizing educators whose teaching activities have advanced the knowledge of welding undergraduate or postgraduate students in their respective engineering institutions. This year’s recipient is Prof. Bryan A. Chin, Auburn University.

2:30 p.m. – 3:30 p.m.

Howard E. Adkins Memorial Instructor Membership Award Lecture

The Howard E. Adkins Instructor Membership Award is sponsored by Mrs. Wilma Adkins and family, and is given as a means of recognizing high school, trade school, technical institute, or junior college instructors whose teaching activities have advanced the knowledge of welding for students in their respective schools. This year’s recipient is Richard Hutchison, Orange Coast College.

3:30 p.m. – 5:00 p.m.

Panel Discussion: Best Practices in Modern Welding Education

Ed Norman, Southwest Area Career Center; Tim Lawrence, SkillsUSA; Bryan A. Chin, Auburn University; Richard Hutchison, Orange Coast College.
## SCHEDULE-AT-A-GLANCE

### MONDAY, NOVEMBER 14

#### WELDING

**CONFERENCES**

- W20: Welding Technology to the Rescue • 8:30 a.m. – 3:00 p.m.

**SEMINARS**

- W20: D1.5 – Bridge Code Clinic • 8:00 a.m. – 12:00 p.m.
- W21: D15.1 – Railroad Code Clinic • 1:00 p.m. – 5:00 p.m.
- W22: Metallurgy Applied to Everyday Welding • 8:00 a.m. – 5:00 p.m.

**PROFESSIONAL PROGRAM**

- W33: Session 1: International Trends in Welding Research • 8:00 a.m. – 10:00 a.m.
- Session 2: NSF LUCRC Sponsored • 2:00 p.m. – 5:00 p.m.
- Session 3: Solid-State Processing • 2:00 p.m. – 5:00 p.m.

**SPECIAL PROGRAMS**

- W40: Education Annual Program – FREE • 8:00 a.m. – 5:00 p.m.
- W41: Certified Welding Sales Representative – FREE Sample Session • 1:00 p.m. – 2:00 p.m.
- W42: Certified Welding Inspector – FREE Sample Session • 2:00 p.m. – 3:00 p.m.
- IIW and the 2012 Annual Assembly Session – FREE • 11:30 a.m. – 1:00 p.m.

AWS Professional Welders Open Competition • 10:00 a.m. – 5:00 p.m.

#### TECHNOLOGY

- Time: 8:00 a.m. – 10:00 a.m.
- Session: 10:30 a.m. – 12:30 p.m.
- Time: 1:30 p.m. – 3:30 p.m.

**FINISHING**

- C01: The Basics of Industrial Finishing
- C02: Understanding & Lowering Finishing Costs
- C03: Right Sizing Your Finishing System

**FORMING & FABRICATING**

- F01: Introduction to True Kaizen
- F02: NEW Creating an Employee Empowered Culture to Drive Performance

**MANAGEMENT**

- F03: Error-proof Metaforming
- F04: NEW Increasing Productivity and Quality Monitoring

**STAMPING**

- S01: High Strength Steels (AHSS)
- S02: Stamping Advanced High Strength Steels (AHSS)

**TUBE & PIPE**

- T03: NEW Fundamentals of Tube Mill Operations

### Levels

- **B** = Basic
- **I** = Intermediate
- **A** = Advanced

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<table>
<thead>
<tr>
<th>W20: Welding Technology to the Rescue</th>
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<td>F04: NEW Increasing Productivity and Quality Monitoring</td>
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<td>W40: Education Annual Program – FREE</td>
<td>F05: NEW Fundamentals of Tube Mill Operations</td>
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<tr>
<td>W41: Certified Welding Sales Representative – FREE Sample Session</td>
<td>F06: NEW Advanced Tube Mill Operations</td>
</tr>
<tr>
<td>W42: Certified Welding Inspector – FREE Sample Session</td>
<td>F07: NEW Advanced Tube Mill Operations</td>
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</tbody>
</table>
## SCHEDULE-AT-A-GLANCE

### TUESDAY, NOVEMBER 15

#### WELDING

**CONFERENCES**
- W27: National Welding Education Conference • 9:00 a.m. – 4:30 p.m.
- W29: 8th Conference on Weld Cracking • 8:30 a.m. – 4:00 p.m.

**SEMINARS**
- W23: D1.1 – Road Map • 8:00 a.m. – 5:00 p.m.
- W24: ASME Section IX, B31.1 & B31.3 Code Clinic • 8:00 a.m. – 5:00 p.m.
- W26: Advanced Visual Inspection Workshop Day 1 • 8:00 a.m. – 5:00 p.m.

**PROFESSIONAL PROGRAM**
- W34: Session 4: Shipbuilding • 8:00 a.m. – 12:00 p.m.
- W35: Session 5: Arc Welding Processes • 8:00 a.m. – 12:30 p.m.
- W36: Session 6: NSF IUCRC Sponsored • 2:00 p.m. – 5:00 p.m.
- W37: Session 7: Weld Modeling • 2:00 p.m. – 5:00 p.m.

**SPECIAL PROGRAMS**
- W39: AWS Awards Luncheon • 12:00 p.m. – 2:00 p.m.
- W40: Education Annual Program (including Plummer and Memorial Lectures) • FREE • 10:30 a.m. – 5:00 p.m.
- W41: Certified Welding Supervisor – FREE Sample Session • 8:00 a.m. – 9:00 a.m.
- W42: Certified Radiographic Interpreter – FREE Sample Session • 9:00 a.m. – 10:00 a.m.
- W43: Thermal Spray Basics: Putting Coatings to Work • FREE • 1:00 p.m. – 5:00 p.m.
- AWS Professional Welders Open Competition • 9:00 a.m. – 5:00 p.m.

**TECHNOLOGY**

**CUTTING**
- F30: NEW CO₂ Laser Cutting [B]
- F31: NEW Panel-CO₂ Laser Cutting Situations and Solutions [B]
- F32: Modern Pretreatment: The Basics [B]
- F33: Modern Pretreatment: The Basics [I]
- F34: Modern Pretreatment: The Basics [A]
- F40: Waterjet Cutting Advancements [A]
- F41: Laser Cutting Considerations for First-time Buyers [A]

**FINISHING**
- C30: NEW Efficient Curing with Infrared for the Finishing Industry [B]
- C31: Fast Color Change [A]
- C32: How to Achieve Quality Finishes When Using a Custom Coater [B]
- C40: NEW Energy Savings for Finishing [A]
- C41: The Future of Coatings Technology [A]

**FORMING & FABRICATING**
- F33: Getting Started with Robotics [B]
- F34: NEW Visual Controls to Improve Work [A]
- F35: Top 10 Secrets of Lean Success for Managers [A]
- F36: NEW Social Marketing on Speed – A Crash Course [A]
- F37: NEW Financial Planning Strategies [A]
- F43: Demand Pull in the Fabrication Job Shop [A]
- F44: NEW Five Marketing Moves for Tomorrow [A]

**STAMPING**
- S30: Beyond Forming: Fabrication in the Stamping Press [A]
- S31: Improving Stamping Efficiency [A]

**TUBE & PIPE**
- F38: Tube & Pipe Joining & Inspection [A]

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<table>
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<tr>
<td><strong>WEDNESDAY, NOVEMBER 16</strong></td>
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<tr>
<td><strong>WELDING</strong></td>
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<tr>
<td><strong>CONFERENCES</strong></td>
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<tr>
<td>W30: What's New in Power Sources • 8:30 a.m. - 4:00 p.m.</td>
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<tr>
<td>W31: Thermal Spray Technology: High-Performance Surfaces • 9:00 a.m. - 5:00 p.m.</td>
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<td><strong>SEMINARS</strong></td>
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<tr>
<td>W25: The Why and How of Welding Procedure Specifications • 8:00 a.m. - 5:00 p.m.</td>
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<tr>
<td>W26: Advanced Visual Inspection Workshop Day 2 • 8:00 a.m. - 5:00 p.m.</td>
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<tr>
<td><strong>RWMA SCHOOL</strong></td>
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<tr>
<td>W32: RWMA Resistance Welding School Day 1 • 7:45 a.m. - 5:30 p.m.</td>
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<tr>
<td><strong>PROFESSIONAL PROGRAM</strong></td>
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<tr>
<td>W33: Session 1: Laser Materials Processing • 8:00 a.m. - 11:30 a.m.</td>
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<tr>
<td>Session 2: Filler Metals, Overlays and Repair • 8:00 a.m. - 12:00 p.m.</td>
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<td>Session 3: Sensing and Control • 2:00 p.m. - 5:30 p.m.</td>
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<td>Session 4: Joining Metallurgy • 2:00 p.m. - 5:30 p.m.</td>
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<td><strong>SPECIAL PROGRAMS</strong></td>
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<tr>
<td>W40: Education Annual Program - FREE • 9:00 a.m. - 5:00 p.m.</td>
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<tr>
<td>AWS Professional Welders Open Competition • 9:00 a.m. - 5:00 p.m.</td>
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<td><strong>TECHNOLOGY</strong></td>
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<tr>
<td>8:00 a.m. - 10:00 a.m.</td>
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<tr>
<td><strong>CUTTING</strong></td>
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<td><strong>FINISHING</strong></td>
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<tr>
<td>C70: Finishing Essentials: Racking &amp; Stripping [A]</td>
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<tr>
<td>C71: Process Control &amp; Preventive Maintenance [A]</td>
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<tr>
<td>C72: NEW Ultrafiltration of Electrocoat Paint [A]</td>
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<td><strong>FORMING &amp; FABRICATING</strong></td>
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<td><strong>MANAGEMENT</strong></td>
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<tr>
<td>F54: NEW Hydroforming – It's Lower Cost than You Think! [A]</td>
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<td><strong>STAMPING</strong></td>
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<tr>
<td>S50: NEW Best Practices for Manufacturing: World Class Safety and How to Compete Globally [A]</td>
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<tr>
<td>S60: NEW Vibration Control and Installation Methods to Improve the Performance of Metal Working Machinery [A]</td>
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<td>F54: NEW Hydroforming – It's Lower Cost than You Think! [A]</td>
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**THURSDAY, NOVEMBER 17**

### WELDING

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<tr>
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<tbody>
<tr>
<td>RWMA SCHOOL</td>
<td>W32: RWMA Resistance Welding School Day 2 • 8:00 a.m. – 3:45 p.m.</td>
</tr>
</tbody>
</table>
| PROFESSIONAL PROGRAM | W36: Session 12: Materials Weldability • 8:00 a.m. – 11:00 a.m.  
Session 13: Industrial Technology • 8:00 a.m. – 12:00 p.m. |
| SPECIAL PROGRAMS | W40: Education Annual Program – FREE • 9:00 a.m. – 12:00 p.m.  
AWS Professional Welders Open Competition – Awards Ceremony • 11:00 a.m. – 12:00 p.m. |

### TECHNOLOGY

<table>
<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>8:00 a.m. – 10:00 a.m.</td>
<td>C80: <strong>NEW</strong> “Green” Pretreatment</td>
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<tr>
<td>10:30 a.m. – 12:30 p.m.</td>
<td>C81: <strong>NEW</strong> Finishing Large Parts</td>
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### FINISHING

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### FORMING & FABRICATING

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<tr>
<td>F80: <strong>NEW</strong> Part and Surface Cleaning Technologies</td>
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<td>F81: <strong>NEW</strong> Automated Deburring; A Surprising Cost and Time Saving with Tech Tour</td>
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<td>F82: <strong>NEW</strong> Value People Component of Lean</td>
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<td>F83: <strong>NEW</strong> CLOUD Computing Basics</td>
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<td>F84: <strong>NEW</strong> Leadership: Critical Communication and Team Development</td>
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<td>F85: <strong>NEW</strong> Basics of Tube &amp; Pipe Fabrication</td>
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<tr>
<td>F86: <strong>NEW</strong> Advanced Tube and Pipe Fabrication with Tech Tour</td>
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### MANAGEMENT

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<tr>
<td>F87: <strong>NEW</strong> Cloud Computing Basics</td>
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<td>F88: <strong>NEW</strong> Leadership: Critical Communication and Team Development</td>
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<td>F89: <strong>NEW</strong> Establishing a World Class Safety Culture</td>
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### TUBE & PIPE

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<tr>
<td>F90: <strong>NEW</strong> Press Brake Troubleshooting</td>
<td></td>
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<tr>
<td>F91: <strong>NEW</strong> Establishing a World Class Safety Culture</td>
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**Questions regarding the educational programs at FABTECH can be directed to the following representatives:**

- **WELDING**
  - Contact AWS, Selvis Morales
  - smorales@aws.org
  - 800-443-9353

- **FORMING & FABRICATING, MANAGEMENT, TUBE & PIPE**
  - Contact FMA, Julie Maddock
  - julie@fmanet.org
  - 888-394-4362

- **STAMPING**
  - Contact PMA, Allison Grealis
  - agrealis@pma.org
  - 216-901-8800

- **CUTTING, FORMING & FABRICATING, LEAN**
  - Contact SME, Ilia Lee
  - ilee@sme.org
  - 800-733-4763

- **COATING, FINISHING**
  - Contact CCAI, Anne Goyer
  - anne@gowmgmt.com
  - 859-356-1030

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[\(=\) Basic \(=\) Intermediate \(=\) Advanced]
Welding Show 2011

Professional Program

Pick and choose between concurrent sessions for the latest in welding research and commercial developments. Pay by the day or attend the entire four-day program, with special discounts for students and members of AWS, FMA, SME, PMA, or CCAL.

4-day Professional Program Member: $225, Nonmember: $360 (Code W37)
4-day Student Professional Program Member: $75, Nonmember: $90 (Code W38)
1-day Professional Program Member: $150, Nonmember: $225
Monday (W33), Tuesday (W34), Wednesday (W35), Thursday (W36)

Monday, November 14
8:00 a.m. – 5:00 p.m.

SESSION 1: Room N139
INTERNATIONAL TRENDS IN WELDING RESEARCH
Chair: Stephen Liu, Colorado School of Mines

A. 8:00 a.m. “State of the Welding Related Industries and Trends of Welding Research & Development in Singapore”
Ang Chee Pheng, President of the Singapore Welding Society

B. 9:00 a.m. “NSF-CIMJSEA Program Introduction”
Suresh Babu, OSU; Stephen Liu, CSM; John DuPont, Lehigh; and Sindo Kou, Univ. Wisconsin, Madison. Soon after this special session, the audience will be directed to the Adams Lecture.

SESSION 2: Room N139
NATIONAL SCIENCE FOUNDATION INDUSTRY/UNIVERSITY COOPERATIVE RESEARCH CENTER SPONSORED
Chair: Stephen Liu, Colorado School of Mines

A. 2:00 p.m. “Separating the Good Welds from the Bad Welds”
John P. H. Steele, Colorado School of Mines

B. 2:30 p.m. “Development of a High-Chromium Nickel-Base Filler Metal with Improved Weldability for Nuclear Power Plant Construction and Repair Applications”
Adam T. Hope, Eric Fusner, and John C. Lippold, The Ohio State University; and Steve L. McCracken, EPRI

C. 3:00 p.m. “Weldability of A356+0.5Cu and Its Nanocomposites”
Dake Wang, Hongseok Choi, Xiaochun Li, and Sindo Kou, University of Wisconsin

D. 3:30 p.m. “Welding of Stainless Steel — Effect of Sulfur on Weld Pool Phenomena”
Sindo Kou, University of Wisconsin; C. Limmaneevichitr, King Mongkut’s University of Technology-Thonburi; and P. S. Wei, Kaohsiung, Taiwan

E. 4:00 p.m. “Newly Developed Low Transformation Temperature (LTT) Welding”
Tariq Alghamdi and Stephen Liu, Colorado School of Mines

F. 4:30 p.m. “Weld Solidification Behavior of Ni-Base Superalloys for Use in Advanced Supercritical Coal-Fired Power Plants”
David Tung and John C. Lippold, The Ohio State University

SESSION 3: Room N140
SOLID-STATE PROCESSING
Chair: Yoni Adonyi, LeTourneau University

A. 2:00 p.m. “Friction Stir Welding of ISO 3183 X80M Steel”
Antonio J. Ramirez, Tahiana F. C. Hermenegildo, and Tiago F. A. Santos, Brazilian Synchrotron Light Laboratory; Conrado R. M. Afonso and Ricardo R. Marinho, CENPES- Petrobras

B. 2:30 p.m. “Adaptation of Al-to-Steel FRW-I to Thick Sections”
Wendell L. Johnson and Jerry E. Gould, Edison Welding Institute

C. 3:00 p.m. “Solid State Welding of High Performance Steels”
Nathan Dix, Josh Hammond, and Yoni Adonyi, LeTourneau University

D. 3:30 p.m. “Friction Stir Welding of Lean Duplex Stainless Steel”
Tiago Felipe de Abreu Santos, Marina Magnani, and Antonio Jose Ramirez, Brazilian Synchrotron Light Laboratory

E. 4:00 p.m. “Susceptibility of Carbon Steel Welds to Hydrogen Embrittlement”
Wei Zhang, Zhili Feng, John Wang, and Larry Anovitz, Oak Ridge National Laboratory

F. 4:30 p.m. “Mechanical and Microstructural Evaluation of Friction Stir Processed Diffusion Bonded Magnesium and Magnesium Metal Matrix Composites”
Scott Gordon and Stephen Liu, Colorado School of Mines

Tuesday, November 15
8:00 a.m. – 5:00 p.m.

SESSION 4: Room N139
SHIPBUILDING
Chair: Maria Posada, Naval Surface Warfare Center/Carderock Division

A. 8:00 a.m. “Fracture Toughness of Welded NUCu-140”
Brett Leister, John DuPont, and Jeffrey Farren, Lehigh University
B. 8:30 a.m. "Microsampling of Friction Stir Welded Ti Alloys"
Sal Nimer and Marc Zupan, University of Maryland, Baltimore County; and Jennifer Wolk, Naval Surface Warfare Center, Carderock Division

C. 9:00 a.m. "Automated Welding Technology for VCS Submarines"
Nancy C. Porter and Steve Massey, Edison Welding Institute; and Ned Kaminski, General Dynamics Electric Boat

D. 9:30 a.m. "Ultrasonic Impact Treatment of Aluminum 5456 Plate and Welds"
Kim N. Tran and Caroline Scheck, Naval Surface Warfare Center, Carderock Division; Lourdes Salamanca-Riba, University of Maryland, College Park; and Marc Zupan, University of Maryland, Baltimore County

E. 10:00 a.m. "Understanding the Effect of Tool Design in Friction Stir Welding of HSLA-65 Steels"
David Lammlein and Maria Posada, Naval Surface Warfare Center, Carderock Division

F. 10:30 a.m. "Fusion Welding Repair of 5xxx Series Aluminum Friction Stir Welds"
Maria Posada, Naval Surface Warfare Center, Carderock Division

G. 11:00 a.m. "Underwater Friction Stir Welding of HY80 Steel"
Terry R. McNelley, Sarath K. Menon, Garth W. Young, and William C. Stewart, Naval Postgraduate School; and Murray W. Mahoney, Consultant

H. 11:30 a.m. "Nondestructive Testing False Positives on Friction Stir Weld Applications"
Bruce H. Halverson, Marinette Marine Corporation

SESSION 5:
ARC WELDING PROCESSES
Room N139

Chair: Daniel Hartman, Manufacturing Behavioral Science

A. 8:00 a.m. "Double Electrode GMAW with One Welding Power Supply"
Jinsong Chen, Adaptive Intelligent Systems LLC; and Yi Lu and YuMing Zhang, University of Kentucky

B. 8:30 a.m. "Submerged Arc Welding of High Strength Steel by Cold Wire Feed"
Biswajyoti Basu, Naval Materials Research Laboratory; R. Rahul and E. Jeevarasan, National Institute of Technology; and S. Jerome and Arun Kumar Shah, Panipat Institute of Engineering Technology

C. 9:00 a.m. "Welding Arc Interruptions in Tandem Pulsed GMAW"
Ruham Pablo Reis, Federal University of Rio Grande - FURG

D. 9:30 a.m. "Study of Silicate Islands in GMAW"
Richard Derrien, Stephen Liu, and Erik Lord, Colorado School of Mines

E. 10:00 a.m. "Full Penetration Welding Using Laser Enhanced GMAW"
Yi Huang and YuMing Zhang, University of Kentucky

F. 10:30 a.m. "Submerged Arc Welding Line Pipe with Three Electrodes"
Stephen Kenny, University of Alberta

G. 11:00 a.m. "Residual Stress Analysis in Machining of Duplex Welds"
Carolina Payares-Asprino and Patricia Munoz-Escalona, Universidad Simon Bolivar; and Anaemelis Sanchez, Fundacion Instituto de Ingenieria

H. 11:30 a.m. "Selection of Welding Consumables for Metal Arc Welding Under Oil (MAW-UO)"
Hamad H. Almoussaneer, Stephen Liu, and David L. Olson, Colorado School of Mines

I. 12:00 p.m. "Droplet Heat Content in Nickel Sheathed WC-Cored GMAW Wires"
Kevin M. Scott and Patricio F. Mendez, University of Alberta
SESSION 7: WELD MODELING  
Room N140  
Chair: Zhili Feng, Oak Ridge National Laboratory  
A. 2:00 p.m. “Surface and Interface Phenomena in Thermoelectric Element Welding”  Ithamar Glumac, Ben Sokolove, and Yoni Adonyi, LeTourneau University  
B. 2:30 p.m. “A Computational Modeling Tool for Welding Repair of Irradiated Materials”  Zhili Feng, Oak Ridge National Laboratory; and Eric Willis and Ken Wolfe, Electric Power Research Institute  
C. 3:00 p.m. “3D Weld Pool Surface Characterization”  XueWu Wang, YuMing Zhang, and WeiJie Zhang, University of Kentucky  
D. 3:30 p.m. “Modeling and Microstructure Evolution Analysis of Friction Stir Processing of Magnesium Alloy”  Zhenzhen Yu, Wei Zhang, and Zhili Feng, Oak Ridge National Laboratory; and Hahn Choo, University of Tennessee  
E. 4:00 p.m. “Examination of Cross Tension Test for DP Steels”  Murali Tumuluru and David J. Radakovic, U.S. Steel  
F. 4:30 p.m. “Modeling and Control of Droplet Development in Laser Enchanced GMAW”  Yan Shao and YuMing Zhang, University of Kentucky  

WEDNESDAY, NOVEMBER 16
8:00 a.m. – 5:00 p.m.  
SESSION 8: LASER MATERIALS PROCESSING  
Room N139  
Chair: Tom Lienert, Los Alamos National Laboratory  
A. 8:00 a.m. “Characterization of a Materials Processing Laser”  T. J. Lienert, J. O. Sutton, M. S. Piltch, and P. Burgardt, Los Alamos National Laboratory  
B. 8:30 a.m. “Issues with Laser Welding through a Fused Silica Window”  T. J. Lienert, J. O. Sutton, M. S. Piltch, R. T. Forsyth, and P. A. Papin, Los Alamos National Laboratory  
C. 9:00 a.m. “Reducing Alloying Element Vaporization from Stainless Steel Weld Pools Produced by Pulsed Laser Welding”  T. DebRoy, Penn State University; and T. J. Lienert, Los Alamos National Laboratory  
D. 9:30 a.m. “Properties Variation in Stainless Steel Laser Welds”  Charles V. Robino, Brad L. Boyce, and Corbett C. Battaile, Sandia National Laboratories  
E. 10:00 a.m. “Modeling of Laser Spot Micro-Welding of Silicon”  Ashwin Raghavan, Penn State University  
F. 10:30 a.m. “Scaling Thermocapillary Weld Pool Shape”  Peng S. Wei, C. L. Lin, and H. J. Liu, National Sun Yat-Sen University; and T. DebRoy, Penn State University  
G. 11:00 a.m. “Comparing Laser and Resistance Interconnection Welds”  Gerald A. Knorovsky, Danny O. MacCallum and Louis A. Malizia, Jr., Sandia National Laboratories  

SESSION 9: FILLER METALS, SURFACING, AND REPAIR  
Room N140  
Chair: Patricia Mendez, University of Alberta  
A. 8:00 a.m. “Welding Fume Study for Certain SMAW Electrodes Used in the Mining Industry”  Kin-Ling Sham and Stephen Liu, Colorado School of Mines  
B. 8:30 a.m. “Analysis of Molten Surface End Face of Al-Mg Filler Metal Alloy and Process-Integrated Quality Assurance in Pulse GMAW”  Rajasekaran Shamugasugam and Umarani Rajasekaran, El-Shaddai Welding and Cutting Consultants  
C. 9:00 a.m. “New Self-Shielded Flux Cored Electrode”  Wesley Wang and Stanley Ferree, ESAB  
D. 9:30 a.m. “Reduction of Cr(VI) in Stainless Steel Welding Fume”  Tetsunao Ikeda, Hiroshi Sugahara, and Hirohisa Watanabe, Kobe Steel, Ltd/ Kobelco Welding of America, Inc.  
E. 10:00 a.m. “Depositing Ni-WC Wear Resistant Coatings with Hot-Wire Assisted GTAW”  Stuart Guest, Adrian Gerlich, and Patricio Mendez, Canadian Center for Welding and Joining, University of Alberta  
F. 10:30 a.m. “Wear Performance of Welded Hardbanding Materials”  Dan Danks, Abbe Doering, and Joe Scott, Wear & Friction Resources  
G. 11:00 a.m. “Structure and Properties of FBW Rail Repairs”  David Workman and Jerry E. Gould, Edison Welding Institute  
H. 11:30 a.m. “Combating Corrosion by Weld Overlay — A Unique Experience”  J. V. D. Murty, Qatargas Operating Company Limited
SESSION 10: SENSING AND CONTROL  
Room N139

Chair: YuMing Zhang, University of Kentucky

A. 2:00 p.m. “Computation of GMAW Pool Surface from Laser Reflection”  
Xiaoji Ma and YuMing Zhang, University of Kentucky

B. 2:30 p.m. “Near-Infrared Vision System for Arc-Welding Monitoring”  
Carolina Pimenta Mota, Marcus Vinicius Ribeiro Machado, and Louriel Oliveria Vilarinho, Federal University of Uberlandia; and Roberto Mendes Finzi Neto, Federal University of Goias

C. 3:00 p.m. “Analytical Computation of GTAW Weld Pool Surface”  
Zhenzhou Wang, University of Kentucky

Yulong Li, State Key Laboratory of Advanced Welding Production Technology, Harbin Institute of Technology; and Zhichao Jiang, Yan Feng, and Hua Zhang, Nanchang University

E. 4:00 p.m. “Machine-Human Cooperative Control of Welding Process”  
Weijie Zhang and YuMing Zhang, University of Kentucky

F. 4:30 p.m. “Wireless Embedded System for Signal Monitoring”  
Marcus Vinicius Ribeiro Machado, Carolina Pimenta Mota, Louriel Oliveria Vilarinho, Federal University of Uberlandia; and Roberto Mendes Finzi Neto, Federal University of Goias

G. 5:00 p.m. “Adaptive Fill Algorithm in Varying Weld Groove”  
Yong-Beak Kim, Jeom-Goo Kim, Hyeong-Soon Moon, and Ji-On Kim, Hyundai Heavy Industries

SESSION 11: JOINING METALLURGY  
Room N140

Chair: Suresh Babu, The Ohio State University

A. 2:00 p.m. “Ultrasonic Soldering for Dissimilar Material Joining”  
Edward W. Hederick, Edison Welding Institute

B. 2:30 p.m. “Au-Al Intermetallic Formation in a Resistance Weld”  
Donald F. Susan, Gerald A. Knorovsky, and Paul T. Vianco, Sandia National Laboratories

C. 3:00 p.m. “Constitution Diagram for Dissimilar Metal Welds”  
Elijah K. Gould, BP America; and John C. Lippold and Boian T. Alexandrov, The Ohio State University

D. 3:30 p.m. “Weld Behavior of Ultra-High Strength Egin Steel”  
Daniel H. Bechetti, Jr. and John N. DuPont, Lehigh University

E. 4:00 p.m. “Advanced Brazing Technologies for Nuclear Fuel Cladding”  
Edward D. Herderick, Kirk Cooper, and Nate Ames, Edison Welding Institute

F. 4:30 p.m. “Microstructure of Alloy 625 Weld Overlay”  
Cleiton Carvalho Silva, Conrado Ramos Moreira Onoso, Helio Cordeiro de Miranda, and Jesualdo Pereira Farias, Federal University of Ceara; and Antonio Jose Ramirez, Brazilian Synchrotron Light Laboratory

THURSDAY, NOVEMBER 17
8:00 a.m. – 11:00 p.m.

SESSION 12: MATERIALS WELDABILITY  
Room N139

Chair: Boian Alexandrov, The Ohio State University

A. 8:00 a.m. “Application of Cold Cracking Tests for Determining the Preheating Temperature in High Strength Steels”  
Monica Zalazar, Universidad Nacional del Comahue; and Eduardo Asta, ESAB Argentina

B. 8:30 a.m. “Hydrogen Assisted Cracking in Dissimilar Metal Welds”  
Boian T. Alexandrov, Jeffrey M. Rodelas, and John C. Lippold, The Ohio State University; and Shu Shi, Shell International Exploration and Production, Inc.

C. 9:00 a.m. “Impermeable Low Hydrogen Covered Electrodes”  
Alexandre Queiroz Bracarense, Claudio Turani, Ezequiel Caires Pereira Pessoa, and Ivanila Felizardo, Federal University of Minas Gerais

D. 9:30 a.m. “Characterization of Grade 91 Steels to Tempering”  
Daniel Saltzmann, Boian T. Alexandrov, and John C. Lippold, The Ohio State University

E. 10:00 a.m. “Development of Welding Technology for Bicycle Frame”  
Mok-Young Lee and Woong-Seong Chang, RIST, and Norman Zhou, University of Waterloo

F. 10:30 a.m. “Effect of Oxide/Ferrite Phase on the Toughness of SDSS”  
Kim Dae Joo, Bae Sang Deock, and Choi Jun Tae, Hyundai Heavy Industries
SESSION 13: INDUSTRIAL TECHNOLOGY
Room N140

Chair: Nancy Porter, Edison Welding Institute

A. 8:00 a.m. “Automated Narrow Gap GTAW”
Barbara K. Henon, Arc Machines, Inc.; and Jonathan T. Salkin, Arc Applications, Inc.

B. 8:30 a.m. “Green Stud Welding Technologies Save Energy and Labor”
Chris Hsu, Nelson Stud Welding, Inc.

C. 9:00 a.m. “Increase Joint Success with an Internal Groove”
Larry Zirker, Marve Marker, and Kyle Kofford, Idaho National Laboratory

D. 9:30 a.m. “Product and Process Comparisons of Welding Fumes”
Stanley E. Ferree and Frank Lake, ESAB

E. 10:00 a.m. “Mechanization of Short Welds in Heavy Fabrications”
Steve Massey and Nancy Porter, Edison Welding Institute

F. 10:30 a.m. “Wrapped Textile Cord Process for Welding Wire Finish”
Kai Boockmann, Michaela Boockmann, and Gerhard Boockmann, Boockmann GmbH

AWS POSTER SESSION
SHOW FLOOR NORTH HALL

The AWS Poster Session is an integral part of the AWS Professional Program. Graphic displays of technical achievements are presented for close, first-hand examination in the Poster Session. Posters present welding results and related material, which are best communicated visually, as well as research results that call for close study of photomicrographs, tables, systems architecture, or other illustrative materials. Posters are presented in five categories: students in high school welding program, students in a two-year college or certificate program, undergraduate students, graduate students, and professionals. Be sure to stop by and observe this year’s entries.

CATEGORY A: 2-YEAR DEGREE STUDENT LEVEL
Heat Generation in Resistance Spot Welds
Michael Lannom, Carlos Medina, and Steven Zeal, Orange Coast College, Costa Mesa, Calif.

A Method for Teaching Pipe Fitting
Jose Leon, Matthew L. Lainhart, and Ralph E. Long, Cochise Community College, Sierra Vista, Ariz.

CATEGORY B: 4-YEAR DEGREE STUDENT LEVEL
Power Measurements According to ASME Section IX QW409.1
Benjamin Sutton, Francis Krivanka, and Sujin Kim, The Ohio State University, Columbus, Ohio

Evaluation of PWHT Response of the CGHAZ in F22 Steel
Benjamin Sutton, Francis Krivanka, and Sujin Kim, The Ohio State University, Columbus, Ohio

Effectiveness of Power Ratio Control on Dilution
Daniel Schmerge, Michael Vitas, and Kristen Hammer, The Ohio State University, Columbus, Ohio

Electro-Spark Deposition of Dissimilar Materials
Michael N. Eff, Steven N. Dolasinski, and Paul E. Root, The Ohio State University, Columbus, Ohio

Shielding Gas Selection for GMAW of Steels
Paul Limmer, Dorian Matthews, and Brian Love, The Ohio State University, Columbus, Ohio

Alloyed Tungsten Electrode Comparison
Russell Scoles, Samantha Bell, and Seth Glenn, The Ohio State University, Columbus, Ohio

CATEGORY C: GRADUATE STUDENT LEVEL
PWHT Response and Phase Transformation Behavior of F22 Steel
Eric W. Fusner and Dr. John Lippold, The Ohio State University, Columbus, Ohio

Diode Laser Brazing of AZ31B-Steel Using Ni Interlayer
Ali M. Nasiri, David C. Wickman, and Norman Y. Zhou, University of Waterloo, Waterloo, Canada

Mechanism for Cathodic Cleaning of Aluminum Oxide
Shane Michael Krause, Montana Tech of the University of Montana, Butte, Mont.

CATEGORY D: PROFESSIONAL LEVEL
Application of Penetration Enhancing Compound in Titanium Alloy Welding
Sun Zheng and Pan Dayou, Singapore Institute of Manufacturing Technology (SIMTech), Singapore
Advancements in CO₂ Shielded Gas Metal Arc Welding

Bill Guest, OTC Daihen, Inc.

This presentation will explain the background of why this shielding gas is favored among Southeast Asian countries employing GMAW, and explore new digital inverter welding power source technologies that minimize spatter typically inherent with this process.

Computed Radiography

R. W. Kruzic, Chicago Bridge & Iron Co.

Advances in computed radiography (CR) are playing a vital role in the examination of critical weldments. This presentation will describe this technique, its pros and cons, and Code requirements.

Quality Assurance in Field Heat Treatment

Gary Lewis, Superheat FGH

Experts are suggesting that roughly 90% of material anomalies and premature weld failures in CSEF steels, like P91, can be attributed to improper pre and postweld heat treatment. While the benefits of CSEF steels are well documented and growing in popularity, welding processes and skill sets become more critical than on steels with lower chrome content. Sensitivity to PWHT becomes more significant than ever before. Superheat FGH will share results obtained in recent collaborative experimentation with AWS, EPRI, and energy partners to present opportunities utilizing emerging technological advancements and progressive process control solutions to improve field construction results and long term sustainability. Attempts will be made to shed light on some of the pitfalls of traditional field service practices and shortcomings of existing weld procedures, code guidelines and specifications that, in many cases, have been established with more forgiving materials in mind. Topics discussed will include significance of heat treatment in achieving material properties, practical methods of heat treatment in use today, shortcomings and improvement recommendations for existing weld procedures, AWS and ASME code requirements, insight to implementation pressures, and new technologies available to enhance quality control, process quality management, and enhanced oversight capabilities.

10:15 a.m. – 10:30 a.m. Morning Break

10:30 a.m. – 11:05 a.m.

DeltaSpot - Resistance Spot Welding with Process Tape

Stefan Mayr, Fronius USA LLC

With DeltaSpot, Fronius solved a high degree of issues with conventional resistance spot welding. Indexing process tapes protect the electrodes from any kind of contamination like zinc, aluminum oxide, or any other kind of coatings that usually harms the electrodes and leads to quality issues or even nonweldable situations. Unique shapes of electrodes are possible, since process tapes and not the electrodes are in direct contact with the welded material and therefore tip dressing is not necessary. DeltaSpot features 10,000 spots nonstop welding on aluminum; two or more sheet combinations; no impact on the surface; welding of all aluminum alloys; welding from soft- to ultra-hard-coated steel; coatings and materials, which present problems in conventional spot welding (like boron steel).

11:05 a.m. – 11:40 a.m.

Reciprocating Wire Feed Systems for Plate Products

Randy Dull, Edison Welding Institute

In today’s market, reciprocating wire feed systems for sheet metal welding are available. However, Edison Welding Institute has expanded that application area by developing a similar system for the welding of thick sections. Aside from his work on reciprocating wire feed systems, Dull is also working on distortion control for U.S. Navy ships. He has expertise in most arc welding processes as well as low-current GTAW and PAW applications. He also has expertise in automatic welding, weld tooling, offline robotic programming, and flame straightening.

11:40 a.m. – 1:00 p.m. Lunch

1:00 p.m. – 1:35 p.m.

20 kW Hybrid Laser Arc Welder

Duncan Pratt, GE Global Research

GE Global Research has unveiled a 20-kW high-power hybrid laser arc welding (HLAW) system, one of the largest in North America. The system wields enough power to weld steels nearly 1 in. thick in a single pass versus the up-to-a-half-dozen passes required with current welding technologies. HLAW is expected to dramatically increase the speed at which industrial products are manufactured. For example, going from conventional welding processes to HLAW to weld the aircraft carrier USS Saratoga could have saved nearly 800 tons of weld metal (equal to the weight of more than 600 compact cars) and reduced the welding time by 80%. GE is exploring this technology for application across its infrastructure manufacturing operations, including the oil and gas, power generation, aviation, and rail industries.

1:35 p.m. – 1:50 p.m.

Automated Back Gouging of Thick Plate Weld Joints for DDG 1000 Construction

Bruce Horn, Concurrent Technologies Corp.

Timothy Freidhoff, Concurrent Technologies Corp.

General Dynamics - Bath Iron Works (BIW) manually arc gouges
and grinds the Peripheral Vertical Launch System (PVLS) and Anti-Propagation Wall (APW) structures on DDG 1000 to produce the desired weld joint profile and quality. This labor-intensive process is slow, and the repetitive motion causes numerous injury claims, such as carpal tunnel syndrome. This project developed an automated backgouging tool that will leverage work done in a previous Navy Metalworking Center (NMC) project that developed a track weld shaver system. The system was modified to create a proof-of-concept demonstration that was successful in backgouging thin (<1 inch) plates requiring a shallow profile depth (¼ to ½ inch). In order to meet the DDG 1000 backgouging requirements for PVLS and APW, the weld shaver was modified with 1) larger diameter slotting cutter, 2) a redesigned housing, 3) a higher torque cutter drive, and 4) drive and guide wheels in order to be able to backgouge to a depth of ½ inches. Modifying the track weld shaver for DDG 1000 backgouging has increased the production rate by at least 150% and eliminated the labor required to clean and dress by grinding a deep arc gouged joint. As a result, estimated labor savings of approximately $400K per DDG 1000 has been identified.

1:50 p.m. – 2:10 p.m.
A New Hybrid Laser Arc Welding Center Opens Up
Doug Zoller, American Tank & Fabricating Co.

Traditional welding processes have forced designers and fabricators to account for the limitations in arc welding. The hybrid laser arc welding process takes advantage of traditional gas metal arc advantages and couples that with the high energy density of laser welding. This merger of technologies gives a weld that has advantages over either process separately.

2:10 p.m. – 3:00 p.m.
Question-and-Answer Session

Tuesday, November 15
8:30 a.m. – 4:00 p.m.
Room N230B
8TH CONFERENCE ON WELD CRACKING
Member: $345, Nonmember: $480 · Registration Code: W29
Conference Chair: Robert Irving

At AWS’s eighth conference on weld cracking, the different types of cracking, their respective causes, and their solutions will be thoroughly examined. No incident causes so much alarm as a weld crack. This program will identify and analyze the types of cracks — and more importantly — what to do about them.

8:30 a.m. – 9:05 a.m.
Understanding Weld Cracking in Steels
Joseph C. Bundy, Hobart Brothers Co.

There is a great deal to be said about the consequences, the causes, and the remedies pertaining to weld cracking. In this presentation we will touch on all three and delve into the solidification and liquation cracking prevalent in hot cracking as well as the problems caused by diffusible hydrogen. The topics of pre- and postweld heat treat will also be examined.

9:05 a.m. – 9:40 a.m.
Crack Avoidance in Creep-Strength-Enhanced Ferritic Steels
William F. Newell, Jr., Euroweld Ltd.

Cracking and failure in creep strength-enhanced ferritic steels are attributable to both direct and indirect causes. Factors initiating from original material, manufacture (base metal, fittings, weld metal), design, fabrication, installation, and operation, all possess potential contributors to cracking. Specific items will be identified and highlighted within each factor in a format that illustrates how crack avoidance can be achieved. Examples will be used to enhance understanding and potential implementation of avoidance remedies.

9:40 a.m. – 9:55 a.m.
Morning Break

9:55 a.m. – 10:30 a.m.
Hot Cracking in Austenitic Stainless Steels
Damian J. Kotecki, Damian Kotecki Welding Consultants, Inc.

This presentation reviews solidification cracking, liquation cracking, and ductility dip cracking in austenitic stainless steel welds. Metallurgical causes of these three distinctly different cracking phenomena are discussed. Approaches for mitigating these phenomena are described, in order to assist the welding industry in obtaining sound welds in most situations.

10:30 a.m. – 11:05 a.m.
How to Prevent Cracking When Welding Aluminum Alloys
Tony Anderson, ITW Global Welding Technology Center

This presentation will examine the primary reasons for hot cracking to occur when welding the various aluminum alloys. It will evaluate the crack sensitivity associated with the various alloying elements that are added to aluminum and how we can use crack sensitivity curves to predict and thereby reduce the hot cracking potential of our welds. It will further discuss the importance of correct filler alloy selection and how the filler alloy/base alloy combination can be critical in the prevention of solidification cracking.

11:05 a.m. – 12:30 p.m. Lunch

12:30 p.m. – 1:05 p.m.
Hydrogen Induced Cracking in Welding High Performance Steels
Yoni Adonyi, LeTourneau University

Over the past decades, steelmakers made significant alloying and processing changes to lower heat-affected zone (HAZ) hardenability in structural steels. Accordingly, hydrogen-induced cracking was found to have “migrated” from the HAZ to the fusion zone. Typical Tekken (Y-groove) testing for HAZ became less useful.
in predicting minimum preheats. Instead, gapped bead-on-plate (GBOP) testing proved to be a better tool for predicting hydrogen-induced cracking susceptibility. The presentation discusses work performed on GBOP testing high-performance steels for bridge fabrication having yield strength up to 100 ksi, in which most preheats were eliminated by control of diffusible hydrogen, consumable strength, and heat input. These studies were funded by the American Iron and Steel Institute, Federal Highway Administration, and several state Departments of Transportation.

1:05 p.m. – 1:40 p.m.
**Investigation of Weld Metal Cracking in a Hydrotreater Vessel**
Robert W. Warke, LeTourneau University

Following several inspections and just prior to the on-site erection of a heavy-wall 2½Cr-1Mo-½V hydrotreater vessel, a continuous, through-wall transverse crack was discovered in one of its girth welds. This case study details the investigation of this costly and unusual crack to its even more unusual root cause, how it managed to evade prior detection, and the implications and code interpretations that arose from the tests that ensued.

1:40 p.m. – 1:55 p.m. Afternoon Break

1:55 p.m. – 2:30 p.m.
**Preventing Cracking in Nickel-Base Alloys**
Donald J. Tillack, Tillack Metallurgical Consulting, Inc.

There are numerous causes for weld-associated cracking in nickel alloys and they generally can be classified as happening during welding, during heat treatment, or during service exposure. This presentation will examine the various cracking mechanisms that can occur during each of these scenarios. Examples will be given and suggestions will be offered regarding how to prevent the cracking.

2:30 p.m. – 3:05 p.m.
**Phased Array Ultrasonics for Detecting and Sizing Cracks in Welds**
Michael Moles, Olympus NDT

Cracking in new construction welds can be a serious problem as it can lead to structural integrity issues. Detection of cracking for AWS applications is normally performed using standard AWS D1.1 procedures. These procedures involve inspecting using search units with 45-, 60- or 70-deg beams with conventional manual ultrasonics. Manual inspections are now being performed using a special AWS array with a special wedge that generates all three beams – in compliance with the AWS D1.1 Code. The special phased array is built to AWS specifications, i.e., 2.25 MHz and correct aperture. The crack detection scans are used with a manual instrument that permits accurate location of the defect on an appropriate weld overlay. In addition to these standard AWS D1.1 approaches, time-of-flight diffraction and back diffraction detection and sizing examples will be shown, even though these are outside the AWS D1.1 Code.

3:05 p.m. – 3:40 p.m.
**Pressure Vessel Crack Prevention in Weld Repairs and Alterations**
James T. Worman, The National Board of Boiler and Pressure Vessel Inspectors

The American Society of Mechanical Engineers (ASME) Code provides design rules for fabricating pressure vessels. After the Data Report is signed and the vessel is in service, the National Board Inspection Code (NBIC) shall be followed for all repairs and alterations. NBIC Part 3, Repairs and Alterations, provides requirements to help prevent weld cracking in the repair and alteration of pressure vessels.

3:40 p.m. – 4:00 p.m.
**Question-and-Answer Session**

9:40 p.m. – 4:30 p.m. Room N138
**NATIONAL WELDING EDUCATION CONFERENCE**

Member/Nonmember: $149 · Registration Code: W27

Presented by the National Center for Welding Education and Training (Weld-Ed), this conference is designed to bring together educators for professional development and networking opportunities. Weld-Ed’s focus is on the preparation of welders, welding technicians, and welding engineers to meet the needs of industry. This conference will include presentations on topics such as Weld-Ed accomplishments in the last year, the partnership between Weld-Ed and AWS, welding industry workforce needs, recruitment tips and tools for educators, competency models, tips on partnering with other secondary and post-secondary schools, welding education trends, curriculum, distance learning updates, new technology applications, and presentations from welding educators who will share their best practices.
Ed's ten regional partner colleges, a crosswalk of student learning outcomes across partner colleges, and is the current core being taught by the majority of colleges.

12:00 noon – 1:00 p.m.  Room N129
Lunch and Speaker from Hypertherm

1:10 p.m. – 3:10 p.m.
Advanced Manufacturing and Process Showcase 
Industry representatives share their products and services that can benefit the welding educator.

1:10 p.m. – 1:40 p.m.
Session #1 Lincoln Electric,
1:40 p.m. – 2:10 p.m.
Session #2 Miller
2:10 p.m. – 2:40 p.m.
Session #3 ESAB
2:40 p.m. – 3:10 p.m.
Session #4 Nelson Stud
3:10 p.m. – 3:20 p.m. Break
3:20 p.m. – 4:10 p.m.
Coffee Break (Using Technology in the Classroom)
This session gives information on some exceptional online media that educators will definitely want to know about. A representative from Pearson will share novel online tools that can be used by educators in day-to-day classroom teaching.

4:10 p.m. – 4:30 p.m.
Affiliate Network/Wrap up and Evaluations
Duncan Estep, Lorain County Community College
Join Weld-Ed in its quest to build a solid foundation of highly trained technicians to fulfill the demand of industry.

Wednesday, November 16
8:30 a.m. – 4:00 p.m.  Room N127
WHAT'S NEW IN POWER SOURCES?
Member: $345, Nonmember: $480 · Registration Code: W30
Conference Chair: Robert Irving
The latest welding machines are equipped with greatly improved capabilities, including multiprocess operation. Meet the experts and understand the relative benefits of emerging power source technologies. The experts will be on hand to compare innovations.

8:30 a.m. – 9:05 a.m.
Modern Power Source Technology that Drives Process Improvement
Todd McEllis, Miller Electric Mfg. Co.
The goal of the welding industry is no different than that of other industries – improve productivity, ensure consistent quality, and of course lower costs. It is difficult if not impossible to attain these goals without accurate real-time and historical weld process information. In the past, some companies have attempted to use “bolt on” equipment to obtain this type of information. Welding power source manufacturers have now begun to incorporate weld process and production management information into their product offering. This discussion will focus on how the information provided by this new generation of power sources can be used to increase productivity, improve quality, reduce costs, and better manage the overall welding operation. AXCell power source will be used as an example.

9:05 a.m. – 9:40 a.m.
AC Pulse GMAW for Aluminum, Mild and Stainless Steels
Phil Mosquera, OTC Daishen Inc.
This presentation will explain AC Pulse Mig welding, a new GMAW transfer used for welding thin sections and gap filling of aluminum and other alloys. Introducing electrode negative polarity to the GMAW pulse arc to control heat input and improve travel speed will be explained. Automotive and other industry applications for this technology will be covered.

9:40 a.m. – 9:55 a.m. Morning Break

9:55 a.m. – 10:30 a.m.
Advances in Production Monitoring
Bruce Chaney, The Lincoln Electric Co.
Production monitoring capabilities in the welding environment continue to expand with both new and maturing communication technologies. These communication technology advancements, coupled with innovative power source technologies, provide for not only shop-based production monitoring but also monitoring in remote areas. As a result, new solutions bring the data to you, regardless of where you or the power sources are. In addition, advancements in mobile computing also provide a unique
opportunity for both data streaming and monitoring from a variety of platforms. Information on the emerging technologies, their capabilities, and implementation will be presented.

10:30 a.m. – 11:05 a.m.
**Advanced GMA Welding**
*Wesley Doneth, Fronius USA LLC*

The new CMT Advanced technology represents the first time that welding current polarity changing and reversal of the wire movement has been incorporated into process control, thus broadening the range of processes for joining light and ultra-light gauge sheet. CMT Advanced offers a 60% improvement in deposition rate.

11:05 a.m. – 12:30 p.m. Lunch

12:30 p.m. – 1:05 p.m.
**High Performance GMAW — New Machines, New Techniques Will Provide a Boost in Performance**
*Paul Blomquist, Applied Thermal Sciences, Inc.*

At this time, there are several power sources, either in the market or under development, that promise a range of increased speed and penetration for GMAW operations. The most productive of these, Hybrid Laser Arc Welding (HLAW), provides a 10X increase in weld speed, but comes with vastly higher equipment cost (on or about 20X), and requires very specialized equipment. While this can be compelling for high-volume applications, for everything else it makes sense to evaluate the state of the art of GMAW technology to determine if traditional performance can be improved at a lower capital cost. A National Shipbuilding Research Program Welding Technology Panel Project on High Performance GMAW is under way, aimed at ascertaining the technologies that can achieve the goal of doubling weld penetration and speed. This review will make full use of the knowledge and requirements of the shipyard team members, with further input from the Welding Technology Panel of the NSRP. Following this analysis phase, the most promising approach will be down-selected. Several power sources are just entering the market, and at least one foreign research project is showing potential to drastically increase penetration using currently available inverter-type power supplies by an ingenious modification of parameter sets.

1:05 p.m. – 1:40 p.m.
**WeldScore — Embedded Weld Data Quality Monitoring**
*Joe Daniel, The Lincoln Electric Co.*

The capability of traditional weld data quality monitoring has been expanded by embedding technology into the control systems of welding power supplies. Higher data sampling rates and a fundamental processing improvement increases the defect detection capability, as well as the detection reliability of weld data quality monitoring. Information on this technology and defect detection examples will be presented.

1:40 p.m. – 1:55 p.m. Afternoon Break

1:55 p.m. – 2:30 p.m.
**Gold Track VI**
*Robert Tollett, Liburdi Automation Inc.*

The state-of-the-art control architecture of the Gold Track VI is expandable to 8 servos of wire and motion control, has USB and Ethernet ports, and supports the latest technology in connectivity to the Internet, MODBUS, and high-speed data monitoring. In addition to the welding functions, the servo and I/O functions can be connected through the auxiliary port and used to operate custom applications such as lathes, seamers, machining, and inspection equipment.

2:30 p.m. – 3:05 p.m.
**Controlled Short Circuit GMAW Process Competes Favorably with SMAW, GTAW**

The combination of Regulated Metal Deposition, or RMD™, and the Pro-Pulse™ Pulsed MIG process provides an efficient method of welding pipe from root to cap with one wire and one gas. The presentation includes a case study involving Graham Corporation, the world leader in engineered-to-order vacuum and heat transfer equipment. These processes have significantly reduced rework (down from 3.2 to 1.3%) and lead times. This includes faster travel speeds on root passes (between 6 and 12 in./min) and a 22% productivity increase over manual GTAW. In summary, the described technology provides the following: it reduces rework on the root pass in pipe welding applications and distortion by reducing overall heat input in pipe welding applications. The need for backpurging in stainless pipe welding applications is also eliminated. Travel speeds are also increased.

3:05 p.m. – 4:00 p.m.
**Question-and-Answer Session**

9:00 a.m.-5:00 p.m.
**ROOM N128**

**THERMAL SPRAY TECHNOLOGY: HIGH-PERFORMANCE SURFACES**
*Member: $345, Nonmember: $480 · Registration Code: W3I*
*Conference Chairs: David Wright and Dan Hayden*

The American Welding Society and The International Thermal Spray Association are organizing the Third Thermal Spray and Coatings Conference, to be held in conjunction with FABTECH 2011. This one-day event is intended to introduce the process and its uses to new potential users with morning and afternoon sessions focusing on actual applications and new developments in thermal spray technology.
In addition, on Tuesday, November 15, a free half-day tutorial on thermal spray fundamentals titled Thermal Spray Basics: Putting Coatings to Work is scheduled. The tutorial is being sponsored by the International Thermal Spray Association.

9:00 a.m. – 9:30 a.m.
**Thermal Spray — Around the World in 80 Ways**
*Jean Mozolic, The Mozolic Consulting Group*

Thermal Spray has a rich past, an active present, and an exciting future. Let’s travel the thermal spray world and explore the history, the applications, and innovations occurring from North America to Europe to the BRIC countries and emerging economies.

9:30 a.m. – 10:00 a.m.
**Advancing Cold Spray Applications to Industry Markets**
*David W. Wright, Accuwright Industries, Inc.*

Accuwright Industries, a leader in research and development and production applications of cold spray processes, is bringing more industries to the production line by developing materials and applications in a more economical way. Accuwright has developed aluminum and magnesium component repair for the aerospace and motorsports industries.

10:00 a.m. – 10:30 a.m.
**“Should We Offer Thermal Spray Coated Fabricated Products?” What a Steel Fabricator Should Know About Thermal Spray Applied Anodic Coatings**
*James Weber, James K. Weber Consulting*

Today, with the cost of paint and surface preparation skyrocketing, and increasing environmental concerns with both, thermal spray applied coatings are more attractive than ever and oftentimes provide the most cost-effective inspection and maintenance-free surface to steel. Let’s discuss what steel fabricators should know about thermal spray coatings, where they can be sold and used, what type of performance guarantees can be offered, and how tough they are.

10:30 a.m. – 10:55 a.m. Morning Break

11:00 a.m. – 11:30 a.m.
**What is Thermal Spray?**
*Larry F. Grimenstein, Nation Coating Systems, Inc.*

The growth of thermal spray coatings increases every day. This short talk will cover terminology, materials, processes, and applications to provide you with a general idea of whether this thermal spray technology fits your industrial problem area.

11:30 a.m. – 12:00 noon
**Quality Control of Thermal Spray Coatings**
*Joseph P. Stricker, St. Louis Metallizing Company*

This talk will cover the various methods of inspecting the quality of coatings that are applied by the combustion process, electric arc process, plasma flame spray process, and high-velocity oxyfuel process (HVOF). The discussion will cover the cross-section techniques, bond strength testing, hardness testing, coating density, imbedded grit, bend testing, and methods for checking coating thickness using electronic gauges.

12:00 p.m. – 12:30 p.m.
**High Density Twin Wire Arc Spray Coatings**
*Frank Rogers, Thermion, Inc.*

Thermion presents equipment design theories and process information and test data for its new “High Density Twin Wire Arc Spray.” This high-velocity process produces density with less than 0.5% porosity; with some materials the macros revealed less than 0.1% porosity.

12:30 p.m. – 1:25 p.m. Lunch

1:30 p.m. – 2:00 p.m.
**Corrosion Protection Technology Without Size Limitations**
*Fred van Rodijnen, Sulzer Metco Europe GmbH*

Corrosion is the most costly process for engineered structures on the planet such as bridges, wind turbine towers, water towers, ships, and other large structures constructed from steels and iron alloys. Thermal spray is a very attractive process for maintenance of these type structures.

2:00 p.m. – 2:30 p.m.
**Effect of HVOF Process Conditions on Chrome Replacement Coatings**
*Satish Dixit, Plasma Technology, Inc.*

WC-10Co-4Cr chrome replacement coatings were deposited by two different HVOF coating techniques namely JP 5000 and JetKote. In this study, the effect of process conditions and feedstock materials on coating microstructure and composition was studied. Plasma diagnostics were employed in order to assess the particle state during coating process and its effect upon subsequent coating characteristics. Coatings were also characterized using X-ray diffraction, SEM-EDS analysis, and ASTM B 117 corrosion testing.

2:30 p.m. – 3:00 p.m.
**Thermal Sprayed Zinc and Aluminum Coatings for Atmospheric Corrosion Protection**
*Dan Hayden, Hayden Corporation*

A discussion of the uses and methods of application of zinc and aluminum to corrosion-prone materials in outdoor and marine service. This discussion will explain the mechanisms by which the coatings perform unique advantages of these coatings over other alternatives, and the most common means of application.
3:00 p.m. – 3:25 p.m. Afternoon Break

3:30 p.m. – 4:00 p.m.
**Much Ado about Nothing: Why the Concern about Porosity**
Dale Moody, Plasma Powders and Systems

The paper discusses the basics of thermal spray porosity for the fabricator considering incorporating thermal spray into the operation; what it is, when is it good, when is it bad, how is it controlled and how is it measured. Data on minimizing porosity using a HVOF process is included.

4:00 p.m. – 4:30 p.m.
**Using Robotic Offline Programming for Improved Thermal Spray**
Kevin Nelson, Blue Technik LLC

This presentation will explore the use and benefits of CAD-based thermal spray robotic offline programming methods used to develop thermal spray robot paths on workpieces of complex geometry, economic considerations, and effective deployment of this technology in the thermal spray shop.

4:30 p.m. – 5:00 p.m.
**Measurement and Sensing Requirements for Improved Plasma Spray Process Capabilities**
Dennis Radgowski, Cyber Materials LLC

This paper explores plume sensor requirements in the context of improving the plasma spray process. Plasma spray plume sensors can be used to reduce variation and streamline development of new processes, but the sensors must provide accurate and comprehensive measurements.

5:00 p.m. Adjournment

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**SEMINARS**

Monday, November 14

8:00 a.m. - 12:00 p.m.  Room N133

**D1.5 - BRIDGE CODE CLINIC**

*Member: $175, Nonmember: $310 Registration Code: W20*

This 4-hour seminar will help you prepare for the AWS D1.5, Bridge Welding Code, exam with instruction in code navigation, structure, and design. The seminar will focus on areas of the code relevant to the welding inspector, specifically clauses and sections concerning materials and design, fabrication, inspection, and qualification. Note that endorsements are supplemental inspection credentials available to AWS Certified Welding Inspectors (CWIs) and Senior Certified Welding Inspectors (SCWIs), but non-CWI/SCWIs can also participate in the seminar and examination to expand their professional credentials. Please note that there is a separate application and fee required to take the certification exam. Exams for the CWI, including Part C and endorsements are being held at FABTECH on November 17. Advance application through AWS is required for qualification to take exam(s). Call 800-443-9353 ext. 273, or go to [http://www.aws.org/certification](http://www.aws.org/certification) for certification and registration requirements.

Participants are expected to provide their own code books. AWS D15.1/D15.1M:2007 standard can be purchased at the AWS bookstore at [http://pubs.aws.org/](http://pubs.aws.org/).

8:00 a.m. – 5:00 p.m.  Room N135

**METALLURGY APPLIED TO EVERYDAY WELDING**

*Member: $345, Nonmember: $480 Registration Code: W22*

Metallurgy of welds in carbon and low-alloy steels shouldn't be complicated. This short course will help you understand how welding affects the properties of base materials, and how weld defects occur.

**Who Should Attend**

Owners, inspectors, engineers, and supervisors who specify welding and need to understand the interactions of base metal, filler metal, and welding processes should attend.

Tuesday, November 15

8:00 a.m. – 5:00 p.m.  Room N227A

**D1.1 - ROAD MAP**

*Member: $345, Nonmember: $480 Registration Code: W23*

This one-day program will provide participants with a comprehensive overview of AWS D1.1/D1.1M: 2010, Structural Welding Code — Steel. Each of the code sections, including General Requirements, Design of Welded Connections, Prequalification, Qualification, Fabrication, Inspection, Stud Welding and Strengthening and Repair of existing structures, will be summarized, with emphasis on their interrelationships and usage. In addition, the role of mandatory and no mandatory annexes will be reviewed, along with tips for how to use the code commentary. Though not a prerequisite, this session provides a broad basis of understanding the code for those who are attending other detailed sessions later.

**Who Should Attend**

This program will benefit managers, engineers, supervisors, inspectors, and other decision makers who need a good overall understanding of what is and what is not covered by AWS D1.1/D1.1M:2010 in order to improve their job effectiveness.

Participants are expected to provide their own code books. AWS D1.1/D1.1M:2010 standard can be purchased at the AWS bookstore at [http://pubs.aws.org/](http://pubs.aws.org/).

8:00 a.m. – 5:00 p.m.  Room N230A

**ASME SECTION IX, B31.1 & B31.3 CODE CLINIC**

*Member: $345, Nonmember: $480 Registration Code: W24*

This 8-hour seminar will help you prepare for the ASME Section IX, B31.1, and B31.3 examination for endorsement or Part C of the CWI. Note that endorsements are supplemental inspection credentials available to AWS Certified Welding Inspectors (CWIs) and Senior Certified Welding Inspectors (SCWIs), but...
non-CWI/SCWIs can also participate in the seminar and examination to enhance their educational background.

Participants are expected to provide their own code books. Please note that there is a separate application and fee required to take the certification exam. Exams for the CWI, including Part C and endorsements are being held at FABTECH on November 17. Advance application through AWS is required for qualification to take exam(s). Call 800-443-9353 ext. 273, or go to http://www.aws.org/certification for certification and registration requirements.

Tuesday, November 15 – Wednesday, November 16
8:00 a.m. – 5:00 p.m. Room N229
ADDITIONAL VISUAL INSPECTION WORKSHOP
Member: $550, Nonmember: $685 Registration Code: W26
A 16-hour course for CWI exam candidates to review the basic concepts and applications of visual inspection. After a discussion of the limitations and advantages of visual inspection, types of weld data that may be obtained by visual inspection are presented and discussed. Includes the many types of discontinuities encountered during the visual inspection of welds. Common tools used for visual inspection are presented and discussed (a machinist’s scale, dial calipers, micrometers, fillet weld gauges, the Palmgren gauge, and the V-WAC). Participants will use these gauges to make measurements on weld replicas. This will prepare candidates for Part B of the exam.

A sample weld specification containing acceptance criteria is presented and discussed, after which students use the specification and visual inspection tools to evaluate the weld replicas using a series of specific questions and scenarios.

By attending, you can learn:
• How to use weld-measuring instruments
• Compliance to a specific code
• Do’s and don’ts of documentation
• When a discontinuity is OK
• When a defect is rejectable
• Why visual inspection can be the most effective NDE technique

Exams for the CWI, including Part B are being held at FABTECH on November 17. Advance application through AWS is required for qualification to take exam(s). Call 800-443-9353 ext. 273, or go to http://www.aws.org/certification for certification and registration requirements.

Wednesday, November 16
8:00 a.m. – 5:00 p.m. Room N230A
THE WHY AND HOW OF WELDING PROCEDURE SPECIFICATIONS
Member: $345, Nonmember: $480 Registration Code: W25
If you are responsible for planning a welding operation, which of the following items are most critical: base metal, welding process, filler metal, current and range, voltage and travel speed, joint design tolerances, joint and surface preparation, tack welding, welding position, preheat and interpass temperature, or shielding gas? This course provides the answers.

Who Should Attend
This session will benefit owners, managers, engineers, and supervisors who must qualify, write, or revise their own welding procedure specifications to satisfy codes and contract documents.

Topics covered:
• Proper preparation and qualification of welding procedure specifications

You can learn:
• Selecting and documenting welding variables
• Documenting standard procedure qualification testing for commonly used processes for joining ferrous plate and pipe

RWMA WELDING SCHOOL
Member: $475, Nonmember: $695 · Registration Code: W32
The two-day resistance welding school is sponsored by the American Welding Society and the Resistance Welding Manufacturing Alliance, and conducted by industry specialists. The basics of resistance welding and real-life application of the process are covered. Participants learn at their own pace and discuss specific welding concerns with the instructors. You are invited to bring your own samples for discussion.

Please plan to be present for both days of the school. The program is limited to 100 students. In addition, there will be tabletop exhibits both days, demonstrating the latest resistance welding products offered by RWMA-member companies. The registration fee includes a copy of the Resistance Welding Manual, Revised Fourth Edition (a $125 value), and a course binder containing all instructor presentations.

Wednesday, November 16
7:45 a.m. – 8:00 a.m. Room N227A
Welcome & Introduction to Resistance Welding
Bill Brafford, Tuffaloy Products, Inc.

8:00 a.m. – 8:30 a.m. Room N227A
Basics of Resistance Welding Video – Part I

8:30 a.m. – 11:00 a.m. Room N227A
Electrodes and Tooling
Bill Brafford, Tuffaloy Products, Inc.

Focus on the classification, selection, and maintenance of electrodes and fixtures as they pertain to numerous applications. By revealing some problem-solving techniques and suggestions, Brafford will familiarize you with some powerful problem/evaluation/solution techniques that will keep your production process running longer and more efficiently.

11:15 a.m. – 12:15 p.m. Room N226
Tabletop Exhibits

12:15 p.m. – 12:45 p.m. Room N226
Lunch

12:45 p.m. – 2:45 p.m. Room N227A
Welding Controls
Don Sorenson, ENTRON Controls, LLC
This discussion focuses on the selection, descriptions, and applications of welding timers, contactors, and accessories. Packed with a punch, Sorenson drives home H = I^2 RT in a way you’ll never forget. He shows you how this invaluable formula is used in every resistance welding application — every day, every cycle, all the time.
**Electric Power Systems**

**Mark Siehling, RoMan Manufacturing, Inc.**

This session reviews the descriptions and maintenance of electrical power components and conductors from the weld control to the electrode. This lively presentation has something for everybody. Utilizing several small demonstrations, Siehling helps you understand this very important part of the resistance welding process.

**Thursday, November 17**

8:00 a.m. – 10:00 a.m.

**Welding Processes and Machines**

**Tim Foley, Automation International, Inc.**

This session will reinforce the very essence of how the resistance welding process works and how the process relates to each of the four resistance welding processes. This session will be full of application examples from each process and how machinery utilizes the individual components and elements illustrated in the other sessions.

10:15 a.m. – 10:45 a.m.

**Basics of Resistance Welding Video – Part II**

**AWS VOLUNTEER COMMITTEE MEETINGS**

<table>
<thead>
<tr>
<th>Location</th>
<th>Monday November 14</th>
<th>8:00 a.m. – 5:00 p.m.</th>
<th>C Room N127</th>
</tr>
</thead>
<tbody>
<tr>
<td>C - Convention Center</td>
<td>C2 Committee and Subcommittees on Thermal Spray</td>
<td>1:00 p.m. – 5:00 p.m.</td>
<td>C Room N130</td>
</tr>
<tr>
<td>C - Convention Center</td>
<td>D14G Subcommittee on Welding of Rotating Equipment</td>
<td>1:00 p.m. – 5:00 p.m.</td>
<td>C Room N130</td>
</tr>
<tr>
<td>C - Convention Center</td>
<td>D18 Committee on Welding in Sanitary Applications</td>
<td>1:00 p.m. – 5:00 p.m.</td>
<td>C Room N130</td>
</tr>
<tr>
<td>C - Convention Center</td>
<td>C7/C7B High Energy Beam Welding and Cutting Committee</td>
<td>2:00 p.m. – 6:00 p.m.</td>
<td>(H) Lake Ontario</td>
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<thead>
<tr>
<th>Location</th>
<th>Tuesday November 15</th>
<th>8:00 a.m. – 10:00 a.m.</th>
<th>C Room N227</th>
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<tbody>
<tr>
<td>C - Convention Center</td>
<td>D14B Subcommittee on Welding Design in Heavy Equipment</td>
<td>8:00 a.m. – 5:00 p.m.</td>
<td>C Room N130</td>
</tr>
<tr>
<td>C - Convention Center</td>
<td>D15C Subcommittee on Track Welding</td>
<td>8:00 a.m. – 5:00 p.m.</td>
<td>(H) Lake Michigan</td>
</tr>
<tr>
<td>C - Convention Center</td>
<td>D17D Subcommittee on Resistance Welding in Aerospace Applications</td>
<td>8:00 a.m. – 5:00 p.m.</td>
<td>(H) Lake Michigan</td>
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<tr>
<th>Location</th>
<th>Wednesday November 16</th>
<th>7:30 a.m. – 9:00 a.m.</th>
<th>C Room N134</th>
</tr>
</thead>
<tbody>
<tr>
<td>C - Convention Center</td>
<td>D14 Committee on Welding of Heavy Machinery</td>
<td>3:00 p.m. – 5:00 p.m.</td>
<td>C Room N134</td>
</tr>
<tr>
<td>C - Convention Center</td>
<td>D16 Committee on Robotic Welding</td>
<td>9:00 a.m. – 11:00 a.m.</td>
<td>C Room N134</td>
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<tr>
<th>Location</th>
<th>Thursday November 17</th>
<th>8:00 a.m. – 12:00 noon</th>
<th>C Room N134</th>
</tr>
</thead>
<tbody>
<tr>
<td>C - Convention Center</td>
<td>D17 Committee on Welding in Aerospace Applications</td>
<td>8:00 a.m. – 12:00 noon</td>
<td>C Room N134</td>
</tr>
<tr>
<td>C - Convention Center</td>
<td>C6D Committee on Friction Stir Welding</td>
<td>9:00 a.m. – 11:00 a.m.</td>
<td>C Room N134</td>
</tr>
</tbody>
</table>
FREE EXPO ADVANCE REGISTRATION FORM

- FREE advance registration with this form until November 11, 2011. Register after this date or onsite and the registration fee is $50.
- Online registrants: receive an immediate e-mail confirmation. Fax/Mail-in registrants: receive confirmation within 5 business days.
- Students: Do not use this form to register. Please call (800) 733-4763 for assistance.
- No one under 16 years of age admitted.

3 EASY WAYS TO REGISTER

ONLINE: www.fabtechexpo.com
FAX: (508) 743-9696
MAIL TO: FABTECH 2011
c/o Convention Data Services
107 Waterhouse Road
Bourne, MA 02532

If you register online or via fax, DO NOT mail this form. Photocopy this form for additional registrants.

PROMO CODE:

☐ Mr. ☐ Ms. ☐ Mrs. ☐ Dr.

Please print – One Form per Person
Name ___________________________ Title ___________________________

Business Address Required:
Company ___________________________________________________________
Address ___________________________________________________________
City/State/Zip __________________________ Postal Code/Country _____________
Phone __________________________ Ext. __________________________ Fax __________________________
E-mail __________________________

☐ Please do not use my e-mail for communications outside of FABTECH.

PAYMENT

Forms received without payment will not be processed. Payment due in U.S. Funds.
☐ Check enclosed (checks payable to SME) Total amount due $ __________________________
☐ Authorize charge to my credit account (Complete credit card information below)

Signature __________________________

Credit Card Number __________ Expiration Number __________ CVV/CID# (3 or 4 digits)

To help us better understand the demographic profile of our audience, please indicate the year you were born: _____________

November 14-17, 2011
McCormick Place | Chicago, Illinois

Are you a first time visitor to the show?
☐ Yes  ☐ No

Check if you are a member of:
A ☐ AWS  B ☐ FMA  C ☐ SME  D ☐ PMA  E ☐ CCU  F ☐ None of the above

Check your ONE primary job function:
1 ☐ Owner/Company Mgmt/Corporate Executive  8 ☐ Product Design and R&D
2 ☐ Manufacturing/Production  9 ☐ Purchasing
3 ☐ Foreman/Shop/Supervisor  10 ☐ Distributor
4 ☐ Manufacturing/Engineering  11 ☐ Sales & Marketing
5 ☐ Welding Engineer  12 ☐ Educator/Instructor
6 ☐ Welder, Welding Operator  13 ☐ Other (Please specify)

Check the number of employees at your facility:
0 ☐ Less than 20  4 ☐ 250–499
1 ☐ 20–49  5 ☐ 500–999
2 ☐ 50–99  6 ☐ 1,000–2,499
3 ☐ 100–249  7 ☐ 2,500 and Over

Indicate the products or services you plan to evaluate at the show:
A ☐ Arc Welding  S ☐ Metal Suppliers
B ☐ Assembly  T ☐ Plate & Structural Fabricating
C ☐ Bending & Forming  U ☐ Press Brakes
D ☐ Brazing & Soldering  V ☐ Punching
E ☐ Business Services  W ☐ Resistance Welding
F ☐ Coil Processing  X ☐ Robotics
G ☐ Cutting  Y ☐ Safety & Environmental
H ☐ Fastening & Joining  Z ☐ Saws
I ☐ Finishing (Paint & Powder Coating)
J ☐ Finishing/Plating
K ☐ Gases & Gas Equipment
L ☐ Hydraulic Forming
M ☐ Inspection & Testing
N ☐ Job Shop/Contract Mfg.
O ☐ Lasers
P ☐ Lubrication
Q ☐ Maintenance & Repair
R ☐ Material Handling

Indicate your company's total budget for these products or services during the next 12 months:
A ☐ Up to $20,000  E ☐ $500,001–$1,000,000
B ☐ $20,001–$50,000  F ☐ $1,000,001–$5,000,000
C ☐ $50,001–$200,000  G ☐ Over $5,000,000
D ☐ $200,001–$500,000

Indicate your purchasing authority:
A ☐ Evaluate/Recommend  C ☐ Approve
B ☐ Specify  D ☐ No Role

Check the primary industry your company serves:
A ☐ Agriculture  N ☐ Medical/Surgical
B ☐ Aerospace  O ☐ Industrial/Commercial Machinery
C ☐ Automotive  P ☐ Fabricated Metal/Stampings
D ☐ Other Transportation  Q ☐ Chemical & Petroleum
E ☐ Shipbuilding/Marine  R ☐ Alternative Energy
F ☐ Architectural, Engineering  S ☐ Mining/Utilities/Power Generation
G ☐ Construction  T ☐ Military/Defense
H ☐ Heavy Equipment  U ☐ Education/Academic
I ☐ HVAC  V ☐ Non-Manufacturing
J ☐ Appliance  W ☐ Other Manufacturing
K ☐ Consumer Products  X ☐ Other Manufacturing
L ☐ Electronics/Computers
M ☐ Furniture

(Please specify): ___

FABTECH 2011
November 14–17, 2011
McCormick Place | Chicago, Illinois

• No one under 16 years of age admitted.
• Students: Do not use this form to register. Please call (800) 733-4763 for assistance.
• Online registrants: receive an immediate e-mail confirmation. Fax/Mail-in registrants: receive confirmation within 5 business days.
• Indicate the products or services you plan to evaluate at the show.
• Indicate your company’s total budget for these products or services during the next 12 months.
• Indicate your purchasing authority.
• Check the primary industry your company serves.
Please indicate your name and member number to receive full pricing benefits. Complete form on reverse side.

Company: ____________________________

I am a member of: □ AWS □ FMA □ SME □ PMA □ CCAI □ Non-member • Member Number: ____________________________

**FABTECH EDUCATIONAL SESSIONS**

NOTE: After Sept. 23 and on-site, add $25 to the purchase price of FABTECH Educational Sessions.

<table>
<thead>
<tr>
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<th>MEMBER</th>
<th>NON-MEMBER</th>
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<tbody>
<tr>
<td>1 Session</td>
<td>$150</td>
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<tr>
<td>2 Sessions</td>
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<tr>
<td>3 Sessions</td>
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<tr>
<td>4-5 Sessions</td>
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<tr>
<td>6-9 Sessions (Maximum value includes two $15 lunch vouchers)</td>
<td>$675</td>
<td>$775</td>
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Please select the sessions below you would like to attend. The price for each session is noted above.

**FABTECH SESSIONS SUBTOTAL:** $__________

**AWS WELDING SESSIONS**

1-Day Welding Education Conference: $149
1/2-Day Seminars: $175
1-Day Conference or Seminar: $345
2-Day Seminar: $550
2-Day RWMA Welding School: $475
1-Day Professional Program: $355
4-Day Professional Program: $225
4-Day Student Professional Program: $75
AWS Awards Luncheon: $30
Special Programs: FREE

Please select the AWS sessions below you would like to attend. The price for each session is noted above.

**AWS SESSIONS SUBTOTAL:** $__________

**TOTAL FEES**

Full payment must accompany your registration.

Please complete Payment Section on reverse side.

Cancellation Policy

Cancellations must be made in writing and faxed to Attn: FABTECH Conference Cancellation at (312) 425-3407 no later than October 28, 2011 to receive a full refund minus a $50 administrative fee. Cancellations received after this date are non-refundable.

Entry into the exposition is included in paid event fee.
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- Stainless steel flux-cored wire
- Mild steel flux-cored wire
- Mild steel solid wire

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www.kobelcowelding.com

See Us at FABTECH booth #6306
For Info go to www.aws.org/ad-index
Welding Show 2011
Exhibit Highlights

This alphabetical listing of exhibitors in the 2011 AWS Welding Show offers a preview of what they display in each booth. AWS Sustaining Member Companies are highlighted in color.

ABB, Inc. 5758
www.abb.com/robotics
ABB will exhibit its industrial robots and modular manufacturing systems. The company’s solutions focus helps manufacturers improve productivity, product quality, and worker safety.

ABICOR Binzel Corp. 5733
www.binzel-abicor.com
ABICOR Binzel will offer GMA, GTA, robotic, air- and water-cooled torches, accessories, and welding chemicals.

Ace Industrial Products 6527
www.aceindustrialproducts.com
Ace Industrial Products will feature its heavy-duty welding fume extractors, including source-capture portable and mobile equipment, downdraft tables, extraction arms, and general capture air cleaners. The company’s extractors are suited for both shop and field work, and are effective in the capture and control of hexavalent chromium.

Air Liquide 6563
www.alspecialtygases.com
Air Liquide will display its ARCAL™, BLUESHIELD™, FLAMAL™, and LASAL™ gases engineered for welding, cutting, and metalworking applications. The company also offers industrial-grade equipment suited for use with these gases.

Airflow Systems, Inc. 5318
www.airflowsystems.com

Airgas 6146
www.airgas.com

Ajan Elektronik Servis San Ve 5822
www.ajancnc.com
Ajan Elektronik Servis San Ve will showcase its CNC plasma and oxyfuel cutting, drilling, and pipe-cutting machines.

Alabama Laser 6363
www.alabamalaser.com
Alabama Laser will spotlight its laser job shop services, custom laser systems, and process development. This includes laser cladding, cutting, welding, etching/marking, heat treating/hardening, hybrid welding, and micromachining.

Alabama Robotics Technology Park 6464
www.alabamartp.org

Aladdin Welding Products, Inc. 5406
www.aladdin3in1.com
Aladdin Welding Products will highlight its welding rod for the repair of aluminum and other white metals along with low-temperature joining supplies.

Albany Door Systems, Inc. 6604
www.albanydoorsystems.com

---

The New EXEL EPS-1500
Advanced Fusion Welding Power Supply

- High resolution, 12” color touch-screen for quick and easy programming
- Information-rich display screen with real-time weld-process feedback
- Patented S³ weld scheduling
- Compatible with most fusion weld heads
- Reliable and Portable (37 lbs.)

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Exel Orbital Products is a subsidiary of Arc Machines, Inc.

See us at FABTECH booth #5746 For info go to www.aws.org/ad-index
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MATERIAL REMOVAL,
GRINDING, DEBURRING,
WELD PREPARATION,
MAINTENANCE,
LINEAR MOTION, AND
SURFACE FINISHING
Technical and application
support backed by over
100 years of experience.

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Bringing Innovation to the Surface.
Visit us at AWS/Fabtech 2011 in booth 5307 & 1442!

Albany Door Systems will present its high-speed in-
dustrial machine protection doors that shield peo-
ple, machinery, and products during the manufac-
turing process. They are used in applications such
as welding, robotic cells, cutting, milling, painting,
tool handling, and conveyor and storage systems.
Also, these metal, fabric, and rubber door models
are durable, low maintenance, and include en-
hanced safety features.

AlcoTec Wire Corp.
www.alcotec.com

AlcoTec Wire will feature its Powered Pak-Trak
(patent pending) that reduces spool-change
downtime because one drum contains the wire of
20 spools. An adjustable cast diameter gives
long, continuous seam welds without arc wander,
improving weld quality. In addition, the product
delivers wire from up to 100 ft away and is com-
patible with all aluminum alloys.

Allcryo
www.allcryo.com

Allcryo will exhibit its refurbished cryogenic and
CO₂ tanks, plus equipment.

ALM Corp.
www.almcorp.com

ALM will feature its positioners for welding or as-
sembly and custom heavy-duty lifting equipment.

AmeriCp
www.americ.com

The leading manufacturer and master distributor of
BRASS, BRONZE, AND COPPER ALLOYS IN THE USA

See us at FABTECH booth #437
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For Info go to www.aws.org/ad-index
Proper sizing of cable for welding equipment is essential for safety, longevity, and quality welds. CCI understands the demands of the welding industry. Excelene® cables are manufactured to the highest performance standards.

Don’t settle for undersized cables:
• Undersized cables have as much as 31% less copper
• Undersized cables produce up to 33% more electrical resistance
• More resistance creates excessive heat and wear while in use
• Undersized cables can reduce the lifespan of your equipment
• Undersized cables can reduce the quality and integrity of weld joints

CCI’s Excelene® meets or exceeds the rigorous demands for voltage drop and overall performance for the welding industry.

CCI — Power with the best.
America Fortune Co. 5403
www.visa-chinese.com

America Fortune will display its high-pressure and acetylene cylinders along with additional welding supplies.

American Friction Welding 6905
www.teamafw.com

American Society for Nondestructive Testing 7006
www.asnt.org

American Technical Publishers 7026
www.go2atp.com

American Technical Publishers will showcase its broad range of applied postsecondary education content with programs in the welding skills area.

American Torch Tip Co., Inc. 7114
www.americantorchtip.com

American Welding Society 6200, 7153
www.aws.org

The American Welding Society (AWS) was founded in 1919 as a multifaceted, not-for-profit organization with a goal to advance the science, technology, and application of welding and related joining disciplines. AWS will provide a wide array of technical, education, and certification programs at the show. Visit www.aws.org/show for details.

AWS Certification. The Society develops and
these programs are offered domestically and internationally. Welding professionals are encouraged to take advantage of opportunities in welding as they identify qualified personnel and provide individuals with meaningful career objectives. The American Welding Society (AWS) offers a variety of certification programs for welding professionals to help industry identify qualified personnel and provide individuals with meaningful career objectives. The AWS Certified Welding Inspector (CWI) program offers domestic and international certification for CWIs and CAWIs. Since 1976, more than 72,000 have been certified. The AWS CWI program has become the gold standard for weld inspection credentials and has enhanced the careers of many thousands of welding professionals. In 1989, the AWS Certified Welder program was launched to document the qualifications of welders nationwide. Certified Welder certifications are maintained by AWS in a National Registry. The testing facilities used to conduct the qualification procedures are accredited by AWS and published in a list of Accredited Test Facilities (ATFs). In 1991, the AWS Certified Welding Educator program was introduced, allowing welding instructors to earn this important credential. AWS also offers several endorsements designed to enhance an individual’s credentials and/or satisfy 9-year recertification for CWIs and SCWs. Current endorsements include D1.1, D1.2, D1.5, D15.1, API 1104, ASME Section IX; B31.1 and B31.3, ASME Section VIII Div. 1 and IX, Structural Bolting, and Structural Drawing Reading. Other AWS certification programs are Senior Certified Welding Inspector, Certified Welding Supervisor, Certified Radiographic Interpreter, Certified Welding Fabricator, Certified Robotic Arc Welding Operator and Technician, Certified Welding Engineer, and Certified Welding Sales Representative. All of these programs are offered domestically and internationally. Many are offered internationally. Stop by the Certification booth to find out why AWS certifications may be the right answers for you and your company.

AWS Foundation, Inc. Five years ago, the American Welding Society Foundation inaugurated the Welding for the Strength of America Capital Campaign to add financial support to assist with the critical shortage of welders in the United States workforce. The effort has dual goals: establish additional scholarships to support entry-level students and those already involved in the welding profession; and build funding to support the AWS Welder Workforce Development Program. The predicted 200,000 welder shortage by 2018 must be addressed and AWS has assumed this critical role, but to do so we must have financial support from our industry partners. Since the start of the AWS Foundation scholarship program in 1991, we have awarded more than $5.5 million for welding training to more than 3900 individuals. The diversity of the awards is varied, but the major emphasis is welder workforce development. For the 2011–2012 school term, awards were made to more than 450 students for more than $390,000.

We need your help to respond to more significant levels of support. To date, we have raised more than $6.16 million, but that is just an initial need if we are significantly going to impact the welder workforce shortage. We appeal to you, your company, and others you know who are adversely impacted by the welder shortage, to join us. Call Sam Gentry at (800) 443-9353, ext. 331, or visit us at the AWS Foundation, Inc. Booth #7153 to explore career opportunities in welding. Also, stop by Booth #7153 to explore career opportunities in welding. The American Welding Society Foundation has launched the Welding for the Strength of America Mobile Career Exhibit. A virtual welding lab with VRTEX 360 machines is available to test your welding skills. Many additional educational components are part of the welding educational mobile exhibit, including a social media center. Join us for the inauguration of this rolling revolution as we work toward attracting a new welding workforce for the future.

AWS Membership. AWS provides services to more than 68,000 individual members and 1900 corporate members worldwide. AWS members include engineers, scientists, educators, researchers, welders, inspectors, welding foremen, company executives, and sales associates. Member interests include automatic, semiautomatic, and manual welding, as well as brazing, soldering, ceramics, laminations, robotics, and safety and health. Drop by the AWS Membership Booth #6500 located in the entrance of the North Hall, to sign up for an Individual Membership and receive a popular welding publication (up to a $192 value) at a 90% discount. Browse through the AWS Bookstore and save 25% on more than 300 AWS publications. Save $135 and get a two-year AWS Membership.
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See us at FABTECH booth #5525

ship when you sign up for the Professional Program at the Show. Stay informed on the latest products, trends, and technology through 12 issues of the Welding Journal. Looking for a job? Establish valuable partnerships with others in your field by attending local AWS Section meetings and dozens of educational events. Gain a voice in determining the future of your industry by getting involved in one of AWS's 180 technical committees. For depth, detail, and technical insight, AWS has the answers.

Welding Journal/Welding Journal en Español/Inspection Trends. Welding Journal is the official publication of the American Welding Society. This monthly magazine contains feature articles on practical and applied welding technology, information on AWS activities and programs, a variety of monthly columns, and peer-reviewed welding research papers. Industry experts also answer readers’ questions regarding stainless steel, aluminum, brazing, and resistance welding. The Welding Journal has received numerous editorial and design awards over the years. Welding Jornal en Español contains the best from the Welding Journal translated in Spanish.

Inspection Trends serves the nondestructive examination industry including more than 31,000 AWS Certified Welding Inspectors. It contains timely features on all phases of nondestructive examination, profiles of inspection personnel, newest technology, and columns that bring the latest industry news and practical answers to inspection questions.

AMET, Inc.
www.ametinc.com

AMETEK Specialty Metal Products for Welding & Thermal Spray
www.ametekmetals.com

Antec Electronics (Wuxi) Co., Ltd.
www.antecchina.com

Aquatex Corp.
www.aquatexcorporation.com

Arc Machines, Inc.
www.arcmachines.com

Arc Specialties, Inc.
www.arcspecialties.com

ARCON Welding Equipment, LLC
www.arconweld.com

ARC Abrasives will display its products and services based on the three actions — weld removal, deburring and flash removal, and metallic surface finishing.

Arc Machines, Inc.
www.arcmachines.com

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

See us at FABTECH booth #6549

Arc Products
www.arc-products.com

Arc Products will showcase its range of automated welding products. The company’s inhouse capabilities include electrical and mechanical engineering, fabrication, and assembly. Also featured will be its product line, AP Automation, which includes joint tracking, torch height control (AVC), magnetic arc control, and a line of orbital welding equipment.

Arc Specialties, Inc.
www.arcspecialties.com

Arc Specialties — a supplier of engineering services, process and procedure development, systems integration, service, parts, and training — will display its robot, CNC, and PLC systems as well as parts welded with GTAW, PTAW, SAW, and RSW processes.

ARCON Welding Equipment, LLC
www.arconweld.com

ARCON Welding Equipment will highlight its inverter arc and stud welding power supplies known as Workhorse; unveil its new 8-kW inverter preheater/welding machine; and offer welding packages for its SMA, GTA, GMA, stud, and preheater welding equipment. The company’s welding machines are designed for harsh environments such as shipyards, mines, power plants, oil rigs, paper mills, as well as fabrication and maintenance operations.
ArcOne® will present its autodarkening technology and respiratory protection products, including the new iDF™, Intelligent Darkening Filter, as well as a new line of digital AD filters all available in the newly redesigned Vision® helmet.

Atema, Inc.
www.atema.com

ATI Industrial Automation
www.ati-ia.com

Atlanta Drive Systems, Inc.
www.atlantadrives.com

Auburn Manufacturing, Inc.
www.auburnmfg.com

Avani Environmental, LLC
www.avanienvironmental.com

AW&S Co., Ltd.
www.awands.co.kr

Axelent, Inc.
www.axelentusa.com

Axeient will feature its perimeter safety fencing products for robotic and material handling applications.

Axxair SA
www.axxair.com

B&B Steel Products, Inc.
www.bandbsteei.com

Basis-Tech Industrial, Ltd.
(Crystal Clear)

Bay State Surface Technologies
www.baystatesurfacetech.com

Beijing China XingGang Technologies Co., Ltd.
www.vegaweld.com

Bellman-Melcor, Inc.
www.bellmanmelcor.com

Bernard
www.bernardwelds.com

Bernard will display its GMA guns and consumables. The company will share booth space with Hobart Brothers, Smith Equipment, Tregaskiss, and Weldcraft. Also, it will have experts in the booth to address welding and product inquiries from visitors.

BESSEY Tools North America
www.besseytools.com

BESSEY® Tools will showcase its metalworking clamping products and the innovation that goes into these newly patented items.

Bishop-Wisecarver Corp.
www.bwc.com

BLUCO Corp.
www.bluco.com

Bluco will highlight its modular fixturing system for welding that features precision machined welding tables and a reusable set of tooling components, such as patented bolts, angles, clamps, and blocks, to fixture virtually any size and shape weldment. Hands-on demonstrations will take place at the booth and application engineers will be on hand to address questions.

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Simply the Best Tool for Welding Small Pipe

Thirty-five years of listening to our customers and continuous product improvement have led to the Pipemaster 515 and D-Head. The system welds pipe from 1" - 14" (tubes from 1" - 5" OD).

Let us demonstrate how you can increase your productivity and lower defect rates with the high duty cycle that only machine welding can achieve.

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By Andre A. Odermatt

Easy to Read & Thoroughly Researched
A new book that explores the origins of welding processes. Those fascinated with history or involved with welding in some form will find this book of interest.

Richly Illustrated in Full Color
“...if you enjoy welding and history, this book will give you many hours of pleasant reading. It is written in a readily understood manner and is loaded with interesting tidbits of welding lore,” stated A.F. Manz (Welding Journal, April 2011.)

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BMM Welding Material Co. 5437
www.bjmnt.com

BMM Welding Material will offer its alloys; wires, rods, bars, and electrodes of copper, aluminum, nickel, titanium, magnesium, hafnium, zirconium, tungsten, molybdenum, and silver; stainless steel, CO₂, and flux cored wire; gouging carbon electrode; and ceramic nozzles.

Bohler Welding Group USA, Inc. 5764
www.bohlerweldinggroupusa.com

At the Bohler Welding Group booth, visitors may discuss the applications, specifications, and approvals needed by today’s international welding community in the power generation, petrochemical, and offshore industries as well as maintenance and repair applications. The company will also exhibit its electrodes, wires, strip, flux, and flux cored wires along with Bohler, T-PUT, Soudokay, UTP, Fontargen, and Avesta brands.

Bonal Technologies, Inc. 6415
www.bonal.com

Bonal Technologies, a subharmonic vibratory technology of metal provider, will be showcasing its Pulse Puddle Arc Welding® and MetaLax® 2400 touch-screen controlled stress relief equipment that offer less weld distortion, less weld cracking, greater ductility, no size or weight limits, and portability for field use.

Bortech Corp. 7009
www.bortech.com

Bortech will present its services in working with companies that want to make automated circular GMAW overlay welds for the purpose of machine repair, corrosion protection, abrasion resistance, or repetitive circular fabrication applications. At the company’s booth, it will feature its machines capable of cladding bores, outside diameters, flange faces, or conical surfaces. Typical applications include repairing heavy equipment, pumps and valves, and heat exchanger nozzle cladding. Bore sizes can range from ½ in. to 12 ft.

Bosch Power Tool Corp. 6517
www.boschtools.com

Bosch will display its line of power tools and power tool accessories, including angle grinders, cordless models, shears, nibblers, and bench-top versions for the welding and metal fabrication channels.

Bradford Derustit Corp. 6502
www.derustit.com

Bradford Derustit will spotlight its metal cleaners, pickling/passivation products, cleaning items, and degreasers.

Broco, Inc. 6314
www.brocoinc.com

Broco, an exothermic cutting and underwater welding systems company, and Rankin Industries, a designer and manufacturer of hardfacing electrodes, wires, and powders, will offer a range of maintenance and repair welding, cutting, and wear-resistant products. It will also present a line of automatic, semiautomatic, and manual GMA carbide overlay equipment.

Buffalo Shrink Wrap 6922
www.buffaloshrinkwrap.com

Buffalo Shrink Wrap will offer a line of heavy-duty shrink wrap and application equipment for protecting items during shipping and storage. The easy-to-learn, step-by-step process is versatile, and any size or shape item can be protected. A properly applied shrink wrap cover will keep the item clean, dry, and protected from damaging elements.

Bug-O Systems/Cypress Welding 5726
www.bugo.com

Bug-O Systems/Cypress Welding Equipment will showcase the Bug-O Fill-o-matic. This new, powerful, but smaller trackless fillet welding machine is available with stitch and/or oscillation capabilities. Also on display will be a new line of technology in positioning, workholding, and material-handling equipment.

Burkert Fluid Control Systems 6461
www.burkert-usa.com

Burkert Fluid Control Systems will offer gas...
products and systems, including on/off solenoid and proportional solenoid valves, mass flow controllers/meters, and gas boxes. It will also present methods to control and monitor complex multichannel processes with precision, repeatability, and flexibility.

**Cadi Co., Inc.**  
5720  
www.cadicompany.com

**Capital Weld Cleaners**  
5427  
www.capitalweldcleaners.com

**Carhartt Workwear at Rugged Outfitters**  
6639  
www.ruggedoutfitters.net

**CEIA USA**  
6918  
www.ceia-usa.com

**Censia SPA**  
5430  
www.censia.it

**Cerbaco, Ltd.**  
5405  
www.cerbaco.com

**CGW-Camel Grinding Wheels USA**  
6950  
www.cgwcamel.com

CGW-Camel Grinding Wheels will offer a range of abrasives for the metal fabrication industry, including flap discs, thin cut-off wheels, de-pressted-center wheels (cutting, grinding, and pipeline), surface conditioning products, wire brushes, and carbide burrs. Featured products will include trimmable zirconia and ceramic flap discs, 3-in-1 wheels (cut/grind/finish), and diamond wheels for metal applications.

**Changzhou Golden Globe Welding & Cutting Equipment Co., Ltd.**  
6931  
www.czgg.com

Changzhou Golden Globe Welding and Cutting Equipment will exhibit its services in manufacturing, welding, and cutting subassemblies. Its other capabilities include scientific research, a technical force, advanced processes and equipment, and inspection facilities.

**Changzhou Huauri Welding & Cutting Equipment Co., Ltd.**  
6541  
www.huauri-cn.com

**Changzhou Huaya Aluminium Industry Co., Ltd.**  
5344  
www.czhyal.com

**Changzhou Longren Mechanical & Electrical Co., Ltd.**  
5440  
www.longrenwelding.com

Changzhou Longren Mechanical & Electrical will display its GMA, GTA, and plasma guns and torches, along with parts.

**Changzhou Shine Science & Technology Co., Ltd.**  
5439  
www.shine-xunan.com

**Changzhou Wujin Golden Globe Welding & Cutting Machinery Co., Ltd.**  
5346  
www.cn-goldenglobe.com

Changzhou Wujin Golden Globe Welding & Cutting Machinery will showcase its GMA, GTA torches, and accessories; safety guns equipment; and welding and cutting tools.

**Chart, Inc.**  
6441  
www.chart-ind.com

Chart will spotlight its line of cryogenic and low-temperature products for the purification, liquefaction, distribution, storage, and end-use applications of natural gas, helium, nitrogen, argon, oxygen, and carbon dioxide for final use in a multitude of energy, industrial, commercial, and scientific applications.

**Chicago Women in Trade**  
7039

**China Daheng Group, Inc.**  
6544  
www.aurosfy.com

China Daheng will highlight its optical, mechanical, and electronic integrated products as well as digital autodarkening welding filters.

**Chinese Mechanical Engineering Society, The**  
5237  
www.essen.cmes.org

At The Chinese Mechanical Engineering Society’s booth, visitors can learn about its more
Has the lack of a CWI become an obstacle to your success?

The Hobart Institute of Welding Technology has many years of proven experience and success in training and preparing AWS Certified Welding Inspector/Certified Welding Educator students. Our students take the exam on the last day of their 2-week course, right in their classroom.

Visual Inspection
Nov. 21-22 • Jan. 4-5

Arc Welding Inspection & Quality Control
Nov. 28-Dec. 2 • Feb. 20-24 • May 7-11 • Jun. 11-15

Prep for AWS Welding Inspector/Educator Exam
Oct. 3-14 • Oct. 31-Nov. 11 • Dec. 5-16 • Jan. 23-Feb. 3

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

CS Unitec, Inc. 5838
www.csunitec.com

CS Unitec will spotlight its electric, hydraulic, and pneumatic metalworking tools for construction and industrial applications. New products will include the PIPE-MAX combination grinding tool/polisher, Multi-Max stationary multipurpose grinding tool/polisher, and Flexible Drive Shaft grinding tool. The company will also offer a line of surface finishing and fabrication tools for grinding, sanding, polishing, beveling, and deburring stainless steel, steel, aluminum, and other nonferrous metals along with a line of specialty abrasives and accessories.

CTS Fabrication 7303
www.princezant.com

Cyl-Tec, Inc. 6727
www.cyl-tec.com

Cyl-Tec will highlight its compressed gas cylinders, cylinder services, and accessories. Cylinder sales include DOT/TC high-pressure, acetylene, aluminum, and portable cryogenic cylinders along with beverage carbonation cylinders. Its cylinder services include ultrasonic and hydrostatic cylinder testing, liquid cylinder repair, and acetylene requalification. The company will also offer parts and accessories for all the above cylinder products.

D/F Machine Specialties, Inc. 6466
www.dfmachinespecialties.com

D/F Machine Specialties will demonstrate its GMAW and GTAW torches for robotic and welding automation equipment, welding products, and accessories. The company will also offer its line of parts and consumables, including water- and air-cooled torches; semiautomatic, automatic, and robotic torches; plus tandem, open-arc, gasless, and submerged arc torches.

CTS Fabrication 7303
www.princezant.com

Cyl-Tec, Inc. 6727
www.cyl-tec.com

Cyl-Tec will highlight its compressed gas cylinders, cylinder services, and accessories. Cylinder sales include DOT/TC high-pressure, acetylene, aluminum, and portable cryogenic cylinders along with beverage carbonation cylinders. Its cylinder services include ultrasonic and hydrostatic cylinder testing, liquid cylinder repair, and acetylene requalification. The company will also offer parts and accessories for all the above cylinder products.

D/F Machine Specialties, Inc. 6466
www.dfmachinespecialties.com

D/F Machine Specialties will demonstrate its GMAW and GTAW torches for robotic and welding automation equipment, welding products, and accessories. The company will also offer its line of parts and consumables, including water- and air-cooled torches; semiautomatic, automatic, and robotic torches; plus tandem, open-arc, gasless, and submerged arc torches.

CS Unitec, Inc. 5838
www.csunitec.com

CS Unitec will spotlight its electric, hydraulic, and pneumatic metalworking tools for construction and industrial applications. New products will include the PIPE-MAX combination grinding tool/polisher, Multi-Max stationary multipurpose grinding tool/polisher, and Flexible Drive Shaft grinding tool. The company will also offer a line of surface finishing and fabrication tools for grinding, sanding, polishing, beveling, and deburring stainless steel, steel, aluminum, and other nonferrous metals along with a line of specialty abrasives and accessories.

D/F Machine Specialties, Inc. 6466
www.dfmachinespecialties.com

D/F Machine Specialties will demonstrate its GMAW and GTAW torches for robotic and welding automation equipment, welding products, and accessories. The company will also offer its line of parts and consumables, including water- and air-cooled torches; semiautomatic, automatic, and robotic torches; plus tandem, open-arc, gasless, and submerged arc torches.

Diagraph MSP, an ITW Co. 6450
www.diagraphmsp.com

Diagraph MSP will feature its marking identification products, including stencil equipment, inks, and applicators. It will also demonstrate its GP-X industrial marking pens (Classic, Eco, Grizzly, and Anchor) and other low VOC marking identification products.

Deloro Stellite, Inc. 6739
www.stellite.com

Deloro Stellite will present its wear- and corrosion-resistant products of Stellite® and Deloro® alloys available as castings, rods, powders, and wires, plus equipment for hardfacing applications. It will also offer castings, wrought products, P/M, and hardfaced components that can be supplied to the finish machined tolerances specified.

Dengensha America Corp. 5314
www.dengensha.com

Dengensha America will exhibit its resistance welding equipment. Its product line includes pedestal welding machines, lightweight and servo weld guns, automatic nut and bolt feeders, controls, consumables, and spare parts.

Devasco International, Inc. 6851
www.devasco.com

Diamond Ground Products, Inc. 6503
www.diamondground.com

Diamond Ground Products will showcase its services dedicated to the improvement of weld quality and welder productivity, plus tungsten and tungsten preparation.

Diamond Vantage 7043
www.diamondvantage.com

Dinse, Inc. 6463
www.dinse-us.com

Dinse will spotlight its robotic and manual arc welding torches and equipment; push-pull robotic and manual welding torches for aluminum
NEW WHISPER Grinding Wheel - Another Productivity Innovation From PFERD

PRODUCTIVITY ON ALL FRONTS
The unique structure of this new reinforced grinding wheel gives both higher stock removal and more healthful working conditions. WHISPER doesn’t compromise comfort for aggressive grinding or sacrifice safety to service life. It promotes productivity on all fronts. Much lower levels of noise, vibration and dust plus quicker, smoother work results all lower labor costs, making WHISPER ideal for economical, high volume, quality finishing.

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WHISPER does tough jobs quietly but once you start using it, you’ll want to spread the word loudly. All these features in one wheel? Too good to keep quiet. Call your local PFERD distributor or contact us directly at 1-800-342-9015 or by email at solutions@pferdusa.com. Learn more about getting these latest innovations as standard features.

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See Us at FABTECH booth #6309

See us on the web at www.pferd.com
To design surfaces that last in the harshest of conditions, engineers worldwide partner with Sulzer for their answers.

Let’s be frank. Whether it’s a surface that resists corrosion, impact, wear, or any other demanding environment, you want it to last as long as possible. It also has to fit your production process. These are challenges we relish. For example, high-throughput gun technology quickly applies long-lasting corrosion coatings to mile after mile of oil and gas transport pipelines. The result? Coatings that last up to 25 years, greatly reducing long-term pipeline maintenance and the likelihood for corrosion and leaks, saving both cost and the environment. Whatever your surface challenge, and whatever your processing needs—integration into a mass production line or efficient manual spray—partner with Sulzer for your surface solution.

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For Info go to www.aws.org/ad-index
and other soft wire filler materials; robotic tandem torch standard as well as push-pull technology; robotic GTAW equipment with or without cold wire feed; cold and hot wire feed systems for lasers; torch cleaning stations; and robotic manual and automation torch changing systems.

Direct Wire & Cable
www.directwire.biz

Diversi-Tech, Inc.
www.diversitech.ca

Donaldson Torit — Donaldson Co., Inc.
www.donaldsontorit.com

Donaldson will be featuring the Torit® PowerCore® TG Series that collects thermally generated dust and fumes. It will also display the WSO mist collector that filters water-soluble coolants, straight oil, and oily smoke.

Dr. Gold & Co.
www.carrymate.com

Dr. Gold will highlight its Carrymate® nonslip transport grips that enable a fast and efficient transport of metal, glass, and granite. They can lift up to 440 lb per pair. The user just has to slide the self-adjusting grips to the side of the panel, and both users can lift the panels with one hand and walk in the same direction.

DualDraw, LLC
www.dualdraw.com

DualDraw will present its indoor air equipment with a focus on industrial downdraft tables and booths. Its patented airflow design maximizes the capture of welding smoke, grinding dust, and noxious fumes. It will show standard designs that can be easily modified in a cost-effective manner to fit unique specifications.

Durum USA
www.durumusa.com

Durum will offer its services for protecting parts and equipment against wear. Its hard-facing products will include welding powders (PTA, laser), rods, wires, and electrodes generally sold under the name Durmat®. The company will also offer PTA torches and welding systems for use in industries such as deep drilling, steel, foundries, glass, mining, dredging, brick-and-clay, agriculture, textiles, chemical, aluminum, excavation, and pump manufacture and repair.

Dynatorch, Inc.
www.dynatorch.com

Dynatorch will display CNC plasma, laser, and oxyfuel cutting machines for plate and tube fabrication. It will also feature low-cost, high-power density servo drive systems with Animatics Smart Motors and retrofit CNC drive systems along with various table sizes.

Easy Abrasives, LLC
www.easyburs.com

E. H. Wachs Co.
www.wachsco.com

E. H. Wachs will showcase its line of portable pipe construction and maintenance tools designed for industries where welded piping systems are integral to operation. The company, which has been providing utilities and contractors with solutions for more than 60 years, will also feature its diverse line of portable tools for cutting, squaring, beveling, and facing of pipe, tube, and vessels. Information will also be available on the company’s rental/lease options, on-site training, custom machine design, and manufacturing of special application machines.

ELCo Enterprises
www.wire-wizard.com

ELCo Enterprises will display its line of weld wire dispensing and weld cell support equipment. The company’s product lines include Wire Wizard® wire dispensing systems and conduit, Torch Wizard™ nozzle cleaning stations, Wire Pilot™ feed assist, and Blue Magic™ and Blue Chill™ antispatters.
C370SA Cold Saw has infinitely variable blade speed for precise cutting

- Infinitely variable blade speed control to match the job requirement
- Semi-Automatic push button solenoid operation
- Air-over-hydraulic system for optimum sawing rates
- Vertical column construction for vibration-free sawing
- Air vise with infinitely variable clamping pressure to prevent distortion
- Full electronic control/information system

See us at FABTECH booth #6502

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

Elderfield & Hall
www.kooltools.com

Electron Beam Technologies, Inc.
www.electronbeam.com

Electron Beam Technologies will exhibit its EB-Flex electron beam cross-linked welding cable, which is made in the USA. Fast ’N Easy bulk electrode accessories will be available and demonstrated for large welding wire packs, reducing downtime due to wire changes. The latest innovations in O&M GMAW/FCAW composite coaxial cables will be presented. Engineers will be available to answer questions.

ENTRON Controls, LLC
www.entroncontrols.com

Environmental Air Solutions
www.keeptheheat.com

Environmental Air Solutions will highlight its KeepTheHeat™ air-to-air heat exchanger, which recycles heat and provides ventilation without losing heat.

ESAB Welding & Cutting Products
www.esab.com

ESAB Welding & Cutting Products will showcase its complete line of welding and cutting equipment and filler metals for virtually every welding and cutting application. Featured will be small and large gantry shape-cutting machines with oxyfuel, plasma, laser, and waterjet processes; arc welding equipment; automated welding lines; plasma arc cutting machines; gas apparatus; filler metals; and more.

Essen Trade Shows
www.essentradeshows.com

Messe Essen will provide information on its international trade shows for welding, cutting, joining, and surfacing all over the world. The largest of its welding shows, Schweissen & Schneiden, takes place every four years in Essen, Germany, and has more than 1000 exhibitors and more than 60,000 trade buyers. It also organizes the Beijing Essen Welding Cutting, the Schweissen & Schneiden India in Mumbai, and the Russia Essen Welding Cutting trade show in Moscow.

FABRICATOR, The
www.thefabricator.com

The FABRICATOR will provide information on its magazine for the metalforming and fabricating industry in North America. The magazine delivers news, technical articles, and case histories that enable fabricators to do their jobs more efficiently. The FABRICATOR has served the industry since 1970.

Fastenal Co.
www.fastenal.com

Fastenal, which provides a full line of fabrication products and other industrial supplies at more than 2500 stores nationwide, will display its extensive line of products, services, and solutions for the metalworking and fabrication industries. Featured will be the company’s in-house manufacturing and engineering resources; FAST industrial vending machines; weld-to-length band saw blade services; and products from the company’s top welding, cutting, abrasive, and fabrication suppliers as well as Fastenal-exclusive brands like Blackstone, FMT, and Tritan.

Fein Power Tools, Inc.
www.feinus.com

Fein will feature its innovative tools for metalworking, the automotive industry, and interior remodeling. The company will showcase its GRIT belt grinder with a unique modular system; basic belt grinders and mounted modules designed and engineered for specific tasks; the GRIT GX program for use in small workshops; and the GRIT G1 program designed for industrial use.

Fibre-Metal/By Honeywell
www.fibre-metal.com

Flame Technologies, Inc.
www.flame technologies.com

Flame Tech will showcase its new point-of-purchase approach for gas apparatus prod-
The company’s welding, cutting, and brazing outfits are now packaged in free heavy-duty canvas toolbags, providing contractors storage for cutting attachments, torch handles, cutting/welding tips, and other tools/equipment. Gas apparatus is now available in clamshell packaging. Other products featured include cutting kits, tote-a-torch kits, flow gauges, and specialty regulators.

Folding Guard Corp. 5571
www.foldingguard.com

Foshan Yihong Welding Co., Ltd. 6938
www.yi-hong.com

Foshan Yihong Welding will display its line of aluminum welding consumables, and silver, phosphorus, copper brazing materials. The company specializes in aluminum welding and silver brazing technology.

Frommelt Safety Products 6638
www.frommelt safety.com

Fronius USA, LLC 6109
www.fronius-usa.com

Fronius will highlight its high-frequency welding technology ranging from compact shielded metal arc, gas metal arc, and gas tungsten arc welding machines to complex automated welding systems and spot welding machines. The company’s products are manufactured to international standards.
DiamondX is a new generation of tools for the metal-working industry. DiamondX concentrates a large number of diamond grits on a single layer with incredibly strong bond. This technology allows DiamondX to cut and grind materials that traditional diamond tools could not.

**Benefits**
- 20% shorter tool life and less down time
- More efficient and Operator friendly, reduced sparks, less debris and no odor
- No tubeless wheel breakage
- Order Wear Maintains tool size and shape

**Products**
- Impressed after Grinding Discs
- Ablative Grinding Discs (Flat)
- Ablative Grinding Discs (Finishing Flats)
- Discs

**GAWDA (Gases and Welding Distributors Association)**
- www.gawda.org
- 7157

**GE Measurement & Control Solutions**
- www.ge-mcs.com
- 6953

**GEDIK WELDING**
- www.gedikwelding.com
- 6751

Fusion will showcase its automation solutions for manufacturers engaged in production brazing and soldering. The company will emphasize its process approach to automating an application, which includes paste alloys, applicator equipment, and automatic machines with the intent of reducing metal joining costs and increasing productivity.

**G&J Hall Tools, Inc.**
- www.gjhalltools.com
- 7020

**Garg Inox, Ltd.**
- www.gargwire.com
- 6650

**Gas Management Solutions, a div. of Shield Technologies**
- www.gas-management-solutions.com
- 6507

Gas Management Solutions will feature its gas saving, gas measuring, and gas leak detection systems for users of gases and compressed air. The company will introduce the shielding gas economonitr, which saves substantial amounts of gas as well as monitors welding machine productivity. Also on display will be Spatter Guard, a weld spatter release agent that eliminates weld spatter and saves cleaning time.

**gasgrab.com**
- www.gasgrab.com
- 6413

The company will display ‘gasgrab’ for safe, manual handling of gas cylinders. Once the scissor action clamps the cylinder, it can be handled safely with far less strain on the user. The product meets all health and safety requirements, improves posture during lifting, and ensures less pressure is being placed on the operator’s back.

**GE Measurement and Control Solutions** will feature its equipment for advanced sensor-based measurement, nondestructive testing and inspection, and condition monitoring that delivers accuracy, productivity, and safety to a wide range of industries. These include oil and gas, power generation, aerospace, transportation, and healthcare. The company has more than 40 facilities in 25 countries and is part of GE Energy Services.

**GEDIK WELDING** will display its line of shielded metal arc welding electrodes, solid gas metal arc welding wires, gas tungsten arc rods, flux cored wires, submerged arc welding wires and fluxes, and welding equipment.

**General Tool**
- www.gtdiamond.com
- 6761

General Tool will showcase its unique process of adhering diamond to the outer face and edge of a steel substrate material and retaining the diamond under extreme load for the metal removal market. Anyone doing heavy grinding will benefit from using these tools through improved throughput, less downtime, and less hazardous operations.

**Goff’s Enterprises, Inc.**
- www.goffscurtainwalls.com/fabtech
- 5418

Gas Management Solutions will feature its gas saving, gas measuring, and gas leak detection systems for users of gases and compressed air. The company will introduce the shielding gas economonitr, which saves substantial amounts of gas as well as monitors welding machine productivity. Also on display will be Spatter Guard, a weld spatter release agent that eliminates weld spatter and saves cleaning time.
NONDESTRUCTIVE TESTING OF WELDS

Olympus NDT offers complete solutions for all your nondestructive weld inspection and code compliance needs

Pipeline girth welds, automotive spotwelds, steel sheet laser welds, structural T-joint welds, and friction stir welds are typical applications that require either manual testing or automated inspection. Olympus NDT offers a wide range of innovative testing products to meet all requirements related to the following technologies and inspection techniques: pulse-echo (PE), TOFD, combined TOFD/PE, phased array UT, linear scans, and sectorial scans.

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

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Great technology you can fit into a welding wire

Global competition means that we all need to do things better. Quality and productivity are not only desired but are essential to compete in the metal fabrication arena. At National Standard, we have worked exceptionally hard over the past 100 years to earn our customer’s trust. Welding Distributors and end users alike know that our products and services play a critical role in achieving world class welding quality.

And now, we are proud to introduce Tru-Core. This is flux cored welding the National Standard way. We appreciate that the welding professional has many things to think about other than the costly repair of a welding defect. And in support of this goal, the development and production of high quality welding wire is our calling card. If fume reduction, spatter control, consistent results and industry leading welder appeal are of interest to you, give us a call. After all, we stayed up at night to sweat the engineering details that yield cost reduction so that you don’t have to. For more information and to request a live demonstration visit www.nationalstandard.com
Goff’s will display its weld curtains and screens designed to withstand the toughest shop environments. Its weld screens are constructed with a strong, lightweight, 1¾-in. extruded aluminum frame, and its welding curtains create a retractable barrier that glides on a track and roller system to contain welding fumes and contaminants as needed. The weld curtains and screens are custom made for each application, block 100% UV light, and are flame retardant.

Golden Eagle Minmetals 5446 (Beijing) Welding Materials Co. www.jyl956.com

Golden Eagle Minmetals will show its line of copper and aluminum welding alloys, and other welding materials.

Goldland Industrial Co. Ltd. 5338 www.goldlandgd.com

Goldland Industrial will display its line of auto-darkening welding helmets, all of which comply with ANSI Z87.1-2003.

Goss, Inc. 6839 www.gossonline.com

Goss will feature its complete line of cutting, welding, brazing, soldering, and heating tools that can be used in a variety of applications. The company has been manufacturing high-quality oxyfuel cutting tools for more than 70 years.

LEADERS & INNOVATORS
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AMI Arc Machines, Inc.

The Preferred Choice for Automated Heavy Wall, Pipe, Vessel, and Valve Welding

For 20 years AMI has led the way in developing the most advanced, reliable and flexible systems for NGT welding. AMI’s Oscillating Electrode Technology offers significant advantages in Quality and Productivity:

- Decreased residual stress in HAZ due to lower heat input
- Consistent side wall fusion with minimal porosity and inclusions
- Reduced number of weld passes
- High deposition rate with hot wire option

Options include: Hot or cold wire torch configurations up to 12” (304mm) and Active-Filter Vision Systems (standard on AMI NGT torches).

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3 models available:
100 pound, 200 pound and
500 pound capacity.

Model 1200 Pipemate
Rotates pipe and tube
from 1 1/8” to 17” diameter,
up to 1200 pounds.

Smart Work Handling
Means
Increased Productivity

Grainger
www.grainger.com

GSM America, Inc.
www.gsmotion.com

Gudel, Inc.
www.gudel.com

Gulf Industrial Solutions
www.gulfindustrialsolutions.com

Gulico International
www.gulico.com

H & M Pipe Beveling
Machine Co., Inc.
www.hmpipe.com

HAI Advanced Material
Specialists
www.halamss.com

HAI Advanced Material Specialists will feature its lines of welding wires, rods, and electrodes; spray equipment, and replacement parts that it manufactures and distributes worldwide.

Harbert’s Products, Inc./
Allied Flux Reclaiming Ltd.
www.recycleflux.com

Harbert’s Products and Allied Flux Reclaiming will feature its custom closed-loop SAW flux/slag crushing (reclaiming/recycling) service, which saves money, is environmentally friendly, and performs the same as new. Information will also be provided on third-party testing, which is available for code applications.

Harper Trucks, Inc.
www.harpertrucks.com

Harris Products Group
www.harrisproductsgroup.com

Harris Products Group will show its gas apparatus and flow control equipment. The company manufactures cutting, brazing, soldering, and welding equipment, as well as fluxes and accessories.

Hascor USA, Inc.
www.hascor.com

Haynes International
www.haynesintl.com

HC Starck, Inc.
www.hcstarck.com

H & M Pipe Beveling Machine Co., Inc.
www.hmpipe.com

HAI Advanced Material Specialists
www.halamss.com

Gulico International will display its line of automatic welding carriages, cutting carriages, welding automation equipment, and accessories. The company will also feature services it provides through company-owned branches in many countries, as well as through an extensive worldwide distributor network.

SME 200 Positioner
3 models available:
100 pound, 200 pound and
500 pound capacity.

SME 1200 Pipemate
Rotates pipe and tube
from 1 1/8” to 17” diameter,
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HIGHYAG Lasertechnologie GmbH
www.highyag.de

HIGHYAG will show its tools for laser materials processing, including modular laser processing heads for fiber lasers, YAG lasers, and other 1-μm laser systems for cutting, drilling, and welding in automotive, semiconductor, and other materials processing applications. Also featured will be the company’s beam delivery systems, which include fiber-optic cables and modular beam systems.

Hobart Brothers
www.hobartbrothers.com

Hobart Brothers will display its filler metals, including tubular wires (flux-cored and metal-cored) designed specifically to improve productivity and lower costs on fabricating and manufacturing applications, as well as aluminum GMAW and GTAW filler metals from MAXAL. Company experts will also be available to discuss filler metal solutions and to answer questions.

Hobart Institute of Welding Technology
www.welding.org

HOT COILS
www.hotcoils.com

Hot Coils will exhibit its line of pipe heat treatment products, including 110-V preweld heating coils for preheat treatment and hydrocarbon bake-out applications. New products include 4–12 in. pipe diameter, 220-V postweld heating coils with integrated computerized controls that provide preheat and post-weld (stress relief) heat-treatment, and 4–36 in. pipe diameter dataloggers that chart the temperature profile of any heat treatment process.

HTC USA, Inc.
Hypertherm, Inc.
www.hypertherm.com

Hyundai Welding Products
www.hdweid.co.kr

IBEDA/Superflash Compressed Gas Equipment, Inc.
www.oxytuelsafety.com

IBEDA/Superflash will exhibit its lines of flashback arresters, quick connectors, thermal spray, heating solutions, manifolds, and other compressed gas equipment. The company will offer demonstrations of its new two-gas mixer, flashback arresters, and other products.

ICR Services
www.icrservices.com

ICR Services will highlight its equipment life cycle services including robot sales and integration, training, field service and engineering, surplus component sales, machinery sales,
Our Nicrobraz® range of high-temperature brazing alloys and products join parts for high-temperature and corrosion applications. We produce powder, paste, rod, tape, stop-off and other brazing aids to customer’s exact specifications. Our in-house laboratories, procedures and process control ensure our products comply with the strictest requirements.

**BRAZING FILLER METALS**

**Nicrobraz®** The original nickel-based brazing filler metal invented by Wall Colmonoy.

**Niferobraz®** Iron-based brazing filler metal that confers excellent resistance to corrosion and temperature.

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**CUSTOM FORMULATIONS**

Wall Colmonoy’s expert technical team and state-of-the-art manufacturing facilities are able to customize alloys for your specific application.

**APPLICATION SYSTEM**

NicroSpray® System developed for applying our range of high-temperature powders quickly and smoothly.

Contact us today with your brazing challenges.
Think innovative automated welding by experiencing the new Swift Arc Transfer (SAT™) and Integrated Cold Electrode (ICE™) processes.

Think quality, consistent filler metals with demonstrations of X-Series® cored wire, Atom Arc® 7018 Acclaim™ stick electrodes, and American-made AristoRod® in action.

Think arc welding reliability by checking out 3-phase industrial machines welding stick, cored wire, and aluminum.

Think aluminum welding at its best with the revolutionary Powered Pak-Trak and quality AlcoTec® aluminum wire.

Think safety with industry-leading Weld Warrior™ personal protection equipment.

Think ESAB for a complete welding and cutting partner. VISIT US AT BOOTH #5946
With Carestream’s New Industrex v4.0 Software

Carestream NDT has been hard at work to bring you innovative new products for your HPX-1 Digital CR System. Now, you can upgrade the performance of your equipment to cutting edge technology and tools with INDUSTREX Digital Viewing Software Version 4.0.

NEW EDGE Filter offers 8 sets of parameters, based on settings found to be most useful in practice, enables the user to view an image with increased detail and clarity.

NEW Wall Thickness Measurement Tool finds the outer and inner walls and calculate the thickness between them.

Visit the Carestream NDT booth to see all of our new products at the ASNT FALL CONFERENCE, Booth 325 October 24-28, Palm Springs, CA

GO TO www.carestream.com/hpx1-industrex.html for details.
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Ideal for welding, forging or annealing, Thermomelt® temperature indicator sticks are available in 88 confirmed temperature ratings and are the fast, accurate and economical solution for surface temperature measurement. Just one of the hundreds of reasons why Markal® is the industry’s marking solutions leader.

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ITW DYMON 6352
www.dymon.com

JASIC Technologies Co., Ltd. 5969
www.jasic.com.cn

Jayesh Industries, Ltd. 6662
www.jayeshgroup.com

JAZ USA, Inc. 5500
www.jazusa.com

JAZ USA, a wholly owned subsidiary of JAZ-ZUBIAURRE, S.A., will feature its line of wire brushes, which includes a wide range of industrial power brushes, tube brushes, hand scratch brushes, and engineered brushes for specific application needs manufactured to ISO 9001:2000 standards.

Jetline Engineering 6453
www.jetline.com

Jiangsu Zhongjiang Welding Wire Co., Ltd. 5342
www.zjwelding.com

Jetline Engineering
www.jetline.com

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WELDING JOURNAL 105
Compact Trackless Fillet Welding Carriage with 4-Wheel Drive Magnetic Traction Welds in All Positions

Increase your production and reduce your welding costs.

- Constant, non-stop travel at a regulated speed produces consistent high-quality welds in a fraction of the time required by hand welding.
- Creates weld bead geometry exact to your specifications, reducing costly overwelding and decreasing filler metal usage by as much as 60%.
- Consistent heat input reduces distortion.
- Improves workers environment – reduces fatigue and repetitive stress – removes operator from heat and fumes.
- Compact and portable – just over 17 lbs (8Kg) – this tractor can be carried anywhere.

Increase your production and reduce your welding costs.

- Constant, non-stop travel at a regulated speed produces consistent high-quality welds in a fraction of the time required by hand welding.
- Creates weld bead geometry exact to your specifications, reducing costly overwelding and decreasing filler metal usage by as much as 60%.
- Consistent heat input reduces distortion.
- Improves workers environment – reduces fatigue and repetitive stress – removes operator from heat and fumes.
- Compact and portable – just over 17 lbs (8Kg) – this tractor can be carried anywhere.

Joysun will display its coated abrasive products. Featured will be a series of standard and high-density zirconia, alumina, ceramic, and SiC flap discs; mounted and flanged, interwoven flap wheels; quick-change discs, and abrasive sanding and filing belts for various industrial applications.

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for WELDING & CUTTING

The Modular Drive System

Provides continuous welding and cutting at precise travel speeds, producing quality welds and cuts in a fraction of the time required by manual operation. Various types of rail allow the system to be used on all types of applications.

Two new accessories available now!

Automated Height Control - automatically maintains torch height using CV process.

Seam Tracking System - electromechanical probe - mounted ahead of the torch - follows the weld joint providing automatic, motorized left/right tracking.

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Upgrade Your Modular Drive System Today!

KimTop will showcase its line of welding equipment, industrial drills and mills, and grinding tools. A wide range of the company's products have passed the technology and production requirements of GB, ANSI, DIN, and CE standards. The company exports to a wide range of countries.

King Architectural Metals, Inc. 6468
www.kingmetals.com

Kiswel USA, Inc. 5962
www.kiswelweldingproducts.com

Kobelco Welding of America, Inc. 6306
www.kobelcowelding.com

Koike Aronson, Inc. 5909
www.koike.com

Koike Aronson/Ransome will exhibit its cutting, welding, and positioning equipment. The company's product lines include CNC waterjet, laser, plasma and oxyfuel cutting machines; turning rolls; head and tailstocks; automated tank welding equipment; portable cutting and welding carriages; cutting tips; cutting torches; and flashback arrestors. Featured will be the company's new Koikejet Model E waterjet; PNC-10 Elite, antidrift turning roll system; and lightweight automatic girth welding machine.

KUKA Robotics Corp. 6339
www.kukarobotics.com

KUKA Robotics will be demonstrating innovative welding solutions that will provide information on decreasing cycle times, increasing throughput, and improving quality and uptime with robotic automation.

Kunshan Gintune Welding Co., Ltd. 5337
www.gintune.com

La-Co Industries/Markal 6712
www.markal.com

La-Co/Markal® will feature a complete line of high-performance paint markers and marking products, including solid paint markers, liquid paint markers, felt-tip ink markers, metal markers, and temperature indicators all designed to meet difficult industrial marking applications.

Lapco Mfg., Inc. 5738
www.lapco.com

Liburdi Dimetrics Corp. 6319
www.liburdi.com

Liburdi Dimetrics will showcase its extensive line of advanced-technology orbital welding products including high precision, vision-based LAWS, Dabber®, and Pulsweel® power sources; multi-axis articulated motion systems; and controllers for applications in the turbine, aerospace, nuclear, industrial, and automotive industries.

Linatrol Systems, Inc. 6371
www.linatrol.com

Linatrol Systems will display its advanced CNC controls for oxyfuel and plasma cutting. The company's products include advanced CNCs, HL90 optical tracing systems, digital servo systems, CAD/CAM software, and plasma power sources. Being introduced is the company's 3D bevel/weld prep machine, which is available for new systems or as an upgrade to current 2D systems.

Lincoln Electric Co. 5922, 6112, 6122
www.lincolnelectric.com

Lincoln Electric will showcase its design, development, and manufacture of arc welding products, robotic arc welding systems, welding fume control equipment, and plasma and oxyfuel cutting equipment, as well as brazing and soldering alloys.

LONGEVITY Welding & Cutting Products 5842
www.lweld.com

LONGEVITY Welding will showcase its line of GTAW, GMAW, and SMAW power sources, and plasma arc cutting machines.

LORD Corp 6365
www.lord.com

LORD will feature its line of high-strength
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Record & view the electrode, arc, puddle, joint, and surrounding base material before, during, and after the welding process with the V2011-UDR Weld Monitoring Video System.

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Lors Machinery
www.lors.com

Lucas Milhaupt, Inc.,
Global Brazing Solutions
www.lucasmilhaupt.com

Lucas-Milhaupt, a Handy & Harman company, will showcase its metal joining products and services, such as alloys, fluxes, automated equipment, product design, training and technical assistance. The company supplies brazing and soldering materials to the electrical/electronic, appliance, and transportation markets worldwide.

Luvata Ohio, Inc.
www.luvata.com

MACOS, Coskunöz Holding
www.coskunozmakina.com

Coskunöz, a supplier of engineering solutions for the manufacturing sector, will feature its MACOS brand resistance welding and plasma arc cutting machines, as well as fabricating machines customized for the automotive, defense, and heating industries.

Magmaweld (Oerlikon Kaynak Elektrodları ve Sanayi AS)
www.magmaweld.com

Magmaweld™ will display its lines of welding consumables, welding machines, and CNC cutting systems.

Magnatech LLC
www.magnatechllc.com

Magnatech will display equipment for orbital tube/pipe welding applications. The TumboMaster power source with autoprogram will be demonstrated welding sanitary stainless tubing. The company's PipeMaster for multipass welding will also be featured.

MagneGas Corp.
www.magnegas.com

MagneGas will showcase its Plasma Arc Flow™ technology that converts liquid wastes into a hydrogen-based, clean-burning fuel essentially interchangeable with natural gas that can be used for metal cutting, cooking, heating, and powering bi-fuel cars.

Manufacturing Solutions, Inc.
www.msi-tx.com

MSI will feature its chamfering and pipe beveling machines, marking equipment, bar shears, nut assembly tables, cylindrical parts feeders, bolt cross drills, and bolt shortening tools, and the services it provides for a variety of industries.

Maryland Brush
www.marylandbrush.com

Maryland Brush will showcase Maryland Brush Abrasives products and services.

Matheson will showcase its industrial, welding, and safety supplies; medical, specialty, and electronic gases; gas-handling equipment; high-performance purification systems; engineering and gas management services; and on-site gas-generation solutions.

Mathey Dearman, Inc.
www.mathey.com

Mathey Dearman will highlight its cutting and beveling machines for all types of pipe and pipe diameters; and pipe-alignment and reforming clamps for welders and pipeliners requiring fast, accurate fitsps.

Matuschek Welding Products, Inc.
www.matuschek.com

Matuschek Welding Products will showcase the weld quality and cost savings benefits of its real-time Master® adaptive control technology for resistance spot welding. Also displayed will be its state-of-the-art mid- and high-frequency inverter power supplies for sheet metal welding and microwelding including precision weld heads and hand-held process analyzers.

MCK Nonwoven Abrasives Co.
www.nonwovenabrasives.com

MCK Nonwoven will display its line of abrasive belts, wheels, and pads for cleaning, deburring, blending, polishing, and finishing.
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Medi Mall, Inc.
www.medimassager.com
7018
Medi Mall will demonstrate its MediMassager family of FDA-certified personal foot and body massage products.

Meltric Corp.
www.meltric.com
6505
Meltric will feature its Decontactor series of switch-rated plugs and receptacles with ratings up to 600 A and 1000 V for use in hazardous environments.

Meta Vision Systems, Inc.
www.meta-mvs.com
5527
Meta will display its laser vision systems for welding automation. The company will introduce several innovative products for robot guidance and machine welding based on new, Smart Laser Sensor technology. Also on display will be CircVision, a collaborative project in the pipeline welding sector co-developed with CRC-Evans for weld joint tracking, adaptive fill, edge bevel, and pre/postweld inspection.

Metabo Corp.
www.metabo.com
6958
Metabo will display its latest lines of power tools and abrasives.

Metal Man Work Gear Co.
www.metalmangear.com
6569
The company will display its Metal Man® lines of welding machines, autodarkening welding helmets, plasma arc cutting machines, and industrial carts and cabinets.

Metallizing Equipment Co.
Pvt. Ltd.
www.mecpl.com
5122
Metallizing Equipment will feature its thermal spray coating equipment for the arc, HVOF, plasma, and flame spray processes, as well as thermal spray booths, grit/abrasive blast machines, blast rooms, acoustic rooms, dust collectors, gun manipulators, paint spray booths, and powder feeders.

Michigan Pneumatic Tool, Inc.
www.michiganpneumatic.com
5671
Michigan Pneumatic Tool will display its lines of abrasive, riveting, material-handling, assembly, fastening, nibbling, cutting, drilling and percussive tools.

Micro Air
www.microironline.com
7012
Micro Air will showcase its solutions to air-quality issues, featuring a complete line of industrial air cleaners, dust collectors, portable collectors, downdraft tables, clean-air booths, source-capture arms, MISTMAX mist collectors, and HYDROMAX wet collectors.

Midalloy
www.midalloy.com
5840
Midalloy, celebrating its 25th year in business, will display its complete lines of stainless, nickel, and low-alloy welding consumables including flux cored and submerged arc fluxes.

Miller Electric Mfg. Co. 5950, 6154
www.millerwelds.com
Miller Electric will introduce new welding equipment and safety products at the show. Featured will be live demonstrations highlighting new welding technologies such as Access®E with Insight™, an advanced GMAW system; XMT® 450 MPa multi-process welding power source; PerformArc™ preengineered welding cells; plus aluminum welding demonstrations using the AlumaFeed™ synergic welding system.

Miller Welding Automation 5954
www.millerwelds.com
MK Products, Inc.
www.mkprod.com
6514
MK Products will feature its Cobramatic® push-pull wire feed technology for aluminum welding systems, Aircrafter™ tabletop rotary positioners, and MK Orbital™ tube welding systems for ultrahigh-purity and high-pressure applications.

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Montipower, Inc. 6465
www.mbxlt.com
Montipower will exhibit its surface-preparation pneumatic and electric power tools and abrasive products for weld cleaning and surface preparation required in the automotive, marine, metalworking, and other industries.

Moore Industrial Hardware 7015
www.mooreindhardware.com
Moore Industrial will display samples of its extensive lines of stainless steel over center catches, piano hinges, draw latches, and grab handles, as well as yoke ends, gas springs, tank flanges, rubber hood latches, heavy-duty drawer slides, grab and flush-mounted D ring handles, and other products.

Motoman Robotics 5709
Motoman Robotics will be demonstrating several new products. The fully integrated ArcWorld IV-6200SL welding solution features dual MA1400 welding robots and a “slim line” positioner. Ideal for multiple robot layouts, the MA3100 “Master Arc” welding robot features an extended-reach arm that reduces the need for tracks and is suited for use with larger workpieces. MotoEye™ LT and MotoEye LT-HD, new software for arc welding joint-tracking applications, will also be shown.

MPT Industries 6903
www.mptindustries.com
MPT Industries will display its specialty lubricants including oxygen-compatible and chemical-resistant thread sealants and greases, solvent-free multipurpose lubricants, 100% synthetic motor oils, engine and gear treatments, and industrial additives.

MTA-USA 5103
www.mta-usa.com
MTA-USA will feature its products for industrial cooling, including chillers for use with lasers, and cutting, welding, profiling, optics, medical, and engraving operations.

MTI Power Services 6764
www.mtipowerservices.com
MTI Power Services will detail its field services for providing welding and machining solutions to the nuclear- and fossil-power-generation, pulp and paper, chemical, refinery and new-construction industries.

NASA 6816
www.msfc.nasa.gov
The National Aeronautical and Space Administration (NASA), Marshall Space Flight Center, Huntsville, Ala., will offer a special display at its booth.

Nation Wide Products 6600
http://pipeproguides.com
Nation Wide will demonstrate its Pipe-Pro cutting guides that are placed around pipes of various diameters for making precise 22.5-, 45-, and 90-deg cuts.

National Standard LLC 6758
www.nationalstandard.com
National Standard will introduce its Tru-Core flux cored welding wire line plus Smart Pak recyclable bulk weld wire package that accommodates three wire payout systems: direct pull, round cone, and square base with round cone.

Nederman, Inc. 5358
www.nedermanusa.com
Nederman will exhibit its filtration extraction systems for controlling dusts, mists, and fumes generated by welding and other industrial operations.

Nelson Stud Welding 5509
www.nelsonstud.com
Nelson Stud Welding will offer demonstrations of its latest lines of lightweight, portable, inverter technology featuring an operator teach mode for proper setup and greater adjustment of weld inputs. Also on display will be the Nelware process monitoring system that records all weld input data and shuts down the welding process when it detects a suspect weld.
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For Info go to www.aws.org/ad-index
New Fire will display its line of industrial thermal insulating, welding, and cutting and safety products.

Newland (Tianjin) Welding Wire and Metal Products Co. Ltd. will feature its specialized welding wires and rods made from copper, copper alloys, and various nonferrous metals, for use in the motor vehicle, shipbuilding, locomotive, and other industries.

Nimak Braeuer North America, Inc. will feature its integrated transformer guns and high-quality resistance welding machines, as well as automated turntables, robot cells, and services.

Ningbo Dabu Welding Technology Co. Ltd. Ningbo Dabu Welding Technology, a high-tech joint venture formed with Ningbo Dabu Electric Appliance Co., Ltd., will show its electric wires and cables; inverter machines for SMAW, GMAW, and GTA welding; plasma arc cutting equipment; spot welding equipment; battery chargers; and autodarkening welding helmets.

Ningbo Jinfeng Welding & Cutting Machinery Mfg. Co. Ltd. The company will feature its line of industrial processing equipment, including CNC machines for laser cutting and bevel cutting, gantry submerged arc welding, and butt joint plane welding machines.

Ningbo Powerway Alloy Material Co. Ltd. Ningbo will display its line of copper alloy resistance welding electrode materials, including CuZr, CuCr, and CuC/Zr alloys, as well as its lines of bronze, nickel-silver, brass, and specialty alloys.

Nordfab Ducting will display its latest Quick-Fit clamp-together ducting for dust, mist, and fume collection. The ducts can be installed, taken apart for cleaning, and reconfigured without tools.

North (Nanjing) Instrument Technology Industries Group The company will feature the latest releases in its extensive lines of welding machines, inverters, air plasma arc cutting machines, submerged arc welding machines, gas regulators, and autodarkening welding helmets.

Norton Abrasives Norton will display the latest entries in its extensive line of abrasive products that are engineered to give excellent performance for specific applications classified in good, better, and best performance/price tiers.

Nutron Nameplate, Inc. Nutron will display a representative assortment of its metal and plastic nameplates, panels, overlays, and ANSI/ISO safety signage and molded products. Described will be the company's custom services for product design, prototyping, MIL-STD 130 UID signage, and membrane overlays.

OKI Bering OKI Bering will display a sampling of its industrial welding and safety products from some of the 100 manufacturers it represents.

Olympus NDT Olympus will showcase its latest products for ultrasonic testing, phased array, eddy current, remote visual inspection and high-speed video and...
related support technologies for determining the quality and integrity of construction welds such as those in pipelines and bridges, as well as sheet metal spot welds, and other welds found in manufacturing.

Optrel® AG
www.optrel.com
Optrel® will show its extensive line of welder protective garments and products for ears, eyes, skin and body, hands and feet, and welding fume, plus a line of autodarkening welding helmets.

OTC DAIHEN, Inc.
www.otc-daihen.com
OTC Daihen will highlight its line of digital power sources, and other products in its line of intelligent welding machines.

OXFORD ALLOYS, Inc.
www.oxfordalloys.com
Oxford Alloys will feature its broad range of welding wire and electrodes including nickel alloys, stainless steel, titanium, aluminum, bronze alloys, and low-alloy steel. Representatives will be available to discuss its new line of stainless steel coated electrodes and other products and applications.

Oxylance, Inc.
www.oxylance.com
Oxylance will feature its exothermic cutting systems, burning bars, lance pipe, underwater cutting and welding rods, safety equipment, and related accessories for the primary metals and demolition industries.

Pador Marketing Group
www.pador.com
Pador Marketing Group will showcase its heat treating and postweld heat treating equipment and supplies.

Pearl Abrasive Co.
www.pearlabrasive.com
Pearl Abrasive will present its lines of depressed-center wheels, cup stones, flexible wheels, flap discs, wire brushes, cut-off wheels, cloth belts, segmented diamond blades, and sandpapers.

PECo Process Equipment Co.
www.peco-us.com
PECo Process Equipment will feature its extensive line of manufacturing services and welding equipment including laser, capacitor discharge, plasma, resistance, and other welding machines, and welding jigs and fixtures.

Pandjiris, Inc.
www.pandjiris.com
Pandjiris will feature its complete line of standard positioning equipment, including positioners, turning rolls, manipulators, slides and swivels, seamers, sidbeams and carriages, headstocks and tailstocks, turntables, 3 o’clock welding machines, and complete turnkey systems designed and manufactured to meet its customers’ needs across a wide range of industries.

PDS Bartech, Inc.
www.pdsbartech.com
PDS Bartech will showcase its heat treating and postweld heat treating equipment and supplies.

PFAERD, Inc.
www.pferdusa.com
PFAERD will detail its single-source solutions for hand finishing, grinding, cutting, and specialty applications.
Phoenix International, Inc. 5625
www.phx-international.com

Phoenix International will showcase its line of welding electrode and flux-holding and baking ovens. Also displayed will be Safetube rod canisters for short-term electrode protection in the field.

Pipe Fitters Local Union #597 7142
Plymovent North America 6800

Plymovent will detail its products, systems and services for ensuring clean air in the workplace. Its specialty is to provide solutions for efficiently controlling welding fume, and grinding, cutting, and polishing dusts.

Polymet Corp. 5209
www.polymet.us

Polymet will display its line of high-performance wires for welding, hard-facing, and thermal spraying.

Postle Industries, Inc. 5739
www.postle.com

Postle Industries will present its line of hard-surfacing technology products, including flux cored tubular hard-facing wires and welding electrodes for the most demanding wear applications.

Practical Welding Today 7107
www.thefabricator.com

Practical Welding Today® is a bimonthly magazine that provides hands-on information, real-world applications, and useful advice for welders.

Praxair, Inc. 6133
www.praxair.com

The Praxair booth will present the company’s welding and cutting gases, services, and consumables, and equipment for thermal spray and numerous other manufacturing industries.

PTR — Precision Technologies, Inc. 6166
www.ptreb.com

Precision Technologies will feature its electron beam welding solutions for the automotive, aerospace, power-generation, defense, petro-chemical, and research applications.

Preston-Eastin, Inc. 5546
www.prestoneastin.com

Preston-Eastin will feature its welding head cross slides typically used as auxiliary equipment on manipulators or side beam carriage for controlled positioning of the torch head. Units are available in 100- and 150-lb capacities for single-axis and compound operation with travel lengths of 6, 12, and 18 in. with manual and powered adjustment.

Primax Mfg. & Trading, Inc./Caiman Gloves 7207
www.caimangloves.com

Primax will feature its line of Caiman industrial gloves with a wide variety of styles, materials, and features, and Boarhide premium welding leather chaps, jackets, vests, and leggings.

Prince & Izant Co. 7304
www.princeizant.com

Prince & Izant will feature its lines of alloys and preforms for the welding, brazing, and soldering industries. Brazing alloys include aluminum, bronze, copper, gold, nickel, phosphorous, silver, vacuum-grade silver, and cadmium-bearing products.

PROFAX/LENOCO 6326
www.profax-lenco.com

Profax and Lenco, two independently owned companies, will highlight their new products including a straight-line track cutting machine, hand-operated pipe beveler, ceramic backing tape, water-soluble purge paper, and a line of positioners, turning rolls, and manipulators. Other products include welding accessories, welding and cutting guns and consumables, and a variety of welding machine repair parts.

ProMotion Controls, Inc. 5668
www.promotioncontrols.com

ProMotion Controls will feature its intelligent PC-based shape-cutting controls, nesting software, and associated products for use with oxyfuel, plasma, laser, and waterjet cutting equipment.

Quality Welding Products, Inc. 6555
www.qwpinc.net

Quality Welding Products will display its picking and passivation products for stainless, nickel, aluminum, and titanium, available in paste, spray, and bath. Also to be shown is its stainless steel flux-coated tungsten wires that eliminate the need for purging or backing flux.

Raja Ratna Metal Industries Ltd. 6942
www.rajaratna.com

Rajaratna® will showcase its complete line of stainless steel wires for gas metal arc, gas tungsten arc, and submerged arc welding.

Radyne Corp. 5433
www.radyne.com

Radyne will showcase its energy and cost-efficient induction heating technologies for silver, copper, and fluxless brazing and heat-treating solutions. Simple benchtop units to automated turnkey systems are available. The modular in-
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Integrate FlexScan can easily be fitted with robotics, or manually loaded/unloaded.

Red Rock/Romar MEC 7133
www.fitupgear.com

The Red Rock/Romar booth will feature the company’s line of magnetic fitting tools, gas-surge preventers, and 16-gauge, magnetically secured welder windshield.

Reis Robotics USA, Inc. 7119
www.reisroboticusa.com

Reis Robotics will detail its advanced technology for planning and executing turnkey solutions for welding in all major application fields.

Resistance Welding Mfg. Alliance (RWMA) 6200
www.aws.org/rwma

RWMA is a standing committee within the American Welding Society. Since 1935, it has been the authoritative source of information and experience for the resistance welding industry. It offers a host of benefits to its members. At its booth, visitors can meet with members who will discuss any technical questions dealing with the resistance welding process.

Revco Industries, Inc. 6909
www.revcoindustries.com

Revco Industries will display its Black Stallion® and BSX product lines of welding and safety gloves; protective fire-resistant and leather apparel; and high-temperature products including fire blankets, welding screens, and accessories.

Rex-Cut Products, Inc. 6433
www.rexcut.com

Rex-Cut Products will showcase its line of cotton-fiber abrasive grinding wheels for use on stainless steel, aluminum, exotic metals, and mild steel. Also shown will be flap discs, cut-off wheels, carbide burrs, and accessories.

Rhino Cutting Systems 6371
www.rhinocuttingsystems.com

Rhino Cutting Systems will feature its custom-engineered oxyfuel and plasma cutting machines for 2D cutting and 3D beveling and weld prep applications.

Robinson Tech Int’l Corp. 7031
www.rit-abrasive.com

Robinson will feature its line of cut-off wheels, grinding and abrasive flap discs, diamond polishing discs, and wire brushes for weld prep and finishing.

Robotic Technologies of TN 6469
www.robotiq.com

Robotiq will show its adaptive gripper for installation on industrial and mobile robots for precision parts handling.

Rolled Alloys 6602
www.rolledalloys.com

RoMan Mfg., Inc. 5301
www.romanmfg.com

RoMan will highlight its transformer technology, including water-cooled AC transformers and DC power supplies for furnace, heating, plating, and welding applications.

Roueche Co. LLC, The 5722
www.trcwelding.com

Roueche will showcase its line of flexible resistance projection/spot welding machines.

Royal Arc Electrodes Ltd. 6904
www.royal-welding.com

Royal Arc will display its wide line of welding electrodes, including flux and metal core, stainless steel, mild steel, low-hydrogen, low-heat input, hardfacing, and cutting and casting types. Also to be shown is its line of abrasive grinding and cutting products.

Saf-T-Cart, Inc. 6558
www.safcart.com

Saf-T-Cart will present its line of cylinder carts, cages, pallets, cylinder banks, pallet beds, and trailers designed for welding sites.

Saint-Gobain 5012
www.nortonabrasives.com

For more information, visit the Metal Fabricator’s Directory at FABTECH2011.org.
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For info go to www.aws.org/ad-index

See us at FABTECH booth #6839

The Norton line of abrasives will be featured at the Saint-Gobain booth, including numerous products for weld prep and finishing.

**Sakura of America**
www.sakuraofamerica.com

Sakura of America will display its markers and writing instruments for industrial applications. Featured will be the Solid Marker™ that marks most surfaces through rust, dust, water and even underwater, and comes in a variety of colors, including a glow-in-the-dark version, for temporary and permanent applications.

**Sandvik Materials Technology**
www.smt.sandvik.com/nafta

Sandvik will display its line of products for welding austenitic stainless steels, duplex stainless steels and nickel alloys for use with the gas metal arc, gas tungsten arc, submerged arc, electroslag, and shielded metal arc welding processes.

**Sanpo Publications, Inc.**
www.sanpo-pub.co.jp

Sanpo will promote its EFP (Extreme Face Protector), a new-style welding helmet featuring 180-deg lens design, face-forming profile, and many other features for welding, grinding, and splash guard applications.

**Sciaky, Inc.**
www.sciaky.com

Sciaky will showcase its Direct Manufacturing (DM) solution, a large-scale, fully programmable means of achieving near-net-shape parts. Also highlighted will be its resistance welding systems, and contract welding services to the aerospace, automotive, defense, medical, and manufacturing industries.

**Sellstrom Mfg. Co.**
www.sellstrom.com

Sellstrom will feature its line of safety equipment and personal protective equipment. Highlighted will be the new Impulse™ MAGSENSE™ autodarkening filter featuring magnetic technology, DP4™ Plasma Faceshield, and 17 SpatterGuard™ high-temp fabrics that meet the new ANSI/FM 4950 Standard.

**Servo-Robot, Inc.**
www.servorobot.com

Servo-Robot will showcase its mobile and intelligent welding automation and advanced 3D laser vision systems for welding robots providing real-time joint tracking, adaptive control, and visual inspection of welded components, as well as guidance for robotic material handling. Featured will be the MWR-50 mobile welding robot that is guided by laser vision and includes an embedded video camera.

**Servore Co.**
www.servore.com

Servore will demonstrate its unique ultrafast autodarkening welding helmets featuring Easy Touch™ auto-lift visors permitting use while welding, grinding, and chipping.

**Shanghai Gonglue Machinery & Elect Tech Co. Ltd.**
www.xunweld.com

Gonglue will feature its complete lines of welding fluxes, wires, and strips. Products include mild steel and low-alloy steel flux and wire, stainless steel and nickel alloy wire and strip for submerged arc welding.

**SIUI, an ISO-certified company, will demonstrate its latest ultrasonic welding flaw detectors.**
www.siui.com/ndt

**Shenzhen Huayilong Electric Co. Ltd.**
www.szhuayilong.com

Shenzhen Huayilong will feature its professional welding and cutting machines.

**Shenzhen Riland Industry Co. Ltd.**
www.riland.com.cn

Shenzhen Riland will feature its professional welding and cutting machines.
Shenzhen Riland will display its new inverter welding power source, the result of 16 years of development.

Sherwin, Inc. 6916
www.sherwininc.com
Sherwin will demonstrate its line of fluorescent dye penetrant products used to detect critical flaws throughout the welding and nuclear power industries.

SKM Industries, Inc. 6651
www.skmproducts.com
SKM Industries will display its lines of marking tools and paint markers.

SKS Welding Systems GmbH 5966
www.sks-welding.de
SKS Welding Systems will detail its preconfigured robotic welding packages.

SME Member Lounge 5000
www.sme.org
Smith Equipment 5950
www.smitequipment.com
Smith Equipment display its cutting, heating, and welding products including alternate-fuel outfits for use with propane, propylene, and natural gases; Mizon flowmeters; and Silverline specialty gas regulators.

Sorex Welding Co. Ltd. 6666
www.sorexweld.com
Sorex Welding will display its full product line of flux cored wires and stainless electrodes.

Southern Welding Systems Int’l LLC 6327
www.swsintl.com
Southern Welding Systems will feature its lines of safety, welding, and industrial products.

Special Metals Welding Products Co. 6538
www.specialmetalswelding.com
Special Metals Welding Products will display its line of nickel-based welding consumables for joining nickel alloys, high-performance steels, cast irons, and dissimilar metals as well as hardfacing steel for corrosion or erosion protection. Shown will be products in the Monel®, Inconel®, Inco-Weld®, Ni-Rod®, Incoloy®, and Incoflux® lines.

Spring Creek Products 6669
www.springcreekproducts.com
Spring Creek will display its lines of welding goggles and autodarkening welding helmets, chipping hammers, wire brushes, acetylene cutting tips, grounding clamps, tip cleaners and numerous other products.

St. Louis Metallizing Co. 5104
www.stlmetallizing.com
St. Louis Metallizing will show samples of its thermal spray and custom coating services.

Steelmax Tools 6269
www.steelmax.com
Steelmax Tools will feature new product introductions and provide live demonstrations of its portable magnetic drills and metal-cutting saws.

SteelTailor Ltd. 6525
www.steeltailor.com
SteelTailor will highlight its CNC plasma machines for cutting sheet metal as thin as 0.3 mm. The company also provides sourcing service to machine manufacturers and suppliers.

Steiner Industries 6533
www.steinerindustries.com
Steiner Industries will showcase its line of protective clothing, gloves, and welding supplies, all designed to promote safety and increase productivity in the workplace.

Stork Climax Research Services 5317
www.storksmr.com/crs
Stork Climax Research Services will promote its numerous services to the welding and man-
Arcos, *The Standard of Excellence in Covered Electrodes and Bare Wire*, offers two outstanding welding products designed to withstand critical temperature extremes.

Arcos 625 and Arcos 1N12 (625) are nickel-chromium-molybdenum products which are designed to be virtually immune to chloride-ion stress-cracking. They feature moderate strength, good fabricability and excellent oxidation resistance. Each is military-approved and provides superior corrosion resistance, over a range of temperatures from cryogenic to extremely elevated (up to 1,800°F).

Arcos 625 is ideal for welding alloys 625, 601, 802 and 9% nickel. This wire is well suited for welding piping systems and reactor components in the power generation industry and for high temperature service in a wide variety of other engineering applications.

Arcos 1N12 (625) is utilized for welding alloys such as 625, 800, 801, 825 and 600. This covered electrode is the smart choice for applications including petrochemical plants, reactor components, furnace equipment, heat exchangers and offshore marine environments.

To learn about the many advantages of specifying Arcos 625 and Arcos 1N12, call us today at 800-233-8460 or visit our website at www.arcos.us.

Arcos Industries, LLC
394 Arcos Drive • Mt. Carmel, PA 17851
Phone: (570) 339-5200 • Fax: (570) 339-5206

For info go to www.aws.org/ad-index
Switch from weld to grind in a matter of seconds.

You can't afford downtime and lost productivity when workers switch between welding and grinding jobs. So we developed our Fibre-Metal® QuickSwitch™ System to go from one job to the other in just a few seconds. This system delivers high-performance head, face, and eye protection, along with all-day comfort – no matter how often workers switch between tasks. Let the Fibre-Metal QuickSwitch System help make your business safer and more productive. For a free demo, contact one of our safety experts today at 888-422-3798.
ufacturing industries, including nondestructive testing, positive material identification, and welding engineering.

**Strong Hand Tools**
www.stronghandtools.com

Strong Hand® Tools will demonstrate its workholding products, including Adjust-O Magnets, which feature on/off switches; 4-in-1 sliding arm clamps; and 3-axis fixture vises to secure workpieces during welding. Introduced will be the new BuildPro modular welding tables and modular fixturing kits for the efficient holding, locating, and positioning of fixtures.

**Suhner Industrial Products, Inc.**
www.suhnerabrasivesusa.com

Suhner will demonstrate its industrial-quality tools and abrasives, including high-precision air and electric tools, and durable flexible-shaft grinders and polishers.

**Sulzer Metco U.S., Inc.**
www.sulzermetco.com

Sulzer Metco will showcase its plasma-assisted surface coating process and intelligent gun technology at the booth.

**Sumner Mfg. Co., Inc.**
www.sumner.com

Sumner will present its pipe- and material-handling solutions, in addition to a group of new products including welding setup tools to increase productivity and safety while fabricating and welding pipe.

**Sunstone Engineering**
www.sunstonespottwelders.com

Sunstone Engineering will display its spot welding products for automotive, aerospace, electronics, military, and general industrial applications.

**Superheat FGH Services, Inc.**
www.superheatfgh.com

Superheat will feature its industrial heat-treatment services for the oil and gas, power, and construction industries.

**Superior Abrasives, Inc.**
www.superiorabrasives.com

Superior Abrasives will display its lines of coated and nonwoven abrasives for grinding, polishing, and finishing.

**Superior Products, Inc.**
www.superiorprod.com

Superior Products will feature its gas-management systems highlighted by new versions of the Mighty-Max automatic changeover manifold, plus two new versions for laser-assist gases, and a new line of cryogenic hoses, pressure relief valves, and cryogenic connections.

**Swagelok Mfg. Co., LLC**
www.swagelok.com

Swagelok will display products in its fluid system line, including measurement devices, quick-connects, valves, filters, leak detectors, lubricants, sealers, hoses, and flexible tubing.

**TAFA, Inc.**
www.praxairsurfacetechnologies.com

Tanis Technologies LLC
www.tanistechnologies.com

Tanis Technologies will feature its products to improve working environments in the fabrication and manufacturing industry.

**TDC Filter, Inc.**
www.tdcdfilter.com

**Team Industries, Inc.**
www.teamind.com

Team Industries will highlight its Generation III and Generation IV hydraulically elevated welding positioner and gripper as part of a complete workstation that improves weld quality and increases operator efficiency. This welding positioner features a programmable AC motor drive and interchangeable gear multipliers to provide the power and controllability to slowly roll heavy-wall pipe. The positioner also allows operators to weld small-diameter pipe.

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For Info go to www.aws.org/ad-index
DGP is the industry leader in Tungsten and Tungsten preparation offering low-cost and high-quality Tungsten electrodes, Tungsten grinders & replacement diamond grinding wheels.

We have been dedicated to the improvement of weld quality and welder productivity since 1992.

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Titus Flux, Inc./American Welding & Flux
www.titussteel.com

The company will highlight its submerged arc welding flux and consumables as well as reclamation equipment.

TJ Snow Co.
www.tjsnow.com

Trystar
www.trystar.com

Tregaskiss
www.tregaskiss.com

Trendex Information Systems, Inc.
www.trendexsys.com

Tri Tool, Inc.
www.tritool.com

Tri Tool will feature its complete line of pipe weld preparation machines for pipe and tube, as well as custom-designed machinery for special applications. The company also offers on-site service solutions including turnkey project management, machining operations, and automatic and manual code welding using certified machinists and welders.

Tri-Mer Corp.
www.tri-mer.com

Trystar
www.trystar.com

TWI North America, LLC
www.twinorthamerica.com

U-Mark, Inc.
www.umarkers.com

United Abrasives, Inc./SAIT
www.unitedabrasives.com

United Abrasives will feature its full line of bonded abrasives for grinding and cutting wheels, cup wheels, cones, plugs and a host of similar bonded products. The company will also highlight its sanding sheets, belts, rolls, flap, fiber, and PSA discs, wire brushes, non-woven abrasives, tungsten carbide burs, diamond wheels, new carbide-tipped metal cutting blades, and a full line of accessories.

Valmont Coatings
www.valmont.com

Valmont Coatings will explain its services as a job shop for hot-dip galvanizing, with galvanizing plants throughout the United States.

Vicon-Plasma Automation, Inc.
www.vicon-automation.com

Vicon-Plasma Automation will feature the Monarch, a plasma cutting system offering cutting applications from sheet metal to plate, structural steel to I-beam, angle iron, channel, and tubing. The company will also display a custom cut-to-length and rollforming line. Vicon VIsoft software demonstrations will be ongoing throughout the show.
Vitronic Machine Vision 5971
www.vitronic.com

VSM Abrasives 6927
www.vsmabrasives.com

VSM Abrasives will feature its coated abrasives, including fiber discs, belts, PSA, and velcro discs.

Walter Surface Technologies 5349
www.walter.com

Walter Surface Technologies will spotlight its solutions for surface conditioning, shaping and preparation, surface finishing, cleaning, and protection with technologies that include abrasive systems, chemical cleaners, lubricants, and biotechnology.

Washington Alloy Co. 6746
www.weldingwire.com

Wayne Trail Technologies, Inc. 5769
www.waynetrail.com

Wayne Trail Technologies will feature its capabilities to supply systems and automation used in metal forming, metal joining, and metal fabricating industries. Market technology segments include press automation; robotics, welding, and fixtureing; laser systems; tube bending and fabricating; hydroform and structural frame automation; system integration; and build to print/ manufacturing services.

Weartech International, Inc. 6506
www.weartech.net

Weartech International, a manufacturer of cobalt- and nickel-based wear, corrosion, and high-temperature resistant alloys, will highlight its hardfacing consumable rods, electrodes, wires, and powders. In addition, services are available to cast solid alloy parts and provide machining and hardfacing.

WEC Equipment & Machining Solutions 5461
www.aggressive-equipment.com

WEICON, Inc. 6940
www.weicon.com

Weld-Aid Products 6549
www.weldaids.com

The company will highlight its Nozzle Kleen® coatings that maximize tip, nozzle and diffuser life by preventing spatter buildup; its Weld Kleen® coatings to minimize grinding by preventing spatter build-up on parts and fixtures; Lube-Matic® coatings for maximizing tip and liner life by cleaning and lubricating welding wires; and Brite Zinc® for a high-luster, zinc-rich, rust-inhibiting coating.

Weld.com 5428
www.weld.com

Weld.com will connect people, products, and services globally with a goal to create an environment where you can find all the information you need throughout the welding and cutting industry in a quick and easy-to-navigate Web site, one click at a time. It is a go-to resource for everything welding and cutting.

Weldas Co. 5718
www.weldas.com

Weldcoa 6825
www.weldcoa.com

Weldcoa will feature its automated cylinder filling equipment, material handling, and gas filling equipment for welding supply and gas distributors, as well as its specialization in palletized truck, trailer, fill plant, and other related palletized equipment.

Weldcraft 5950
www.weldcraft.com

Weldcraft will be showcasing its GTAW torches and accessories, including its Crafter Series, WP Series, MicroTig™ and Quick Connect™ System, designed to improve quality and performance. Company representatives will be available to answer questions and provide product recommendations. The company will share space with Bernard, Hobart Brothers, Smith Equipment, and Tregaskiss.

WeldDaddy/Seecoa Technology 5361
www.welddaddy.com

WeldDaddy will showcase its spatter defense systems for protective coating of GMAW torch assemblies (nozzles, contact tips, and diffusers), as well as for weld tooling and fixturing. Product demonstrations will be conducted.

Welding Alloys Group 6520
www.welding-alloys.com

The company will feature its tubular welding wires and automatic welding equipment for many applications.
2 new welding innovations
from KIMBERLY-CLARK PROFESSIONAL*
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1. Sustaining Company
Join an elite group of 500+ leading companies in the materials joining industry. Sustaining Company Membership is AWS' most prestigious level of membership, and is perfect for companies looking for the Best Value of all AWS Memberships. Upon becoming a Sustaining Company member, you'll receive your choice of one of three exclusive money-saving benefits:
   1.) AWS Standards Library ($10,000+ Value),
   2.) Discount Promotional Package - save 5% on Welding Journal advertising,
   3.) 10 additional AWS Memberships ($920 value).

2. Supporting Company
The ideal fit for mid-size companies that want to give their employees the power of AWS, but need more than one Individual Membership. AWS Supporting Company Members have access to practical knowledge on how to improve productivity, solve production problems and improve their competitive position.

3. Affiliate Company
Independent Welders and Welding Shops worldwide can take advantage of an AWS Affiliate Company Membership. Designed exclusively for independent welding and fabricating shops, this membership was developed to meet specific needs: to keep you better informed, aware and responsive to the tides and trends of the welding industry; to improve productivity, solve production problems, and improve your competitive position. AWS Affiliate Company Members are provided with benefits to help them compete in the marketplace.

4. Welding Distributor
Welding Distributors worldwide can take advantage of this Membership designed to help increase their end-user base and improve their competitive position in the marketplace. AWS' web of communication tools will put distributors in touch with key industry manufacturers, including AWS' nearly 1,000 Sustaining and Supporting Company Members, most of which are leading producers of welding and equipment supplies. Any welding distributor, small or large, would greatly benefit from this membership.

5. Educational Institution
Designed exclusively for educational institutions that strive to maintain the professionalism of their teaching staff, and strive to be a leader in the education community. AWS Educational Institution Members are committed to the future of the industry, and set a great example for their educators, staff and students. AWS Educational Institution Members are provided with benefits to help their educators, staff and students.

To Learn More About AWS Corporate Memberships, please call 800-443-9353, ext. 480, or visit www.aws.org/membership
The Welding Equipment Manufacturers Committee (WEMCO) is a standing committee of the American Welding Society (AWS) dedicated to providing a common voice to the welding industry. This organization represents manufacturers who make products for welding processes and applications. It also provides information and services to welding industry end-users, distributors, and manufacturers, as well as promotes coalitions between AWS, GAWDA, and other industry organizations. WEMCO hosts beneficial annual events, which includes first-class business speakers and key industry leaders, enlightening presentations, and dynamic forums. Members are exposed to networking opportunities that promote and exchange ideas in a noncompetitive atmosphere.

**Welding Technology Corp.**
www.weldtechcorp.com

**Weldlogic, Inc.**
www.weldlogic.com

Weldlogic will promote its automated welding systems including programmable power supplies, micro-GTA systems, lathe-type weld positioners, seam welding machines, plate bending rolls, and custom systems.

**Weldsale, LLC**
www.weldsale.com

Weldsale will feature its platens where one can weld, bend, straighten, cut, heat, grind, glue, drill, hammer, twist, screw, and assemble a product. Whether bolted together into large beds or used individually, platens last a long time. The company also will exhibit its flame clear pyramids to protect oxyfuel and plasma cutting tables.

**Weldship Corp.**
7028

**Wendt USA, LLC**
www.wendtusa.com

This specialty manufacturer will spotlight its abrasive, finishing, and polishing products for metal fabrication including abrasive, nonwoven, and felt versions for grinding, blending, and polishing applications. Selection includes a wide range of sizes and specifications to cover both common and specialized needs.

**Western Enterprises**
www.westernenterprises.com

Western Enterprises will present its line of products that are primarily used in the control, transmission, and storage of compressed gases for industrial, medical, and specialty gas applications.

**WireCrafters, Inc.**
www.wirecrafters.com

WireCrafters will highlight its perimeter guarding modules RapidWire-HD, the new RapidGuard, and the new line of stainless steel partitions for the food, beverage, pharmaceutical, and medical markets.

**Wisconsin Wire Works, Inc.**
www.wisconsinwireworks.com

Wisconsin Wire Works will exhibit its copper and bronze wires for the welding and thermal spray industries including deoxidized copper, silicon bronze, phosphor bronze, and aluminum bronze, as well as naval bronze, low-fuming bronze, and nickel silver brazing rods and wire.

**Witt Gas Controls**
www.wittgas.com

Witt will feature its gas control and gas safety equipment including gas mixers, gas analyzers, leak detection systems, flashback arrestors, check valves, pressure regulators, and more.

**Wolf Robotics, LLC**
www.wolfrobotics.com

Wolf Robotics will present its capabilities as a metalworking integrator offering standard cells and custom engineered systems for arc welding and cutting, machine tending, and material removal applications, as well as full-time customer service, and operation and process training.

**Wolverine Joining Technologies**
www.silvaloy.com

Wolverine Joining Technologies will highlight its brazing alloys, solders, and fluxes including Sil-
As the welding industry moves from transformer based power supply design to inverter based design, efficiency, size and dependability have become increasingly important. Magnetics® Kool Mu® E cores offer a cooler, smaller and reliable solution for power factor boost inductors used in welding power sources.

**Cooler** — Generally, inductors using gapped ferrite E cores can have excessive heat due to heavy copper losses from eddy currents caused by the fringing flux across the gap. Inductors made with Kool Mu E cores have a built-in distributed air gap and run cooler than those made with cores having discreet air gaps such as ferrites.

**Smaller** — Because inductors made with Kool Mu E cores run cooler, it is possible to replace a larger component with a smaller size Kool Mu E core. Core size reduction is of particular importance in applications where efficient use of space and weight is a concern, for example portable devices.

**Reliable** — Iron powder cores are subject to thermal aging, an irreversible increase in core loss as a result of prolonged exposure to elevated temperatures. Magnetics Kool Mu E cores do not degrade as temperature increases, making them a reliable choice for inductors in critical applications.

For info go to www.aws.org/ad-index
Select-Arc Metal Cored Electrodes

Select-Arc, Inc., a leader in advancing metal cored technology, has expanded its comprehensive line of premium metal cored electrode products to better serve your growing demands. Whatever your critical welding application – from automotive exhaust systems to construction equipment, power generation plants to earthmoving machinery, railcars to shipbuilding, and many more – Select-Arc offers just the right metal cored product to meet your exacting specifications. The Select carbon steel and low alloy metal cored wires and our extended family of SelectAlloy stainless steel, metal cored electrodes are designed to enhance your productivity and increase your profitability.

Select-Arc metal cored electrodes provide these significant benefits:

- High travel speeds
- Reduced fume generation
- Ability to handle poor fit-up
- Very smooth spray transfer
- Superb bead geometry
- No spatter or slag to clean up
- Elimination of cold lap
- Reduction of subsurface porosity

For more information on finding the Select-Arc metal cored electrode that is ideal for your specific application, call us at 1-800-341-5215 or visit our website at www.select-arc.com.

For Info go to www.aws.org/ad-index
COMING EVENTS

NOTE: A DIAMOND (♦) DENOTES AN AWS-SPONSORED EVENT.


ICALEO®, 30th Int’l Congress on Applications of Lasers & Electro-Optics. Oct. 23–27, Hilton Hotel, Walt Disney World® Resort, Orlando, Fla. AWS is a Cooperating Society of this event and AWS members receive the same discounted conference registration fee as LIA members. Presented by Laser Institute of America (LIA); www.ical eo.org.


China Aerospace & Aviation Technology Show(CAATS), Nov. 1–5. SNEC, Shanghai, China; www.caats.aero/.

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

♦ FABTECH. Nov. 14–17. 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; www.fabtechexpo.com or www.aws.org.


Educational Opportunities


Canadian Welding Bureau Courses. Welding Inspection Courses


Grounding Courses. Oct. 20, 21, Chicago, Ill. Instruction on how to protect equipment against lightning strikes and power surges. Lyncole XIT Grounding; www.lyndale.com; (800) 962-2610; (310) 214-4000.


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

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; www.asminternational.org, search for “courses.”
Seminars, Code Clinics, and Examinations

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9-Year Recertification Seminar for CWI/SCWI For current CWIs and SCWIs needing to meet education requirements without taking the exam. The exam can be taken at any site listed under Certified Welding Inspector.

| **LOCATION**                     | **SEMINAR DATES** | **EXAM DATE** |
| Dallas, TX                       | Oct. 17–22        | No exam       |
| New Orleans, LA                  | Nov. 7–12         | No exam       |
| Miami, FL                        | Dec. 11–17        | No exam       |
| **LOCATION**                     | **SEMINAR DATES** | **EXAM DATE** |
| Lincoln Electric Co., Cleveland, OH | Oct. 24          | (216) 383-8542 |
| OTC Daihen, Inc., Tipp City, OH   | Oct. 31           | (937) 667-0800 |
| ABB, Inc., Auburn Hills, MI      | Nov. 7            | (248) 391-8421 |
| OTC Daihen, Inc., Tipp City, OH   | Dec. 12           | (937) 667-0800 |
| MATC, Milwaukee, WI              | Dec. 10           | (414) 297-6996 |
| **LOCATION**                     | **SEMINAR DATES** | **EXAM DATE** |
| Norfolk, VA                      | Oct. 17–21        | Oct. 22       |

International CWI Courses and Exams Schedules
Please visit www.aws.org/certification/inter_contact.html.

Certified Welding Supervisor (CWS)

| **LOCATION** | **SEMINAR DATES** | **EXAM DATE** |
| Norfolk, VA   | Oct. 17–21        | Oct. 22       |

Certified Radiographic Interpreter (CRI)

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

Certified Welding Sales Representative (CWSR)

CWSR exams will also be 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 the first two days).

Certified Robotic Arc Welding (CRAW)

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

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

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

| **LOCATION** | **SEMINAR DATES** | **EXAM DATE** |
| Norfolk, VA   | Oct. 17–21        | Oct. 22       |

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, or call (800/305) 443–9353, ext. 273, for Certification; or ext. 455 for Seminars. Apply early to avoid paying the $250 Fast Track fee.

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      Tel: (800) 441 7343 | www.avestawelding.com
Canada Tel: (888) 725 3593 | www.bwgca.com

See Us at FABTECH booth #5764
For Info go to www.aws.org/ad-index
Double-Groove Welds

The selection of groove weld type and configuration is influenced by accessibility, economy, the particular design of the structure being fabricated, distortion control, and the type of welding process to be used.

Square-groove welds are economical, provided satisfactory soundness and strength can be obtained. However, their use is limited to relatively thin material. For thick joints, the edge of one or more members must be prepared to a particular geometry to provide accessibility for welding and ensure the desired soundness and strength.

In the interest of economy, joint designs should be selected with root openings and groove angles that require the smallest amount of weld metal while providing sufficient accessibility to achieve sound welds. The selection of a root opening and groove angle is also greatly influenced by the metals to be joined, the location of the joint in the weldment, distortion and shrinkage control, and the performance required.

Double-groove welds are groove welds made from both sides. Figure 1 shows the various types of double-groove welds.

Fig. 1 — The different types of double-groove welds.

Pros Hone Their Welding Skills at the AWS Instructor Institute

The 2011 AWS Instructors Institute was held July 24–28 at AWS headquarters in Miami, Fla. Listed here are the attendee’s name and District number:

Jesse Crosby, 1; Thomas Colasantos, 2; Sharon Bally, 3; Robert Simpson, 4; Sherman Smith, 5; Harry Carlson, 6; Elisa Ramsey, 7; Jim Thompson, 8; Cynthia Harris, 9; Michael Sampson, 10; Roy Bailiff, 11; Bob Bruss, 12; Allan Tomnitz, 13; Coy Hall, 14; Jay Gerdin, 15; Greg J. Siebert, 16; Paul Stanglin, 17; Drew Fontenot, 18; Ken Nelson, 19; Robert Ulibarri, 20; Jason Corder, 21; and Scott Miner, 22. Assisting with the instruction were facilitator Ed Norman, District 13 Director Rick Polanin, District 5 Director Steve Mattson, Nick Peterson and J. C. Cowley with Miller Electric Mfg. Co., Jason Schmidt and Lou Kleinsmith with Lincoln Electric Co., Jay Ginder and Shelby Smith representing ESAB Welding & Cutting Products, and Ronnie Mercer with Thermadyne.

AWS staff members assisting with the program included David Hernandez, director, education development; Nichole Bradley, academic program coordinator; and Martica Ventura, director of operations, education services.

Notice of AWS Annual Meeting

The Annual Meeting of the members of the American Welding Society will be held Monday, Nov. 14, 2011, beginning at 9:00 AM at McCormick Place, Chicago, Ill. The regular business of the Society will be conducted, including election of officers and ten members of the Board of Directors. Any business properly brought before the membership will be considered.

Nominations Sought for National AWS Officers

AWS members who wish to nominate candidates for President, Vice President, Treasurer, and Director-at-Large on the AWS Board of Directors for the term starting Jan. 1, 2013, may:

1. Send their nominations by Oct. 4, 2011, to Gricelda Manalich, gricelda@aws.org, c/o John C. Bruskotter, chairman, National Nominating Committee,

2. Present their nominations in person at the open session of the National Nominating Committee meeting scheduled for 2:00 to 3:00 PM, Tuesday, Nov. 15, 2011, at McCormick Place, Chicago, Ill., during the FABTECH show. Nominations must be accompanied by biographical material on the candidate, including a written statement by the candidate as to his or her willingness and ability to serve if nominated and elected, letters of support, plus a 5-x-7-in. color portrait. Note: Persons who present their nominations at the show must provide 20 copies of the biographical materials and written statement.
The AWS Technical Activities Committee (TAC) and the International Standards Activities Committee (ISAC) met Aug. 3, 4 at CNH headquarters in Burr Ridge, Ill. TAC is an AWS member volunteer committee comprised of the chairs of each major AWS technical committee (for example, D1 Structural Committee, B2 Qualification Committee, A5 Committee on Filler Metals and Allied Materials Committee, etc.) and six at-large members. TAC administers the activities for all AWS technical standards. Its principal role is to establish rules and procedures by which AWS standards are drafted, approved, and published. Also, TAC approves new standard projects and reviews and approves pending publications. At Burr Ridge, TAC discussed the translation of AWS standards into additional languages, approved a new recommended practice for friction stir welding, discussed better methods to address interpretation requests, approved a new set of operating procedures, heard reports on activities in other organizations and committees (ASME, NESCC), and addressed many other actions and issues.

Standards for Public Review


ISO Standards for Welding

In the United States, 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. Copies of draft international standards are available for review and comment from your national standards body, which in the United States is ANSI, 25 W. 43rd St., 4th Fl., New York, NY 10036; (212) 642-4900. Send comments regarding ISO documents to your national standards body.

Technical Committee Meetings

All AWS technical committee meetings are open to the public. Persons wishing to attend a meeting should call the staff secretary of the committee. Dial (800/305) 443-9353 at the extension shown.


Oct. 10–12, C3 Committee and Subcommittees on Brazing and Soldering. Providence, R.I. Steve Borrero, ext. 334.

Oct. 12, SH1 Subcommittee on Fumes and Gases. Columbus, Ohio. Steve Hedrick, ext. 305.


The following meetings will be held at FABTECH in Chicago, Ill.


Nov. 14, C7 Committee on High Energy Beam Welding and Cutting. Brian McGrath, ext. 311.


Nov. 14, D18 Committee on Welding and Sanitary Applications. Steve Hedrick, ext. 305.

Nov. 15, C5 Committee on Arc Welding and Cutting. Rakesh Gupta, ext. 301.

Nov. 15, C6 Committee on Friction Welding. Brian McGrath, ext. 311.

Nov. 15, D9 Committee on the Welding, Brazing, and Soldering of Sheet Metal. Alex Diaz, ext. 304.

Nov. 15, D14 Committee on Machinery and Equipment. Matt Rubin, ext. 215.


Nov. 15, D14I Subcommittee on Hydro-accumulators. Matt Rubin, ext. 215.

Nov. 15, D15C Subcommittee on Track Welding. Steve Borrero, ext. 334.

Nov. 15, D17D Subcommittee on Resistance Welding. Alex Diaz, ext. 304.

Nov. 15, D17J Subcommittee on Friction Stir Welding. Alex Diaz, ext. 304.

Nov. 16, A5K Subcommittee on Titanium and Zirconium Filler Metals. Alex Diaz, ext. 304.

Nov. 16, B1 Committee on Methods of Inspection. Brian McGrath, ext. 311.

Nov. 16, BIB Subcommittee on Visual Examination of Welds. Brian McGrath, ext. 311.

Nov. 16, D15 Committee on Railroad Welding. Steve Borrero, ext. 334.


Nov. 16, D16 Committee on Robotic and Automatic Welding. Brian McGrath, ext. 311.

Nov. 16, D17K Subcommittee on Fusion Welding. Alex Diaz, ext. 304.

Nov. 16, G2D Subcommittee on Reactive Alloys. Call Alex Diaz, ext. 304.

Nov. 17, C1 Committee on Resistance Welding. Effram Abrams, ext. 307.

Nov. 17, C6D Subcommittee for Friction Stir Welding. Brian McGrath, ext. 311.

Nov. 17, D17 Committee on Welding in the Aircraft and Aerospace Industries. Alex Diaz, ext. 304.

Opportunities to Contribute to AWS Welding Standards and Codes

Volunteer to serve on an AWS technical committee to help develop the standards that serve industry’s ever-changing needs. Currently, more than 1800 volunteers participate on the 160 AWS technical committees and subcommittees.

Membership on AWS technical committees is open to everyone. Review the committee openings outlined here, then contact the committee secretary listed to learn more about the advantages and responsibilities for contributing to this important work. E-mail the committee secretary listed, or call (800/305) 443-9353 at the extension shown.

Local Heat Treating of Pipe Work

The D10P Subcommittee for Local Heat Treating of Pipe to revise D10.10, Recommended Practices for Local Heating of Welds in Piping and Tubing. Contact B. McGrath, bm McGrath@aws.org; ext. 311.

Joining Wrought Nickel Alloys

The G2C Subcommittee on Nickel Alloys seeks volunteers to review G2.1M/G2.1, Guide for the Joining of Wrought Nickel-Based Alloys, and participate in the meetings and teleconferences. Contact Alex Diaz, adiaz@aws.org; ext. 304.

Oxyfuel Gas

C4 Committee on Oxyfuel Gas Welding to update C4.5, Uniform Designation System for Oxyfuel Nozzles; C4.6, Thermal Cutting — Classification of Thermal Cuts — Geometric Product Specification and Quality Tolerances; and to prepare C4.7, C4.8, Recommended Practices for Safe Oxygen-Ethylene Welding of Steel. Effram Abrams, eabrams@aws.org; ext. 307.

Thermal Spray

2011 District, Section, and Student Chapter Awardees

Listed below are the awardees’ District number, name, and Section affiliation.

Section Meritorious Award
1 Rick Moody, Boston
2 Alex Duschere, Long Island
4 Bill Rice, SW Virginia
4 Mike Robinson, Tidewater
4 Dean Johnson, Tidewater
4 Charles Githens, Triangle
4 Eric Umphreys, Triangle
4 John Lafferty, Charlotte
4 Chris Taylor, NE Carolina
4 Bill Rhodes, SW Virginia
4 David Cash, SW Virginia
6 E. Burrell Fisher, Syracuse
8 Frank Miller, Greater Huntsville
8 Tim Singleton, Nashville
8 Greg Ralphe, Nashville
8 Travaris Irions, NE Mississippi
8 George Smith, NE Mississippi
9 Yating Chai, Auburn-Opelika
9 Jennifer Head, Auburn-Opelika
9 Heath Butler, Auburn-Opelika
9 Suijiong Li, Auburn-Opelika
9 Shen Horikawa, Auburn-Opelika
9 Seon Baekim, Auburn-Opelika
9 Mike Skiles, Acadiana
9 John Tabony, Baton Rouge
9 Cal Pepper, Baton Rouge
9 Debra Stanglin, North Texas
9 Paul Stanglin, North Texas
9 Johnny Day, Oklahoma City
9 Matt Fair, Central Arkansas
9 Angela Harrison, Central Arkansas
9 Angela Harrison, Central Arkansas
9 Michael Park, Detroit
9 Raymond J. Roberts, Detroit
9 Ben Newcomb, Madison-Beloit
9 Al Sherrill, Fox Valley
9 Charles Hubbard, Chicago
9 Barney Piotrowski, Illinois Valley
9 Zach Awad, JAK
10 Earl Young, Tri-River
10 Tony Brosio, Indiana
10 Marty Siddall, NW Pennsylvania
10 Kenny Jones, Mahoning Valley
11 Michael Park, Detroit
11 Ray Hammonds, Greater Huntsville
11 Charles Frederick, Nashville
11 Steve Scott, Auburn-Opelika
11 Jim Sullivan, Mobile
11 Troy Moule, Madison-Beloit
12 Dick Shintani, Chicago
12 Abner Piotrowski, Illinois Valley
13 Zach Awad, JAK
14 Earl Young, Tri-River
14 Tony Brosio, Indiana
14 Richard E. Blaisdell, Kansas City
14 Angela Harrison, Central Arkansas
14 Ryan Rummel, Lake Charles
14 Grant Peltier, Houston
14 Christ Unterman, Houston
14 Thomas Kienbaum, Colorado
14ie Betts, Manchester
15 Steve Williams, Nashville
15 Josh Haskins, northeast Carolina
13 Jodi Jones, Blackhawk
16 Don Johnson, Tri-River
16 Brent Wright, Tri-River
16 Tom Newman, Tri-River
16 Jamie Thomas, Lexington
16 Mike Arand, Louisville
16 Keith Otten, St. Louis
16 Erin Fromont, Indiana
16 Jim Phillips, Indiana
16 Gary Blanchard, Indiana
16 Grant Von Lunen, Kansas City
17 Gilbert Moore, Tulsa
17 Dwight Grayson, North Texas
17 David Noth, Ozark
17 Jerald White, Central Arkansas
17 Michael Dugan, Central Arkansas
18 Kyle Emmans, Texas
18 Oscar Medina, Corpus Christi
18 Jose Gomez, El Paso
18 Dan Jones, Houston
18 Aaron Toups, Lake Charles
18 Kenny Moore, Rio Grande Valley
18 Richard Salinas, Rio Grande Valley
18 Jason Bingham, shamrock
18 Rick McArdle, Lake Charles
18 Clifton Rogers, San Antonio
18 Hamp Drew, San Antonio
20 Edward McHenry, New Mexico
20 Chris Martinez, New Mexico
20 Jessie Ramos, New Mexico
20 Glenn Ashley, Colorado
20 Kevin Cruz, Colorado
20 Leslie Punches, Wyoming
20 Robert Udy, Utah
20 Dale Mortensen, Idaho/Montana
20 Jim English, California Central Coast
20 Tim Conboy, California
20 James Cooney, Sierra Nevada
20 Mark Feuerbach, Sacramento Valley

District Meritorious Award
1 Gild Trigo, Montreal
1 Michel Marier, Montreal
2 Tom Gartland, Long Island
2 Eric Doherty, New Jersey
4 Ron Hunnicutt, Tidewater
4 Greg Frederick, Charlotte
6 E. E. Ford, Indiana
8 Randy Hammonds, Greater Huntsville
8 Charles Frederick, Nashville
9 Steve Scott, Auburn-Opelika
9 Jim Sullivan, Mobile
10 Marty Siddall, NW Pennsylvania
10 Kenny Jones, Mahoning Valley
11 Michael Park, Detroit
11 Raymond J. Roberts, Detroit
12 Ben Newcomb, Madison-Beloit
12 Al Sherrill, Fox Valley
13 Charles Hubbard, Chicago
13 Barney Piotrowski, Illinois Valley
13 Zach Awad, JAK
14 Earl Young, Tri-River
14 Tony Brosio, Indiana
14 Richard E. Blaisdell, Kansas City
14 Angela Harrison, Central Arkansas
14 Ryan Rummel, Central Texas
14 Grant Peltier, Houston
14 Chris Unterman, Houston
20 Thomas Kienbaum, Colorado
20 Pierreette Gorman, New Mexico
21 Jim Hollenberg, Hawaii
21 Ray Jablonski, Hawaii

Section Educator Award
2 Paul Jannotti, Long Island
4 Christopher Githens, Triangle
4 Steven Drippo, SW Virginia
4 Bobby Petry, SW Virginia
4 Lori Safrit, Charlotte
4 Steve Gere, Charlotte
4 Anver Clason, Charlotte
4 Walter Duke, Tidewater
4 Paul Miller, Tidewater
4 Richard Mims, Tidewater
4 Teresa Williams, NE Carolina
5 Gordon McCaffar, Syracuse
5 Bobby Graham, NE Mississippi
5 Rich Collier, NE Mississippi
5 Jim Higdon, Greater Huntsville
5 Artur Savoy, Acadiana
5 Tommy Smith, Acadiana
9 Ronnie McBride, Auburn-Opelika
9 Tim Turner, Birmingham
10 Johnny Grimes, Mobile
10 Owen Brown, New Orleans
10 Paul Deslauriers, New Orleans
116 Hermann Dykes, Pascagoula
187 Cynthia Harris, Pascagoula
18 William Harris, Pascagoula
18 Nick Baughman, Stark Central
18 Art Baughman, Stark Central
18 Scott Burdge, Stark Central
18 Travis Crate, Drake Well
19 Mark Schreiber, Cleveland
19 Jodi Jones, Blackhawk
19 Larry Cleveger, Blackhawk
20 Don Vorvath, Tri-River
20 Brent Wright, Tri-River
20 Tom Newman, Tri-River
20 Jamie Thomas, Lexington
20 Mike Arand, Louisville
20 Keith Otten, St. Louis
20 Erin Fromont, Indiana
20 Jim Phillips, Indiana
20 Gary Blanchard, Indiana
20 Grant Von Lunen, Kansas City
21 Gilbert Moore, Tulsa
21 Dwight Grayson, North Texas
21 David Noth, Ozark
21 Jerald White, Central Arkansas
21 Michael Dugan, Central Arkansas
21 Kyle Emmans, Texas
21 Oscar Medina, Corpus Christi
21 Jose Gomez, El Paso
21 Dan Jones, Houston
21 Aaron Toups, Lake Charles
21 Kenny Moore, Rio Grande Valley
21 Richard Salinas, Rio Grande Valley
21 Jason Bingham, Shamrock
21 Rick McAdory, Lake Charles
21 Clifton Rogers, San Antonio
21 Hamp Drew, San Antonio
20 Edward McHenry, New Mexico
20 Chris Martinez, New Mexico
20 Jessie Ramos, New Mexico
20 Glenn Ashley, Colorado
20 Kevin Cruz, Colorado
20 Leslie Punches, Wyoming
20 Robert Udy, Utah
20 Dale Mortensen, Idaho/Montana
20 Jim English, California Central Coast
20 Tim Conboy, California
20 James Cooney, Sierra Nevada
20 Mark Feuerbach, Sacramento Valley

District Educator Award
2 Donald Scott, New Jersey
2 Joe Kass, Long Island
4 Brandon Hoffner, Charlotte
4 Russell Wahrman, Triangle
6 Gordon McCaffar, Syracuse
8 Lamar Gifford, Greater Huntsville
8 Frank Miller, Greater Huntsville
9 Dale Box, Pascagoula
9 Doug-Joo Kim, Auburn-Opelika
10 Nick Baughman, Stark Central
10 Travis Crate, Drake Well
12 Dan Cifras, Racine-Kenosha
13 Mike Spangler, JAK
14 John Durbin, Tri-River
14 Alan Mattox, Lexington
16 Grant Von Lunen, Kansas City
17 Paul Stanglin, North Texas
17 Steve Williams, Central Arkansas
18 Clifton Rogers, San Antonio
18 John McKechnie, Sabine
18 Anne Matula, Corpus Christi
20 Jeff Braegger, Wyoming
20 Robert Ullbarri, New Mexico
22 Dan Turner, San Francisco
22 Scott Berry, Sacramento Valley
### Section CWI of the Year Award
- Robert Coulstring, III, Boston
- Ray Rosko, Charlotte
- Ken Schabert, Niagara Frontier
- Franklin Woodruff, NE Mississippi
- David Corbe, NE Mississippi
- Kevin Reed, NE Mississippi
- Scottie Smith, Auburn-Opelika
- Frank Smith, Auburn-Opelika
- Stephen Mohon, Baton Rouge
- Mark Miller, Baton Rouge
- Roderick Kaiser, Baton Rouge
- Bill Cohea, Baton Rouge
- Howard Stephens, Birmingham
- Chris Fernandez, New Orleans
- Albert Theriot, New Orleans
- Larry Porter, Pascagoula
- William Harris, Pascagoula
- Richard Harris, Cleveland
- Michael Gromada, Mahoning Valley
- Michael Owens, Drake Well
- Paul Leadingham, Illinois Valley
- William Judd, Tri-River
- Coy Hall, Lexington
- Bruce Craig, Indiana
- Tony Brosio, Indiana
- Mike Bumgarner, LA
- George Compton, St. Louis
- Cole Williamson, St. Louis
- Jason Miles, Kansas City
- Chad Barr, Oklahoma City
- Dale York, Tulsa
- Rob Tessier, North Texas
- John Ryan, Central Arkansas
- Dan Bricker, East Texas
- Pete Lopez, Corpus Christi
- David Twitty, El Paso
- Barney Burks Jr., Houston
- Terry Buxton, Lake Charles
- Jim Stuckey, Sabine
- Howard Thoms, San Antonio
- Jason Wales, Colorado
- John Olsen, Southern Colorado
- Russell Shelby, Wyoming
- Getsy Golkol, Utah
- Doug Williams, San Francisco
- Charles Bookout, Fresno
- District CWI of the Year Award
- John Wilfong, New Jersey
- Robert Simpson, Charlotte
- Steve Gorny, Charlotte
- Eric Bradly, NC Carolina
- Marvin Tyler, Triangle
- Damen Johnson, Florida W Coast
- Ken Schabert, Niagara Frontier
- Jim Higgins, Greater Huntsville
- Gary Gammill, NE Mississippi
- Jim Thompson, Greater Huntsville
- Nick Cooper, Mobile
- Scottie Smith, Auburn-Opelika
- Richard Harris, Cleveland
- Ken Coryell, Cleveland
- Glen Knight, Detroit
- Lawrence Gross, Milwaukee
- James Hoffman, Lakeshore
- Tim Pinson, Lexington
- Joe Kent, Louisville
- Todd Studebaker, St. Louis
- Jack Laudig, Indiana
- Jason Miles, Kansas City
- John Schrader, Central Texas
- Dale Yorkey, Colorado
- David Twitty, El Paso
- Rick Garcia, Corpus Christi
- Justin Gordy, Houston
- Maria McCosh, Idaho/Montana
- Marjorie Oliver, Colorado
- Mike Best, Nevada
- Sam Lindsey, San Diego
- Kerry Shattell, Sacramento Valley
- Mark Reese, Sacramento Valley
- Section Private Sector Instructor Award
- Charles Estes, Tidewater
- Mike Robinson, Tidewater
- Corbin Robbins, Tidewater
- Frank Jablonski, Triangle
- Randy Woolington, NE Mississippi
- Sara Godwin, Mobile
- Roy Larille, New Orleans
- Eddie Dixon, New Orleans
- Gerald Taylor, Pascagoula
- Linda Taylor, Pascagoula
- Robert Gardner, Cleveland
- Travis Crate, Drake Well
- Joe Kent, Louisville
- Chad Mayden, St. Louis
- Tony Brosio, Indiana
- Landisdown, Ozark
- Mark Smith, Tulsa
- Justin Gooch, Houston
- W. A. Grimm, Corpus Christi
- Ned Janini, Utah
- John Moore, Utah
- Rex Harrison, Utah
- Jimmy Shaesteen, Colorado
- Steven Yates, Wyoming
- Matt Miller, Sacramento Valley
- Pat Linggi, Sacramento Valley
- Charles Shelton, Sacramento Valley
- Mike Marzetta, Santa Clara

### District CWI of the Year Award
- John Wilfong, New Jersey
- Robert Simpson, Charlotte
- Steve Gorny, Charlotte
- Eric Bradly, NC Carolina
- Marvin Tyler, Triangle
- Damen Johnson, Florida W Coast
- Ken Schabert, Niagara Frontier
- Jim Higgins, Greater Huntsville
- Gary Gammill, NE Mississippi
- Jim Thompson, Greater Huntsville
- Nick Cooper, Mobile
- Scottie Smith, Auburn-Opelika
- Richard Harris, Cleveland
- Ken Coryell, Cleveland
- Glen Knight, Detroit
- Lawrence Gross, Milwaukee
- James Hoffman, Lakeshore
- Tim Pinson, Lexington
- Joe Kent, Louisville
- Todd Studebaker, St. Louis
- Jack Laudig, Indiana
- Jason Miles, Kansas City
- John Schrader, Central Texas
- Dale Yorkey, Colorado
- David Twitty, El Paso
- Rick Garcia, Corpus Christi
- Justin Gordy, Houston
- Student Chapter Member Award
- Steve Howe, Charlotte
- Jody Holloman, Charlotte
- Tim Jones, Triangle Section
- Michael Gaberski, Triangle
- Michael Chandler, Triangle
- Dev Walker, Baton Rouge
- Jason Hanagriff, Baton Rouge
- Sean Carter, Baton Rouge
- Pheadra Penton, Baton Rouge
- Seth Badeaux, Baton Rouge
- Malachi Wilkerson, Pascagoula
- Neal Holden, Pascagoula
- Jonathan Leonard, Pascagoula
- Matthew Satterly, Pascagoula
- Dave McVay, Stark Central
- Ronald Shearer, Stark Central
- Kyle Short, Stark Central
- Erick Spero, Drake Well
- Brandon Smith, Mahoning Valley
- Jorge Villalobos, San Antonio
- Louisa Matthews, San Antonio
- Ethan Trade, Sabine
- Jeff Henderson, New Mexico
- Kevin Snow, New Mexico
- Joe Stavichoia, Idaho/Montana
- Jonathan Meeks, Sacramento Valley

### Student Chapter Member Award
- Travis Weidner was awarded the Student Chapter Member Award for 2009-2010 "In recognition of his outstanding school, community, and industry achievements and for generous contributions of time and effort to the Nashville Section, District 8." Weidner recently demonstrated his outstanding orbital welding skills in Gadsden, Ala. He graduated from Tennessee Technology Center, Crossville, with a diploma in welding. He is employed at OptiMech LLC in Hendersonville, Tenn.
Member-Get-A-Member Campaign

Listed below are the members participating in the 2011–2012 AWS Member-Get-A-Member Campaign. Standings are as of August 22. For campaign rules and a prize list, see page 145 of this Welding Journal. For complete campaign rules, visit www.aws.org/mgm. Call the AWS Membership Department at (800) 443-9353, ext. 480, with any questions about your member proposer status.

Winners’ Circle
Listed are the sponsors of 20 or more Individual Members per year, since June 1, 1999. The superscript denotes the number of years the member has earned Winners’ Circle status.
E. Ezell, Mobile
J. Compton, San Fernando Valley
J. Merzthal, Peru
G. Taylor, Pascagoula
L. Taylor, Pascagoula
B. Chin, Auburn
S. Exders, Detroit
M. Haggard, Inland Empire
M. Karagoulis, Detroit
S. McGill, NE Tennessee
B. Mikeska, Houston
W. Shreve, Fox Valley
T. Weaver, Johnstown/Altoona
G. Woomer, Johnstown/Altoona
R. Wray, Nebraska

President’s Club
Sponsored 3–8 new members
G. Bish, Atlanta — 3
B. Goerg — 3

President’s Honor Roll
Sponsored 2 new members
G. Fehrman, Philadelphia
G. Jacobson, Cumberland Valley
T. Palmer, Atlanta
H. Suthar, Charlotte
D. Wright, Kansas City

Student Sponsors
Sponsored 3 or more Student Members
G. Bish, Atlanta — 50
R. Belluzzi, New York — 34
J. Bruskotter, New Orleans — 17
R. Evans, Siouxland — 17
E. Norman, Ozark — 16
T. Palmer, Atlanta — 14
D. Schnalzer, Lehigh Valley — 11
C. Kipp, Lehigh Valley — 9
R. Hutchinson, Long Beach/Or. Cty. — 3

AWS Life Members Get Free FABTECH Professional Program

AWS Life Members get free admission to the upcoming FABTECH expo plus complimentary registration for the entire Professional Program — a $325 value. FABTECH is scheduled for Nov. 14–17 at McCormick Place in Chicago, Ill.
The free registration entitles Life Members to attend any of the technical sessions presented during the four-day period.
Life Members are urged to take advantage of this valuable benefit. The registration form may be requested from the Membership Dept.; call toll-free (800) 443-9353, ext. 260.

To obtain your free registration, mark “AWS Life Member: Free Registration” at the top of your Registration Form. Then FAX both sides of the form to (305) 443-7559, Attn: Ruben Lara, accounting director; or mail the form to Ruben Lara, AWS, 550 NW LeJeune Rd., Miami, FL 33126.

Honorary Meritorious Awards

The deadline for nominating candidates for these awards is December 31 prior to the year of the awards presentations. Send candidate materials to Wendy Sue Reeve, wreeve@aws.org; 550 NW LeJeune Rd., Miami, FL 33126.

William Irgang Memorial Award
This award is given 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 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
This award is given to an individual who promoted the advancement of welding internationally by fostering cooperative participation in technology transfer, standards rationalization, and promotion of industrial goodwill. It includes a $2500 honorarium.

Honorary Membership Award
This award acknowledges eminence in the welding profession, or one who is credited with exceptional accomplishments in the development of the welding art. Honorary Members have full rights of membership.

Int. 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 award consists of a certificate and a one-year AWS membership.

Nominate Your Candidate for the M.I.T. Prof. Masubuchi Award

November 2, 2011, is the deadline for submitting nominations for the 2012 Prof. Koichi Masubuchi Award. It 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. Nominations should include the candidate’s experience, publications, honors, and awards, and at least three letters of recommendation from fellow researchers. E-mail your nomination package to Todd A. Palmer, assistant professor, The Pennsylvania State University, tapi03@psu.edu. Sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology (M.I.T.), this award includes a $5000 honorarium.
AWS Meets with Its International Agents

AWS recently held business meetings with its International Agents in South America, Mexico, Malaysia, and the Middle East. These International Agents administer AWS certification programs and promote AWS activities throughout their regions. Shown above are the representatives at the meetings held March 23, 24 in Lima, Peru; May 12 in Monterrey, Mexico; June 26–28 in Kuala Lumpur, Malaysia; and (not pictured) June 5–7 in Dubai, UAE. The Peru meeting included representatives from the following International Agents: Indura, EVC, PUCP, ABS, Senati, and SGS; the Mexico International Agents include Dalus, UTP, OMCS, Istuc, and Comimsa; and the Malaysia International Agents are Sirim, Cutech, Intertek Moody, AES, Setseo, SWS, IWTRL, KWIC, Pentromentor, and CTSHV.

Representing the American Welding Society at the meetings were Cassie Burrell, deputy executive director; Priti Jain, director, international business and certification programs; and Melissa Gomez and Donald Llopis, senior international certification coordinators.
New AWS Supporters

Sustaining Members
Aquilex Corp.
2225 Skyland Ct., Norcross, GA 30071
Representative: Darren Barborak
www.aquilex.com
Aquilex Corp. is a major provider of critical maintenance, repair, and industrial cleaning solutions to the global energy industry. It provides its services primarily to the oil and gas refining, chemical and petrochemical production, fossil and nuclear power generation, and the waste-to-energy sectors.

Demmer Corp.
1600 N. Larch St., PO Box 12030
Lansing, MI 48906
Representative: Robert Hill
www.demmercorp.com
Demmer Corp. is a vertically integrated fabricator with well-defined processes and rigorous procedures designed to ensure quality. It specializes in welding, forming, assembly, engineering, and prototypes for the defense, aerospace, and automotive industries.

Taylor-Wharton Int’l
4718 Gettysburg Rd., Ste. 300
Mechanicsburg, PA 17055
Representative: Andrew W. Pazahanick
www.taylorwharton.com
Taylor Wharton Cryogenics, LLC, designs and manufactures cryogenic products for the industrial gas, life science, and beverage carbonation markets globally. Its products include standard and engineered bulk tanks, micro bulk tanks, high and low-pressure liquid cylinders, hospital reserve tanks, beverage carbonation tanks, and cryogenic freezers, refrigerators, and dewars.

J. Horst Mfg. Co.
279 E. Main St., Dalton, OH 44618
Representative: Roland Horst
www.jhorst.com
J. Horst Mfg. Co. is a custom job shop. Although it has no name brand products of its own, it machines, fabricates, and assembles parts that are used in many different industries nationally and internationally.

Supporting Members
Brownsville Marine Products, LLC
1800 Paul Thomas Blvd.
Brownsville, PA 15417

Frank Lill & Son, Inc.
656 Basket Rd., Webster, NY 14580

UTBR Unitechnologies LTD
Rua: Alfredo Da Costa Figu, No. 805
Jardim Santa Candida, Campinas, SP
13087-534, Brazil

Affiliate Companies
Alpha Professional Tools
103 Bauer Dr.
Oakland, NJ 07436

Centerline Machine, Inc.
PO Box 285, Waupaca, WI 54981

Crow Corp.
23715 FM 2978 Rd., Tomball, TX 77375

Flushing Iron Weld, Inc.
131-25 Maple Ave., Flushing, NY 11355

Gill Welding & Fabrication
315 Raccoon Valley Rd.
Heiskell, TN 37754

Industrial Metal Supply Co.
5150 S. 48 St., Phoenix, AZ 85040

Industrial Sculpting
4101 Roxanne Dr., Las Vegas, NV 89108

NORTEST
98 Arch Makariou III, PO Box 12603
Latsia, Nicosia 2251, Cyprus

Pikes Peak Community College
5675 S. Academy Blvd #C16
Colorado Springs, CO 80906

Schake Industries, Inc
673 Colber Ave., Oil City, PA 16301

Professional Fall Protection Supply, Inc.
204 Phillips Ln., Greer, SC 29650

R.A.S. Industries Ltd.
8020 128 St.
Surrey, BC V3W4E9, Canada

Specialty Welding, Inc.
1300 S. County Rd. 21
Leoti, KS 67861

Viking Fabrication Service
2353 International St.
Columbus, OH 43228

V.L.K Construction, Inc.
18-41 Steinway St,
Astoria, NY 11105

Educational Institutions
Broaddus ISD
One Bulldog Plaza
Broaddus, TX 75929

Eminent Career Development Link Institutions Pvt. Ltd.
2nd Fl. N.P. Tower W. Fort
Thrissur, Kerala 680004, India

Gary Job Corps Center
2800 Airport Blvd., Hwy. 21 E.
San Marcos, TX 78667

National Saudi Training Institute for Development
PO. Box 267, MSQ, 115, Oman

New River Community & Technical College
527 Odd Rd., PO Box 307
Ghent, WV 25843

AWS Member Counts

Grades
Sustaining..........................512
Supporting..........................305
Educational..........................569
Affiliate...............................466
Welding Distributor...............51
Total Corporate.....................1,903
Individual.........................57,228
Student + Transitional...........10,701
Total Members......................67,929

September 1, 2011
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Scott Lee (left) receives his past chairman’s award from Dick Gregoire at the May 7 Maine Section program.

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

CONNECTICUT
JUNE 18
Activity: The Section held its annual CWI seminar and examination at the Bradley Airport with 32 members attending. Russ Norris supervised the exam, assisted by Nissa Norris and Tim Kinnaman.

MAINE
MAY 7
Activity: The Section held its election of officers. Mike Gendron was named incoming chair and outgoing Chair Scott Lee was named treasurer. Dick Gregoire presented Lee an appreciation award for his services.

JUNE 30
Speaker: Mike Gendron, project manager
Affiliation: Metso Paper, Honeycomb Div.
Topic: Upcoming year in the Maine Section
Activity: The Maine Section held an executive board meeting at Run of the Mill Public House in Saco, Maine, to plan the upcoming season’s events. Scheduled is an open house vendors’ night at Southern Maine Community College for the last Thursday in January.

District 2
Harland W. Thompson, director
(631) 546-2903
harland.w.thompson@us.ul.com

District 2
NEW JERSEY
MAY 17
Speaker: Paul Lenox, CWI
Affiliation: MRP, South Plainfield, N.J.
Topic: Emerging careers in welding
Activity: The Section hosted an appreciation dinner to acknowledge the winners in the 2011 New Jersey State SkillsUSA welding contest. Conducting the program were CWI Jim Dolan, Section chairman, and CWI Paul Lenox, cochair of certification. The event was held at Somerset Vocational School in Bridgewater, N.J.

New Jersey Section Chair Jim Dolan (left) and Paul Lenox are shown at the May event.
Central Piedmont Community College Student Chapter members are shown during their working trip to New Orleans. From left are Steve Gore, Larry Hoke, Curt McGuire, Sherry Spiner, Jonathan Kish, Chris Harris, Advisor Ray Sosko, Jill Roberts, David Holcomb, Greg Bellamy, and Lloyd Harris.

Mahoning Valley Section golfers are (from left) Terry Jacobs, Chuck Moore, Amy Turjanica, Nick Ambrosini, Carl Ford, and Leon Stitt.

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

Central Piedmont C. C. Student Chapter
May 15–20
Activity: The Student Chapter members embarked on a week-long service-learning trip to New Orleans, La., where they worked for Phoenix New Orleans (PNOLA) renovating houses damaged by Hurricane Katrina. Leading the group were faculty members Advisor Ray Sosko, Steve Gore, Jill Roberts, and Greg Bellamy. Participating were students Larry Hoke, Curt McGuire, Sherry Spiner, Jonathan Kish, Chris Harris, David Holcomb, Lloyd Harris, and Ezra Martin.
Shown at the Chicago Section board meeting are from left (seated) Cliff Iftimie and Pete Host; (standing) Eric Purkey, Eric Kraus, Marty Vondra, Jeff Stanczak, past AWS President Jim Greer, Chair Craig Tichelar, Hank and Vemette Sima.

**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

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

**District 7**
Don Howard, director  
(814) 269-2895  
howard@ctc.com

**District 8**
Joe Livesay, director  
(931) 484-7502, ext. 143  
joe.livesay@ttcc.edu

**District 9**
George Fairbanks Jr., director  
(225) 473-6362  
fits@bellsouth.net

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

**District 11**
Robert P. Wilcox, director  
(734) 721-6272  
rmwilcox@wowway.com

**District 12**
Daniel J. Roland, director  
(715) 735-9341, ext. 6421  
daniel.roland@us.fincantieri.com

**District 13**
W. Richard Polanin, director  
(309) 694-5404  
rpolanin@icc.edu

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At the Madison-Beloit Section meeting, Dave Diljak (left in both photos) presents certificates of appreciation to outgoing co-chairs Anton Stute (left photo) and Ben Newcomb.

**MAHONING VALLEY**

**AUGUST 5**


**MADISON-BELOIT**

**JUNE 6**

Activity: The Section’s board members met to review the quality of last season’s events and programs and plan programs for the upcoming season. Secretary Dave Diljak presented Anton Stute and Ben Newcomb certificates of appreciation for serving the Section as co-chairmen for 2010–2011.
The winning team members in the Indiana Section golf outing are (from left) Pat Stevenson, David Laird, Ed Baker, and Darron Granger.

The Arizona Section toured the welding lab at Mesa Community College in August.

Dennis Pickering, Central Arkansas Section chair, presents the District 17 Director Award to Allie Reynolds.

Jay Glass (right) receives the Section Educator Award from Dennis Pickering, Central Arkansas Section chair.

District 14
Robert L. Richwine, director
(765) 378-5378
bobrichwine@aol.com

INDIANA
July 19
Activity: The Section hosted its annual golf outing in Indianapolis, Ind. The winning team was David Laird, Pat Stevenson, Darron Granger, and Ed Baker, representing Ivy Tech Community College.
TRI-RIVER
AUGUST
Activity: Chair John Durbin recognized Henderson C. C. for receiving a Workforce Development grant from the AWS Foundation, Inc., in the amount of $19,095, to support the training and development of area employees. Also recognized were Ohio Valley Marine, Pittsburg Tank and Tower, and Alliance Coal for their roles in helping the college receive the grant. Participating were college representatives Pat Lake, Jim Nance, and Kris Williams; Cooper Lilly, program advocate; Phillip Wilkerson, Ohio Valley Marine Services Dry Dock; Mike Wilkerson, Allstate Tower Manufacturing; and Bill Judd, Pittsburg Tank and Tower.

District 15
Mace V. Harris, director
(612) 861-3870
macevh@aol.com

District 16
David Landon, director
(641) 621-7576
dlandon@vermeermfg.com

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

CENTRAL ARKANSAS
JULY 29
Speaker: Jimmy Brewer, Section vice chair
Affiliation: U.A. of Plumbers and Pipefitters Local #155
Topic: The future of AWS
Activity: Chair Dennis Pickering presented the Section Educator of the Year Award to Jay Glass from South Arkansas Community College. Allie Reynolds, from Welsco, earned the District Director Award. The event was held at Arkansas Career Training Institute in Hot Springs, Ark.

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

District 19
Neil Shannon, director
(503) 201-5142
neilshhn@msn.com

BRITISH COLOMBIA
JUNE 3
Activity: The Section hosted the District 19 Stump the Experts welding quiz contest in Delta, B.C., Canada. The event is held each year before the District conference. This year’s winning team members are Shawn McDonald, Rich Campbell, and Jim Berkey.

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

District 20 Conference
JUNE 3
Activity: The District 20 conference was held in Golden, Colo., hosted by the Colorado Section. William Komlos, District 20 director, conducted the program.

District 22
Dale Flood, director
(916) 288-6100, ext. 172
d.flood@tritool.com

ARIZONA
AUGUST 17
Activity: Thirty Section members met at the welding facilities of Mesa Community College in Mesa, Ariz. Rod Hamnll, welding program director, led the tour of the welding laboratory.

International Section
SAUDI ARABIA
Calendar
The 14th Middle East Corrosion Conference & Exhibition is scheduled for Feb. 12–15, 2012, at Gulf International Convention Center Gulf Hotel, Kingdom of Bahrain. Contact Dr. Moufaj Jafar, chairman, technical committee, moufaj.jafar@aramco.com; or visit www.mecconline.org.
Guide to AWS Services
550 NW LeJeune Rd., Miami, FL 33126; (800/305) 443-9353; FAX (305) 443-7559; www.aws.org
Staff extensions are shown in parentheses.

AWS PRESIDENT
John L. Mendoza
Managing Director
Lone Star Welding
3319 Kashmir, San Antonio, TX 78223

ADMINISTRATION
Executive Director
Ray W. Shook
Deputy Executive Director
Cassie R. Burrell
Sr. Associate Executive Director
Jeff Weber
Chief Financial Officer
Gesana Villegas
Executive Assistant for Board Services
Grecelda Manallach

Administrative Services
Managing Director
Jim Lankford
IT Network Director
Armando Campana
Director
Hidal Nuñez
Director of IT Operations
Natalia Swain

Human Resources
Director
Luisa Hernandez
Director, Compensation and Benefits
Dora A. Shade

International Institute of Welding
Senior Coordinator
Sissibeth Lopez

GOVERNMENT LIASON SERVICES
Hugh K. Webster
Director, Convention and Expositions
Jeff Weber
Selvis Morales

INTERNATIONAL SALES
Managing Director, Global Exposition Sales
Joe Krall
Corporate Director, International Sales
Jeff P. Kamenetz
Brazing and Soldering
Manufacturers’ Committee
Jeff Weber

GAWDA — Gases and Welding Distributors
Association
John Osipina
Operations Manager
Natasha Alexis

RWMA — Resistance Welding
Manufacturing Alliance
Manager
Susan Hopkins

WEMCO — Welding Equipment
Manufacturers Committee
Manager
Natalie Tapley

PUBLICATION SERVICES
Department Information
Managing Director
Andrew Cullison
Welding Journal
Publisher
Andrew Cullison
Editor
Mary Ruth Johnson
National Sales Director
Rob Saltzstein
Society and Section News Editor
Howard Woodward
Welding Handbook
Editor
Annette O’Brien

MARKETING COMMUNICATIONS
Director
Ross Hancock
Public Relations Manager
Cindy Wehl
Webmaster
Jose Salgado
Section Web Editor
Henry Chinena

MEMBER SERVICES
Department Information
Deputy Executive Director
Cassie R. Burrell
Director
Rhenda A. Kenny
Services as a liaison between Section members and AWS headquarters

CERTIFICATION SERVICES
Department Information
Director, Certification Operations
Terry Perez
Director, Int’l Business & Certification Programs
Pritti Jain
Directs all international business and certification programs. It is responsible for oversight of all agencies handling AWS certification programs.

Director, Certification Programs
Linda Henderson
Oversees the development of new certification programs, as well as AWS-Accredited Test Facilites, and AWS Certified Welding Fabricators.

EDUCATION SERVICES
Corporate Director
Annette Alonso
Director, Operations
Martica Ventura
Director, Education Development
David Hernandez

AWS AWARDS, FELLOWS, COUNSELORS
Senior Manager
Wendy S. Reeve

TECHNICAL SERVICES
Department Information
Andrew R. Davis
Director, National Standards Activities
John L. Gayler
Manager, Safety and Health
Stephen P. Hedrick
Senior Manager, Technical Publications
Rosalinda O’Neill

AWS FOUNDATION, INC.
Chairman, Board of Trustees
Gerald D. Utratchi
Information: yrinsky@aws.org
Executive Director, Foundation
San Gentry
Solutions Opportunity Squad
Monica Pfarr

The AWS Foundation is a not-for-profit corporation established to provide support for the educational and scientific endeavors of the American Welding Society. Further the Foundation’s work with your financial support. Call for information.
Astralloy Steel Products Inc. Birmingham Ala. is a steel service center offering wear and impact-resistant steel products.

“We are cutting steel 3/4 in. and above. To do this we needed a better, more cost effective system and the ability to cut thicker plate,” said Mattocks.

“We considered purchasing new CNC plasma cutting systems but a large capital outlay in the six figures was not an option.” says Mattocks.

Instead, the company purchased four plasma conversion systems from ATTC to be used for specialty cutting work.

Changing over the torches took 15 minutes and changing the consumables was quick and easy.

With the conversion, Astralloy improved cutting capacity and reduced the rework.

The PHD technology converts a conventional plasma system to a high definition-style cut quality without a big capital investment.

“The new torches have increased productivity by about 25 percent due to an increase in speed and longer consumable life. Now, there is very little grinding time needed to remove slag and dross. Grinding time was reduced by 75 percent, from eight hours to two,” said Mattocks.

“All in all it was a good investment,”

John Mattocks
Branch Manager
Astralloy Steel Products
Guide for Water-Damaged Electrical Equipment

Evaluating Water-Damaged Electrical Equipment provides advice on the safe handling of electrical equipment that has been exposed to water from flooding, firefighting activities, or hurricanes. It clearly outlines items that will require complete replacement and those that can be reconditioned by a trained professional. Equipment covered includes electrical distribution equipment, motor circuits, power equipment, transformers, wire, cable and flexible cords; wiring devices; GFCIs and surge protectors; lighting fixtures and ballasts; motors, switches, and electronic products. The six-page document is designed for use by suppliers, installers, inspectors, and users of electrical products. The document may be downloaded free from the Web site shown.

National Electrical Manufacturers Assn. 
www.nema.org/stds/water-damaged.cfm 
(703) 841-3336

Certified Lift Magnets Pictured in Brochure

A six-page, full-color brochure illustrates and describes the company’s lift magnets with emphasis on their compliance with ASME B30.20, Section 20-3.3, the industry’s standard for inspection, testing, and maintenance of close proximity operated lifting magnets. Detailed is the company’s magnet exchange program, and 5-Star Service® magnet refurbishment program. Visit the Web site to download brochure B-103 in PDF.

Eriez 
www.eriez.com 
(814) 835-6000

Videos Demonstrate Dust Collection Equipment

The Web site offers 18 videos that demonstrate the company’s lines of air-pollution control equipment, engineering services, and technical support. Showcased are the Gold Series® dust collectors and Hemipleat® filters in operation. The first video listed, titled Dust and Fume Collection Capabilities, is a 10-min presentation by company President Lee.
Morgan who gives an interesting overview of the company’s capabilities.

Camfil Farr APC
www.farrapc.com/videos/
(800) 479-6801

All-Purpose Bottles, Bags, and Containers Pictured

Consolidated™ Plastics
www.consolidatedplastics.com
(800) 362-1000

Gas Cylinder Blasters Illustrated in Brochure

A 20-page, full-color catalog illustrates and describes a wide assortment of plastic bottles, pails, containers, nesting tote boxes, and polyethylene bags, and accessories for general shop and maintenance uses. Also shown are Nalgene® bottles, graduated beakers, clear PVC bottles, funnels, paper cups, heavy-duty spray bottles, thermo impulse sealers and trimmers, plastic and paper twist ties, heavy-duty resealable bubble bags, and “stand-up” flat-bottomed, gusseted poly bags for greater capacity, and 4-mill, lay-flat poly tubing on rolls up to 1200 ft.

Viking Blast & Wash Systems
www.vikingcorporation.com
(800) 835-1096

Free-Standing Air-Filtration System Detailed

The Circulator™ free-standing general filtration system is detailed in a four-page, full-color brochure. Designed exclusively for extracting and filtering welding fume that is released during the most common welding fabrication processes, the units are intended to supplement natural ventilation that may be present to reduce the overall concentration of fumes. Detailed are the four main components, the fan, filter unit, Circulator™ air-dispersion head, and Green-Drive™ control system that continuously monitors the air flow and performance. General data include 6000 ft³/min airflow, air-flow throw adjustable from 49 to 164 ft, drum capacity 26 gal, total weight 1764 lb, with a footprint of 47 × 96 in.

The Lincoln Electric Co.
www.lincolnweldfumecontrol.com
(216) 383-2667

Grinding Solutions Detailed in Literature

The eight-page, full-color Grinding and Finishing Solutions Guide details the company’s lines of power brushes and abrasives for cleaning, finishing, and deburring applications. Shown are a variety of flap discs for various applications including the Tiger™ Disc for high cut rates and long life; Vortec™ Pro® line for value; and the trimmable Tiger Disc for increased flexibility. Shown are ceramic flap discs for cool and fast cutting action on aluminum, stainless steel, Inconel®, titanium, and other hard-to-grind metals.

Weller Corp.
www.wellercorp.com
(800) 835-9999

ASQ Upgrades Its Web Site

The society has launched a redesigned Web site, optimized for mobile device access, that features interactive and rich-media content to bring quality ideas, tools, resources, and social networking to the global quality community. Featured are articles and case studies, features from Quality Progress magazine, the View from the Q blog by CEO Paul Borawski, Quality for Life™ stories, research studies, videos, developments from its national service centers in India, China, and Mexico, and technology and training information.

American Society for Quality
www.asq.org
(414) 272-8575

— continued on page 166
**PERSONNEL**

**Fronius Adds Sales Application Engineer**

Fronius USA, LLC, Brighton, Mich., has appointed Jordan Henry a sales application engineer in the technical support department. Jordan, a recent welding engineering technology graduate from Ferris State University, has worked in the industry for more than two years.

**Taylor-Wharton Appoints President**

Taylor-Wharton Int’l LLC (TWI), Mechanicsburg, Pa., has appointed Len York president of Taylor-Wharton Cryogenics. York currently serves as chief financial officer of TWI, and will continue to perform this financial role along with his new duties.

**Harris Products Announces Technology Director**

The Harris Products Group, a Lincoln Electric Co. based in Mason, Ohio, has appointed Jeff Crawford director of information technology. Crawford previously served another company as director of information technology and business development.

**Intelligrated Appoints VP**

Intelligrated®, an automated material-handling solutions provider, has appointed Greg Cronin executive vice president. Prior to joining the company, Cronin served Quiet Logistics, Inc., as vice chairman and executive vice president.

**Airgas Names Two Presidents**

Airgas, Inc., Radnor, Pa., has named Chuck Broadus president of Airgas South, based in Suwanee, Ga. He succeeds Jay Sullivan who was recently appointed south division vice president and chief financial officer. Broadus, who joined the company in 2003, most recently served as president of Airgas Refrigerants. Bob Bradshaw has been named president of Airgas Mid South, succeeding Terry Lodge who served in the post since 2007. Bradshaw, who joined the company in 1993, had served as area vice president for the South Central Texas area of Airgas Southwest since 2005. He will be based in Tulsa, Okla.

**Finetech Hires Applications Engineer**

Finetech, headquartered in Berlin, Germany, has appointed Norman Faucher an applications engineer for its Eastern U.S. Application Lab in Manchester, N.H. Faucher, a veteran in the electronics industry, has many years of customer support and microcircuit surface mount technology and industrial soldering experience.

**Twarog Receives Die Casting Award**

The North American Die Casting Assn. (NADCA), Wheeling, Ill., has selected Daniel Twarog to receive its Herman H. Doehler Award in recognition of his outstanding contributions to the advancement of the die casting industry, the art of die casting as represented by technical achievement, advancement in plant operation, and other activities. Twarog, with 34 years in the metalcasting industry, became NADCA executive vice president in 1995, and has served as president since 1999. His achievements include research in investment casting technology, lost foam emission characterization, tramp element effects in aluminum and copper alloys, alternate reuse technology for foundry waste sand, and developing a replacement alloy for lead in copper castings.

**SICK Ldt. Names President**

SICK Ldt., Minneapolis, Minn., a supplier of sensors, safety systems, and automatic identification products for industrial applications, has appointed Craig S. Smith president of SICK Ltd. in Canada. Smith previously worked for Siemens Water Technologies, a subsidiary of Siemens Canada, Ltd.

**SME Honors Eleven Industry High Achievers**

The Society of Manufacturing Engineers (SME), Dearborn, Mich., recently presented its 2011 Industry Achievement Award and elected ten members to its 2011 Class of Fellows.

Wilfried Vancrean, managing director at Materialise NV in Belgium, was presented the 2011 RTAM Industry Achievement Award at the recent Society of Manufacturing Engineers’ conference. Sponsored by the society’s Rapid Technologies and Additive Manufacturing Community, the award recognizes manufacturing professionals who have made exceptional contributions and accomplishments in the additive manufacturing industry or any industry through the application of additive manufacturing technologies. Vancrean founded Materialise NV in 1990, one of the first rapid prototyping service bureaus in Europe.

Named to the SME 2011 Class of Fellows were Viktor P. Astakhov, General Motors Business Unit of PSMI in Rochester Hills, Mich.; George Bullen, Smart Blades, Inc., Oxnard, Calif.; F. Frank Chen, University of Texas at San Antonio; Dianne Chong, Boeing Research & Technology, Seattle, Wash.; Placid M. Ferreira, University of Illinois at Urbana-Champaign; Changsheng Guo, United Technologies Research Center, East Hartford, Conn.; Wallace Hopp, University of Michigan at Ann Arbor; Jack Jeswiet, Queen’s University at Kingston, Ont., Canada; Pradeep Rohatgi, University of Wisconsin at Milwaukee; and Lihui Wang, University of Skövde, Skövde, Sweden. Each was cited for his or her notable impacts in the field of manufacturing, including leadership, education, research and development, inventions, publications, and/or service to the profession.

**Obituary**

Scott R. Goodspeed

Scott R. Goodspeed, 63, who had battled cancer, died peacefully Aug. 8 at his home in Greenville, Maine. He was a member of the AWS C2D Subcommittee on Thermal Spraying: Theory and Practice; most recently served three years at Camfil Farr APC (where he was nicknamed Scott Goodspray); and earlier served as eastern — continued on page 166
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NEWS OF THE INDUSTRY
— continued from page 14

Miller Starts ‘Nominate a Hero’ Promotion

Miller Electric Mfg. Co., Appleton, Wis., launched a new Web site, www.millerwelds.com/hero, to support the introduction of its “Nominate a Hero” promotion, where customers can submit information on a coworker or friend for a chance to win prizes.

The program recognizes individuals who make a special contribution to their workplace and the welding industry through job performance, education, training, and other worthy causes.

Visitors have the opportunity to fill out a profile on their hero — to be entered into the promotion. Ten finalists will be chosen, and members of the general public will have the chance to vote for their favorite three next summer. The three grand-prize winners will be flown to Miller headquarters in Appleton, Wis., and awarded a company product of their choosing, in addition to Arc Armor® welding apparel.

Miller will also feature at least one hero per month on the site, in addition to information on products, service, and support.

Eddie Kane Steel Opens Alabama Facility

Eddie Kane Steel Products, Inc., added its newest distribution facility in Tuscaloosa, Ala. The opening of this sales, warehouse, and distribution center will allow the company to better service its hot-rolled carbon steel plate customers in the south. The strategically located facility will mean faster delivery times for many users, too.

“This latest expansion of Eddie Kane Steel in central Alabama means significant freight savings for our customers in the southern U.S. and Mexico, which is absolutely important to fabricators and processors as fuel prices as well as raw material prices continue to rise,” said Augustine F.X. (Gus) Kane, president of Eddie Kane Steel Products.

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**NEWS OF THE INDUSTRY**

— continued from page 164

**Industry Notes**

- After working with Yanbu Steel for several months, Don Burgart, Koike Aronson, Inc./Ransome positioner sales manager, was officially awarded a $3.1 million contract. The main scope of this project is to build large oil storage tanks for Sandi Aramco Yanbu Refinery in Saudi Arabia by using specialized welding systems that Koike has now been hired to design.

- June U.S. manufacturing technology orders totaled $459.39 million according to the Association for Manufacturing Technology and American Machine Tool Distributors’ Association. This amount was reported by companies participating in the U.S. Manufacturing Technology Orders program. With a year-to-date total of $2,453.78 million, 2011 is up 103.9% vs. 2010.

- Dr. Stephen Scott, president of Wake Tech Community College, Raleigh, N.C., recently announced the late Harold and Shirley Brenner bequeathed $500,000 to the Wake Tech Foundation. It will fund endowed scholarships for students in technical programs, including welding.

- Grafflin intends to acquire the shares of Fabory Group, a European distributor of fasteners and related MRO products. The transaction price will be approximately $344 million.


- The Lincoln Electric Co., Cleveland, Ohio, teamed up with Picture Car Warehouse to serve as the exclusive welding supplier for the car-heist motion picture, Drive.

- The Harris Products Group, a brazing, soldering, and welding alloys and equipment provider, recently hosted Rep. Jean Schmidt (R-OH) at its headquarters in Mason, Ohio. The company also launched a multilingual, multiregion Web site at www.harrisproducts.com.

- Sigma Labs, Inc., Santa Fe, N.Mex., received a contract from Alcoa, Inc., to demonstrate the feasibility of applying its In-Process Quality Assurance technology to the welding of advanced aluminum structures.

- Chambersburg Area Senior High School students in Pennsylvania will have a new classroom tool in 2011–12. The school board recently voted to solicit bids for an industrial work cell robotic welding machine. Cost of the equipment is $15,000.

- EWI acquired a new Miyachi Unitek™ LW2AG, 532-nm wavelength green laser for its laser welding lab at its headquarters in Columbus, Ohio, to use for joining applications.

- Solder Direct, the e-commerce Web site for Kapp Alloy & Wire, Inc., Oil City, Pa., launched a site at www.solderdirect.com. It includes an updated shopping cart and product search.

- Eriez® will move its 5-Star Service® center to its newly purchased building in Erie, Pa., that will also handle manufacturing Hydroflow® fluid filtration and recycling equipment.

- Praxair Distribution, Inc., Danbury, Conn., acquired the assets of Weldco Inc., Cincinnati, Ohio, a distributor of industrial and specialty gases, plus ancillary welding equipment.

- DHPS, Lenoir City, Tenn., is expanding diesel cylinder head remanufacturing capacity utilizing its refined fusion welding technology. This process helps commercial, military, and governmental organizations meet their reuse and recycle goals.

- Hypertherm has been selected as a 2011 Business of the Year by Business New Hampshire Magazine. One of nine New Hampshire businesses honored, the company was selected for its performance in manufacturing and technology.

- TÜV Rheinland, Cologne, Germany, is acquiring Sonovation B.V., the Netherlands, a nondestructive examination provider. The company will be named TÜV Rheinland Sonovation.

- Muscle Robotics, Inc., a distributor focused on manufacturing industrial machines and equipment, opened its head U.S.-based office in Santa Clara, Calif.
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Laser Enhanced Metal Transfer — Part 1: System and Observations

A laser impinging on the droplet in gas metal arc welding applies an auxiliary detaching force without any significant change in current

BY Y. HUANG and Y. M. ZHANG

ABSTRACT

Laser-enhanced gas metal arc welding (GMAW) is a recent modification of conventional GMAW that applies a relatively low-power laser to the droplet. A systematic series of experiments were designed and conducted to test this modification. A high-speed camera recorded the metal transfer process during each experiment. The behaviors of the laser-enhanced metal transfer process observed from high-speed images were analyzed using the established physics of metal transfer. The characteristics and uniqueness were identified. In all experiments, the laser was found to affect the metal transfer process as an additional detaching force that tended to change a short-circuiting transfer to drop globular or drop spray, reduce the diameter of the droplet detached in drop globular transfer, or decrease the diameter of the droplet such that the transfer changed from drop globular to drop spray. In addition, this force also provided an effective method to minimize the wandering of the droplet of a relatively large diameter and thus to control the location where it merged into the weld pool. As a result, the uncontrolled drop globular transfer in conventional GMAW as characterized by large droplets and poor weld formation was changed to a controlled drop globular process with improved droplet directionality and weld formation. The large current range associated with drop globular transfer, which required pulsing to change to spray transfer for practical applications, could now be used without pulsing. Desired heat input and current/arc pressure waveforms may thus be delivered by GMAW through laser enhancement.

Introduction

Gas metal arc welding (GMAW) is currently one of the most widely used welding methods due to its productivity (as a result of using an automatically fed consumable electrode) (Refs. 1, 2) and its convenience for mechanized/robotic applications. The transfer of the melted wire (electrode) onto the base metal is a process referred to as metal transfer. A good understanding of this metal transfer process and its mechanism plays a fundamental role in effectively using/improving this welding process for production of better welds at higher productivity and has thus been an active area of research and development in the welding community (Refs. 3-7).

A key issue is that of how the metal transfer largely depends on the welding current, which also determines other critical parameters including heat input and arc pressure. An application may require a preferred metal transfer mode that needs to be produced using a particular welding current while this current may result in a heat input and arc pressure that is not suitable for this application.

KEYWORDS

GMAW
Laser
Metal Transfer
Drop Globular
Drop Spray
Short Circuiting
Transition Current
Welding Current

For example, many applications prefer the metal transfer to take place in the spray mode, but it requires a current higher than the transition current (Ref. 8) to produce in conventional GMAW. In this mode, the arc pressure is (Ref. 9)  

\[ P_a = \frac{1}{4} \left( R_g^2 - R^2 \right) - 2 \varepsilon \left( R \cos(\alpha) \cos(kz) \right) \]  

where the arc current density  

\[ J_a = \alpha I \left( \frac{\alpha R^2}{(\beta^2 - 1)} + \pi R^2 \right) \]  

and \( \mu_0 \) is the permeability, \( R_g \) is the arc current radius, \( R \) is the equilibrium radius of the droplet, \( \varepsilon \) is the amplitude of the perturbation, \( \alpha \) is angular frequency, \( t \) is the time, \( k \) is a wave number, \( z \) represents the axial coordinate of a cylindrical coordinate system, \( \alpha \) is the ratio of arc to the liquid current density, \( I \) is the current, and \( \beta \) is the ratio of arc to the liquid radius (Ref. 9). It can be seen that the arc pressure is proportional to the square of the welding current. Increasing the welding current thus increases the arc pressure. An extremely high arc pressure is often not acceptable for many applications.

Pulsing current has been an effective method to achieve the spray transfer at a needed heat input determined by the mean current. However, the peak current in the pulse still must be higher than the transition current (Ref. 8). The high arc pressure issue aforementioned still remains, and an extremely high arc pressure often blows the liquid metal away from the weld pool and possibly causes melt through (in complete joint penetration applications). Further, the high peak current itself also increases undesirable fumes (Ref. 10).

The patented surface tension transfer (STT) method (Refs. 11-13), which adjusts the current waveform reactively based on the particular stage during the short-circuiting transfer process, is an effective method to reduce spatter to a min-
The American Welding Society classifies metal transfer into three major types/modes: short-circuiting, globular, and spray (Ref. 8). The International Institute of Welding (IIW) further classifies globular transfer into drop globular and spelled globular (Refs. 18, 19). The metal transfer process is governed by the forces exerted on the droplet. In dynamic-force balance theory (DFBM) (Refs. 19, 20), five major forces were used to analyze the metal transfer process. Surface tension is the main retaining force to support the droplet, while the gravitational force, electromagnetic force, aerodynamic drag force, and momentum force typically tend to detach the droplet. In the short-circuiting transfer mode, the detaching force, mainly the gravitational force, is not large enough to balance out the retaining force; the droplet would touch the weld pool. In this case, the merging of the droplet into the weld pool is critical in determining the production of possible spatter and the formation of the weld. For the globular transfer mode, as the repelled globular typically generates severe spatter, only the drop globular transfer may be adopted in applications. In the drop globular transfer, as the droplet cannot be detached at a reasonable small diameter, large and oscillating droplets may be expected in conventional GMAW that cause not only potential arc instability/fluctuation, but also uncontrolled droplet travel directions that directly result in the merging of the droplet with the weld pool at undesired locations to produce poor weld formations. The drop spray transfer mode is usually characterized by uniform droplet diameter, regular detachment, directional droplet transfer, and it is thus widely used in the industry.

The metal transfer in GMAW has been traditionally regarded as a two-stage process: first, a droplet forms at the end of the solid wire under the arc heating effect; second, the droplet detaches from the end of the welding wire and travels in the arc zone. The merging of the droplet into the weld pool after the travel in the arc-zone is also a stage in the transfer process but has not been much studied. As has been seen above, the merging is critical as it determines the process stability (short-circuiting transfer) or the capability to produce good weld formations (drop globular or spray transfer). To emphasize this, the authors add merging as the third stage for the convenience of analysis in this paper.

Existing methods aforementioned (Refs. 10–17) are “neat” using smart approaches to resolve different issues and difficulties, but being “neat” also restricts their applications in wider ranges. Toward the development of a more general method, the laser-enhanced GMAW as shown in Fig. 1 has been proposed/developed at the University of Kentucky (Ref. 21). It adds a relatively low-power laser to conventional GMAW, and the objective is to provide an auxiliary force to help detach the droplet at a desired diameter with any desired current that best suits the application, including future adaptive control applications where the current needs to be adjusted freely as determined by the control algorithm. It is apparent that laser-enhanced GMAW is fundamentally different from laser hybrid GMAW (Refs. 22, 23) where a laser beam of substantially high power aims at the base metal rather than the droplet. In a previous paper (Ref. 21) that first documented laser-enhanced GMAW, the laser recoil pressure force was demonstrated to be the additional force to help detach the droplet. The present paper analyzes its metal transfer mechanism in order to understand its uniqueness as a desirable process.

Experimental System and Conditions

Experimental System Setup

The principle of the proposed laser-enhanced GMAW is shown in Fig. 1. A laser beam aims at the droplet. The intention is to detach the droplet using the laser recoil pressure as an auxiliary detaching
force to compensate for the lack of the electromagnetic force or gravitational force associated with a relatively small amperage that is needed for a particular application, rather than provide additional heat to speed the melting of the wire. The associated additional heat from the laser should be negligible in comparison with that of the arc used.

Figure 2 shows the specified parameters to realize the laser-enhanced GMAW system used in this paper. To conduct the laser-enhanced GMAW process in an expected way, parameters need to be set appropriately. As shown in Fig. 2, three parameters should be determined: contact tube-to-workpiece distance $d_1$, angle between laser beam to GMAW welding gun $\theta$, and the distance from the point where the laser intersects the wire axis $d_2$. Standards to set these parameters are found in Ref. 21. Experimental results suggest that $d_1$ be set around 20 mm, $\theta$ be around 60 deg for easy installation at the expense of reducing system compactness, and $d_2$ be set at a range from 3 to 7 mm.

A high-speed camera was used to capture the video of the welding process for off-line analysis. Figure 3A shows the high-speed camera used that is capable of recording the metal transfer at 33,000 frames per second. A band-pass filter centered at 810 ±2 nm with full width at half maximum 10 ±2 nm was used to observe the process and record the images. All images presented in this study were recorded using the high-speed camera shown in Fig. 3A with this band-pass filter.

The University of Kentucky Welding Research Laboratory possesses a Nuvonyx Diode laser ISL-1000L (Fig. 3B) whose focal beam dimension is $1 \times 14$ mm and wavelength is 808 nm. When this laser is used, less than $1\%$ of the laser beam can be applied onto the droplet to generate the recoil force to detach the droplet as the diameter of the wire is 0.8 mm, and the diameter of droplet may be just slightly greater. For this research, the efficiency of the laser was not a primary concern, and the use of a laser of larger power and larger focal zone should not affect the effectiveness of the experimental results.

Figure 3B shows the arrangement of the laser in relation with the welding gun. In this experimental setup, the laser beam is aligned with the wire. In order to protect the end of the laser from possible contamination from fumes, a shielding board (not shown in Fig. 3B) is added between the laser and welding gun, and the laser is projected through a hole on the shielding board to the wire.

**Experimental Conditions**

A CV (constant voltage) continuous waveform power supply was used to conduct experiments. Pure argon was used and the flow rate was 12 L/min (25.4 ft³/h). The workpiece was mild steel, and experiments were done as bead-on-plate at a travel speed of 6.6 mm/s (15.6 in./min). The wire used was ER70S-6 of 0.8 mm (0.03 in.) diameter. The distance from the contact tube to the workpiece was 20 mm as aforementioned.

The welding voltage was set at four levels: 26, 28, 30, and 32 V. For each voltage, four different wire feed speeds, 250, 300, 350, and 400 in./min, were used to produce different welding current levels, resulting in 16 sets of experimental conditions. In all experiments, welding currents were not more than 135 A, which will generate short-circuiting or repelled globular transfer or non-wire-axis drop globular in conventional GMAW. The laser beam was continuously applied along the wire (solid and droplet) at four different levels of laser intensities for each of the 16 experimental conditions: 0, 46 W/mm², 54 W/mm², and 62 W/mm². There were thus a total of 64 experiments conducted. For convenience, the parameters will be presented as a set (wire feed speed, voltage, laser intensity). Figure 4 shows the mean current measured in all experiments. It can be seen that all the currents were lower than the transition current, which is approximately 150 A (Ref. 8) for the wire material and diameter. The current increases significantly as the voltage setting increases because of the reduced wire extension. However, the effect of the laser on the current is insignificant, no more than 5 A.

**Metal Transfer**

The diameter of the detached droplet is obtained from the series of high-speed images in this study. All images presented have the same dimension scale except for those presented individually. The time interval of consecutive images in the same series is constant. Figure 5 illustrates the scene in a typical metal transfer image.

**Observations**

Figure 6A shows a typical metal transfer cycle for the experiment conducted using wire feed speed, voltage, and laser intensity equal to 300 in./min, 30 V, and 0. This is a short-circuiting transfer in which...
the second and third stages of the metal transfer are combined. From Fig. 4, the current in this experiment was approximately 110 A. In the cycle shown in Fig. 6A, the combined detaching force from the electromagnetic and gravitational force was not sufficient enough to balance out the retaining force, i.e., the surface tension that is determined by the surface tension coefficient and diameter of the wire, before the droplet touched the weld pool. The transfer was short circuiting and spatter was produced. Examination of recorded images during this experiment showed that the short circuiting transfer dominated, although the globular transfer also occurred occasionally.

Figure 6B is a typical metal transfer cycle from the comparative experiment with the laser at an intensity of 62 W/mm². As can be seen, the large droplet did not touch the base metal before detaching, and there was no spatter produced. This is a free flight transfer type, and it is drop globular according to IIW classification (Refs. 18, 19). Examination of all images showed that all the metal transfer occurred as drop globular. It is apparent the laser made the difference in changing the metal transfer.

Per Ref. 21, the recoil pressure is the major force the laser applies to the droplet. Application of a laser beam to a droplet at an appropriate direction as in
this study ensures the recoil pressure to be a detaching force. The added detaching force from the laser recoil pressure reduces the need from other sources for the detaching force. When the electromagnetic force is given, the added detaching force from the laser recoil pressure reduces the needed gravitational force to balance out the surface tension. As a result, the diameter of the droplet needed for detachment is reduced. If the needed diameter is reduced sufficiently such that the droplet can grow to this diameter before it touches the weld pool, the short-circuiting transfer changes to a free flight transfer type as observed in Fig. 6B.

For these two comparative experiments, the laser does not change the mean welding current significantly as can be seen from Fig. 4B. However, as the droplet does not touch the weld pool, the fluctuation of the welding current is reduced as can be seen in Fig. 7. Further, because the droplet is detected before touching the weld pool, the average transfer time is reduced from 183.3 ms without the laser to 178.3 ms with the laser. The average diameter of droplet decreases from 2.23 mm without laser to 1.89 mm with the laser. The laser thus reduced the needed diameter (weight) of the droplet for detachment and changed the metal transfer type.

Figures 8–10 are typical metal images from three additional groups of comparative experiments using different wire feed speeds at 30 V. Because of the changes in the wire feed speed, the mean current varies from experiment to experiment (Fig. 4A, C, D).

First, the typical metal transfer as shown in Figs. 8A and 9A for 250 and 350 in./min without the laser was all short-circuiting transfer and a significant amount of spatter was produced. When the laser was applied, as can be seen from Figs. 8B and 9B, the metal transfer, changed to drop globular transfer and spatter was not formed. As the mean welding current did not increase (Fig. 4A and C), it was the authors’ opinion that it was the laser recoil pressure that effectively changed the type of the metal transfer. In addition, the changes in the metal transfer resulted in less fluctuating welding current as shown in Figs. 11 and 12, and the metal transfer process was thus more stable.

Second, when the wire feed speed increased to 400 in./min such that the current increased, the short-circuiting transfer no longer dominated. Figure 10A shows a consecutive transfer process where a short-circuiting transfer followed a drop globular transfer. This was typical in the experiment with 400 in./min without the laser, and different from other experiments in the series at the same voltage but lower wire feed speeds where the short-circuiting transfer dominated. The increased mean current was the major reason for the frequent occurrence of the drop globular transfer, but the welding current fluctuated into relatively low levels (Fig. 13A) also produced short-circuiting transfers from time to time. When the laser was introduced, short-circuiting transfers no longer occurred and transfers became totally free flight, as shown in Fig. 10B. The droplet diameter became similar to that of the electrode wire and transfer was close to droplet. As can be seen in Figs. 4D and 13, the mean current and current levels did not increase by the laser. It was the laser recoil pressure that effectively changed the metal transfer mode from a mix of short-circuiting and drop globular to the drop spray and reduced the fluctuation in the welding current.

Analysis

As has been observed above, the application of the laser changed the metal transfer. If the metal transfer in conventional GMAW is short-circuiting, the application of the laser at the intensity used could change it to the drop globular transfer. (The authors believe that it may further change to the spray transfer as long as the intensity of the laser is sufficient.) When a mix of short-circuiting and globular transfers dominates, it may change to the drop spray even with the laser intensity used. When the drop globular could be obtained, the laser reduced the diameter of the droplet detached. In all cases, the diameter of the detached droplets was decreased as further shown in Fig. 14. The laser recoil pressure was identified as the major cause of these observed changes.

To analyze further, let’s recall that in conventional GMAW, the major sources of the detaching force are the gravitational, electromagnetic, aerodynamic drag, and momentum forces, while the major retaining force is the surface tension at the interface of the solid wire and liquid droplet (Refs. 19, 20). When the diameter of the wire and material are given, this surface tension can be considered constant because the temperature at the interface aforementioned is the melting point and changes with neither the welding current nor the application of the laser. When the welding current is lower than the transition current such that the current exits from the droplet around its bottom, the electromagnetic force as a detaching force is relatively small. The aerodynamic drag force and momentum forces are typically relatively small and often negligible in analysis such that there is a need for a large gravitational force to balance out the surface tension for detachment. In this case, as shown in Fig. 6 and Figs. 8–10, the
diameter of the droplet is larger than that of the wire.

More specifically, when the wire feed speed is low, such as 250 to 300 in./min, the droplet needs to grow to acquire a sufficient mass to produce a sufficient gravitational force to balance out the surface tension. However, before this large mass is obtained, the droplet touches the weld pool because of the relatively slow growth (due to the relatively small current and arc heat). The metal transfer is dominated by the short-circuiting transfer. When the wire feed speed/welding current increases, for example to 350 in./min, such that the welding current and electromagnetic force increases, the mass needed to balance out the surface reduces. However, if this reduced mass needed is still not achieved before the droplet touches the weld pool, the transfer will still be short circuiting. In laser-enhanced GMAW, the laser recoil pressure is added to the detaching force, and the needed mass is reduced. If the needed mass is produced before the droplet touches the weld pool, the metal transfer would change from short circuiting to drop globular or effectively reduce the diameter of the droplet detached. As shown in Fig. 14, all the diameters of droplet in laser-enhanced GMAW are smaller than their respective counterparts in conventional GMAW. As long as there is a large enough laser recoil pressure (laser intensity), the drop globular and, the authors believe, drop spray would be obtained. To verify the latter, a larger intensity laser is needed.

Further, when the wire feed speed increases, such as to 400 in./min, the transfer will be dominated by a mix of globular and short-circuiting transfer in conventional GMAW. For the laser intensity applied, the short-circuiting transfer in conventional GMAW will change to drop globular in laser-enhanced GMAW. The drop globular in conventional GMAW could remain or change to the drop spray. In both cases, the diameter of droplet detached reduces in laser-enhanced GMAW, and the drop spray occurs when the diameter reduces to a level close to that of the wire.

**Controlled Drop Globular Transfer**

In the laser-enhanced GMAW experiments conducted in this study, drop globular was a major metal transfer mode. The authors found the drop globular transfer with an enhancement from a laser behaves differently from those without a laser enhancement in conventional GMAW.

Figure 15 shows two images in a cycle of drop globular transfer in conventional GMAW at 400 in./min, 30 V, and 0 W/mm². Figure 15A is the image of the droplet shortly before its detachment. It is found that the center of the sphere of the droplet is not exactly along the axis of the wire. In fact, as long as the droplet is not detached, the center of the sphere oscillates, as shown in Fig. 10A. The trajectory of the detached droplet is thus not fixed. It is not fixed along the axis of the wire and may change from cycle to cycle. As a result, the transverse location where the detached droplet merges with the weld pool is not fixed and may change from cycle to cycle. The images in Fig. 15A and B demonstrate this uncontrolled location associated with a droplet globular transfer in conventional GMAW. This type of drop globular is referred to as uncontrolled drop globular transfer in this study.

Figure 16 are counterpart images, of those in Fig. 15. Under (400 in./min, 30 V, 62 W/mm²), they show the droplet shortly before its detachment and merging into the weld pool.
weld pool in drop globular transfer with a laser enhancement. It is apparent that this laser-enhanced drop globular transfer differs from its counterpart in conventional GMAW. The center of the droplet sphere is approximately along the axis of the wire. There is indeed a slight deviation of this center from the axis, but observation and analysis of images in different cycles show:

1) its magnitude and direction are both consistent in different cycles; and 2) this slight consistent deviation is away from the direction of laser application. It is apparent that this deviation is caused by the laser recoil pressure. Because the droplet is approximately along the axis and the slight deviation is consistent in magnitude and direction, the transverse location of the merging is also consistent, slightly away from the axis of the wire. As can be seen, the application of the laser brings certain controls to the drop globular transfer, and the resultant drop globular becomes a controlled drop globular.

Drop globular is seldom used in industry (Ref. 8), and its uncontrolled droplet trajectory in a natural/uncontrolled form may be the major reason. However, there is a lack of effective solutions in literature. In laser-enhanced GMAW, the trajectory of the droplet is controlled by the laser recoil pressure, and the merging of the droplet in drop globular transfer becomes controllable. It is the laser that made the drop globular become controllable in this study. Laser enhanced drop globular transfer is a controlled drop globular transfer, but it is possible that a controlled drop globular may also be achieved using other means.

Compared to the uncontrolled drop globular process, a controlled drop globular process produces welds more consistently because of the controlled/consistent droplet trajectory and transverse merging location. As can be seen in Fig. 17A, a typical weld produced by uncontrolled drop globular lacks control on the transverse direction. Spatter is also found because some droplets may merge into the weld pool at its edges (Ref. 8). Rough weld surfaces are also found because of the uncontrolled positions where large droplets merge into the weld pool. In laser-enhanced GMAW, all issues, weld direction inconsistency, spatter, and rough weld surfaces, are resolved by the controlled/consistent droplet trajectory, controlled/consistent/appropriate merging location, and reduced droplet size, as shown in Fig. 17B. Quality welds may thus be produced by the laser-enhanced GMAW at a controlled drop globular transfer, and drop globular thus may become a valid process for applications where the current requires desired waveforms or need to be below the transition current.
Conclusions

- An experimental system has been established, and a series of 64 sets of experiments have been designed and conducted to symmetrically study the laser-enhanced GMAW.
- The laser aiming at the droplet in laser-enhanced GMAW applies an auxiliary detaching force on the droplet without a significant increase in the current.
- Free flight transfers could be successfully produced at continuous currents from 90 to 135 A with a 0.8-mm-diameter steel wire without spatter.
- Laser-enhanced metal transfer process is also governed by the established physics of metal transfer except for there is a need to include the additional detaching force generated by the laser.
- If the metal transfer is short-circuiting in conventional GMAW, laser-enhanced GMAW may change it to drop globular transfer. If conventional and laser-enhanced GMAW both produce drop globular, the latter reduces the diameter of the droplet. If the metal transfer is short-circuiting or drop globular transfer in conventional GMAW, laser-enhanced GMAW may become the drop spray. The established physics of metal transfer can explain all changes by counting the additional detaching force introduced by the laser.
- Controlled drop globular transfer in laser-enhanced GMAW offers desirable metal transfer characteristics that benefit the formation of quality welds.
- Controlled drop globular transfer extends the capability of the productive GMAW process into the range of constant current that conventionally produces an undesirable drop transfer, which is not most suitable for practical use.
- Laser enhancement provides an effective method to achieve a controlled drop globular transfer and to enable GMAW to use a constant current in an increased range to meet the requirements for different applications.

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References

Application of Electro-Spark Deposition as a Joining Technology

The implicit high cooling rates and low individual splat volumes associated with electro-spark deposition facilitate joints in both difficult-to-weld materials as well as dissimilar material combinations

BY J. GOULD

ABSTRACT

Electro-spark deposition (ESD) has long been used as both a repair and coating technology for a range of material systems. Applications have ranged from repair of Ni-based superalloys to deposition of carbide coatings onto steel cutting blades. The technology is unique in that deposition is accomplished by individual splats of material from the electrode onto the substrate. The scale of these splats is sufficiently small to result in extremely high cooling rates. These high cooling rates have facilitated deposition of difficult to work with materials. In addition, the process has allowed application onto widely disparate dissimilar materials systems. In this work, the technology has been evaluated for direct welding in two candidate applications. These include a nano-stabilized stainless steel for fusion energy applications, and refractory metal to cast Ni-based superalloy combinations for nuclear space propulsion. Sample joints were fabricated for each of these applications, and assessed using metallographic and mechanical testing techniques. Joints on the nano-stabilized steels retained the fine character of the substrate, albeit with some coarsening of the stabilizing precipitates. Joints between the refractory metals and cast Ni-based superalloy were done with a Hastelloy® X filler. Joints showed minimum reaction zones, and properties characteristic of the softer of the two materials joined. Results are discussed in terms of rapid solidification and solid-state phase transformation suppression. Metallurgical and productivity implications are then discussed, and criteria for potential applications described.

Introduction

Electro-spark deposition (ESD) is a microwelding process that uses rapid electrical power discharges to accomplish metal transfer from an electrode to a contacting substrate. Typically, the process is conducted with a capacitive discharge power supply that provides the short-duration current pulses (10–400 μs). These current pulses are supplied at a range of frequencies ranging from a few hundred to a few thousand hertz. The electrode itself is generally integrated into some device creating high-speed motion relative to the substrate. Examples include both rotating and vibratory approaches. The applied current pulse combined with the intermittent contact (associated with the high relative contact velocity) results in extremely rapid heating, with subsequent localized transfer of material from the electrode to the substrate.

Electro-spark deposition was first defined as early as 1924 (Ref. 1), where it was used for local deposition of martensitic coatings on steels. From the 1940s to the present day, this process has been investigated primarily for a range of coating applications (Refs. 2-7). Initial work with ESD used capacitive-discharge power sources, where motion of the electrode created the resulting charge and discharge cycles. In more recent years, Si-controlled rectifier (SCR) and insulated gate bipolar transistor (IGBT) circuits have been used (in conjunction with either resistor-capacitor (RC) type analog or microprocessor-based triggering) to create more rapid and reproducible charging and discharging of the capacitors, with subsequent improvements in deposition rates (Ref. 6). As suggested above, various motion mechanisms have also been explored, including vibratory, translational, and rotational modes (Refs. 2-4). The resulting combination of processing and electrode motion conditions has resulted in uneven coating thicknesses of up to 1 mm (Ref. 4).

Through this work, ESD has also been shown to be sensitive to a wide range of material, process, environmental, and torch motion conditions (Ref. 2). It is also of note that there are trade-offs between deposition rates and quality. It has been reported (Ref. 4) that above a deposition thickness of roughly 100 μm, a phenomenon termed “lumping” occurs. Lumping is defined by a nonuniform coating, with localized heavy deposition of material. Lumping appears to be a progressive process (areas of lumping appear to continue to receive preferential deposition of material) and is strongly affected by the quality of the shielding gas. For most applications, both high deposition rates and good surface finish are necessary if the process is to be used effectively.

Electro-spark deposition is commonly used for repair and buildup of Ni-based superalloys (Refs. 8, 9). Current ESD practices for such applications allow dep-
position rates up to 10 mg/min (Refs. 8, 9). The low deposition rates implicitly associated with this technology generally negate the approach to surface repairs. However, analysis of these repairs indicates both high as-deposited properties minimal metallurgical defects (Ref. 9).

A key advantage of ESD is the rapid thermal cycles associated with the technology. Metallurgical assessments of deposits made with ESD have demonstrated that a single pass typically results in a layer thickness of from 1 to 5 μm (Ref. 9). Previous work has suggested cooling rates in the range of $10^5{\,}^\circ{\text{C}}/s$ to $10^6{\,}^\circ{\text{C}}/s$ (Ref. 9). Cooling rates of this magnitude are considerably outside the range of other conventional joining processes (Ref. 10). Rather, these cooling rates more are consistent with impulse methods such as percussion welding (Ref. 11), and magnetic pulse welding (MPW) (Ref. 12). Microstructural observations in Ni-superalloy deposits also demonstrate similarities with those from percussion welding (Ref. 11) and MPW (Refs. 13, 14).

Electro-spark deposition, percussion welding, and MPW all can be considered variants of “impulse” technologies. Each is essentially driven by capacitively stored electrical energy, occurs over an effective discharge cycle in the range of 10s to 100s of microseconds, and results in resolidified molten zones with thicknesses in the range of microns. It is of interest that percussion and MPW are commonly applied to both difficult to join and dissimilar material combinations (Ref. 15).

In this work, the use of ESD on two specific material combinations is addressed. The first is joining of mechanically alloyed steels. Nano-structured ferritic alloys (NFAs) are currently under consideration for fusion energy applications (Ref. 16). These materials of nominally a ferritic stainless steel composition, stabilized by a high density of Y-Ti-O precipitates. A typical alloy is MA957. Materials are mill ground into powders (Fe-14Cr-W-Ti and Y2O3), and hipped or extruded for final consolidation. This results in a high density of nano features, largely based on the Y-Ti-O composition, with particle sizes ranging up to ∼8 nm. These materials show excellent tensile and creep strengths, as well as offer potential for mitigating radiation effects (Ref. 17). Joining is a challenge with these materials. Thermal processing associated with most welding processes is anticipated to coarsen the precipitates and negate their effectiveness as strengthening mechanisms. Electro-spark deposition was considered here, largely to assess the influence of the rapid heating and cooling rates on coarsening characteristics of the Y-Ti-O precipitates.

The second application addresses joining high-volume fraction gamma prime Ni-based superalloys to refractory metals. The primary application here is for space nuclear propulsion (Ref. 17), allowing a transition from the refractory metal-based reactor to a high-temperature Ni-based superalloy turbine. Concepts for space nuclear propulsion in the early 21st century have incorporated high-temperature Brayton cycles with working fluid temperatures on the order of 850°C (Ref. 17). Concept designs involve a refractory metal-based nuclear reactor as the heat generation source, and a Ni-based superalloy Brayton cycle turbine for mechanical power generation. Candidate materials
for the reactor itself include Mo-Re and Ta-W alloys. Materials for the turbine range from wrought to cast Ni-based superalloys. Metallurgically, bonding of either Mo- or Ta-based systems to Ni-based systems is problematic. In both cases, there are disparities in melting points, low-melting eutectics, and a range of intermetallic compounds. The presence of eutectics is problematic since this can lead to solidification cracking in the fusion zone, as well as liquation cracking in the heat-affected zone (HAZ). Brittle, intermetallic formation can lead to poor mechanical performance in the weld area. These concerns largely rule out conventional fusion welding processes for these applications. Electro-spark deposition was considered for joining these materials largely based on the success of other impulse welding approaches (MPW, percussion welding) for joining such disparate material combinations.

**Experimental Procedures**

Electro-spark deposition welding was demonstrated for the MA957 application on material specimens nominally 10 mm wide, 17 mm long, and 2 mm thick. Samples were placed together in a butt configuration, and a scalloped joint prep, nominally 1.2 mm deep with a 6-mm radius, was used. The welding electrode was nominally 3 mm in diameter, 100 mm long, and made of matching material. The assembly configuration is shown in Fig. 1. The electrode itself was prepared with a nominal 90-deg included angle at the tip for these trials. The ESD unit is shown in Fig. 2. This is an ASAP unit with hand-held torch. Deposition conditions are provided in Table 1. Processing paralleled previous work on Ni-based alloys (Ref. 9). Deposition was done with augmented cross-flow shielding as shown in Fig. 3. The weld was completed by first creating layers of material to fill the scalloped joint prep. The joint prep was then repeated on the reverse side, and then filled using the developed ESD practice. Total time for assembly of this joint was on the order of several hours. Resulting specimens were examined through metallographic inspection, hardness testing, and limited tensile testing. Metallographic sectioning and preparation was done using standard techniques. Samples were examined in the unetched condition. These samples were also used for Vickers hardness testing. This was done on a LECO system with a 1-kg weight. Tensile testing was done on a single specimen, transversely across the weld. The specimen used a reduced gauge section, nominally 5.3 mm wide by 1.7 mm thick. This preparation resulted in machined surfaces at the faces and edges of the gauge area. Tensile testing was done at 1.27 mm/min, recording loads to failure.

The refractory metal to Ni-based superalloy trials were done with two configurations. These included two refractory metal alloys, T-111 (Ta-8%W-2%Hf) and Mo-47%Re, each welded to a cast Ni-based superalloy (MarM-247). Samples for joining were prepared as ½ tensile specimens. Materials were nominally 0.5 mm thick, with a 13-mm base width, reduced to 6 mm in the gauge area. Actual joint prep was again a scallop configuration, similar to that described above. In this case, the scallop was 0.35 mm deep with a 3-mm radius. The welding electrode in this case was of a Hastelloy®-X material, nominally 1.6 mm in diameter. The actual joining configuration was similar to that described in Fig. 1. Welding was done with the same ASAP power supply and torch as shown in Fig. 2. A major difference for these trials was the use of enhanced shielding techniques. Since oxidation during deposition was a major concern, all deposition trials were done in a hard glove box, shown in Fig. 4. In this glove box, the dewpoint could be maintained below -70°C and 1-ppm oxygen. The power supply, torch, and any necessary tooling were placed in the chamber prior to conducting the deposition trials. The ESD setup included a Cu fixture with two restraining straps. In addition, Hastelloy® backing plates and run-off tabs were used to maintain both quality and geometry of the joint. Welding practices similar to those shown in Table 1 were used. This practice resulted in a peak current on the order of about 180 A and a pulse width of roughly 60 μs. Sample current waveforms...
for the T-111 to MarM 247 and Mo-47%Re to MarM 247 practices are provided in Figs. 5 and 6, respectively. The process can be described as first buttering the refractory metal and MarM 247 with the Hastelloy®-X, and then filling in the remainder of the joint. In all cases, the back of the sample was also ESD filled to ensure final geometry of the specimen. Assembly of each tensile specimen took roughly 8 h. Samples for metallographic inspection were mechanically polished and subjected to a two-state etching process. The Ni-based superalloy half of the joint was etched with a 40% HCl, 30% HNO3, 10% glycerol, 20% acetic acid solution. This solution allowed clear resolution of the retained solidification structure in these materials. The refractory alloy half of the joint was etched in a 20% HF, 10% HNO3, 15% H2SO4, balance H2O solution that was effective in decorating grain and structural boundaries in these materials. Tensile testing was done on replicate samples of each configuration. Testing was done at the NASA Glenn Research Center (Ref. 18). Samples had the run-off tabs removed and were ground nominally flat. Testing was done to provide yield strengths, tensile strengths, and elongations to failure.

Results

Welding of the MA957 samples was conducted using the procedures defined above. The surface of the resulting joint is shown in Fig. 7. The individual splats are evident, as well as the consistency of the final joint geometry. A cross section of the weld is provided in Fig. 8. The cross section clearly indicates that the joint morphology itself consists of a number of overlaid splats. These splats are of a very fine scale, not appreciably coarser than the grain size of the base material. The morphology of the joint also shows some dark bands, nominally running along the contour of the fill. These may be related to soot that becomes integrated into the joint with subsequent passes. It is also apparent that there is virtually no HAZ associated with this weld. Here, the base metal microstructure extends to within a few hundred microns of the first deposited splat layer.

Hardness variations across the joint are presented in Fig. 9. The base material shows a hardness level of nominally 330 VHN. Within the weld, hardness swings are noted. Peak hardnesses in excess of 350 VHN are observed within this weld, as well as values as low as 290 VHN. The high hardnesses in the weld are believed related to the fine splat morphology implicit in the fusion zone. The low hardness observations may be related to high levels of porosity within these welds as has been suggested elsewhere (Ref. 16). A single tensile test was done on one of these ESD joints due to limited material availability. The joint exhibited an ultimate strength of roughly 700 MPa, and failed along the FZ-HAZ interface. The strength here is about 65% that of the base material (Ref. 19). The resulting failed sample is shown in Fig. 10. The failure corresponds to the region of low hardness (in Fig. 9), and is probably the result of porosity as discussed previously. Finally, small angle neutron scattering (SANS) analysis was done elsewhere (Ref. 16) and suggests some redistribution of the nano-features. That work indicated the nano-features roughly doubled in size (2.4 to 4.7 nm) and decreased in density (0.6 to 0.12%) as a result of ESD processing. It was also suggested that this coarsening may have been partially responsible for the loss in properties seen in this part of the weld.

An example of a rewelded tensile refractory metal to Ni-based superalloy specimen is provided in Fig. 11. The morphology is quite similar to that seen for the MA 957 welding trials described previously. Joints are again relatively smooth and conform nominally to the overall shape of the part. This is characteristic of the fine splats deposited during ESD processing.

Macrographs of the T-111 to MarM 247 and Mo-47%Re to MarM 247 joints are provided in Figs. 12 and 13, respectively. The cross sections indicate minimal dilution, and relatively high density of the deposits. Deposition on both the scalloped and back sides of the joint can also be seen. These results suggested that interactions between the fill and the substrate were highly localized. This is can be observed in the higher magnification micrographs for representative T-111, Mo-47%Re, and MarM interfaces in Figs. 14–16, respectively. Results for deposition of the Hastelloy®-X onto the two refractory metals indicate little change to the substrates, with splats nominally 5 μm thick apparently wetting the surfaces. In this case, any compositional changes must be considered over this first layer of splats. For the deposit onto the Mar-M 247 alloy (Fig. 16), there is clearly some mixing and compositional transition. However, this transition again appears to be limited to the first one or two layers of splats (10–15 μm).

Duplicate tensile tests were made for each of these joint combinations. Yield, tensile, and elongation results are provided for each joint tested in Table 2. The T-111 to MarM 247 joints showed yield strengths above 600 MPa, tensile strengths near 700 MPa, and elongations ranging from roughly 5 to 9%. Alternately, the Mo-47%Re to MarM 247 joints showed both yield and tensile strengths of roughly 800 MPa, with little elongation (~0.5%). The results here are compared with mechanical properties data for each material (T-111, Mo-47%Re, MarM 247, Hastelloy X) from standard literature sources (Refs. 20–23). These results are presented in
Fig. 14 — Details of the T-111 substrate to Hastelloy®-X fusion zone interface following ESD welding.

Fig. 15 — Details of the Mo-47%Re substrate to Hastelloy®-X fusion zone interface following ESD welding.

Table 3. In each case, the yield strength of the weld corresponds to the weaker of the two attached substrates, rather than the Hastelloy®-X filler.

**Discussion**

**Cooling Rates during Electro-Spark Deposition**

As suggested previously, a key characteristic of electro-spark deposition is the high implicit cooling rates associated with the technology. Some estimation of these cooling rates can be achieved from simple thermal analysis. During ESD, it is understood that liquid droplets of the filler metal are formed by individual percussive actions (Ref. 8), resulting in the observed individual splats. The thermal analysis involves interpreting the behavior of the individual molten splat as it impinges on the surface. This is essentially a one-dimensional heat transfer problem, in which the heat of fusion is conducted away from the splat into the metal substrate. The governing equation here is of the form

\[ T(x,t) - T_0 = e^{-f} \left( \frac{x}{2N_{\alpha} N_{A}} \right) \]

Where \( T(x,t) \) is the temperature as a function of displacement into the substrate \( x \), and time after splat impact \( t \), \( T_0 \) and \( T_c \) are the initial (melting) temperature of the splat and the ambient temperature, and \( \alpha \) is the thermal diffusivity. The boundary condition for this construct can then be established by matching the thermal gradient into the substrate to the available heat of fusion in the splat. This can be expressed as

\[ -k \frac{dT}{dx} \bigg|_{x=0} = \frac{d}{dx} \left( \H_{m} \rho_{x} \frac{A}{C_{p}} \right) \]

Where \( k \) is the material thermal conductivity, \( \rho \) is the density, \( x_{sp} \) is the splat thickness, \( H_{m} \) is the heat of fusion, and \( f \) is the fraction molten material remaining in the splat. The former expression can also be differentiated to define the thermal gradient in the substrate. This has the following form:

\[ \frac{dT}{dr} \bigg|_{x=0} = \frac{d}{dr} \left( \frac{T - T_0}{\sqrt{\pi \alpha t}} \right) \]

For \( t > 0 \). The latter form of Equation 3 then can be combined with Equation 2, and reorganized to provide the following integral relationship:

\[ \int_{t_0}^{t} \frac{T - T_0}{\sqrt{\pi \alpha t}} \, dt = \frac{x}{\sqrt{\pi \alpha}} \int_{t_0}^{t} T - T_0 \, df \]
Combining Equations 3, 5, and 6 then yields the following cooling rate expression:

$$\frac{dT}{dt} = -\frac{2\alpha C_p}{\pi x^2 H_m} \left(T - T_m\right)^2$$  

(7)

This corresponds to peak cooling rates occurring at the termination of solidification of the splat. For comparison purposes, Equation 7 has been used to plot implicit cooling rate results for a number of the applications described in this paper. Material thermal properties for these applications are estimated from data available in the literature (Refs. 23–25), and are provided in Table 4. These results are shown in Fig. 17. Most notable, cooling rates here are seen to range from roughly 10<sup>6</sup>C/s to 10<sup>8</sup>C/s. This is considerably higher than the 10<sup>5</sup>C/s to 10<sup>6</sup>C/s rates reported previously (Ref. 9). It must be remembered, however, that these cooling rates represent those occurring at the instant of solidification, and will moderate rapidly at lower temperatures. The results shown in Fig. 17 do indicate the influence of splat thickness, as well as the substrate and deposited materials used. These results suggest first that a doubling in the resulting splat thickness can reduce cooling rates by an order of magnitude. Also, it appears depositing MA957 or Hastelloy X onto similar material substrates results in similar cooling rates. This is not surprising, in that thermal properties are similar for these two material systems (Table 4). However, cooling rates increase by roughly a factor of three when the Hastelloy® X is deposited onto the tantalum substrate. This appears related to the high thermal diffusivity associated with the substrate material.

**Metallurgical Implications of ESD Welding**

Electro-spark deposition, as indicated previously, accomplishes material transfer through melting and resolidification of discrete volumes of material. These volumes are necessarily small, resulting in the 1- to 5-μm splat thicknesses shown in the two applications presented. The analysis shown here suggests that implicit cooling rates for these splats can be as high as 10<sup>6</sup>C/s to 10<sup>8</sup>C/s at the terminus of solidification. Observations of other researchers have suggested that solidification of the splats occurs with a fine dendritic structure (Ref. 26). This observation is consistent with the experience of this author. The morphology of the splats, consistent with the results presented in this work, also appears to occur without identifiable segregation. To understand this solidification behavior, it is helpful to look to related process technologies, particularly MPW. As suggested previously, MPW shows similar thermal cycles and solidification morphologies (melt zone thicknesses) as seen on the individual splats during ESD. Recent work (Ref. 27) has been done evaluating chemical compositions of resolidified melt zones during MPW Al to Cu and Al to steel. That work has shown that the composition of the melt zone is uniform, apparently devoid of local segregation. While the authors of that work suggest that the resulting compositions may be intermetallic related, they do not match up to any intermetallic in the systems studied. This work can also be seen as verification of rapid solidification without segregation.

The implication of such observations is that the solidification times during ESD (or other impulse processes) are sufficiently short that the concept of local equilibrium has broken down. Local equilibrium is the mechanism (Ref. 28) of segregation during solidification, and is one of the contributors to the instabilities that lead to cell/dendrite formation (Ref. 29). Without sufficient time for this segregation to occur, the material behaves as a pure material, with the scale of the solidification structure driven by surface tension (Ref. 28). Impulse processes then offer the potential for solidification without compositionally driven cracking mechanisms (Ref. 30). Further, such extreme cooling rates also offer potential for

### Table 4 — Thermal Properties for Each of the Materials under Evaluation during the Modeling Studies (410 SS properties are used in lieu of available values for MA957)

<table>
<thead>
<tr>
<th>Material</th>
<th>410 SS&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Hastelloy X</th>
<th>T-111</th>
</tr>
</thead>
<tbody>
<tr>
<td>α (m&lt;sup&gt;2&lt;/sup&gt;/s)</td>
<td>7.57 x 10&lt;sup&gt;-6&lt;/sup&gt;</td>
<td>7.74 x 10&lt;sup&gt;-6&lt;/sup&gt;</td>
<td>2.24 x 10&lt;sup&gt;-5&lt;/sup&gt;</td>
</tr>
<tr>
<td>C&lt;sub&gt;p&lt;/sub&gt; (J/kg·°C)</td>
<td>460</td>
<td>440</td>
<td>150</td>
</tr>
<tr>
<td>H&lt;sub&gt;m&lt;/sub&gt; (J/kg)</td>
<td>2.72 x 10&lt;sup&gt;5&lt;/sup&gt;</td>
<td>3.06 x 10&lt;sup&gt;5&lt;/sup&gt;</td>
<td>1.70 x 10&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>k (W/m·°C)</td>
<td>26.9</td>
<td>27.2</td>
<td>56</td>
</tr>
<tr>
<td>ρ (kg/m&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>7730</td>
<td>7990</td>
<td>16650</td>
</tr>
<tr>
<td>T&lt;sub&gt;m&lt;/sub&gt; (°C)</td>
<td>1505</td>
<td>1310</td>
<td>2996</td>
</tr>
</tbody>
</table>

<sup>a</sup>410 SS is used as a substitute here for MA957.
suppressing diffusion-based solid-state phase transformations. This offers additional potential for avoiding deleterious phase formation. It is not surprising then, that impulse technologies are often applied to dissimilar combinations. Successful MPW Al to Cu (Refs. 13, 27), Al to steel (Ref. 27), percussion welding Ag to Cu, and even ESD of complex coatings (Refs. 3, 6, 13) all demonstrate the capabilities of these technologies. Indeed, ESD welding has been found useful for the applications described due to the homogeneity of the deposit, and minimization of any transition zones between materials.

Electro-spark deposition, of course, achieves these high cooling rates by depositing microvolumes of metal onto a nominally cold substrate. Clearly, the benefits of the technology are reduced as the deposition rate increases. In fact, ESD only appears to be functional at deposition rates in the milligram/minute range. As a result, using this process to create joints is a time-intensive process (multiple hours to create a single thin-gauge tensile coupon). Further, these joints must consist of hundreds, if not thousands of overlaid deposits (splats).

The required processing suggests that ESD welding is limited in its applications. These inevitably will be very high value-added applications, where material compatibility is a major joining challenge. A transition joint between refractory metals and cast Ni-based superalloys is one such example. Similarly, complex material systems that react adversely to welding thermomechanical cycles are another potential application such as the MA957 application described previously. Finally, the process may be adaptable where automation (providing the multiple overlayers required to achieve a joint) can be used. An example of this is transition joints, which can be made to a relatively simple geometry and then adapted into a larger configuration.

Conclusions

Electro-spark deposition welding is an adaptation of ESD for the attachment of complex material substrates. Thermal cycles during ESD are analogous to other impulse-type processes, including percussion welding and MPW. As a result, deposits made during ESD processing have extremely high implicit cooling rates. Analysis conducted here suggests these cooling rates can be on the order of 10^9 to 10^9°C/s at the terminus of sput solidification. These high implicit cooling rates are seen as enablers to joining metallurgically complex materials, as well as substrate combinations that are metallurgically incompatible. Work here has demonstrated two such applications. The first is the attachment of new grades of mechanically alloyed (MA957) stainless steels. The second is dissimilar material attachments between refractory metals and cast Ni-based superalloys. Successful joints were made in both cases. MA957 joints were made with some coarsening of the nano-features, but overall exhibited a refined microstructure. Refractory metal joints were made with strengths approaching that of the weaker of the two base materials joined. The approach is technically feasible for a wide range of materials and combinations currently not able to be joined today. However, the process is exceptionally slow (single digit milligram/minute deposition rates), and must be limited to extremely high-value applications, where materials joining is exceedingly problematic. Potential applications include transition joints for dissimilar material combinations, and those of sufficient simplicity that extensive automation can be employed.

References

Effects of Laser Parameters on Porosity Formation: Investigating Millimeter Scale Continuous Wave Nd:YAG Laser Welds

An evaluation of the role continuous wave laser process parameters has on pore formation in milliscale keyhole mode welds is presented

BY J. T. NORRIS, C. V. ROBINO, D. A. HIRSCHFELD, AND M. J. PERRICONE

ABSTRACT

Porosity formation in milliscale partial penetration Nd:YAG laser keyhole mode welds is not well understood. Prior investigations of weld porosity examining the relationship between process parameters and laser keyhole stability have largely been qualitative and mostly focused on welds outside the milliscale regime with a penetration in excess of 2 mm. Little characterization of milliscale keyhole regime welds, ubiquitous in dense miniature packaging, has been performed and as a result, very limited design guidance is available for manufacturing of such components. The present study utilizes a systematic evaluation of the role with continuous wave (CW) laser process parameters on pore formation in milliscale keyhole mode welds. Parameters investigated include laser output power, weld speed, and beam size. Porosity characteristics were obtained through X-ray radiography and contrasted to metallographic weld analysis and laser process parameters. Results showed distinct trends in pore formation. For CW laser welds, the average pore size was found to increase linearly with the weld cross-sectional area and parabolically as a function of heat input. Three porosity types were identified that exhibit unique size, location preference, and frequency. Deeper penetration pore-free welds were achieved by using longer lens focal lengths (larger focused beam size). As a result, a simplified geometric weld model is proposed that correlates laser beam spot size as a function of lens focal length and penetration to the onset of porosity. Process parameter maps have been developed to assist in successful weld development. It is shown that through the use of appropriate process parameters, weld porosity can be greatly reduced, if not fully suppressed, in milliscale Nd:YAG laser keyhole mode welds.

Introduction

Porosity in laser welds has largely been attributed to laser keyhole instabilities in the weld pool. Collapsing of the keyhole is thought to trap a gas pocket creating a void (pore) in the weldment — Fig. 1. The mechanisms that lead to instability are not fully understood as many factors are believed to contribute to the general condition of the keyhole. Factors including weld size, laser output modes (e.g. pulsed, continuous wave [CW], and modulated), material type, and weld joint geometry, all impact laser keyhole formation and evolution. Given that many variables affect keyhole stability, it is not surprising that many researchers consider porosity formation to be random (Refs. 1–3). Prescribed methods for avoiding this defect are scarce in the literature and tend to focus predominantly on large-scale welds, commonly much greater than a 2-mm penetration (Refs. 2, 4). Very little information on mitigation tactics for smaller milliscale (<2 mm) laser welds common to dense, miniaturized packaging exists (Refs. 5, 6).

Risk related to weld porosity is not easily quantified as it can result in a loss of weld strength, premature fatigue failure, increased in-service creep, and depending upon the gases trapped inside the pores, reduced corrosion resistance (Ref. 7). Each of these can be detrimental to the component’s functionality. The extent to which these weld failures occur depends largely upon application — magnitude and type of loading forces, service environment, expected life, etc. — and the severity of the porosity. Applications that suffer the most as a result of porosity are high-reliability applications such as medical and satellite hardware. Reduced reliability and increased risk imposed by weld porosity cannot be accommodated in these applications. Because these component types are often temperature sensitive due to their dense miniaturized packaging, they require a low-heat input joining process, specifically laser keyhole mode welding. As component designs are driven toward smaller and denser packages, porosity in milliscale welds must be better understood.

The objective of this study is to analyze porosity formation in milliscale continuous seam Nd:YAG laser keyhole mode welds and provide guidance for manufacturing such welds. Efforts focused on closure type welds in 304L austenitic stainless steel and the effect of operating parameters, specifically laser output power, weld speed, and lens focal length (or spot size).

Experimental Setup

A Rofin-Sinar Nd:YAG laser, Model CW 015 HQ, and a GSI Lumonics Nd:YAG laser, Model JK802, were used to produce sharp-focus, standing-edge welds on hot rolled 304L stainless steel sheets 1.27 mm thick — Fig. 2. Both lasers...
were flash lamp driven and fiber delivered. Weld sample composition (in wt-%) was 0.03% C, 18.09% Cr, 0.2% Cu, 1.73% Mn, 0.16% Mo, 0.06% N, 8.57% Ni, 0.36% Si, 0.024% P, and 0.001% S. Weld samples were dimensioned to 100 × 25.4 × 1.27 mm with a weld length of 89 mm. In order to minimize deformation for optimum part fitup and maintain square joint corners, weld samples were electric discharge machined (EDM) and lightly machine finished along the long edge to remove any EDM wire deposit. Prior to welding, all samples were ultrasonically cleaned in isopropyl alcohol.

The average laser power was measured prior to each test set using either an Ophir Nova II meter with a 1000-W thermal head detector or Macken Instruments P2000 laser power probe. The average power ranged from 300 to 1200 W at travel speeds from 13 to 51 mm/s with a spot size of 200 to 500 μm. Spot size was measured with a Prometec Laser Scope UFF100. All welds were made at a sharp focus using 80-, 120-, 160-, and 200-mm lens focal lengths. Ultrahigh purity (UHP) argon shielding gas was delivered with a side shield nozzle trailing the weld pool (Rofin-Sinar welds) or coaxially (GSI Lumonics welds) at flow rates of ~33 standard L/min. Weld porosity was quantified by postweld X-ray radiography using an AXI Viscom Micro Focus X-ray at 120 kV and 100 μA.

X-ray radiography was used to characterize porosity throughout the fusion zone. The standing edge joint geometry allowed for a “side-to-side” X-ray of the sample resulting in images that reduce pore volume to a two-dimensional projection relative to the weld penetration — Fig. 3. Top-down X-rays revealing pore locations along the weld width were not taken because small pores would not appear due to the height of the samples. Therefore, differentiating individual pores within the same plane relative to the weld width was not possible. As a result, some pores may appear irregular in shape or oversized, and thus limits the pore analysis to the approximation of pore diameter, location, and frequency (relative to the weld penetration).

While some inference of pore location relative to width may be obtained from metallographic transverse cross sections, this information is not believed to be critical to the pore analysis. Due to the restricted contrast between the pores and surrounding material, pore diameter resolution was limited to 0.13 mm. Pores measuring less than 0.13 mm diameter and comparatively rare in occurrence were defined as micro pores, pore free, or having a diameter of 0.075 mm (one-half the pore diameter resolution) for the purpose of graphical analysis. For each weld sample, the average pore diameter was determined by superimposing multiple line segments (25 mm in length) over a region of porosity, measuring the width of each pore intersecting the line, and then calculating an average diameter. This ensured that all pore sizes were accounted for despite considerable differences in contrast.

By multiplying the number of pores within a line segment with the weld speed, the frequency of pore formation could be determined. Attempts were made to use automated image analysis software to determine the pore characteristics, but it was unsuccessful due to large contrast variations between pores. The result was undetected or oversized pores, the extent of which varied between samples. Longitudinal and transverse metallographic cross sections were made to allow the assessment of weld penetration, width, and cross-sectional area. Three to four transverse sections, chosen randomly along the length of the weld, were made per weld sample.

**Results and Discussion**

**Identification of CW Porosity Types**

Analysis of the CW welds revealed three types of porosity that can be qualitatively described as uniform, transitional, and root. Uniform porosity appears to have an even distribution throughout the fusion zone of small-diameter pores generally less than 0.25 mm — Fig. 4A. This type of porosity was only observed at high-weld velocities (i.e., 34 mm/s). Root porosity, often referred to as linear porosity (Ref. 8), predominately forms at the root of the weld, appears relatively consistent in size (for a fixed weld parameter), forms at a perceived frequency, and coincides with lower travel speeds — Fig. 4C. This episodic formation implies that keyhole collapse likely occurs at a regular frequency. Transitional porosity exhibited characteristics of both root and uniform porosity containing periodic

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**Fig. 1** — Common Nd:YAG laser beam weld porosity. A transverse metallographic cross section exposing an irregularly shaped pore (~0.5-mm-diameter dark region) formed at the base (root) of the weld.

**Fig. 2** — Weld setup schematic. Weld joint consists of two side-butted flat plates. The laser is focused at the top of the sample and centered on the weld joint. Welds made with the Rofin laser used trailing side nozzle gas shielding (as shown above). Welds made with the Lumonics laser used coaxial shielding along the beam path (not shown).

**Fig. 3** — X-ray radiography schematic. X-ray image taken through the weld joint.
medium size pores at the root and smaller pores distributed throughout the fusion zone — Fig. 4B. This porosity type appeared at intermediate weld speeds. The corresponding micrographs for each porosity type show the effect process parameters have on weld shape and likely the type of porosity formed. All porosity types measured considerable variation around the average pore diameter value but generally had a standard error of 0.03 mm or less. These trends in CW weld porosity suggest that porosity is not as random as was expected for milliscale welds (Refs. 3, 9, 10).

Effects of CW Power and Travel Speed

A broad range of welding parameters for the 120-mm focal length lens was evaluated in this study. This range produced welds of various sizes, shapes, and penetrations all meeting the constraint of a milliscale weld. An analysis of these welds revealed that increasing travel speed decreases the nominal pore size for a given penetration, and that welds having comparable depths can be produced with considerably different pore and weld attributes. Examination of the 120-mm lens data set welded with UHP argon yielded a penetration-porosity map, Fig. 5, where weld depth and average pore size were examined as a function of CW power and travel speed. Well-behaved trends in penetration and average pore size are seen for the milliscale keyhole mode welds in the range examined.

Figure 5 shows solid and dashed lines corresponding to penetration and average pore size, respectively, as a function of CW power. Each line is color coded with respect to travel speed. It is apparent in the diagram that as weld speed increases, moving from upper left to lower right, average pore diameter decreases.

For example, weld A of Fig. 5 shows a keyhole mode weld with a 1.1 aspect ratio (depth to width) made at 13 mm/s and 575 W (44 J/mm heat input). These parameters yielded root porosity with a nominal pore diameter of 0.25 mm. In contrast, weld B, also a keyhole mode weld but having a greater aspect ratio (1.7) and made at 34 mm/s and 935 W (27 J/mm heat input), resulted in uniform porosity with a nominal pore size of 0.14 mm. The resulting size and shape of these welds is indicative of the unique heat flow patterns occurring in each part and as it is suggested by these data, exhibit distinct pore formation susceptibilities. The combination of power and speed that produced weld A resulted in more severe, larger-diameter pores. Both weld A and B have similar penetration (1.7 and 1.9 mm, respectively) but have considerably different heat inputs (44 vs. 27 J/mm, respectively). [Note, weld penetration is measured from the root of the weld to the original weld sample surface.

To understand the mechanisms driving porosity formation and for developing methods to avoid its occurrence, characterization of process parameter effects on the direction of heat flow in the part (i.e., 2D, 2.5D, 3D) resulting in welds of various sizes and shapes is necessary. As shown in Fig. 5, weld A and B have comparable penetration depths but differ in weld size and shape, and show different susceptibilities to weld porosity formation. As will be established, these differences relate to the heat input associated with each set of welding parameters; in this case, 44 and 27 J/mm, respectively. The combination of power and speed producing weld A yielded increased lateral melting (increasing weld cross-sectional area) without the benefit of increased penetration.

In Fig. 6, the effect of lateral melting (weld size) to pore size is more closely examined. In agreement with what might intuitively be expected, pore size increases with increasing weld size. Perhaps less intuitive, however, is the observation that average pore diameter increases linearly with weld cross-sectional area (proportional to weld volume per unit length). The implication is that for a given weld penetration (for this weld type and laser mode), increased lateral melting directly increases porosity formation susceptibility. These data also illustrate the importance of molten weld pool inertial forces on keyhole stability. In a keyhole mode weld, vapor pressure recoil displaces the molten material, and in this way increases the penetration depth (Refs. 3, 11–13). Once penetration and the vapor recoil force are maximized, continued melting of the surrounding metal increases the molten layer surrounding the keyhole. In turn, a higher vapor force is then needed to counter the increased molten volume, but because beam irradiance is relatively constant, the vapor recoil force of the fully developed keyhole is fixed (exhibits an upper threshold specific to the process parameters used). The molten material eventually overcomes the vapor force and collapses the keyhole.

A similar argument has been proposed for keyhole collapse in deep penetration.
CO₂ laser welds (Ref. 14). The increased melting that occurs near the surface in a CO₂ weld due to the high-temperature plasma, which gives the CO₂ weld its nail-head appearance, results in a condition where the vapor pressure is inadequate to maintain a stable keyhole. In turn, the keyhole is collapsed by the localized surface melting and a root type pore is formed. Excessive (lateral) melting appears to result in keyhole instabilities in both milliscale and deep penetration nail-head shaped welds, and these instabilities, in turn, result in the formation of porosity.

The results of Figs. 5 and 6 demonstrate the effect lateral melting has on pore formation and minimized porosity size (for a given penetration) requires process parameters that yield small area high aspect ratio welds. In a CW mode weld, this is largely achieved by increased travel speed.

Quantitatively illustrated in Figs. 5 and 6 is the advantage of small area high aspect ratio welds where minimum heat input is used to achieve the desired weld penetration. From an engineering standpoint then, a reasonable way to quantify effective melting along the joint is by the weld penetration efficiency (ηp) or the depth of penetration per unit of linear heat input. By reducing weld volume through decreases in heat input, pore size is minimized as well as weld temperature and distortion in the part. These observations hold particular significance for heat-sensitive parts where the pursuit of a high penetration efficiency operating space is crucial for optimal weld development. This figure of merit, weld penetration efficiency, allows for welds of varying power and speeds to be characterized and compared, and for the welding process to be optimized in a quantifiable sense relative to design requirements (i.e., penetration). Weld A of Fig. 5 has a weld penetration efficiency of 0.04 mm/J/mm while that of weld B is 0.07 mm/J/mm.

Further analysis of the 120-mm lens data set welded under UHP argon identified that linear heat input (laser output power divided by the weld speed) can be used to predict the nominal pore size observed in this weld type. This combines the individual effects of power and speed, and allows for a more general evaluation of weld parameters to nominal pore size and penetration depth. Evaluating pore size as a function of heat input also revealed that porosity types readily segregated into distinct operating regimes.

In Fig. 7, penetration depth and nominal pore size for the 120-mm data set are plotted as a function of heat input. Representative lines are drawn to distinguish between regions of porosity type. The slope of each line represents penetration efficiency that increases with the increasing slope of the line. In this plot, weld speed is effectively decreasing from left to right. It was observed that for constant weld speeds, the tendency to form pores changes from none or micro porosity to either root, transitional, or uniform porosity with increasing power (and therefore heat input). As an example, welds made at high weld speeds (e.g., 34 mm/s) yielded high aspect ratio (high penetration efficiency) keyhole mode welds that exhibited a shift from micro porosity to uniform porosity as power increased. Large root pores were not observed in these welds and only minimal lateral melting occurred.

In contrast, welds made at much slower weld speeds (e.g., 13 mm/s) displayed lower penetration efficiency with a lower aspect ratio and increased lateral melting. Porosity transitioned from micro porosity to large root porosity with increasing power. This is because weld volume increases with the increased heat input of the lower travel speed welds and, as has already been shown in Fig. 6, average pore diameter increases with increased weld cross-sectional area.

Further analysis of these data reveals a strong correlation between linear heat input and nominal pore size. Irrespective of weld speed, the nominal pore size was found to increase with heat input. The green parabolic curve of Fig. 7 shows that all discrete porosity types reduce to a single curve. A single point on the curve rep-
representing a constant nominal pore size and heat input corresponds to multiple penetration depths of varying pore types. Therefore, nominal pore diameter for this weld type is a function of operator-defined heat input, and by minimizing this quantity, pore size is reduced. The parabolic rise of the curve illustrates how rapidly pore size increases with increasing heat input. To minimize weld porosity, heat input must be low and penetration efficiency high.

Empirically Determined Process Map for CW Milliscale Welds

Given the well-behaved nature of penetration and average pore diameter relative to CW power and speed, a process map specific to these data was developed and is presented in Fig. 8. It shows the general trends in penetration and pore size relative to CW welding parameters for milliscale keyhole mode welds. Penetration as a function of power and speed is denoted by the solid lines and pore diameter is denoted by the dashed lines. As shown in Fig. 5, increased weld speed yields decreased pore size and so it is in Fig. 8, where only small-diameter pores are noted near the top of the graph. Also identified was the role of heat input in Fig. 7. High heat inputs were shown to result in large-diameter pores. As heat input increases from upper-left to lower-right, so does pore size. These contours were determined using a parabolic curve fit of data shown in Fig. 7. The combined effects of power and speed on penetration are noted by the upward sloping contours of the solid curves. Empirically, penetration can be described as a function of heat input and power by the following equation.

\[
\text{Penetration} = 0.015 \left( \frac{\text{Power}}{\text{Speed}} \right) + 0.0016 (\text{Power}) \quad (1)
\]

In general, the relationship between penetration and heat input is complex, and can be affected by factors such as keyhole mode, joint geometry, and the character of heat flow. Over the penetration range investigated here, however, and for constant travel speeds, penetration was found to change linearly with heat input — Fig. 9A. The size and shape of the weld, for a given material type and joint geometry, are largely controlled by the power transfer and melting efficiencies. These are functions of the delivered laser power and exposure time (Refs. 8, 15, 16), which are represented in Equation 1 as the process parameters power and speed. The use of these parameters to identify weld penetration, therefore, seems logical. A comparison between the calculated and measured penetration values, determined by Equation 1, is presented in Fig. 9B. For weld depths up to 3 mm, the penetration equation (Equation 1) shows good agreement to measured values.

Lens Focal Length Effects on Porosity

To identify the effect of lens focal length on pore formation, additional tests were conducted using 80- and 160-mm lenses with power varying from 300 to 1200 W and a constant weld speed of 17 mm/s. Just as the 120-mm lens transitioned from micro porosity to root porosity with increasing penetration, the same was found for the 80- and 160-mm lenses. It was found that the onset of porosity occurred at the shallowest penetration when using the 80 mm, or shortest, focal length lens and by increasing focal length, penetration was increased before the onset of porosity. This is shown in Fig. 10 where penetration is plotted as a function of lens focal length. Regions of porous and pore-free welds are designated. The 80-mm lens began forming pores between 0.75- and 1.20-mm penetration. Welds produced using the 160-mm lens did not begin forming pores until penetration reached 1.30-1.80 mm. The porosity onset region is marked by the cross-hatched area.

To better understand the observed effect of spot size (lens focal length) on porosity formation, a schematic relating...
keyhole opening (diameter), laser beam diameter, and keyhole depth is presented in Fig. 11. This depiction is adapted, and is similar to those obtained from, high-speed X-ray imaging studies (Ref. 1) and simplified numerical solutions of keyhole phenomenon (Refs. 17-19). The drawing was not generated to scale but is adequate for the following discussion. As has been described by a number of investigators (Refs. 3, 11, 16), as the keyhole depth increases, surface tension and increasing weld pool inertial forces act against the vapor pressure recoil force until a point of instability is reached and the keyhole collapses. Based upon the trends observed in Fig. 10, a relationship between keyhole diameter and weld depth is thought to exist at the point of instability (the onset of porosity).

Theta 2 (θ2) in the drawing of Fig. 11 describes an angle relating penetration to keyhole opening diameter. Under quasi-stable keyhole conditions, this angle, θ2, is assumed to be proportional to the angle formed between the beam radius and depth of penetration, or θ1; as keyhole depth increases, the angle produced decreases. In the graph of Fig. 11, nominal pore diameter is plotted against the quotient of the beam radius and depth of penetration. The arc tangent of the quotient is the angle between the beam radius and keyhole depth (θ1). Represented in the plot are data for welds made with the Rofin and Lumonics systems with a beam radius ranging from 0.160 to 0.240 mm and 0.120 to 0.200 mm, respectively. It was found that at a quotient (beam radius/penetration) value of ~0.15, gross porosity is initiated and becomes more prevalent with decreasing quotient value. As the angle between the beam diameter and weld depth (θ1) decreases, keyhole instability in the form of porosity increases. A value of 0.15 corresponds to a keyhole instability angle of 8.5 deg (arc tangent of the radius over the penetration).

In Fig. 12, the CW data for the Rofin and Lumonics lasers are reconstructed in a manner similar to that of Fig. 10, with penetration as a function of spot size (spot size instead of lens focal length) and with powers, and lens focal lengths for two independent laser welding systems (Rofin and Lumonics lasers), this result supports the geometric model as being reasonable and predictive. It should be noted that the determined shallow angle of 8.5 deg is indicative of the small beam size and much smaller than the actual keyhole opening. From an application standpoint, the observed trend in porosity as it relates to focal length is favorable because longer focal length lenses offer both a larger depth of focus for process robustness and a reduced beam angle, decreasing the likelihood of beam clipping in recessed weld applications. The smaller beam angle also allows for side shielding to be positioned closer to the weld, thereby providing better shield gas coverage.

Conclusions

A study of weld porosity specific to millisecond partial penetration laser keyhole welds in Type 304L stainless steel has been conducted to provide design guidance for manufacturing of pore-free laser welds, quantify porosity characteristics, and to obtain a better understanding of the effects of process parameters on keyhole stability and porosity formation. The following conclusions have been drawn:

1. Radiographic analysis of CW mode laser welds revealed three types of porosity (root, transitional, and uniform) depending upon laser process parameters. Low travel speed, high-heated input schedules resulted in root porosity that transitioned to uniform porosity with increasing speed and reduced heat input.

2. Average pore diameter in CW mode welds increases linearly with weld cross-sectional area; small area, high penetration efficiency welds exhibit minimum porosity. This is primarily achieved through higher travel speeds.

3. The average pore size was found to increase parabolically with laser heat input, irrespective of porosity type.

4. Process mapping was used to empirically relate weld depth and nominal pore diameter to laser CW power and weld speed.

5. In CW millisecond welds, utilizing a larger beam diameter by increased lens focal length deferred the onset of porosity allowing for greater penetration depths to be reached without forming pores. For many applications, this is an easily applied method for porosity reduction.

6. An empirical geometric model was proposed correlating porosity formation to laser beam spot size and penetration depth. The model was verified with millisecond welds produced by two independent laser systems (Rofin and Lumonics). The relationship between laser beam spot size and weld depth is a significant factor affecting weld porosity.

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References


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