Artists Use Welding as Their Medium

Precision Welding Joins Thin Film

Changes in 2010 D1.1 Code Improve Your GTAW

PUBLISHED BY THE AMERICAN WELDING SOCIETY TO ADVANCE THE SCIENCE, TECHNOLOGY, AND APPLICATION OF WELDING AND ALLIED JOINING AND CUTTING PROCESSES, INCLUDING BRAZING, SOLDERING, AND THERMAL SPRAYING
Select-Arc Electrodes Wear Well.

Select-Arc has introduced a comprehensive line of hardsurfacing electrodes specially developed to tackle formidable welding applications. SelectWear™ hardsurfacing wires are formulated to improve your welding productivity, enhance performance and reduce machinery downtime by increasing component life. In addition, these Select-Arc electrodes can provide heightened resistance to other conditions including impact, adhesion, corrosion, erosion and elevated temperatures.

Of course, all Select-Arc hardsurfacing products deliver the same exceptional electrode quality that our customers have come to rely on over the past decade.

For more information on the hardsurfacing electrodes designed with tough applications in mind, call Select-Arc at 1-800-341-5215 or visit our website: www.select-arc.com.

For Info go to www.aws.org/ad-index
Looking out for number one?
Let’s get it done.

We don’t need to tell you about the hazards you face on the job. We do want to tell you about JACKSON SAFETY* welding helmets and safety glasses – your number one combination for maximum comfort and productivity, with patented ADF technology and one-of-a-kind graphics.

Count on KIMBERLY CLARK PROFESSIONAL* for a wide range of industrial safety solutions, including JACKSON SAFETY* Halo X welding helmets and NEMESIS* eyewear.

LET US PROVE IT. Together, we can achieve a higher level of protection, cost-savings and productivity. For your FREE Site Survey, enter promo code WJ710 at www.kcproveit.com
Built TOUGH in the USA by CMI for Welders around the WORLD.

Your best source for Semi-Automatic and Automatic MIG welding guns, including air and water cooled, Push-Pull, and Smoke Extractor.

With us, customer support comes first: from custom designed MIG guns and consumables to rapid delivery.

For a complete range of our products, visit us online at cmindustries.com or call us toll free. 1-800-530-0032

CM Industries has a full line of Robotic Nozzle Cleaning Stations, Wire Cutters, and Replacement Reamer Blades to choose from. Make robotic nozzle cleaning operations easier with CMI.

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

#### 28  Artists 'Think' in Metal
Metal and welding go hand-in-hand for this group of creative individuals
K. Campbell, M. R. Johnsen, and H. Woodward

#### 38  Precision Laser Welding of Thin Structures
A combination of preplaced powder filler material and laser welding addressed the problems of distortion and melt through on 0.25-mm-thick foils
A. Deceuster, G. Stewardson, and L. Li

#### 42  Tips to Improve GTAW Arc Starts
Controlling the variables as consistently as possible leads to positive arc starts
J. Luck

#### 47  A Summary of Revisions in the New D1.1:2010, Structural Welding Code — Steel
The significant changes in the new 2010 issue are explained
J. L. Gayler and D. D. Rager

#### 50  Homes for Haiti
Metal cargo containers, a welding class, dedicated workers, and an actress with a compassionate heart combine to help those left homeless in Haiti
K. Campbell and H. Woodward

### Welding Research Supplement

#### 133-s  Effects of Nb, V, and W on Microstructure and Abrasion Resistance of Fe-Cr-C Hardfacing Alloys
Different compositions in self-shielded flux core electrodes were tested to determine the best formula for wear-resistant deposits
Q. Wang and X. Li

#### 140-s  Hybrid Laser Arc Welding Process Evaluation on DH36 and EH36 Steel
Experiments were conducted to determine the most effective arc and laser power for hybrid welding of DH36 and EH36
C. Roepke et al.

#### 151-s  Effect of Continuous Cooling Transformation Variations on Numerical Calculation of Welding-Induced Residual Stresses
Variations in continuous cooling transformation behavior were studied to find their influence on welding-induced residual stress
J. Caron et al.

---

On the cover: Wolves, The Messengers, was created by Canadian Artist Hilary Clark Cole, who welded the sculpture out of weathering steel. (Photo courtesy of Hilary Clark Cole.)
American Welding Society Purchases New Headquarters Building

The American Welding Society (AWS) recently purchased a 122,482-sq-ft building in the Doral area of greater Miami, Fla., to serve as its future headquarters. Office space is being built out, and it’s expected the move will be completed by late 2011.

The recently renovated five-story office building on a five-acre parcel is located at 8669 NW 36th St., Doral, Fla., about seven miles northwest of the current headquarters. Initially, the Society will occupy about 50% of the building, and 15% is already leased out.

“The American Welding Society has grown significantly in recent years, and we need increased space for meeting rooms with state-of-the-art audio/visual capabilities,” said AWS President John Bruskotter. “The new building provides us with the space we need to continue to grow and to expand our services in the best interest of our members.”

The purchase reflects expansion opportunities for the Society, which has a rising membership of 63,000. Present commercial real estate conditions made purchasing this building the best option, but many possibilities were reviewed over the past two years, including expanding its current facility, purchasing adjacent land, and constructing a new building.

“From a financial standpoint, AWS was in a position of a solid financial base with the growth of our reserves. This enabled us to purchase the building outright without financing it,” said AWS Treasurer Robert Pali.

“The new building allows us to continue to grow and to expand our services in the best interest of our members.”

The Society has changed its headquarters location only a few times, from the Engineering Societies Building in 1919 to the United Engineering Center, both in New York City, followed by the move to Miami in 1971.

Motoman and Yaskawa Electric America Join Forces

Motoman Inc., Dayton, Ohio, and Yaskawa Electric America, Inc., Waukegan, Ill., will combine to form Yaskawa America, Inc. The Motoman operations will form the Motoman Robotics Division of Yaskawa America, and the Yaskawa Electric America operations will form the Drives & Motion Division. Both will continue to operate as independent divisions, retaining the same management structures, and operating in the same geographical regions that are currently in place.

“The global economy is recovering, and we believe this is the perfect time to combine the brand name strength of Yaskawa and Motoman. Using the name Yaskawa on a global basis will strengthen our corporate identity and emphasize the strong global connection between drives, motion control products, and robotics,” said Gen Kudo, Yaskawa America’s chairman and CEO.

Steve Barhorst, president and COO of the Motoman Robotics Division, and Jody Kurzhalts, president and COO of the Drives & Motion Division, believe users will realize benefits from better alignment of their divisions. “Our combined capabilities will lead to more innovative products. We are particularly excited about the prospects for developing advanced controls technology utilizing the expertise and experience of both divisions,” added Barhorst.

Int’l Thermal Spray Association Offers Scholarships

The International Thermal Spray Association Scholarship Program, a contributor to the growth of the thermal spray community, especially the development of new technologists and engineers, offers up to three graduate scholarships worth $2000 each to be awarded each calendar year. Applications are now accepted annually May 1 through July 15, and winners will be announced in August. Visit the scholarship area at www.thermalspray.org for details and a printable application form.
Our world class manufacturing plant in Florence, Kentucky is a showplace for producing the highest quality welding materials in North America.

Visit our website at:
www.kiswelweldingproducts.com
The Key to Avoiding Donor Fatigue: Don’t Stop Believing

It has been said that volunteers are the lifeblood of AWS. Over the years, I have come to appreciate the truth of that observation. I continue to be amazed by the achievements of long-time AWS members, especially our Life Members. Even more remarkable is that many of these long-time members do not assume passive roles but are actively involved with various AWS activities. Dedication at that level and depth deserves special commendation.

At last count, there were more than one-million organizations registered with the Internal Revenue Service as nonprofit entities. With so many choices, why is AWS worthy of receiving your time and resources? Long-time members state they continue giving because they believe in AWS. They support its core values and mission. They are convinced that AWS is the world’s premier welding organization.

This passion for AWS on the part of its members should not be taken for granted. Countless charitable organizations have ceased to exist because their donors stopped believing in the mission. Doubt erodes motivation and gradually donor fatigue sets in.

To help overcome donor fatigue consider the following suggestions.

- **Remember the mission.** AWS continues to advance the science, technology, and application of welding and allied joining and cutting processes including brazing, soldering, and thermal spraying. Since 1919, this core concept has not altered. All AWS strategic plans and initiatives are specifically developed to support this objective. This unswerving focus serves to reinforce your resolve to continue your support.

- **Attend Section meetings.** By attending meetings, you witness firsthand the positive effect AWS has on the lives of real people. Listen as students tell you with enthusiastic voices about the education they are receiving because of an AWS scholarship. Hear others relate how they were able to buy their first house or how they secured gainful employment because they attained a welding-related certification. This interaction will do wonders to rejuvenate your commitment to volunteering.

- **Reflect on what AWS has done for you.** When you thoughtfully reflect on the positive benefits you have received from your association with AWS you will be impelled, yes, I believe even driven, to want to help others achieve similar benefits. You will rediscover the inward drive to stay the course.

As is true with so many long-time members, may the passing of time not diminish your zeal. Remember, AWS and its success are totally dependent on the generosity of members like you. Keep volunteering. Continue giving. Don’t stop believing.

John L. Mendoza
AWS Vice President
Eliminates welds, which takes labor out of the equation. Result? Higher strength and lower cost!

- Plasma & oxy-fuel torches that can cut up to a 10-inch thick carbon steel plate
- Quick-Drill (concurrent drill, tap, countersink & surface mill) capability
- 160-foot long by 17-foot wide water table
- Contour beveling capability

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

Call us at 800-782-2110 for a free quote on your next Metal Drilling & Cutting job.

www.greinerindustries.com
For info go to www.aws.org/ad-index
Florence-Darlington Technical College Holds First Welding Rodeo

Florence-Darlington Technical College (FDTC), Florence, S.C., held its first Welding Rodeo April 30 and May 1 at the college’s Southeastern Institute of Manufacturing and Technology. Five teams of professional welders and five teams of welding students, made up of four welders each, created welded sculptures fitting a motion theme. They were given eight hours to create artwork using a pile of scrap material.

Planning for the event began more than one year ago when the college’s Educational Foundation met with leaders from ESAB Welding and Cutting Products of Florence. “This was a true partnership between the college and ESAB,” said Jill Heiden, executive director of the FDTC Foundation.

Ross Gandy, director of the college’s Advanced Welding and Cutting Center, headed up all compliance issues and oversaw the building and equipping of the welding competition area.

The sculptures were judged by an independent panel of local sculptors. The team from Nucor Steel of Darlington County won the professional division and a $1600 grand prize with their moving dolphin. Honda of South Carolina in Timmonsville took second place and $1200 with a curvy, free-form sculpture mounted on a giant “H.”

Welding students from Central Carolina Technical College, Sumter, S.C., won the amateur division and an $800 grand prize for their portrayal of an eagle catching a fish. ESAB donated $10,000 worth of welding equipment to the winning amateur team and gave welding helmets and gloves to each of the participants. Florence Career Center students finished second with their sculpture, “The Vortex,” and the Florence-Darlington Technical College’s Advanced Welding and Cutting Center team took the Honorable Mention prize for their motorcycle interpretation.

ESAB donated $25,000 to the college’s Foundation for the event. Nucor Steel Vice President Mike Gurley made the winning bid of $2000 for the dolphin made by the company’s team. Hoyt Wood of Lake City, S.C., bought Central Carolina’s creation for $800. ESAB purchased the team’s entry of bull riders in a rodeo ring and will put it on permanent display at the Southeastern Institute of Manufacturing and Technology on the Florence campus. The auction raised just more than $10,000 for the FDTC scholarship program.

Plans are underway to make next year’s competition bigger with room for more teams to compete and with the possible addition of a car show in conjunction with the rodeo. For more information on the Welding Rodeo, visit www.fdtc.edu.
Hydrex Performed Dry Underwater Welding on a Tanker in Port of Galveston, Tex.

A Hydrex class certified welder works underwater in one of the company’s propriety mobile drydocks. (Photo courtesy of Hydrex LLC, Clearwater, Fla.)

Hydrex recently dry underwater welded an insert plate on a tanker as a permanent ship hull repair in-situ. A five-person team of certified technicians and divers from the company’s U.S. office went to the vessel in the Port of Galveston, Tex., to do the work.

The tanker required an insert of 800 × 490 mm for the hull’s bottom. After ascertaining the cargo and ballast tanks were free of chemicals and fumes, and the atmosphere was safe for welders and hot work, the Hydrex team used its propriety mobile mini drydock technology to create a dry environment for performing the welding and completing the permanent hull repair while the tanker remained in the water. Ultrasonic testing confirmed the weld. Also, the company’s team coordinated with the Houston Det Norske Veritas office, and the American Bureau of Shipping supervised and approved the job site.

Welder Bob Dedicated as Hobart Institute Celebrates 80 Years

At the dedication ceremony for Welder Bob, sculptor Gregory Johnson (left), Hobart Institute of Welding Technology President André Odermatt, and William H. Hobart Jr. pose with the bronze sculpture.

Welder Bob, a bronze sculpture erected at the entrance to the Hobart Institute of Welding Technology (HIWT), Troy, Ohio, was formally unveiled at a May 15th ceremony as part of activi-
ties celebrating the institute’s 80th anniversary. The sculpture is 43 in. tall and weighs in at 360 lb, not counting the 450-lb base on which it stands. The honor of unveiling the sculpture went to Elmer Swank, the institute’s most senior welding instructor.

Welder Bob was named in honor of Robert C. Bercaw, the first instructor at the Hobart Trade School, which later became HIWT. It is dedicated to all past, present, and future Hobart instructors. In 1930, Bercaw was personally recruited by William H. Hobart Sr. from the New York Central Railroad to teach welding in a corner of the Hobart Brothers Co. factory. Bercaw was also instrumental in writing the first Hobart training manuals.

Noted artist Gregory Johnson of Cumming, Ga., was commissioned to create the sculpture that was cast by Eagle Bronze Foundry of Lander, Wyo. Typical of Johnson’s works, the sculpture is realistic, including details such as eyelets on the safety shoes, hems on the gloves, and seams on the trousers. One person seeing the piece for the first time immediately identified the gas metal arc welding gun in the sculpture’s hand. The sculptor took care to pose the figure in a realistic position for welding.

The bronze portion stands on a steel base designed and fabricated by the institute’s staff, under the direction of Ron Scott, vice president of Hobart Institute. The base was then powder coated by Aesthetic Finishers, Piqua, Ohio.

Present at the sculpture dedication were André Odermatt, the institute’s president; William H. Hobart Jr., Robb F. Howell, and Greg Schaffer, members of Hobart Institute’s board of directors; Dr. Richard Adams, Ohio 79th District State Representative; and Troy Mayor Michael L. Beamish.

American Welding Society Executive Director Ray W. Shook, who served as HIWT president from 1991 to 1993, was unable to attend the ceremony, but sent a letter that stated in part, “On behalf of the American Welding Society and its 63,000 members from around the world, I want to congratulate you and HIWT for achieving this major milestone.”

Following the dedication ceremony, the institute held an open house where people from the community as well as prospective students toured the facilities. — Information provided by Dan Lea and Martha Baker, Hobart Institute of Welding Technology.

Sheet Metal Welding Conference XIV Draws High Turnout for Sessions, Vendor Display

During the technical program of Sheet Metal Welding Conference XIV, presenters covered a variety of topics including recent developments in resistance welding and other sheet metal joining processes. The event, hosted by the AWS Detroit Section and cosponsored by the Edison Welding Institute, took place May 12–14.

The American Welding Society’s (AWS) Detroit Section recently hosted Sheet Metal Welding Conference (SMWC) XIV at Schoolcraft College’s VisTaTech Center, Livonia, Mich. The event attracted nearly 150 people from the United States, Canada,
Lynnes Welding Training started a facility in Bismarck, N.Dak., offering many types of hands-on classes. A student named Cord (left) from Fishtail, Mont., is shown with instructor Carl Tengesdal.

Conference Attendees Discussed Welder Training Needs

More than 25 educators, suppliers, and welding industry leaders convened at the Tulsa Welding School (TWS) campus in Jacksonville, Fla., for the Super Training and Employment Advisory Committee Conference on April 8. Carl Peters, director of technical training for Lincoln Electric, gave the keynote address at a dinner held the previous evening.

The conference represented the first time in the 60-year history of Tulsa Welding School that industry leaders and educators combined to review the overall curriculums for both of the school’s campuses. Also in attendance were representatives from the American Welding Society, Lincoln Electric, and Texas State Technical College. Some of the topics discussed included the need for more in-depth metallurgy training, the physics of welding, and training on more complicated welding positions representative of real-world environments.

Larry Brown, CEO and founder of Beam Reach Education, the parent company of TWS, hosted and moderated the conference. There was lively discussion regarding the welder training needs of the industry and how the school might incorporate some of them into its programs as well as refine its current offerings. In addition, the conference addressed training needs that may be more specific to the regions where the campuses are located.

Members of the AWS Detroit Section and guests attended the conference’s large vendor display on the evening of May 13.

Edison Welding Institute (EWI), Columbus, Ohio, cosponsored the event as well as coordinated the technical program and registration.

“The Sheet Metal Welding Conference is an important contribution the Detroit Section makes to fulfilling the AWS mission to advance the science and technology of welding,” said Conference Chairman Mike Palko from Ford Motor Co. “With the quality of the technical presentations, the consistent attendance, and dependable sponsors, SMWC clearly fills a need in our welding industry.”

On May 11, Dr. Sivakumar Ramasamy of Emhart Fastening Technologies guided a day-long tutorial on weld quality.

During the three-day conference held from May 12 to 14, 38 papers were presented. Its six sessions and the session leaders included the following: Resistance Welding (Weldability), Dr. Michael Karagoulis of General Motors; Other Joining Processes, Dr. Jerry Gould of EWI; Resistance Welding (General), Dan Galicher of Tower Automotive; Laser Welding, Arnon Wexler of Ford Motor Co.; Resistance Welding Equipment, Joe Beckham of Chrysler Co. LLC; and Arc Welding, Rus Little of Honda.

An evening vendor display held on May 13, coordinated by Susann Morfino of MJM Sales, Inc., also served as the Detroit Section’s monthly meeting. Members and guests visited booths featuring 50 welding equipment and technology vendors.

Dr. Mark Gugel of General Motors served as vice chairman of this year’s event and will be conference chairman for SMWC XV in 2012.

A CD with the entire archive of technical papers from all Sheet Metal Welding Conferences is available from the AWS Detroit Section. For more information about the biennial conference, visit its link at www.awsdetroit.org or contact smwc@awsdetroit.org.

Lynnes Welding Training Opens New Location in Bismarck, N.Dak.

Lynnes Welding Training, Inc., recently expanded to a second campus in Bismarck, N.Dak. The location was chosen due to a growing number of students and inquiries from the western part of North Dakota; the current oil industry boom predominant in the western part of the state; and the fact that the pipelines, power plants, and coal mines in western North Dakota need welders. The school’s original location is in Fargo.

The new 4800-sq-ft space features a training classroom; office; work room; eight welding booths equipped with multiprocess welding machines and custom-built with a unique pedestrian approach allowing for more room; and expansion capabilities available with room to add another five welding booths.

“The success and acceptance of Lynnes Welding Training has been both fun and rewarding, but not without a lot of hard work. We knew that the market for training welders was there and that our training system would fit a niche for certain students who did not want to go to a traditional technical college for welding,” said owner Dave Lynnes, who occasionally teaches at both campuses in addition to running a manufacturing company.

The school offers gas metal arc, gas tungsten arc, shielded metal arc, pipe, and combination welding courses. Both locations provide custom training to businesses in industry. Students can sign up for one to two week basic courses up to advanced courses that last a couple of weeks. Classes are ongoing throughout the year.

Training allows students to spend approximately 15% of their time in class learning about safety, protective gear, equipment maintenance, troubleshooting, power sources, and gases. The remaining 85% of time is spent in the welding booth working, learning, and practicing on the specific process being studied.

Carl Tengesdal, the main instructor at the Bismarck campus, is an American Welding Society (AWS) Certified Welding Inspector, AWS Certified Welding Supervisor, and AWS Certified Welding Educator. On occasion, Chad Erickson, the main instructor at the Fargo campus, will teach at the new location. For more information, visit www.learntoweld.com.
New Laser Hall Opened to Conduct Welding Research

The GKSS Research Centre, in collaboration with Airbus Deutschland GmbH, recently opened a new laser hall that includes a laser system that will be used to research laser beam welding of new lightweight construction alloys. The laser hall will be part of the planned GKSS Lightweight Materials Assessment, Computing, and Engineering Centre.

The laser hall is located at the GKSS Research Centre in Geesthacht, Germany. The company invested more than $1.2 million in the facility, which was opened April 19 by representatives of GKSS and Airbus. The materials researchers from Geesthacht are taking over the system from the Airbus location in Nordenham, Germany.

While the research in Nordenham focused on laser beam welding of length-stiffened profiles known as stringers for the external skin of the aluminum fuselage structure of aircraft, the focus in Geesthacht will be welding of sample models and test components for aircraft fuselage shells.

"The system is ideal for our research in the area of strength and reliability of laser welded lightweight structures," said Norbert Huber, head of material mechanics at GKSS.

Swagelok Opens India Technology Center

Swagelok Co., a developer and provider of fluid system solutions headquartered in Solon, Ohio, recently opened a new technology center in Pune, India. Swagelok will operate the Swagelok India Technology Center, a division of Bombay Fluid System Components Pvt. Ltd., and will provide product assembly services, technical service, education, training, and development directly to customers in the region. It is the company’s fifth technology center worldwide; it also has centers in the United States, Japan, China, and Switzerland.

India represents a growing region for Swagelok, where the company has two authorized sales and service centers that serve a diverse number of industries.

Construction Begins on Nord Stream Subsea Russia-Germany Pipeline

Construction recently began on the Nord Stream Pipeline from Russia to Germany through the Baltic Sea. Nord Stream, along with shareholders and guests from the European Union and Russia, celebrated the start of construction with the symbolic welding together of two pipes at Portovaya Bay, northeast of St. Petersburg.

The pipeline will span 1224 km (760.5 miles) — the longest subsea pipeline in the world — and will run straight through the middle of the Baltic Sea to Germany’s port of Greifswald. It will consist of two parallel lines; the first to be completed in 2011 and the second in 2012.

Three pipelay barges will be used on the project. The Castoro Sei will perform the majority of the offshore construction. In German waters, the shore approach of both pipelines will be built by the Castoro Diesi, and in the Gulf of Finland, the Solitaire will be used.

During the opening ceremony, Russian President Dmitry Medvedev said, “I am confident that the Nord Stream gas pipeline will become another link between Russia and Europe. Its construction meets our long-term goals — and I would like to emphasize this point — it corresponds to the objective of developing our national economies. And, of course, this is our contribution into Europe’s energy security.”

Energy, Shipbuilding, and Construction to Drive Growth in the Indian Welding Market

While the Indian welding market is currently dominated by the use of manual welding equipment, this situation is expected to change as several end-user industries have started demanding automated equipment to support higher productivity, according to a new analysis from Frost & Sullivan. Strategic Analysis of the Indian Welding Equipment Market (www.industrialautomation.frost.com) finds that robust expansion of the Indian shipbuilding, construction, and energy — particularly wind power — sectors will underline strong growth of the Indian welding market over the medium and long term.

According to the report, the market earned revenues of $208 million in 2008, and it is estimated this will reach $311.5 million in 2015.

"While the financial meltdown has adversely affected most end user industries for welding equipment in India, energy, construction, and shipbuilding sectors have, to a large extent, been recession-proof and have been generating moderate demand,” noted Frost & Sullivan Senior Research Analyst Archana Chauhan. “A key driver boosting market revenues has also been the gradual move from manual to automatic and semiautomatic welding equipment.”

In a symbolic act to celebrate the start of construction on the Nord Stream pipeline at Portovaya Bay, Russia, pipes representing the Russian and European natural gas networks were welded together.

The pipeline will span 1224 km (760.5 miles) — the longest subsea pipeline in the world — and will run straight through the middle of the Baltic Sea to Germany’s port of Greifswald. It will consist of two parallel lines; the first to be completed in 2011 and the second in 2012.

Three pipelay barges will be used on the project. The Castoro Sei will perform the majority of the offshore construction. In German waters, the shore approach of both pipelines will be built by the Castoro Diesi, and in the Gulf of Finland, the Solitaire will be used.

During the opening ceremony, Russian President Dmitry Medvedev said, “I am confident that the Nord Stream gas pipeline will become another link between Russia and Europe. Its construction meets our long-term goals — and I would like to emphasize this point — it corresponds to the objective of developing our national economies. And, of course, this is our contribution into Europe’s energy security.”

Energy, Shipbuilding, and Construction to Drive Growth in the Indian Welding Market

While the Indian welding market is currently dominated by the use of manual welding equipment, this situation is expected to change as several end-user industries have started demanding automated equipment to support higher productivity, according to a new analysis from Frost & Sullivan. Strategic Analysis of the Indian Welding Equipment Market (www.industrialautomation.frost.com) finds that robust expansion of the Indian shipbuilding, construction, and energy — particularly wind power — sectors will underline strong growth of the Indian welding market over the medium and long term.

According to the report, the market earned revenues of $208 million in 2008, and it is estimated this will reach $311.5 million in 2015.

“While the financial meltdown has adversely affected most end user industries for welding equipment in India, energy, construction, and shipbuilding sectors have, to a large extent, been recession-proof and have been generating moderate demand,” noted Frost & Sullivan Senior Research Analyst Archana Chauhan. “A key driver boosting market revenues has also been the gradual move from manual to automatic and semiautomatic welding equipment.”

In a symbolic act to celebrate the start of construction on the Nord Stream pipeline at Portovaya Bay, Russia, pipes representing the Russian and European natural gas networks were welded together.
“PlasmaCAM is a well thought-out tool. The software is incredible. I can quickly go from concept to a finished part. I haven’t seen anything we can’t do with this machine. It has saved us so much time and effort, it’s just incredible!”

-Jim, Custom Turbo Engineering
Q: An inspector recently noticed an errant arc strike from an E2209-16 electrode inside a 2205 duplex stainless steel tank we are fabricating. The inspector insisted that we not only grind off the bump but also insisted that we excavate (by grinding) below the surface at least \( \frac{1}{8} \) in. This made the base metal thickness less than the specified minimum, so we had to deposit a repair weld to rebuild the excava
tion from the arc strike. I can understand such a requirement when the steel is hardenable, but I cannot understand such a requirement for a stainless steel that is not hardenable. I think the inspector should have allowed us to just grind the bump smooth at the arc strike. Was the inspector justified in insisting on the excavation?

A: In a word, yes.

You are correct that 2205 base metal (nominally 22% Cr, 5% Ni, 3% Mo, 0.18% N) is not hardenable, so one wouldn’t be worried about martensite formation in the heat-affected zone (HAZ) of the arc strike that could lead to hydrogen-induced cracking. That is a serious concern with carbon steels and low-alloy steels, but not with duplex stainless steels. But there is another concern that justifies the inspector’s requirement that you remove not only the deposit from the arc strike but also the HAZ of the arc strike.

The concern stems from the fact that, when duplex stainless steel is heated to a temperature close to the melting temperature, the metal transforms to virtually 100% ferrite. This happens in the HAZ. Under normal welding conditions, the HAZ cools slowly enough that austenite can nucleate and grow in the HAZ. This requires time for the nitrogen in the ferrite to diffuse to the growing austenite phase regions. But under the extremely rapid cooling conditions associated with an arc strike, the HAZ of the arc strike is quenched and nearly 100% ferrite remains until cooling progresses to a temperature that is too low for austenite to nucleate and grow. Then the nitrogen trapped in the ferrite is no longer soluble in the ferrite, but the nitrogen has no place to go except by diffusion. So, on further cooling, the nitrogen precipitates as chromium nitrides within the ferrite.

The issue of arc strikes on duplex stainless steel was investigated a number of years ago by Sargeant et al. (Ref. 1). They showed that, in the HAZ of the arc strike, very large ferrite grains are formed, with just traces of austenite along the ferrite grain boundaries. Then, just beside the grain boundary austenite, the ferrite grains are free of chromium nitrides. Further from the grain boundary austenite, the ferrite grains are loaded with chromium nitride precipitates. In fact, the microstructure of the HAZ is remarkably similar to that of the resistance welds in 2205 shown in my May 2010 Stainless Q&A column.

Chromium nitrides have the approximate chemical formula \( Cr_2N \), which means that one atom of N will remove 2 atoms of Cr from the ferrite. The effect of Cr removal is compounded by the difference in atomic weight between Cr and N — the atomic weight of Cr is about 52 while that of N is about 14, so the Cr atom is about 3.7 times as heavy as the nitrogen atom. Therefore, on a weight-percent basis, formation of chromium nitrides removes about 7.4 times as much Cr as N from the ferrite. In addition, Cr, being a larger atom than N, diffuses much more slowly than N. The result is that the ferrite around each nitride particle is severely depleted in Cr, and therefore is susceptible to corrosion.

Sargeant et al. further examined the tendency for pitting corrosion to occur at an arc strike in 2205, and found that the HAZ containing chromium nitride precipitates is highly susceptible to pitting. In their study, they determined that the arc strike area needed to be excavated by grinding to a minimum depth of 0.89 mm (0.035 in.) below the original surface of the plate in order to remove the pitting-susceptible HAZ of the arc strike.

Duplex stainless steels like 2205 are commonly used in environments where pitting can occur, so removal of the pitting-susceptible HAZ as well as the arc strike deposit seems prudent. Your inspector demanded excavation at the arc strike to nearly double the depth determined by Sargeant et al., no doubt to be on the conservative side. I expect that your inspector was either aware of this study or his requirement for excavation was set by the inspector justified in insisting on the excavation.

Arc strikes are not isolated to shielded metal arc welding. In the same study, Sargeant et al. examined gas tungsten arc (GTA) metal arc strikes, as can occur either when AC high-frequency arc initiation is not used, or when a welder has difficulty with AC H-F arc initiation because the tungsten electrode has become contaminated. I note here that addition of the order of 2% nitrogen to the argon shielding gas in GTA welding is often recommended to counteract tendencies for nitrogen loss from the weld pool during GTAW. While this is beneficial to the weld, it is somewhat damaging to the arc initiation characteristics of the tungsten electrode when AC H-F is used for arc initiation. In my experience, addition of nitrogen to the GTAW shielding gas normally requires more frequent dressing of the tungsten electrode for effective arc initiation using AC H-F than when pure argon is used as the shielding gas.

Sargeant et al. found that the pitting-sensitive depth of the GTAW arc strike HAZ was less than with SMAW in their study, but they still needed to excavate 0.34 mm (0.013 in.) to remove the pitting-sensitive HAZ.

I personally have witnessed the results of arcing between a 2205 stainless vessel and a copper block used for the current return (ground) to the power source when the copper block was not clamped and a worker inadvertently stumbled over the copper block while welding was occurring. This produced a trail of arc strikes on the stainless as the copper block slid along. All of these arc strikes had to be excavated. Good practice is to rigidly clamp the current return to the workpiece to prevent this sort of event from occurring.

From the above discussion, it should be apparent that precautions should be taken to prevent arc strikes on duplex stainless steel. (In fact, precautions should be taken to prevent arc strikes on any metal.) If an arc strike occurs on a duplex stainless steel, the arc strike should be excavated to a depth sufficient to be sure that any deposited metal at the arc strike, and the HAZ, have been removed.

Reference


Damian J. Kotecki is president, Damian Kotecki Welding Consultants, Inc. He is a past president of the American Welding Society, currently treasurer and a past vice president of the International Institute of Welding, and a member of the AWS ASD Subcommittee on Stainless Steel Filler Metals, and the AWS DIK Subcommittee on Stainless Steel Structural Welding. He is a member and past chair of the Welding Research Council Subcommittee on Welding Stainless Steels and Nickel-Based Alloys. E-mail your questions to: damian@damiankotecki.com, or send to Damian Kotecki, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.
When it comes to getting the tools you need to improve productivity, increase profits and find new ways to survive in today’s competitive business environment, nothing compares to FABTECH. One week, one convenient location, one opportunity to keep your business on the cutting edge.

REGISTER TODAY: www.fabtechexpo.com

NOVEMBER 2-4, 2010
GEORGIA WORLD CONGRESS CENTER | ATLANTA, GEORGIA
Welding Metallurgy and Weldability of Nickel-Base Alloys is a well-organized text and a must read for students interested in the industry as well as practicing professionals. John N. DuPont, John C. Lippold, and Samuel D. Kiser have done a commendable job taking a “snapshot in time of the field.” Current and future new nickel-based alloy development efforts are underway and will encourage future editions. It is also on par with a similar text, Weldability of Steels, by R. D. Stout.

The text is heavy on the high-temperature nickel-based alloy side and light on the corrosion-resistant nickel-based alloy and application sides. A more thought out discussion/chapter on applications would have provided the novice reader with a more vivid description of nickel-based alloy usage. The mention of “power generation, petrochemical, chemical processing, aerospace, and pollution control” is too general and leaves a lot for the imagination. A more vivid description of power generation (fossil, solar, nuclear, fuel cells, bioenergy, with examples); superheater tubing in the petrochemical plants; shell/tube heat exchangers and microchannel reformers in chemical processing plants; aerospace rocket nozzles; and pollution-controlled flue gas desulfurization systems statistically or pictorially illustrating the importance of nickel-based alloys would have been a nice addition.

The text starts off with general classifications of nickel and nickel-based alloys and then gets more specific with fruitful discussions on alloy producer history, trade names (i.e., Inconel®, Hastelloy®), and unified number system designations. The phase equilibria discussions are excellent, and the accompanying bibliography is sufficient to provide direction for readers to delve further into key areas. The authors provide good coverage of the physical metallurgy and weldability of solid-solution-strengthened and precipitation-strengthened nickel-based alloys. Although important, I was surprised to see a discussion on brazing and other joining processes in the oxide dispersion-strengthened alloys and nickel aluminide sections of the text. Examples of brazing, a method also used for joining solid-solution-strengthened and precipitation-hardening nickel-based alloys, was rightfully excluded from the text and is well covered in other texts such as Welding Metallurgy and Weldability of Nickel-Base Alloys, by John N. DuPont, John C. Lippold, and Samuel D. Kiser, is hardcover with 440 pages. Published by John Wiley & Sons, Inc., Newark, N.J., www.wiley.com ISBN 978-0-470-08714-5. Price is $125.00 U.S.

Discussions on repair welding were extensive for precipitation-strengthened and single crystal alloys, yet very brief for solid-solution-strengthened alloys. The section on dissimilar welding was concise, and the included case studies are a must read. Practitioners will probably be skeptical about the overall content in the text as there is limited guidance on welding procedure. Voltage, current, and travel speed affect the metallurgy of the weldment and are rarely mentioned in the text. Energy input discussions were limited to the electron beam welding process, welding of precipitation-strengthened nickel-based alloys, repair welding of single crystal superalloys, and description of Varestraint-type testing. Also, while gas metal and gas tungsten arc welding are addressed, discussions on shielded metal arc welding, a common process used for joining nickel-based alloys, was noticeably absent from the text. The appendices provide a quick reference (i.e., composition, etching formula) for practitioners and the academe.

HENRY J. WHITE, PhD, PE, is a market manager at Haynes International, Inc., Kokomo, Ind.
To: Professors Engaged in Joining Research

Subject: Request for Proposals for AWS Fellowships for the 2010-2011 Academic Year

The American Welding Society (AWS) seeks to foster university research in joining and to recognize outstanding faculty and student talent. We are again requesting your proposals for consideration by AWS. It is expected that the winning researchers will take advantage of the opportunity to work with industry committees interested in the research topics and report work in progress.

Please note, there are important changes in the schedule which you must follow in order to enable the awards to be made in a timely fashion. Proposals must be received at American Welding Society by September 15, 2010. New AWS Fellowships will be announced at the AWS Annual Meeting, November 2010.

THE AWARDS

The Fellowships or Grants are to be in amounts of up to $25,000 per year. A maximum of two students are funded for a period of up to three years of research at any one time. However, progress reports and requests for renewal must be submitted for the second and third years. Renewal by AWS will be contingent on demonstration of reasonable progress in the research or in graduate studies.

The AWS Fellowship is awarded to the student for graduate research toward a Masters or Ph.D. Degree under a sponsoring professor at a North American University. The qualifications of the Graduate Student are key elements to be considered in the award. The academic credentials, plans and research history (if any) of the student should be provided. The student must prepare the proposal for the AWS Fellowship. However, the proposal must be under the auspices of a professor and accompanied by one or more letters of recommendation from the sponsoring professor or others acquainted with the student's technical capabilities. Topics for the AWS Fellowship may span the full range of the joining industry. Should the student selected by AWS be unable to accept the Fellowship or continue with the research at any time during the period of the award, the award will be forfeited and no (further) funding provided by AWS. The bulk of AWS funding should be for student support. AWS reserves the right not to make awards in the event that its Committee finds all candidates unsatisfactory.

DETAILS

The Proposal should include:

1. Executive Summary
2. Annualized Breakdown of Funding Required and Purpose of Funds (Student Salary, Tuition, etc.)
3. Matching Funding or Other Support for Intended Research
4. Duration of Project
5. Statement of Problem and Objectives
6. Current Status of Relevant Research
7. Technical Plan of Action
8. Qualifications of Researchers
9. Pertinent Literature References and Related Publications
10. Special Equipment Required and Availability
11. Statement of Critical Issues Which Will Influence Success or Failure of Research

In addition, the proposal must include:

1. Student's Academic History, Resume and Transcript
2. Recommendation(s) Indicating Qualifications for Research must include one or more letters of recommendation from the sponsoring professor or others acquainted with the student's technical capabilities
3. Brief Section or Commentary on Importance of Research to the Welding Community and to AWS, Including Technical Merit, National Need, Long Term Benefits, etc.
4. Statement Regarding Probability of Success

The technical portion of the Proposal should be about ten typewritten pages; maximum pages for the Proposal should be twenty-five typewritten pages. Maximum file size should be 2 megabytes. It is recommended that the Proposal be typed in a minimum of 12-point font in Times, Times New Roman, or equivalent. Proposal should be sent electronically by September 15, 2010 to:

Vicki Pinsky (vpinsky@aws.org)
Manager, AWS Foundation
American Welding Society
550 N.W. LeJeune Rd., Miami, FL 33126

Yours sincerely,

Ray W. Shook
Executive Director
American Welding Society
Reader Corrects Article on Stainless Steel Welds

A discussion is presented about the “Tips for Welding Stainless Steel” article (pages 46-48) in the May 2010 Welding Journal by Brent Williams, a technical contributor, Weldcraft.

I read with interest the “Tips for Welding Stainless Steel” article, and while it has some interesting points, I find the following paragraph about GTAW of stainless less wrong and possibly dangerous:

“Good austenitic stainless steel welds are straw colored, whereas those in which carbide precipitation has occurred are black. Welds that have the potential for carbide precipitation are generally blue or purple. By considering these colors, you should be able to determine whether you are achieving the correct heat input and travel speeds when welding austenitic stainless steel.”

What is wrong is that the color on the surface of the weld has absolutely nothing to do with whether or not carbide precipitation has occurred. The surface color is only an indication of the temperature of the metal surface when it reached the air outside of the shielding gas coverage. The various colors are the result of the thickness of the oxidation layer. The thinnest layer has a silvery color, while a slightly thicker oxide layer gives a straw yellow color. Darker colors result from still thicker oxide layers. The hotter the metal is when it reaches the air, the darker will be the oxidation layer color. These colors happen whether or not carbide precipitation has occurred.

The possibly dangerous part of the quoted paragraph results if a person welding a non-low carbon grade of stainless, such as 304 or 316, thinks the weld cannot suffer carbide precipitation if the silver or straw yellow color is achieved. If a weld in a higher carbon stainless is put, without subsequent solution annealing and quenching, into service in a corrosive environment, or even into water, corrosion along grain boundaries will likely take place. The factor that determines carbide precipitation is not the color but the carbon content of the base metal. The shop accepting the color statement quoted above is asking for trouble with corrosion.

Whatever the oxidation color, if the base metal is low carbon (maximum 0.03%), pickling to completely remove the surface oxidation colors will render the weld corrosion resistant. But if the base metal is higher in carbon, regardless of the oxidation color of the surface, it will experience carbide precipitation and may experience corrosion along grain bound-

arys in the HAZ. Pickling cannot save such a weld. Only solution annealing and quenching can.

Damian J. Kotecki
AWS Past President
President, Damian Kotecki Welding Consultants, Inc.

We would like to acknowledge Dr. Kotecki for his comments regarding the presence of carbide precipitation in stainless steel welds. Our intention was to simplify this key consideration associated with the welding of stainless steels. However, the generalized relationship between weld discoloration and carbide precipitation in the described situation could be misleading. As stated by Dr. Kotecki, discoloration in stainless steel welds is indicative of the oxide layer and minimal discoloration does not indicate the absence of carbide precipitation — especially in alloys with higher carbon content. More correctly, the procedures described by Dr. Kotecki should be followed to ensure weld quality with minimal presence of carbide precipitation. This clarification and insight from Dr. Kotecki is appreciated and will be applied to this and future references regarding the key differences between oxidation and carbide precipitation in stainless steels.

Weldcraft

CAN WE TALK?

The Welding Journal staff encourages an exchange of ideas with you, our readers. If you’d like to ask a question, share an idea or voice an opinion, you can call, write, e-mail or fax. Staff e-mail addresses are listed below, along with a guide to help you interact with the right person.

**Publisher**
Andrew Cullison
cullison@aws.org, Extension 249
Article Submissions

**Editor**
Mary Ruth Johnsen
mjohansen@aws.org, Extension 238
Feature Articles

**Associate Editor**
Howard Woodward
woodward@aws.org, Extension 244
Society News, Personnel

**Associate Editor**
Kristin Campbell
kcampbell@aws.org, Extension 257
New Products
News of the Industry

**Production Manger**
Zaida Chavez
zaida@aws.org, Extension 265
Design and Production

**Senior Production Coordinator**
Brenda Flores
bflores@aws.org, Extension 330
Production

**Advertising Sales Director**
Rob Saltzstein
salty@aws.org, Extension 243
Advertising Sales

**Advertising Sales & Promotion Coordinator**
Lea Garrigan Budwy
garrigan@aws.org, Extension 220
Production and Promotion

**Senior Advertising Production Manager**
Frank Wilson
fwilson@aws.org, Extension 465
Advertising Production

**Peer Review Coordinator**
Erin Adams
eadams@aws.org, Extension 275
Peer Review of Research Papers

Welding Journal Dept.
550 N.W LeJeune Rd.
Miami, FL 33126
(800) 443-9353
FAX (305) 443-7404
SHOW OFF YOUR PRIDE OF AWS
T-SHIRTS / POLO SHIRTS / HATS / JACKETS / ACCESSORIES / AND MORE

CHOOSE FROM MORE THAN 20 PRODUCTS FOR MEN AND WOMEN
AWS PRODUCT LINE

BUY MERCHANDISE
TODAY AT WWW.LOGODOGZ.NET/AWS

AWS Members now have access to American Welding Society shirts, hats, accessories and more at the AWS E-store. All of the products in this store are branded with the American Welding Society logo. Don’t miss out on an assortment of great products.

FOR COMPLETE PRODUCT LINE
VISIT
www.logodogz.net/aws
BY ROGER B. HIRSCH

Q: I install weld nuts on panels using a pilot pin in the lower electrode as a locator. I have noticed that some of the threads in the nuts are distorted. What could be the cause?

A: There can be two causes for this problem. First, if the pilot pin is conductive you can have arcing on the threads. This can be eliminated by using fully insulated guide pins. The current technology uses ceramic guide pins to eliminate arcing. The second cause could be using a welding schedule that is too long or with too low of a force between electrodes. This causes the nut to become plastic and changes the thread pitch. Just increase force, reduce weld time, and then increase welding current until the desired pull-off strength has been developed.

Q: I have had no problem finding welding schedules in the RWMA Resistance Welding Manual to join most of the parts we manufacture. The only thing I do not see on the schedules is how to set the HOLD TIME. What does this function do, and what number should I set?

A: Hold time is the time after the end of weld heat and the opening of the welding electrodes. It keeps the metal under force until the molten metal of the weld nugget solidifies. If the hold time is too short, the welds will not be at full strength. If the hold time is too long, production time will be wasted. As a rule of thumb, set hold time to 0.03 cycles for metal thicknesses of 0.070 in. or thinner, and 0.05 cycles for thicker metals. If joining two thicknesses, use the thinner of the pair to determine the hold time.

Q: I am trying to make a weld on a panel that must be as clean and flat as possible on the outside of the finished product. The welds are strong enough, but the weld locations have deep dents that are almost impossible to sand out.

A: First, be sure that the electrode on the “show” side of the part is flat and absolutely parallel to the back surface of the panel. While some recommend the use of swirl electrodes, I am a fan of solid flat electrodes with a diameter at least twice that of the upper electrode. Then use full electrode force, short time, and high welding heat to get a nugget without excessively heating the surrounding area. Using too low electrode force will actually increase weld indentation. Try to use a weld schedule from the Resistance Welding Manual for the alloy you are welding.

Q: I have a custom single-point spot welding machine that uses a fixture-type transformer operating on 440-V single-phase power. The operators are complaining about receiving little shocks when they touch the electrodes. A meter placed between the electrode and ground reads 230 V. Does this mean that the transformer has a breakdown between the primary and secondary sides your operators would get more than “little” shocks. I would bet that the secondary of the welding transformer is not grounded. Should there be a ground wire, sized about \( \frac{1}{2} \) the size of the incoming power wires, that should be connected from either of the welding machine’s secondary pads. If installing this ground wire causes arcing between the part and the welding table or fixture, you can leave the secondary floating and install a grounding reactor on the machine secondary. Your resistance welding supplier should be able to supply this inexpensive device.

Q: I use my spot welding machine to silver solder brass and copper parts together. The electrodes are copper-tungsten and I can get good results. However, the operator must continually adjust the welding control to maintain flow of the silver solder. Any ideas?

A: The problem is that you are using the electrodes as external heating blocks, and the amount of heat produced has to do with the starting temperature as well as the height of the copper-tungsten face on the electrodes. The answer is to use a welding control that incorporates an infrared temperature instrument that will monitor the temperature. Once you have this set, you will need to use a welding schedule that has lower heat, lower force per projection, and a longer time than would be used for a single projection. The Resistance Welding Manual has a very nice chart on projection welding with separate settings for a single projection, two to three projections, and more than three projections.

Q: When I join an 18-gauge cold rolled steel (CRS) plate that has three projections to a 14-gauge CRS part I have a hard time getting all three projections to be acceptable. Usually one projection is good, one is borderline, and one just falls apart. What am I doing wrong?

A: Projection welding can drive you crazy. The problem is that the welding machine will pass current through the projection that has the best contact force and might not even start passing current through another projection until much of the weld time has expired. To make all of the welds successful, you have to do two things:

1. The upper and lower electrodes should be flat and absolutely parallel. This means that the welding machine has to be very rigid. Don’t try to do this type of welding using a rocker arm welding machine. Be sure to measure the absolute parallel of the electrodes under full welding force since all welding machines will flex under mechanical load. One trick is to put the machine in no weld, place a piece of a self-carboning form under the projection part, and come down with full welding force. Adjust the electrodes as needed to make the same print on all three projections.

2. Once you have this set, you will need to use a welding schedule that has lower heat, lower force per projection, and a longer time than would be used for welding a single projection. The Resistance Welding Manual has a very nice chart on projection welding with separate settings for a single projection, two to three projections, and more than three projections.

Set the electrode force and weld time per the chart, and then adjust the weld heat until you achieve the desired results.

ROGER B. HIRSCH is president, Unitrol Electronics, Inc., Northbrook, Ill., and chair of the RWMA committee of the American Welding Society. Hirsch holds a degree in electrical engineering from the University of Illinois and in mechanical engineering from IIT. He has worked in the metals manufacturing industry since 1965 and has a list of patented inventions for this industry and others. Send your comments/questions to roger@unitrol-electronics.com, or Roger Hirsch, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126.
Become Certified in Robotic Arc Welding and Join the Ranks of the Elite in the Robotics Industry

AWS understands that the certification of individuals in robotic arc welding is important to the industry, and has developed a program, based on the AWS QC19 standard and AWS D16.4 specification, that defines the requirements for personnel to be considered qualified to test for certification.

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

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

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

Colorado // Wolf Robotics // 4600 Innovation Drive // Fort Collins, CO 80525 // (970) 225-7736
Iowa // Genesis-Systems Group // 8900 Harrison Street // Davenport, IA 52806 // (563) 445-5888
Michigan // ABB, Inc. // 1250 Brown Road // Auburn Hills, MI 48326 // (248) 391-8421
Ohio // The Lincoln Electric Co. // 22221 St. Clair Ave. // Cleveland, OH 44117 // (216) 383-8542
Wisconsin // Milwaukee Area Technical College // 1200 South 71st Street // West Allis, WI 53214 // (414) 297-6996

SEMINAR / EXAM SCHEDULE

<table>
<thead>
<tr>
<th>Week of</th>
<th>AWS Approved Test Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/13/2010</td>
<td>Genesis-Systems, Davenport, Iowa</td>
</tr>
<tr>
<td>10/25/2010</td>
<td>The Lincoln Electric Co., Cleveland, Ohio</td>
</tr>
<tr>
<td>10/25/2010</td>
<td>Genesis-Systems, Davenport, Iowa</td>
</tr>
<tr>
<td>11/1/2010</td>
<td>Genesis-Systems, Davenport, Iowa</td>
</tr>
<tr>
<td>On request</td>
<td>Milwaukee Area Technical College, Milwaukee, Wis.</td>
</tr>
</tbody>
</table>
Much of our welding future depends on the ability of the industry to adapt and promote its technologies to new energy industries.

Examine the many avenues of energy including the important aspects of coal-powered plants, the present and future of nuclear power, activities in pipeline construction, land-based and offshore work in liquefied natural gas, solar energy, wind power and much more...
Conference Program

- The National Science Foundation’s New Center for Integrative Materials Joining
  Sudarsanam (Suresh) Babu – NSF Center for Integrative Materials Joining Science for Energy Applications - Columbus, OH

- Westinghouse’s Position in the Nuclear Renaissance
  Lance S. Harbison - Westinghouse Electric Company, Energy Center - Pittsburgh, PA

- Advances in Submerged Arc Welding of Wind Towers
  Teresa Melfi - Lincoln Electric Co. - Cleveland, OH

- Capabilities in Offshore Welding at Kiewit Offshore Services
  Richard Marslender - Kiewit Offshore Services, Ltd. - Ingleside, TX

- The Use of a Tempering Parameter for the Control of PWHT of Grade P91 and Other CESF Steels
  Jeff Henry - Structural Integrity Associates - Chattanooga, TN

- Using the Latest Technology for Heating and Welding Chrome-Moly Pipe
  James A. Byrne - Miller Electric Manufacturing Co. - Appleton, WI

- Welding Challenges of Liquefied Natural Gas Facilities
  Ben Fletcher - Chicago Bridge & Iron Co. - Plainfield, IL

- Narrow Groove Tandem GMAW and HLAW for Wind Tower and Nuclear Fabrication
  Ian Harris - Edison Welding Institute - Columbus, OH

- EV Batteries & Weld Process Variation
  Benjamin Christian and Daniel Hutchinson - General Motors LLC - Warren, MI

- Advancements in Pipeline Field Construction Welding
  Kevin A. Beardsley - Lincoln Electric Company - Cleveland, OH

- Explosion Welding and Its Application in Downstream Oil Refineries
  Michael Blakely - Dynamic Materials Corporation - Sugar Land, TX

- Duplex Stainless Steels and Nickel-Based Alloys: An Overview
  Cheryl Botti - ATI Allegheny Ludlum - Brackenridge, PA

- Laser-Based Additive Processes for Energy – Related Applications
  Todd Palmer - Pennsylvania State University - State College, PA

- Energy Applications for Advanced Joining Processes
  Ed Hansen - ESAB Welding & Cutting Products - Florence, SC

- The Nuclear Scene
  Nate Ames - Edison Welding Institute - Columbus, OH

- Dissimilar Metal Welding
  Donald J. Tillack - Tillack Metallurgical Consultants Inc. - Catlettsburg, KY

For more information on attending or exhibiting at the conference, please visit www.aws.org/conferences or call 800-443-9353 ext. 462
NEW PRODUCTS

GTAW Arc Starting Technology Enhances Precision Fabrication Work

Blue Lightning™ high-frequency, noncontact arc starting technology has been incorporated on all of the company’s 200-, 350-, and 700-A Dynasty® AC/DC and Maxstar® DC GTAW welding machines. It aids in precision fabrication in tool and die, aerospace, petrochemical, power-generation, and other critical applications. Also, the technology provides consistent, reliable arc starting at all amperages, including as low as 1 A on Maxstar and Dynasty 200 models, 3 A on Maxstar and Dynasty 350 models, and 5 A on Maxstar and Dynasty 700 models. It sets optimal starting parameters based on tungsten size from 0.020 to 0.250 in. diameter. Additionally, the technology controls four arc starting variables — amperage, time at amperage, slope time, and minimum amperage for various tungsten sizes. This increased control ensures the arc start and eliminates the current overshoots that cause melt-through.

Miller Electric Mfg. Co.
www.MillerWelds.com
(800) 426-4553

Roll Benders Operate Vertically, Horizontally

The 3-in.-capacity CP60H pyramid-style profile bending machine comes in standard and variable-speed versions. They have an MPR-40 autorepeat control and incorporated LED readout with 400-position memory. Controls are large and easy to use, with moisture- and dustproof polycarbonate overlays. The benders operate in vertical and horizontal positions and are furnished with an 18-piece universal tooling set, in hardened 55 HRC tool steel. All roll shafts are hardened and journaled in dual, high dynamic load bearings. Lower shafts are motorized with knurled rollers for traction. Extra benefits include dual foot pedal controls for left/right and forward/reverse rolling, concealed oil lines on the ram to eliminate accidental damage, dual emergency stop buttons, totally flush electrical panels, and large easy access tool storage compartments and a mobile control console to allow a safe operator distance.

Eagle Bending Machines, Inc.
www.eaglebendingmachines.com
(251) 937-0947

Nonferrous Mitre Saw Offers Choice of Motors

The Model KM10HS 10-in., high-speed mitre saw is designed for cutting aluminum, brass, plastic, and other relatively soft, nonferrous materials. The saw mitres 45 deg left, 60 deg right, and has capacities of up to 4½ in. at 90 deg, 4 in. x 3½ in. at 45 deg, and 2⅞ in. at 60 deg. Features include choice of a 3-hp, 3-phase 220/440-V TEFC motor or a 3-hp single-phase 220-V motor, a manual switch, 3450 rev/min spindle speed, % in. spindle arbor, sealed ball bearings, V-belt drive, dual cam-lock vises, and an OSHA safety blade guard. The saw measures 25 in. long x 24 in. wide x 17 in. high.

Kalamazoo Industries, Inc.
www.kalamazooindustries.com
(269) 382-2050

Helmet Honors Company’s 115th Anniversary

The 115 Year Limited Edition Viking™ helmet commemorates the company’s 115th year in business. The autodarkening welding helmet features internally mounted continuously variable control and commemorative graphics of founders, James F. Lincoln and John C. Lincoln. Other graphics include a 115 year logo, a
Sanding Block Reduces Airborne Dust

The Dust Doctor® provides an instant means of cleaning loaded abrasive sheets. This tool utilizes microfiber technology to pull sanding dust right from the paper. It also cuts down on the time spent changing paper. Other features include a microfiber outer layer that traps sanding dust and cleans loaded abrasive sheets instantly.

Tools Measure Critical Fitups

The company's tools precisely measure weld joint fitups. For fatigue-sensitive and other critical applications, joint alignment better than 0.020 in. is often required. To measure such high-tolerance fitups, it's appropriate to utilize equipment capable of measuring to the thousands of an inch. The tools offer this degree of precision for measuring inner and outer surfaces of J-Prep and V-Prep weld joints. Laser measurement services are offered as well to improve weld fitup and measure root weld profiles.

Optical Metrology Services
www.omsmeasure.com
(832) 230-0153

Burr Monster®
Premium Tungsten Carbide Burrs

- All Standard Shapes & Sizes
- Large Stocking Inventory
- Same Day Shipping

- Flex & Long Shank
- Special Geometries
- Resharpening Services
- Coatings on request

Proudly Made in the USA

Ph: 888-CARBIDE (227-2433)
www.monstertool.com

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

1927 cross-country pipe welding project using Fleetweld® 5, and a welder repairing an airplane with a Shield-Arc® motor-generator set in 1944. It is lightweight at 19 oz and has a 9–13 shade control and sensitivity adjustments. In addition, the helmet has a grind mode ideal for weld prep and postweld cleanup activities. It is solar-powered with battery assistance, has a view size of 3.78 x 1.85 in., and LCD optics that deliver a clear, natural view.

The Lincoln Electric Co.
www.lincolnelectric.com
(888) 355-3213

Sanding Block Reduces Airborne Dust

The Dust Doctor® provides an instant means of cleaning loaded abrasive sheets. This tool utilizes microfiber technology to pull sanding dust right from the paper. It also cuts down on the time spent changing paper. Other features include a microfiber outer layer that traps sanding dust.
Manufacturing
Flux Cored
Welding Wire
COBALT
NICKEL
HARDFACE
STAINLESS
ALLOY STEEL
TOOL STEEL
MAINTENANCE
FORGE ALLOYS
CUSTOM ALLOY
COR-MET, INC.
12500 Grand River Rd.
Brighton, MI 48116
PH: 810-227-3251
FAX: 810-227-9266
www.cor-met.com
sales@cor-met.com

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

dust; soft cushion inner liner that enhances dust collection; flexible magnetic backing for placement on the work surface or cart; and shop air-quality improvement by reducing airborne dust.

Motor Guard Corp.
www.motorguard.com
(800) 227-2822

Safety Curtains Interlock with Snap Fasteners

Kwik-Snap interlocking safety curtains snap together, allowing users to create a space to protect employees against weld flash and flying debris. They are constructed of 14-mil PVC and feature snap fasteners, which are sewn into each curtain, along the sides so users can connect the panels in a range of configurations. Also, they come with grommet mounting hooks. Color options include yellow, orange, and bronze. The curtain's standard sizes are 6 x 4 and 6 x 6 ft, and these sizes allow users to arrange the curtain into any number of configurations and sizes.

Frommelt® Safety Products
www.frommeltsafety.com
(800) 553-5560

Waterjet System Provides Small Kerf and Cut Angles

The KOIKEJET features a precision ground ball screw drive for a smooth and accurate cutting motion, along with laser alignment, initial height sensing, and adjustable water level control. The system has a KMT ultrahigh-pressure intensifier pump, plus provides the small kerf and cut angles of waterjet cutting, and precise edges. Its accuracy is ± 0.0003 in. and repeatability is ± 0.001 in. Its Renishaw ballbar dynamic positioning measurement is ± 0.005 in.; the Renishaw ballbar test of squareness and straightness is ± 0.003. These systems are available in a cutting width of 6 ft and cutting lengths of 6, 10, and 12 ft with custom sizes available. It can cut steel, aluminum, brass, copper, titanium, and armor plate from gauge thickness up to 8 in.

Koike Aronson/Ransome, Inc.
www.koike.com
(800) 252-5232

Lightweight Laser Requires No External Gas Supply

The DIAMOND™ E-1000 is a sealed 1-kW CO2 laser that measures less than 59 x 18.5 x 15 in. including its integrated power supply. The product’s features make it suited for use in small machines or space-sensitive applications. It requires no external gas supply, and the only connections to the laser are a power cord and water hose, making it easy to mount on a robotic arm. Its design eliminates external laser gas and service of the gas blower required to support the external gas supply. The design, together with built-in advanced diagnostics, minimize laser down-time and maintenance. Brilliance™ enables faster cutting of nonmetals, cutting mild steel sheets up to ¾ in. thick, and cutting stainless steel sheets up to ¾ in. thick.

Coherent, Inc.
www.Coherent.com
(860) 769-3143

Glove Contains Padded Patch on Its Cuff

The BM88, a comfortable GMA glove added to the BSX® line, has a combination of premium grain pigskin with a cowhide back. This glove introduces the company’s RestPatch®; a padded patch on the glove’s cuff to reduce pressure on the wrist and wrist bone during sustained welding. Other features include a fully lined padded palm, Kevlar® stitching, and
the company's DragPatch®. Also, the index finger and thumb are constructed of fine grain pigskin.

Reuvo Industries, Inc.
www.revoindustries.com
(800) 527-3826

Gauge Calibration Center Gives Precise Measuring

MIC TRAC, a precision electronic calibration and measurement center, comes in two models. The MT-3000 is for part measurement and hand-tool calibration. The MT-4000 offers a higher precision to calibrate cylindrical and threaded ring and plug gauges. An optical glass scale housed within the base unit provides accuracies to ±0.00002 in. Also, receiver pads and anvils are manufactured and precision ground to within 0.00005 in. Both models are available in measurement ranges of 0-12, 0-24, 0-36, 0-48 in., and larger custom sizes. Adding the optional CAL-PAK, a collection of precision fixtures that hold various inspection gauges during calibration, allows versatility.

Gagemaker, Inc.
www.gagemaker.com
(713) 472-7360

Carbide Bur Kits Come in Compact Metal Boxes

The Carbide Bur Kits all include conical, round, cylindrical, and barrel-shaped burs manufactured from Grade K20 micrograin carbide and high-speed, heat-treated steel shanks. Packaged in metal boxes, three kits are offered — 4 piece ⅜-in. Shank Aluminum Cut Bur Kit, 8 piece ⅝-in. Shank Double Cut Kit, and 12 piece ¾-in. Shank Double-Cut Bur Kit. All 100% torque tested for reliability and long life, the burs were selected for each kit to provide machinists with a selection that corresponds to their typical job requirements.

Rex-Cut Products, Inc.
www.rexcut.com
(800) 225-8182

An electrode (p/n 9-8232) and 120-A cutting tip (p/n 9-8233) are designed for the automated SL 100SV torch. In automated applications, the pair provides increased parts life and improved cut surfaces on materials thicker than ⅛ in. The company's T Torch® plasma cutting torch performs with virtually all plasma cutting power supplies. It works with high-frequency, CD, touch, and moving parts start systems.

Thermal Dynamics®
www.thermal-dynamics.com
(800) 752-7621

For info go to www.aws.org/ad-index
Whether they work with stainless steel, weathering steel, brass, copper, or scrap mild steel, metal and welding are the preferred media of these artists.

BY KRISTIN CAMPBELL, MARY RUTH JOHNSEN, AND HOWARD WOODWARD

Artists who sculpt using welding work in a fundamentally different manner than those who create using other materials and methods, explained Canadian artist Hilary Clark Cole. “People who weld work from the inside out; sculptors who work in wood, stone, and sometimes in bronze work from the outside in.”

Following are profiles of six artists who have chosen metals and welding as the media to create art that ranges from the whimsical to the monumental.

Hilary Clark Cole

When Hilary Clark Cole (Fig. 1) first began working with metals and welding she knew she had “found the material that says what I want to say.” Cole believes she’s a pioneer in many ways. Although not the first woman to sculpt with metal, when she began her professional career in the late 1960s, she didn’t see too many other women doing what she was. “I knew what I wanted to do, but there was no one to show me how to do it,” she recalled. “I had to figure out how to do things myself. I had to innovate. The equipment was large and the materials were heavy.”

Clark Cole got her first taste of metalwork while a student at the Ontario College of Art and Design in a jewelry-making class. They taught welding next door, however, and she quickly moved over. In

Fig. 2 — Northern Ontario Bull Moose was the first piece Clark Cole built from COR-TEN steel. The moose stands 9 ft tall, and weighs 1200 lb, about the height and weight of a real moose.

Fig. 3 — Muskox took a year and a half to complete and weighs 1600 lb. The individual steel strips that make up his coat were cut with a plasma cutting machine, shaped (often using Clark Cole’s own body weight to bend the metal), and individually welded into place.

MARY RUTH JOHNSEN (mjohnsen@aws.org) is editor and KRISTIN CAMPBELL (kcampbell@aws.org) and HOWARD WOODWARD (woodward@aws.org) are associate editors of the Welding Journal.
Fig. 4 — Clark Cole said she “lay underneath, sat beside, and climbed on top” to weld the hair on Muskox. The pieces of hair range in size from % in. square to 30 in. long x 3 in. wide.

some ways, she believes her affinity for metal is ingrained. “Fifteen years into my professional career I asked my father what my grandfather did for a living, and it turned out he was a blacksmith.”

Since 1971, Clark Cole has lived and worked in Muskoka, Ont., Canada. Today’s modern welding and cutting equipment has been a boon to her career because of its light weight and capabilities for cutting and welding thicker materials.

“Until 1992, I wasn’t working in heavier materials and most of my pieces were indoor sculptures,” she said. “I couldn’t lift the sheets, let alone cut them. I used a lot of scraps at first and looked for hours to find the shapes I needed.”

Today, she uses oxyacetylene and gas metal arc welding (GMAW) and plasma arc cutting equipment. She creates large, realistic, three-dimensional animals such as Northern Ontario Bull Moose (Fig. 2) and Muskox (Figs. 3, 4) and fanciful figures such as Windswept Silhouette (Fig. 5), as well as small, intimate studies of flowers, wildlife, and humans. For the large pieces, she starts with a maquette, or study model, in light steel in order to establish the anatomy, dimensions, personality, and message of the life-sized work.

The Moose, Muskox, and Windswept Silhouette were all created with % in. COR-TEN® steel plate. This nickel-steel alloy, commonly known as weathering steel, rusts until it achieves a certain color and patina, but does not corrode, making it ideal for creating outdoor sculptures. Clark Cole cuts the metal with the plasma cutting machine; she uses a Beverly shear for lighter materials. She bends the metal through hammering, heating, or as with the pieces that make up Muskox’s long coat, putting the cut metal strips in a vise grip and using her body weight to make the bends.

Fig. 5 — Here, Hilary Clark Cole shares the spirit of her sculpture titled Windswept Silhouette, which is rooted on a piece of Muskoka granite. The sculpture took a year to complete, is 9% ft tall, and weighs 4½ tons. Cole considers it one of her masterworks.

“I don’t really have anyone to help me, and I don’t really want anyone to,” she said. “I want it to be a work of my own hands.” She does have a friend she turns to if she needs something with especially accurate dimensions, but overall, “I don’t like perfect circles. I like my hands to show.”

Clark Cole does extensive research before building a sculpture in order to get the anatomy and movement correct for the creature she is creating. That was true for Ironica, the life-size female figure wearing a suit of armor that she has spent the past year and a half creating — Fig. 6. Clark Cole enjoys chronicling her creations and has extensive write-ups and photos of her pieces on her Web site at www.hilaryclarkcole.com, including a complete diary of the building of Ironica. She believes people need to know how artworks are created and that it helps with their understanding and enjoyment of the piece.

Today she is still in “Ironica recovery mode” and is enjoying working on some small pieces that take only two or three weeks to complete rather than a year or more. This series will be displayed at The Algonquin Art Centre at Algonquin Provincial Park in Central Ontario.

Kevin Stone

Since childhood, Kevin Stone has loved to draw cartoon and fantasy art. Now, thanks to the help of a full-time investor, he’s able to spend his days sculpting as owner of Metal Animation Studio, Inc., Chilliwack, B.C., Canada — Fig. 7.

“My pieces are designed to inspire awe and simply amaze spectators upon viewing,” Stone said.
With more than 20 years of metal fabrication experience, he started sculpting stainless steel about 5½ years ago after an employer asked him to build a gargoyle for the company’s rooftop. He completed the 6.6-ft-tall, 8.5-ft-wide, 300-lb creature in about three months working with leftover shop scraps — Fig. 8.

“I thought it would be fun to challenge myself to try sculpting in metal,” Stone said. “The result was that I found stainless steel to be a wonderful and beautiful material to work with for making art.”

Each of Stone’s three-dimensional creations is hand made with 16-gauge surgical-grade stainless steel. The metal’s longevity qualities include no rust or corrosion. He also intends for his sculptures to be mounted in or above water so light can be reflected off of them.

Stone cuts the stainless steel with a power sheer or grinder with a cut-off wheel; fits and tacks parts together; primarily uses gas tungsten arc welding because the process does not spatter or spark and enables fine detail work; grinds down the welds; and follows a multistep process of polishing with fine-grit polishing pads until achieving a mirror finish.

Letting Eagles Soar

Stone’s first large-scale sculpture, the bald eagle Power and Authority, strikes an attack pose with extended legs and its eyes focused on the prey — Fig. 9. The 20-ft-high sculpture with a 31-ft wingspan captures the bird’s dominating, powerful presence. Its public unveiling, held in 2006, came after ten months of work.

“Inspired by the positive feedback from friends and the public who have seen my work, I decided to make another eagle, bigger and with even more detail,” he said. Power of Flight, Stone’s second bald eagle, captures the bird’s streamlined efficiency and grace — Fig. 10. Unveiled in 2007, it weighs 6000 lb and is 11 ft high with a wingspan of more than 40 ft.

Creating the Chinese Imperial Water Dragon

Stone’s next piece came from an early liking of fantasy art with heroes fighting dragons and monsters to save the king-
The Chinese Imperial Water Dragon has been his most challenging project, taking almost two years to complete. “It was a test of perseverance,” Stone said.

Approximately two miles of gas tungsten arc weld beads were made while putting together the masterpiece — Fig. 11. The dragon’s body features two large coils, and an enameled ball is held in one of its claws. Stone believes it is the world’s largest stainless steel Chinese dragon standing 12 ft tall, 14 ft wide, more than 85 ft long, and weighing 6000 lb — Fig. 12.

In 2009, the dragon unveiling attracted a turnout of almost 2000 people with support from the City Council, Chilliwack tourism, local art groups, and a speech from Chilliwack Mayor Sharon Gaetz.

Additional Projects

In August 2009, Stone assembled a raptor dinosaur using a scaled-up version of a wood puzzle model. It stands more than 7 ft tall and 11 ft long from head to tail. The sculpture’s metal bones were cut using a plasma machine, boxed with 1-in. flat strips, and welded for added strength.

All four sculptures (the two eagles, dragon, and dinosaur) are on display at Stone’s studio in Chilliwack, which is located in the yard of his home and open seven days a week for the public to view these pieces before they sell.

Eventually, Stone would like to work with a Native American carver to create a large totem pole using his chosen medium of stainless steel with a mirror finish. To learn more about the artist, visit www.metalanimation.com.

Jennifer Costa

Jennifer Costa (Fig. 13) is the gallery curator and an assistant professor of art at Illinois Central College, East Peoria, Ill., where she has taught for ten years. Some of her artistic inspiration has become reality by taking artistic advantage of her own scrap metal. Costa mused, “I often found myself thinking what a waste of all of these pieces of steel that I am cutting away to make the larger pieces. I started saving the smaller pieces and then welding them together to create interesting patterns that would play with light.” Most interesting, she said, “I have created sculptural pieces that just happened to have places for a person to sit, thus making them functional as well. My chairs made way for tables, and the tables made way for mirrors, and the mirrors made way for wall pieces with little drawers to pique the interest of the viewer” — Figs. 14–16. She credits her inspiration to the Art Deco and Art Nouveau artists Eileen Gray, Charles Rennie Mackintosh, Louis Ma-
Somewhere, Emile Galle, and others who also made amazing sculptural objects that served practical purposes.

Combining Materials for Effect

“Now,” Costa explained, “I am working on combining materials. I’m not relying solely on wood or on steel, but using both within one piece of artwork in addition to other materials. I love detail and using the natural colors of various woods by having them contrast and complement one another.”

Costa, who holds a master’s degree in fine arts — sculpture, is currently affiliated with VagnHill Galleri, Prairie Arts Center, Bishop Hill, Ill. She teaches 3D Design and Sculpture I at Illinois Central College. Her students learn to braze and weld with the gas tungsten arc process. “My students learn how to do bronze and aluminum casting and can further their welding experience by practicing basic beads using the Lincoln Electric Weld Pak.”

Eric Ockerhausen, advisor for the AWS Illinois Central College Student Chapter, worked with Costa on several AWS-related projects. He also has attended Costa’s classes. He said, “Jennifer Costa is a good welder. She taught me how to work out my ideas using a sketchbook and the construction of maquettes. A hundred of my sketches would usually yield only a couple good ideas, but they embodied the best features of the other 98 sketches that were rejected.” Ockerhausen concluded, “Creating good art is a lot of work!”

Some Tricks of Her Trade

Costa said, “The sculpture lab has a fully equipped woodworking shop and a small welding area. We have a foundry outside with a Speedy Melt Furnace that is capable of melting 30 lb of aluminum and 90 lb of bronze. We are capable of doing lost-wax casting, and resin-bonded sandcasting. Most of my artwork incorporates some variation of aluminum casting, welding, and woodworking. The tables have cast aluminum legs in which I use vapo casting and cast the aluminum directly around a piece of steel. Vapo casting,” Costa explained, “is the process of burying an item carved out of a piece of foam and then pouring molten aluminum down a tube to the foam piece. The aluminum instantly vaporizes the foam and fills the void. The piece of steel placed in the foam is used for welding the legs to a steel frame. Sometimes, I cast the aluminum around bolts and use the bolts to weld to the frame. For welding, I use a Lincoln Electric Weld Pak 100 shielded with CO₂, and for cutting I use a Miller Spectrum 375 Cutmate DC plasma arc system.” For cutting, she prefers to use plasma arc for its ability to give cleaner edges than is possible with oxyacetylene.

Costa exhibits her work locally and nationally, and anyone can view her portfolio at www.jennifercostastudio.com.

Bob Doster

Bob Doster (Fig. 17) first tried his hand at welding when he was eight years old. His father owned a furniture business, then added metalwork when furniture sales slowed. “Fifty-two years later, here I am still welding,” Doster said.

Doster initially learned to weld from jorelle, Emile Galle, and others who also made amazing sculptural objects that served practical purposes.

AWS Illinois Central College Student Chapter, worked with Costa on several AWS-related projects. He also has attended Costa’s classes. He said, “Jennifer Costa is a good welder. She taught me how to work out my ideas using a sketchbook and the construction of maquettes. A hundred of my sketches would usually yield only a couple good ideas, but they embodied the best features of the other 98 sketches that were rejected.” Ockerhausen concluded, “Creating good art is a lot of work!”

Some Tricks of Her Trade

Costa said, “The sculpture lab has a fully equipped woodworking shop and a small welding area. We have a foundry outside with a Speedy Melt Furnace that is capable of melting 30 lb of aluminum and 90 lb of bronze. We are capable of doing lost-wax casting, and resin-bonded sandcasting. Most of my artwork incorporates some variation of aluminum casting, welding, and woodworking. The tables have cast aluminum legs in which I use vapo casting and cast the aluminum directly around a piece of steel. Vapo casting,” Costa explained, “is the process of burying an item carved out of a piece of foam and then pouring molten aluminum down a tube to the foam piece. The aluminum instantly vaporizes the foam and fills the void. The piece of steel placed in the foam is used for welding the legs to a steel frame. Sometimes, I cast the aluminum around bolts and use the bolts to weld to the frame. For welding, I use a Lincoln Electric Weld Pak 100 shielded with CO₂, and for cutting I use a Miller Spectrum 375 Cutmate DC plasma arc system.” For cutting, she prefers to use plasma arc for its ability to give cleaner edges than is possible with oxyacetylene.

Costa exhibits her work locally and nationally, and anyone can view her portfolio at www.jennifercostastudio.com.

Bob Doster

Bob Doster (Fig. 17) first tried his hand at welding when he was eight years old. His father owned a furniture business, then added metalwork when furniture sales slowed. “Fifty-two years later, here I am still welding,” Doster said.

Doster initially learned to weld from
During his time as the featured artist at the University of South Carolina Upstate, Doster created eight large metal sculptures for the campus, including this Suspended Portal. Doster has created many portals over the years, "like the shape and form, but there’s also a transitional meaning, the passing through from one point of time to another."

"When I got out of college, I immediately took a welding course so I could make pretty welds," he recalled. "Mine would stick, but they looked terrible."

Today Doster continues working in his hometown of Lancaster, S.C., where he owns Bob Doster’s Backstreet Studio, Gallery, and Garden, where he not only shows his own work but that of other artists, including wife, Cherry. Among the honors he has received are the 2006 Elizabeth O’Neill Verner award, a governor’s award that is the highest recognition given to artists in South Carolina. Doster was the featured artist for the 2008-09 academic year at the University of South Carolina Upstate in Spartanburg. During that year, he created eight large metal sculptures that are located throughout the campus — Fig. 18.

Doster uses COR-TEN® or stainless steel for much of his work. "I like the rusty material because of the way it looks in the environment. Neither one (weathering or stainless steel) has any upkeep."

He uses the gas tungsten arc, gas metal arc, and shielded metal arc (SMA) welding processes, as well as both manual and CNC plasma arc cutting systems. He also utilizes a variety of hand tools and light bending equipment. Any pieces greater than 12 ft tall, he takes to a friend’s fab shop to take advantage of the cranes and heavier-duty equipment there.

When creating a large-scale piece, he likes to build a small model beforehand. The model allows him to create a visual representation of his ideas and helps him work out any difficulties he might encounter in developing the full-scale artwork.

**Passions and Challenges**

What is Doster passionate about? "Usually the next piece I’m working on," he said. "My passions vary from piece to piece. I’m like a tree, I go from branch to branch." More seriously, Doster explains that one of his most enjoyable challenges is "when someone says ‘This is the space, make something to fit it.’"

An example of that is Cascade, a 40-ft-tall stainless steel sculpture he created for the Saks Fifth Avenue department store in Atlanta, Ga. — Fig. 19. The space required it be no deeper than 4 ft, no wider than 10 ft, and no taller than 40 ft. Erecting the piece on site took 2 ½ nights and the services of structural engineers and riggers to hang it safely. Shoppers view it from different angles as they ride the store’s escalators.

Doster is also clearly passionate about working with children. Thirty years ago he was named to the roster of the Arts in Education program of the South Carolina Arts Commission, and he estimates he has worked with more than 100,000 students since then. The program gives students the opportunity to work with professional artists. The pieces the students make range from small artworks they can carry home with them to large pieces to decorate their schools or communities. The plasma cutting equipment has been helpful to Doster’s educational endeavors because even the youngest children can cut their own pieces with his hand guiding theirs.

"Most of the time I do the actual welding, but at schools with a metal shop, the students do it," he said. Doster lamented the loss of so many vo-tech programs saying there are many students who would...
Pamela Olin

Human figures recur throughout Pamela Olin’s artwork. “I like how the human form can express emotion and attitude,” she said.

The owner of Olin Design Studio, Chicago, Ill., finds inspiration in life. Her love of art began as a child, and she grew up as a creative person, thinking outside the box.

Olin (Fig. 22) works with mild steel. It is versatile, easily found in leftover scraps, and gives weight to sculptures. To make pieces look solid, she uses copper, bronze, brass, and pewter coatings, or allows a patina to develop.

Primarily, she performs GMAW for the tight control it provides, and also uses a plasma arc cutting machine and a supply of hand tools including drills, hammers, and sanders.

Olin has enjoyed making welded art during the past 17 years. “It’s a great rush manipulating material,” she said. “It’ll last. It’s not going to break or go away.”

Benefit from taking welding.

Doster’s goal has always been to make a living as an artist. To that end he relies heavily on commissions such as a series of Cotton Boll sculptures for Founders Federal Credit Union — Fig. 20. He took their corporate logo and turned it into 8- or 12-ft-diameter three-dimensional metal sculptures. He also creates a variety of functional pieces such as benches as well as collectables such as stainless steel palmetto trees and angel oaks — Fig. 21.

He began making palmettos — the state tree of South Carolina — because of one of his five sisters. “She was having a barbecue and said, ‘If you’ll make me a palmetto tree, I’ll sell ten of them that night.’ She sold 100 of them, and I decided I needed to make palmetto trees.” At first he cut them by hand, but now does them on the CNC plasma cutting machine.

For more information on Bob Doster and his Backstreet Studio and Gallery, visit www.bobdoster.com.

Fig. 20 — One of Doster’s commissions was a series of Cotton Boll sculptures for Founders Federal Credit Union offices.

Fig. 21 — Doster uses a computer-controlled plasma arc cutting machine to cut the pieces for his series of small collectibles, which includes palmetto trees.

Fig. 22 — Pamela Olin stands beside Going Forth. The piece represents man’s efforts to explore beyond our sphere of reference.

Fig. 23 — Portal, a steel archway that comes apart in three pieces, is a pivotal piece to Olin — Fig. 23. “That was my very beginning of using human shapes,” she said.

Its three-month construction phase took place in 1995. She used GMAW for the archway’s inner walls to provide structural ability; hand cut human shapes down its sides with a plasma cutting machine; welded those cut-out figurines in a circle at its top; and applied a clear coating. The structure stands 8 ft wide x approximately 10 ft tall x 2 ft front to back. It is placed at a camp’s outdoor chapel.

Two steel sculptures, Going Forth and Fulfill, were made at the same time in 1998 over a span of four months.

Going Forth (Fig. 22), signifying man’s efforts to explore beyond our sphere of reference, features three spiral arms of people with the center having smaller spheres “born” from it, then getting larger as they get farther away. Olin made an armature with ⅝-in. rod as its base, used
Fig. 23 — Olin, standing under Portal, likes the idea that a person can walk through the archway and come out changed.

Fig. 25 — The four figures in Guardians of Peace (from left) are Native American, Asian, Caucasian, and African American.

Fig. 24 — The Fullfill vase, painted in silver, has many human shapes welded on it.

GMAW to place the human figures, and let the metal rust before applying a clearcoat finish. The 36-in.-diameter piece was installed at Congregation Etz Chaim, Lombard, Ill., as a confirmation class gift.

Olin constructed Fullfill using a wire frame of ½-in. rod, built up as a vase, to provide support for the human shapes that were laser cut and gas metal arc welded — Fig. 24. The piece measures 72 in. tall x 36 in. in diameter and appears shiny from silver paint. “It illustrates by working together, we can do something,” she said.

The four Guardians of Peace stand at Highland Park High School, Highland Park, Ill. — Fig. 25. The Native American features an eagle; the Asian wears a hat; the Caucasian carries a shield; and the African American holds an instrument. Each of the hollow figures is approximately 15 ft tall, made with a mosaic of recycled stainless steel, and constructed using SMAW. Olin worked on the project for three months in 2002 with a Brazilian artist.

For new extended figures inspired by Alberto Giacometti, texture can be seen painting with gas metal arc wire. To create the line, Olin made an armature with thin steel rod and laying weld bead along the rods to form the musculature. This welding creates the gentle curves as the heat draws the steel to it. Seeker, sculpted using molten steel with spatter added for texture, holds a 3-in.-diameter sphere and is 12 in. diameter x 52 in. tall — Fig. 26.

Fig. 26 — A recent line of work featuring extended figures with gas metal arc wire used as a medium includes Seeker.

Fig. 27 — Olin, shown above using GMAW to finish a cube sculpture, teaches female welders at Harper College.

Guiding Women Welders

For the past 1½ years, Olin has taught Welding for Women at Harper College, Palatine, Ill. — Fig. 27. The four-week continuing education, noncredit course provides 12 h of instruction. Using GMAW, plasma arc cutting, and a variety of tools, the women create projects such as steel garden accents.

Next, Olin plans to create decorative steel tangled vines for the outside window frames of Pamela’s Parkside Grill, her restaurant in Arlington Heights, Ill. She would like to continue making custom, commissioned, and public fine art along with paintings and home furnishings. To learn more, visit www.PamelaOlin.com.

Sandra Garcia-Pardo

Sculptor Sandra Garcia-Pardo (Fig. 28) maintains her own studio in South, Florida, where she creates art works and teaches art classes. Her works cover a wide range of topics and materials — Figs. 29, 30.
Women Love to Weld

Much of her training involves the use of welding equipment, and she finds it amusing that most of her students are women. She utilizes a variety of materials and media to create art objects that embody her ideas “regarding human relationships (on a personal level) and political ideas (on a broader level).” She has become successful creating art from steel pieces she salvages mostly from junkyards, “giving them a new life” using her talents. “In addition to exploring diverse media such as bronze, paints, engraving, photomontage, collage, and carving,” she said, “she is comfortable painting canvas, drawing, and using whatever materials and skills that are necessary to contribute to the evolution of the piece.

Finding Her Niche

“One day,” she said, “I found my partner in steel. Steel is a great partner to work with. Steel gives character to my pieces which are both strong and delicate, and I am always committed to simplicity — no ornaments — just honest expression and telling of new stories through my art.” Her hope is that viewers will personally identify with her creations.

“When I start a project,” she mused, “I think about the great masters of steel like Weissman, Di Suvero, David Smith, and Antony Caro. I feel inspired by their dedication to their art with no limits.”

She said her appreciation for art was awakened in the city where she was born, Barranquilla, Colombia. It is a land rich in pre-Hispanic and African art and culture. Garcia-Pardo said, “I grew up in a working middle-class family. Since childhood, my inclination for art was evident and was always a passion. I wanted to become a professional, but this was not easy for me. The hardest part was getting no support from my parents.” Her parents were afraid that she would starve to death should she pursue art as a career. They urged her to study something more productive. So, Garcia-Pardo studied publishing design at the Barranquilla School of Fine Arts, but was not content.

Her big breakthrough came when “I was fortunate to receive a government scholarship to study art at the prestigious School of Fine Arts Prilidiano Pueyrredon in Buenos Aires, Argentina. It was there I discovered the marvelous world of talking with art,” she explained. “It was great to find a college to attend in a foreign country. All these years of study at the Fine Arts School and far from my family were really worthwhile. I expected to become a painter artist, but I discovered the sculpture world was just so much more fascinating, seeing I could make anything out of nothing.”

After graduating as a sculptor, Garcia-Pardo came to the United States where she displayed her art in galleries nationwide. Now, her works are exhibited in private collections in the United States, Dominican Republic, Puerto Rico, Spain, and Argentina.

Inspirations for the Art

When asked about how she goes about...
Fig. 30 — Sandra Garcia-Pardo’s unique Education sculpture consists of a series of nine school desk chairs, perhaps to remind kids what they are there for.

Fig. 31 — This welded metal sculpture is just one in the Vanity of Vanities; All Is Vanity series of ingenious Sandra Garcia-Pardo’s works inspired by luxurious handbags. Note the delicate distressed metal surfaces and her signature rust patina.

making her creations, she stated, “I am self-demanding, and I do not let traditions overrule my intentions. I create with no fears, letting the thoughts being captured as they first appear in my mind to later transform them in my art — plenty of simplicity, no ornaments, just honest.” She added, “I decided to make art in an unusual way. I involved myself in welding — an exclusive world for men. The challenge was how to make something beautiful out of rusted, heavy, and ugly junk. My sculptures keep their delicacy regardless of their size or shape. They are graceful because my hands have given new life to the metal skin.”

Now living the life that she loves, Garcia-Pardo currently teaches a hands-on art course she calls Wild Welding Women Workshops. The main topics include electric arc welding, oxyacetylene cutting, and gas metal arc welding. Her shop is well equipped with SMA and GMA welding machines, oxyacetylene torches, grinders, an air-compressor, sand blaster, drill press, and a variety of hand tools for the detail work.

Her new provocative line of satirical art works titled, The Bags of the Vanities, are stunning — Fig. 31. They portray in steel the delicate pricey handbags sold by Chanel, Hermes, and Louis Vuitton to their wealthy clientele. She intends them to serve as a criticism of the astronomical prices the famous brands ask for their products. Hopefully, she said, “This series of sculptures will be an invitation to think about the fetishes surrounding a luxurious article, so when we have some of them on our shoulders, they do not fit so well with the words in Ecclesiastes, ‘Vanity of vanities; all is vanity.’”

Visit http://sandragarciaart.com to view her portfolio and learn more about her classes.
Precision Laser Welding of Thin Structures

Joining of foil materials to produce thin lattice structures was achieved using a laser with preplaced powder filler material

BY ANDREW DECEUSTER, GARY STEWARDSON, AND LEIJUN LI

The common technologies used to join large-scale lattice structures include fusion and resistance welding, brazing, soldering, and adhesive bonding. However, the use of these processes for joining lattice structures utilizing foil materials on the order of 0.25 mm (0.010 in.) or thinner has proven difficult. When subjected to the traditional joining technologies, these foil materials tend to melt through, distort, or form weak bonds. Because of the limitations of current joining technologies, the material's size has become a limiting factor in the design of lattice-structured components.

A majority of the joining issues have come from the traditional manufacturing technique of welding a support rod and wire/strip together as two separate pieces to form the lattice structure — Fig. 1A. The traditional joining techniques have required thicker joining materials to avoid defect formations. While increasing the component thickness allows for proper joining, optimization of materials or design properties cannot be fully utilized.

Arc welding is readily used when lattice-structured components are designed with thicker sections. Typically, resistance welding has been used on thinner sections. In the production of well sieves, resistance welding has been limited to thicker sections that would not qualify as foil materials. Resistance welding requires high pressure and electrical flow; the pressure would cause foil materials to deform. Autogenous laser beam welding has also become popular for welding foil materials, but is limited to certain joint geometries with tight tolerances (Refs. 1, 2). Welding provides the advantage of a complete metallurgical bond that would allow for better heat transfer in thermal management structures. However, the main drawback to any welding process is the distortion associated with the high temperatures needed for welding. The process characteristics of arc welding decrease its feasibility for joining foil materials.

To optimize the materials and/or designs of foil lattice structures, a new joining and fabrication technique was needed. Rather than joining a support rod and wire/strip together, the incorporation of the support rod into the wire/strip could be produced by incorporating the concepts of solid freeform fabrication, where the weld bead would act as the integrated support rod — Fig. 1B. A laser could be used to join foil materials by forming a solid bead with a powder material, as an integrated support rod, while simultaneously tying the foil materials into the bead, similar to the selective laser sintering (SLS) process — Fig. 2.

Several problems are associated with the SLS process using a pure powder bed: When the laser initially scans the surface of the cold powder bed, there is an initial ball that forms from the high surface tension of the bed (Refs. 3, 4). The surface tension creates a steep contact angle, limiting the wettability of the liquid pool (Ref. 5). The oxides in the powder add to the surface tension (Refs. 6, 7). The high surface tension causes the bead to form on the surface of the powder bed instead of penetrating into the bed. The initial

Fig. 1 — A graphic representation showing the use of a secondary support rod (A) vs. integrating the support rod into the foil structure (B).

Fig. 2 — Laser joining of the foil materials with a powder filler material with the spacing of the structure maintained by the fixtures foil material.
balling and any other balling that occurs in the track will deplete powder from the surrounding powder bed, which leads to more problems with nonuniform density and track continuity.

A hybrid laser processing technique based on the idea of solid freeform fabrication using SLS, with the incorporation of solid foil materials, was hypothesized as a means of joining foil material into lattice structures. The incorporation of the foil material into the powder bed helps the process overcome many of the problems associated with SLS using a pure powder bed.

The use of this laser processing technique would benefit many applications that use fragile thin structures in several industries such as wastewater remediation, filtration, biomedical, and thermal management. The process would allow engineers to design higher surface area biological contactors, higher efficiency sieves, cardiovascular stents, higher height-to-width-ratio heat sinks, and a number of other products that would benefit from the use of foil materials. This article discusses the use of laser beam welding with powder filler as a hybrid technique for joining foil material into lattice-style structures.

**Process Setup**

Selective laser sintering is a solid freeform fabrication process that uses a laser to fuse powder materials together. The goal of this solid freeform fabrication process is to produce a finished product from a three-dimensional CAD model in a single manufacturing process. Due to limitations of SLS, foil structures cannot be produced based on the laser spot size and other effects. The incorporation of foils into the process would allow it to produce foil structures of similar material with complete metallurgical bonds. The main concept that can be taken from the SLS process is the ability to produce a solid structure from a powder material. If this idea is combined with normal laser welding, then a hybrid laser process that incorporates foil and powder material can provide an alternative technique for producing foil lattice structures. The powder material forms the support rod while the traveling melt pool bonds the foil materials together.

In the development of this hybrid laser process, fixturing was found to be highly important. Without proper fixturing, the slightest distortion of the foil materials caused the powder filler material to sink into the gap in between the foils. This decrease in powder level caused the foils to not join properly. To overcome this problem, a temporary support material was added in between the foil materials. The support material was the thickness of the desired gap spacing for the structure and was recessed below the surface of the foil materials. The foil and support materials were placed into a clamping fixture that held the materials securely to avoid any distortion during processing. The powder filler was added to the surface to fill the gaps produced by the staggering of the foil and recessed secondary materials and was scraped even with the top of the foil materials.

The recess of the support materials was necessary to create a pocket for the powder filler to be placed to form the bead in the gaps. The depth of recess for the support materials was based on the desired profile of the bead. The recess was increased if a larger bead or deeper penetration was required. Figure 2 shows the processing of a stainless steel foil structure with stainless steel powder placed on top of the copper support material. Once the fixture was set up, a laser was used to join the foil structure in the desired design.

**Laser Processing**

After the foil materials are placed into the fixture, a laser is selected and joining can begin — Fig. 3. Argon shielding is provided through an external nozzle similar to a gas tungsten arc welding gas cup with the laser traveling through the center. Laser processing of the foil materials is versatile. Depending on the desired bead profile either a continuous or pulse laser can be used in processing. The continuous laser can produce a variety of continuous profiles based on power input, travel speed, and focal spot size, while the pulse laser can produce either continuous or intermittent profiles based on power, pulse...
duration, frequency, and focal size. The pulse laser has the advantage of producing point profiles where two foil materials in any location can be joined, allowing for more freedom in structure design.

A set of experiments was carried out to fully characterize the laser processes and show their process capabilities. Due to limited literature on the hybrid laser welding and solid freeform fabrication process, the study dealt with process parameter effects, bead profiles, and distortion of the foil substrates.

Continuous Laser Processing

In evaluating the parameter effects on bead continuity with a continuous laser, numerous experiments were conducted to map out the laser power vs. travel speed parameter space. The resulting process zone boundary can be seen in Fig. 4. The results from other studies showed similar results for the boundary; however, the studies were performed on pure powder beds (Ref. 8). It was determined from the results that the boundary between continuous and discontinuous beads seemed to be based on the energy input (J/mm) and the rate of energy input (watts). The results showed that a rate of more than 100 W, with an energy input of 33.3 J/mm or higher, was needed to maintain a continuous bead.

The sectioned profiles and top-down views of a continuous bead can be seen in Fig. 5. The measurements for the bead profiles varied with the parameter settings. The range for the penetration depth...
was from 0.28 to 1.45 mm. The range for the width of the bead was 1.27 to 2.07 mm. The range of achievable measurements for the profiles shows the versatility of the process to adapt to a variety of products.

The distance between the foil materials was measured to determine how much distortion the laser processing caused. The distortion of the gap between the foil materials was measured and found to have a tolerance of ± 0.02 mm. The lack of distortion in the samples was due to the combination of the laser process and the setup. The use of a laser for joining as compared to traditional joining methods produces much lower energy input, and therefore less distortion. The fixture also provided rigidity to keep the foils from becoming distorted from the laser processing. Due to the laser process and fixture, distortion was minimal across the parameter settings. Distortion did not appear to be an issue when considering parameter selection.

Pulse Laser Processing

The parametric effect of a pulsed laser was studied, due to the increased control of the pulsed laser over process parameters. Increased control of heat input by a pulsed laser would be beneficial for even thinner materials or exact placements of the laser for structural designs. Similar to the continuous laser process, Fig. 6 shows the boundary between continuous and discontinuous bead formation based on process parameters. To maintain continuous tracks, the minimum energy input needed to be above the zone of 64 to 72 J/mm.

Associated with the amount of energy input, the resulting track profiles and top-down views of foil material processed with the pulse laser can be seen in Fig. 7. The measurements showed that the range for the foil profile penetration was 0.50 to 0.65 mm. The range for the microfoil profile width was 1.12 to 1.51 mm. The range for the powder profile penetration was 0.56 to 0.67 mm. The range for the powder profile width was 1.15 to 1.57 mm. The range of measurements shows the capability of the process to conform to a variety of applications.

Distortion of the gaps in the micro-foil materials was measured for each parameter setting. The mean and standard deviation were calculated for the gaps before and after joining. Distortion was present in the samples; however, the distortion was similar regardless of parameter settings. The distortion had a tolerance range of ± 0.01 mm. As with using a continuous laser, distortion did not appear to be an issue when considering parameter selection.

Summary

Using the data gathered from the experiments, a section of a biological component and a heat sink were produced and can be seen in Fig. 8. The joining of foil materials for the purpose of producing thin lattice structures was achieved using a laser with preplaced powder filler material. The boundary between continuous and discontinuous beads was found and the factors for maintaining a continuous bead were found to be a function of laser power input and travel speed. The results showed that the laser process is capable of joining foil materials into lattice structured components. This process will help engineers in the designing of foil lattice-structured components by allowing the support structure to be integrated into the component.

References

As welders familiar with AWS D17.1, Specification for Fusion Welding for Aerospace Applications, and other aerospace codes know, gas tungsten arc welding (GTAW) requires the use of non-contact or high-frequency (HF) arc initiation techniques to eliminate a potential source of inclusions in the weld bead.

High frequency provides a path of least resistance for the welding current to follow. However, in conditions where the arc fails to positively initiate, the HF current sometimes “dances” around the weldment, producing uncontrolled arc start marks on the workpiece, which then must be rejected. Uncontrolled arc starting conditions may also cause a burst of weld current that melts through thin metal or melts the knife-edge of small parts.

To combat these issues, aerospace welders often use a “run-on tab” (a small block of brass or other metal) on which to start the arc and then carry it over to the workpiece. While solving problems, a run-on tab doesn't eliminate the root cause of rejected welds, nor can it be used in all situations.

Fortunately, new HF technology — coupled with new GTAW arc starting technology — now enables aerospace welders to eliminate the root cause of many rejected welds while positively and consistently starting a DC GTAW arc at 1 A (see lead photo). In addition, the thousands of GTAW arc start tests conducted during the R&D phase of technology development produced new insights into conditions that promote better arc starts and weld quality. The following series of photos provides new insights into improving DC GTAW arc starts and reinforces the importance of some existing best practices for aerospace welding.

**Point Root Opening Problems**

Traditional GTAW machines feature a set of HF arc starting points that function in a manner similar to a spark plug gap. Any variability (such as grinding dust, dirt, or high humidity) changes the amount of
resistance required to bridge the root opening — Fig. 1. Inverter technology better managed this variable, but it didn’t eliminate the source of erratic arc starts.

**More Variables Controlled**

Old DC GTAW arc starting technology controlled one variable: amperage. New technology controls four variables: amperage, time at amperage, slope time, and minimum amperage. More control eliminates the current overshoots that cause melt-through.

**Automatic Simplicity**

Obtaining consistent arc starts with new technology is as simple as selecting the size of the tungsten you’re using from a built-in menu — Fig. 3. A “general” category allows users to create a custom program for unique applications, such as unusually long weld cables with increased resistance.

**Consistent Capacitors**

The newest inverters designed for aerospace welding, tool/die welding, and other low-amperage GTAW applications feature solid-state circuitry (Fig. 2) and hardware that functions much like a capacitor with an output controlled by a high-speed power-switching transistor. This circuit provides more consistent HF arc starts because it eliminates sources of variability.

**Shun Cheap Tungstens**

No welding machine in the world can compensate for the poor arc starts and erratic arcs caused by tungstens with poor grain structures. This problem, often caused by improper annealing, manifests itself when the tungsten bends (Fig. 4) and/or shatters instead of breaking cleanly.

**Avoid a Frosted Tungsten**

After a few dozen arc starts, tungsten forms a “frost,” as shown in Fig. 7. This frost insulates the tungsten and degrades arc starts, so dress the tungsten as often as necessary.

**Pay for Performance**

Quality tungstens promote smooth current flow (Fig. 5) and better arc starts because they have a fine, evenly distributed grain structure and evenly distributed doping elements (e.g., lanthanum).

**2% Lanthanated for DC GTAW**

Use a 2% lanthanated tungsten (AWS EWL-a-2, as indicated by the blue band in Fig. 6) for welding stainless steel, Inconel®, nickel and cobalt alloys, titanium, and most other aerospace alloys. Lanthanated tungstens provide excellent arc starting and current-carrying capabilities, are nonradioactive, and can deliver up to 200 arc starts without significant tip erosion (vs. 70 arc starts for 2% thoriated).

**One Acceptable Method**

Whenever the tungsten becomes contaminated, the only acceptable method of removing the contaminated portion is with a high-speed cut-off wheel (Fig. 8) (vs. the “garage” practice of snapping off
the tungsten end on a table edge, which can lead to splintering and cracking).

**Grind with the Grain**

Use a special tungsten sharpener (Fig. 9) that grinds the tungsten longitudinally (which promotes current flow) and eliminates any rough spots that could interrupt smooth current flow.

**The Impact of Point Angles**

Contrary to popular belief, a pointed tungsten does not provide deeper penetration (but it does provide better directional control). The reason is that current flows perpendicular to the grind angle. As seen in Fig. 10, use a longer taper for shallower penetration and a blunter taper for deeper penetration.

**Pointed Tungsten for Low Amperage**

Sharply pointed tungstens (Fig. 11) reduce resistance and improve arc starts in low-amperage applications. In applications above 20 or 25 A, consider putting a very small land on the end of the point to prevent it from melting and becoming included in the weld pool.

**Avoid Oils**

The oil from your fingers can affect arc starts and lead to weld contamination, most notably with titanium. For critical applications, wear nitrile gloves (Fig. 12) when handling the tungsten and welding wire. Clean these items with acetone prior to welding.

**Back off the Gas**

For welding at 10 A or less, reduce gas flow from 15 to 12 ft³/h (Fig. 13) to prevent the gas flow from extinguishing the arc.

**Go with the Flow**

Using a gas lens smoothes gas flow and promotes better gas coverage — Fig. 14A. Without a gas lens, the gas flow becomes...
Fig. MB — no gas lens.

Turbulent. The swirling current could pull in atmospheric contaminants — Fig 14B.

Pay Attention to Consumables

Cups, collets, and collet bodies (Fig. 15) don’t last forever. Worn cups can cause gas turbulence, while worn collets and collet bodies create excess resistance and provide poor conductivity, leading to hot spots on the torch and poor arc starts.

Control the Variables

As this article shows, promoting consistent and positive arc starts and maintaining arc stability depends upon eliminating and controlling every variable possible. The old adage “prior planning prevents poor performance” certainly comes to mind. Manufacturers of GTAW inverters for aerospace applications are working hard to control machine-related variables for the arc starts and low-end arc performance critical to aerospace welding. When welders work equally as hard to manage the variables within their control, they can be confident that better arc starts and arc performance will follow.
To keep pace with the evolving needs of welders, the American Welding Society (AWS) has created a Membership exclusively for welders...

the AWS Welder Membership.

Welders who are committed to making their jobs, as well as their lives easier, are candidates for the AWS Welder Membership.

The AWS Welder Membership will allow you to save on welding equipment that you use every day, give you direct access to a health insurance program that fits your needs, provide you with the latest information in the industry and much more.

You'll connect with the materials joining community through educational seminars, informal get-togethers and special events. You'll be tuned into the latest happenings and trends. You'll get the discounts and benefits that you've been looking for.

- Discounts on welding equipment and tools of the trade offered by participating GAWDA distributors
- Health Insurance Program
- Publications exclusively for welders
- Discounts on auto and home insurance
- Discounts on dental, vision and pharmacy programs
- The Welder's Exchange bulletin board on the AWS web site
- and more...

Membership in AWS is a great way to nurture your professional development. Whether you're just starting out or a veteran welder, you'll benefit from becoming a member. Join today!

Call: (800) 443-9353, ext 480, or (305) 443-9353, ext. 480

Visit: www.aws.org/membership

American Welding Society
Understanding a New Table

The most noticeable change that most users of the code will see in the 2010 edition is the addition of a new table in the prequalification section. The new table, Table 3.8, lists which variables must be included on a prequalified WPS, and how changes beyond certain parameters would require a new or revised WPS to be written. Subclause 3.6 introduces the new table, and users of the code will notice that this subclause no longer references Clause 4, Table 4.5, for the requirements and the ranges for amperage, voltage, travel speed, and shielding gas flow rate. The code also includes commentary on the new Table 3.8 that helps clarify many open questions on prequalified procedures and explains how to use the new table. Code users should be aware that some of the prequalification ranges of the four variables mentioned previously have also been revised with the establishment of this new table. In addition, specific ranges have been placed on other variables not required in previous editions of the code such as wire feed speed and submerged arc welding electrode parameters, to name two. The listing of the other variables in the new table is not a change in the requirements of previous editions of the code in writing a prequalified WPS, rather they are a clarification that changes to those variables require writing a new or revised prequalified WPS. It is the Structural Welding Committee’s consensus that reorganization and consolidation of the instructions on how to establish a prequalified WPS will assist code users.

Weld Profiles

Probably the next greatest change in the code is the redrafting of the well-known weld profile figures, Figure 5.4. The number of illustrations has been increased to better clarify what weld profiles are required in different types of weld joints. A new table accompanying the redrawn figure lists weld profile dimension requirements, such as weld reinforcement and allowable convexity. These requirements are categorized into four schedules (Schedule A, Schedule B, Schedule C, and Schedule D) in the new table as a means to separate different criteria depending on the type of weld and type of weld joint to be welded. Along with redrafting these figures, the code committee has made slight modifications to the code’s requirements such as larger weld reinforcement is now permitted for welds in thicker members. By expanding Figure 5.4, the code now shows specific weld profiles for groove welds in corner and T-joints, shelf bars, and welds between butt joint welded members of unequal thickness. Some of the new weld profiles are shown in Figs. 1–4.

New Thermal Cut Roughness Requirements

Also of note is the elimination of specific thermal cut roughness values as given in previous editions in Subclause 5.15.4.3
and measured to the requirements of ASME B46.1. Now, the new thermal cut roughness values are tied solely to the comparison samples found in AWS C4.1, Oxygen Cutting Surface Roughness Gauge. The requirements in previous code editions have been deemed overly prescriptive, and the code committee thought it appropriate to change the requirements to a comparative standard.

**Access Holes and Beam Copes**

Requirements for weld access holes and beam copes are revised in this edition. Weld access hole dimensions have been modified, and mandatory minimum and recommended maximum depth dimensions of access holes have been set to prevent those that are unnecessarily deep or that are too shallow. The new code also permits a smaller radius on reentrant corners in connection material and beam copes, as the 1-in. (25-mm) radius requirement of previous codes is not supported by research and is excessive for many connection details. Beam copes in galvanized sections must now be ground to bright metal to reduce the possibility of cracking. Preheating before thermal cutting of beam copes and weld access holes in heavy shapes is now mandatory to reduce the formation of a hard surface layer and the tendency to initiate cracks.

**Revised Backing Requirements**

The code committee has revised the requirements for backing, found in Subclause 5.10, to allow for discontinuous backing in some limited statically loaded hollow structural steel (HSS) applications. There are limiting factors including diameter and wall thickness of the HSS shape that control when noncontinuous backing may be permitted, and there are, of course, a few code exceptions to these limitations.

**Prequalification and Qualification**

Under Subclause 3.3, the matching and undermatching table has been revised to clarify that a filler metal chosen for joining a combination of two different strength base materials need only match either of the two materials for the selection to be considered “matching.” Likewise, “undermatching” was clarified to mean a selection of filler metal whose strength is less than either of the base metals being joined.

The requirements of Subclause 3.7.3 have been expanded to include all weath-
ering steels, not just ASTM A 588. ASTM A 709 HPS50W has been added as a pre-
qualified material in Group II of Table 3.1 and Group B of Table 3.2. ASTM A1043
Grades 36 and 50 have been added to Table 4.9.

A new subclause under 3.13 (CJP Groove Weld Requirements) has been
added to clarify that only steel backing is considered prequalified for nontubular
welds made from one side only. The use of material other than steel for backing in
a one-sided nontubular weld may be used if qualified by test in accordance with
Clause 4 (Qualification).

The code clarifies by revisions to 4.35.3
that if an existing qualified WPS is to be
used for applications requiring impacts
but CVN tests were not done during the
initial qualification of that WPS then a
procedure test plate needs to be per-
formed but only impact tests are required
to be run. The other tests associated with
WPS being qualified by test, having been completed during the original WPS Qual-
ification need not be repeated.

**Stud Size**

A 3/8-in. (10-mm) stud size has been
added to the code, and the tolerances on
existing stud sizes have been revised to
allow manufacturers to produce products
that comply with both international and
American standards. These tolerance
changes do not adversely affect the physi-
cal or mechanical properties of the studs.

**Commentary on ESW, EGW, and UT**

New commentary on electroslag and
electrogas welding (ESW and EGW) has
been added as assistance to users in im-
plementing these welding processes. Also,
commentary to alert users when applying
ESW and EGW on quench and tempered
steels, thermomechanical control
processed steel, and precipitation hard-
ened steels subjected to cyclic loading ap-
plications has been added. Both potential
and current users of these processes
should read through the new commentary
to better understand potential pitfalls and
possible remedies suggested there.

Additional commentary has been
added to emphasize that the ultrasonic
testing (UT) acceptance criteria shown in
Tables 6.2 and 6.3 have been established
within specific testing parameters and that
using testing equipment or procedures,
such as transducers of a different size or
angle shown in these tables, may invalid-
ate the results.

**Other Changes**

- The code no longer requires the Type
  1 IIW UT Reference Block; any of the IIW
  “type” blocks may be used.
- Cracks or bursts in headed studs are
  now covered in detail, and the maximum
  length of these cracks has been established.
- A definition for “tubular” has been
  added to Annex K along with a revised
definition for “pipe.”
- Annex N, Form N-3 (ESW/EGW)
  has been completely revised.
- Some guidance has been added to
  the introductory page of the commentary
to assist users in distinguishing commen-
tary on code from items supporting
commentary.

- The words “thorough fusion” have
  been changed to “complete fusion” in
Table 6.1 (visual acceptance criteria) to
match the terminology used in AWS A3.0,
*Standard Welding Terms and Definitions*.

Many other changes, mostly minor,
have been made to this new edition of the
D1.1 Code. The new foreword has a com-
prehensive but succinct list of all changes.
Most changes are also identified in the
published code by underlined text or ver-
tical lines in the margins of the page.

---

**Find more than 400 distributor locations
that offer EXCLUSIVE DISCOUNTS
to American Welding Society Members.**

Take advantage of an exclusive benefit for AWS
Members... the GAWDA / AWS Discount Program. AWS Members receive Members-only discounts on
welding equipment and tools of the trade by participating
distributors. Currently, there are more than 400
participating locations nationwide.

Please note: discounts and items discounted are at the sole
discretion of each distributor/branch. For discount amount,
please contact the company/branch directly.

Check out all participating locations at www.aws.org/distdiscounts

---
AWS is working with the Give Love Foundation and a Miami welding school to build housing units from steel cargo shipping containers

By Kristin Campbell and Howard Woodward

Fig. 1 — Artist’s sketch of how the housing units will look on location. The units employ modified steel shipping containers with prefabricated steel doors.

It’s not often individuals invest their time and money to better the lives of others, especially when long-term needs are involved, but that’s exactly what actress Patricia Arquette is doing. Through the Give Love Foundation she founded along with fashion designer Rosetta Getty, a collaborative project will rebuild communities, homes, and livelihoods for survivors of the magnitude 7.0 earthquake that struck Haiti Jan. 12. It left millions of people in the Cite Soleil, Port-au-Prince, area forced to live in tents and endure the ravages of flooding and water-borne diseases.

The Give Love Foundation’s initial goal is to provide 54 housing units constructed from refurbished steel cargo shipping containers — Fig. 1. Architect Christopher Robertson (Fig. 2) designed the housing structures, which cost about $5000 each to complete, to withstand the rigors of hurricanes and earthquakes. The exteriors will be protected with a reflective ceramic barrier paint to keep the dwellings cooler. Additional foundation goals include developing an ecologically sound sanitation, hygiene, and composting system to support a 400-person village at Bois Neuf Field. The project includes the installation of a water-reclamation

Fig. 2 — Architect Christopher Robertson (left) confers with welding instructor James Brantley at the Robert Morgan Educational Center Welding Lab.

Kristin Campbell (kcampbell@aws.org) and Howard Woodward (woodward@aws.org) are associate editors of the Welding Journal.
and filtration system to provide the village with potable water.

The American Welding Society (AWS) assisted Arquette in finding a welder training facility where the door frames could be assembled for the dwellings. The Robert Morgan Educational Center in Miami, Fla., was selected. Over the past couple of months, welding students at the center have been working to fabricate and weld door frames — Fig. 3.

Creating the Door Frames

Sixteen welding students at Robert Morgan, led by welding instructor James Brantley (Fig. 4), have been making three sizes of steel door frames for installation on the housing units.

When offered the assignment, Brantley said, “I jumped at the opportunity because the students will get experience from doing these things.” This practical experience will help them prepare to go to work. Fabrication takes place during the regular class hours. The night school welding program takes about a year to complete and meets Monday through Thursday from 5:00 to 11:00 pm and on Friday from 5:15 to 8:30 pm.

Sorting Out Project Details

Since early April, Brantley (Fig. 2) has worked alongside his students demonstrating how the doors are to be constructed. The ongoing project has been a nice addition to the curriculum.

The 7-ft-tall doors have widths of 54, 32, and 22 in. “Each container will have three doors. By us doing manual labor here cuts down on the time of having to do it there. It makes it a lot easier,” Brantley explained. An additional job for the welding students includes making steel roofing trusses for the structures using 2 x 2 in. square tubing.

Working on the doors provides the students with many educational benefits. They are required to interpret blueprints; accurately measure, cut, hammer, and grind steel; precisely perform gas metal arc (GMA) and shielded metal arc welding; and make different types of welds including T-, lap, inside and outside corner, and butt joints.

As of press time, about 25 doors have been completed with many more ready to be processed. Once the door assemblies arrive in Haiti, they can be quickly installed on the prepared shipping containers to complete the living quarters.

Student Point of View

Student David Hunsberger gained numerous skills by working on the project, including GMA welding in difficult positions, proper preparation, and perfecting cuts with no slag. “It’s really an awesome feeling. Being able to help them while learning in school is great,” Hunsberger said. He likes working on this project that results in a product with significant value.

“Building so many doors, my welding has gotten a lot better,” Hunsberger added. “It’s given me a lot of real-world experience.” The former graphic artist has found his calling with welding. He anticipates graduating by the end of this year and is interested in pursuing underwater
Patricia Arquette Discusses Her Experiences in Haiti

Patricia Arquette made a special appearance at the Robert Morgan Educational Center Welding Lab in Miami, Fla., May 24, to personally thank the students for their hard work in assembling door frames that will help transform refurbished large steel cargo shipping containers into sturdy shelters for Haitians left homeless by the Jan. 12 earthquake. The project is funded by the Give Love Foundation that Arquette established.

“It blows my mind,” Arquette said of the efforts these welding students have put into the project. She pointed out that their work shows a beautiful mixture of American generosity, abundance, and good-will extended to the Haitian people in their time of great need.

Arquette watched the students cutting steel and welding door frames, and she examined a number of the completed units. Impressed with the quality and quantity of work they had done, she looked forward to seeing the completed shelters erected on-site in Haiti. “I can’t wait to get pictures of them on location with people living in them,” she said.

After watching the students working, Arquette wanted to try her skills at cutting steel plate. She suited-up in protective gear, received a training session, then did a respectable job using the oxy-acetylene process. Her appearance at the welding lab came as a pleasant surprise to the students who were in awe that she wanted to meet them and try her hand at the work they do for the project.

Earlier, Arquette spoke to the Welding Journal about what she saw during the two weeks she recently spent touring the earthquake-devastated regions of Haiti.

She graphically described the gut-wrenching scenes she witnessed in Haiti. She told of children with red hair — a result of malnutrition — trash piled up everywhere, pancaked buildings, rubble all over the streets, dead bodies left exposed for days, collapsed kindergartens with piles of little shoes outside, and the homeless people living in unstable tent shelters erected on soggy ground. The experience has left her emotionally drained.

“It looks like the earthquake happened just yesterday,” Arquette said. “It’s an absolute living-hell nightmare.”

She recognized the essential needs for fresh water and plumbing. Arquette has engaged experts to set up systems to purify drinking water and collect and treat wastes to kill pathogens. “There’s no sanitation there,” she said, adding that maybe 3% of the population had water and flushing toilets.

The number-one problem in Haiti now is malnutrition, and the next most-serious problem is roundworm in kids. It is not enough to just treat the kids for the worms. The worm eggs can live in waste for ten years on the ground, and people can be reinfected simply through contact with contaminated ground or drinking the water.

Compounding this problem, Arquette said, is every canal ultimately empties into the river where the people bathe and get their drinking water, and these canals are full of trash and human waste.

Another concern is unemployment is sky-high in Haiti. Arquette expressed several ideas for relieving their financial dilemma. For example, starting pilot projects, like collecting trash and recycling, for which they can earn money. Another sugges-
welding and operating his own shop.

For Haitian student Jean Ladouceur, this project to help Haiti is a double win as he’s helping himself and his countrymen at the same time. He said the earthquake has taken an emotional toll on his family in Haiti. “I’ve seen how bad it was before. It’s even more of a devastating blow now. No one was expecting something like that to happen,” Ladouceur said.

When Ladouceur graduates this October, he would like to get into fabricating, designing, or building work. “I was definitely surprised to even be a part of this. I came here to be a welder, and the hands-on experience has definitely taught me to do a lot of different things,” Ladouceur said.

The other Robert Morgan Educational Center welding students working on the project are Liston Bailey, Joseph Campbell, Stephen Fowler, Zaire Henry, Omari Moodie, Runako Moodie, Matias Naulin, Nathaniel Pruitt, Roselio Abreu, Diego Grullon, Enoch Montgomery, John Wellons, Kevin Bell, and Christophe Ortiz.

**Upcoming Objectives**

The Give Love Foundation’s future goals include creating large-scale inexpensive sanitation systems for displaced people who are currently living in camps and communities without clean water; developing sustainable cooking fuel alternatives to charcoal; organizing cleanup and environmental programs for communities in Cite Soleil; beginning communal gardening programs to supplement food needs; and revitalizing local agriculture and livelihoods.

**How Others Can Share the Love**

“The American Welding Society is honored to be able to assist Give Love in its efforts to improve the lives of the many families devastated by the earthquake in Haiti,” said Ray Shook, executive director of the American Welding Society. “We hope to continue working with Ms. Arquette and Give Love to make the dream of providing safe living environments for the Haitian people a reality.”

The AWS and the Give Love Foundation offer opportunities for welding schools and individuals to participate in the project. Schools and training centers interested in participating as Robert Morgan Educational Center is now may contact Cindy Weihl at cweihl@aws.org, (800/305) 443-9353, ext. 416. For information about the Give Love Foundation, visit www.givelove.org.
The AWS Foundation is proud to announce its 2010-2011...
Each year, the American Welding Society Foundation provides scholarship funds to help hundreds of students who otherwise would be unable to afford a welding education. We are the only industry foundation with the specific mission of helping to fund the education of welding students. In so doing, we create the careers that sustain and grow our industry.

We get these funds from your contributions. The more you contribute, the more students we can help educate.

To make a scholarship contribution or to set up your own District, Section or National Named Scholarship, contact Sam Gentry at the AWS Foundation. Call 800-443-9353 x331, or email sgentry@aws.org.

Thank you for your continued support.
Master Chart Classifies the Latest Allied Process Developments

In the latest edition of A3.0, Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying, the Master Chart of Allied Processes has been revised to classify the latest process developments and enhancements. In this new version of the chart (Fig. 1), thermal gouging has been added as a separate category.

Figure 2 shows the joining method chart. A3.0 is available through World Engineering Xchange (WEX), Ltd., at www.awspubs.com.

Fig. 1 — Master chart of allied processes.

Fig. 2 — Joining method chart.

The premier event dedicated to aluminum welding technology!

Welding aluminum requires special processes, techniques and expertise.

Join a distinguished panel of aluminum industry experts as they survey the state-of-the-art aluminum welding technology and practices at the 13th Aluminum Welding Conference and Exhibition.

For the latest conference and exhibitor information or to register for the conference, visit our website at www.aws.org/conferences or call 800-443-9353, ext. 462.

♦ Trends in Welding Conf. Aug. 2–5, Cherry Valley Lodge, Newark, Ohio. Cosponsored by American Welding Society and Edison Welding Institute. Contact George Ritter (614) 688-5199; gritter@ewi.org.

♦ ICWJM 2010, Third Int'l Conf. on Welding and Joining of Materials, and Int'l Welding Show Peru. Aug. 9–11, Lima, Peru. To feature weldability of advanced alloys, modeling processes, distortion, advanced NDE of welds, welder training, special welding and joining processes, technology transfer, etc. Sponsored by the AWS Peru Section, organized by Soldexa S.A. and Pontificial Catholic University of Peru in collaboration with the University of Chicago. Visit www.pucp.edu.pe/icwjm/ingles/index.html.


Canadian Manufacturing Week 2010. Oct. 5–7, Toronto Congress Centre, Toronto, Ont., Canada. Sponsored by Society of Manufacturing Engineers. Call (888) 322-7333; canadasales@sme.org.


♦ FARTECH. Nov. 2–4, Georgia World Congress Center, Atlanta, Ga. This show is the largest event in North America dedicated to showcasing the full spectrum of metal forming, fabricating, tube and pipe, welding equipment, and technology. Contact American Welding Society, (800/305) 443-9353, ext. 455; or visit www.aws.org.


♦ JOM-16, 16th Int'l Conf. on the Joining of Materials & ICEW-7, 7th Int'l Conf. on Education in Welding. May 10–13, 2011. LO-skolen Conference and Hotel, Helsingor, Denmark. Contact JOM Institute, Gilleleje, Denmark. Phone +45 48 35 54 58; jom_aws@post10.tele.dk.


Educational Opportunities


Basics of Nonferrous Surface Preparation. Online course, six hours includes exam. Offered on the 15th of every month during 2010 by The Society for Protective Coatings. Members $145, nonmembers $245. Register online at www.sspc.org/training.


Brazing Fundamentals Training Seminars. Oct. 5–7, Embassy Suites, Greenville, S.C. Covers furnace, torch, induction, etc., as well as all filler metal types (Ni, Cu, Ag, Al, etc.). Contact Kay & Associates (860) 651-5595, or visit www.kaybrazing.com.


Hobart Institute of Welding Technology

offers our comprehensive Technical Training courses throughout the year!

Prep for AWS Certified Welding Supervisor Exam
Prep for AWS Welding Inspector/Educator Exam
Visual Inspection
Welding for the Non Welder
Arc Welding Inspection & Quality Control
Weldability of Metals, Ferrous & Nonferrous
Liquid Penetrant & Magnetic Particle Inspection

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

C.W.I. TRAINING
At your fingertips!

The world’s First and Only completely online NDT training program!

Visit us at www.worldspec.org today!
or call toll free:
1-877-506-7773
Save $100 dollars instantly, enter the discount code: aws59c2

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


Preparation and Exam for AWS Certified Welding Inspector/ Educator. Two-week-long courses beginning Aug. 9, Sept. 20, Nov. 1, Nov. 29 in Troy, Ohio. Call Hobart Institute of Welding Technology (800) 332-9448; hiwt@welding.org; or visit www.welding.org.

Preparation and Exam for AWS Certified Welding Supervisor. One-week-long course begins Oct. 18 in Troy, Ohio. Call Hobart Institute of Welding Technology (800) 332-9448; hiwt@welding.org; or visit www.welding.org.

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


Boiler and Pressure Vessel Inspectors Training Courses and Seminars. Columbus, Ohio. Call (614) 888-8320 or visit www.nationalboard.org.

CWI/CWE Course and Exam. Troy, Ohio. This is a two-week preparation and exam program. For schedule, call Hobart Institute of Welding Technology (800) 332-9448, or visit www.welding.org.

CWI/CWE Prep Course and Exam and NDT Inspector Training. Courses. An AWS Accredited Testing Facility. Courses held year-round in Allentown, Pa., and at customers’ facilities. Call Welder Training & Testing Institute (800) 223-9884, info@wwti.edu; or visit www.wtti.edu.

CWI Preparatory and Visual Weld Inspection Courses. Classes presented in Pascagoula, Miss., Houston, Tex., and Houma and Sulphur, La. Call Real Educational Services, Inc. (800) 489-2890, info@realeducational.com.

Consumables: Care and Optimization. Free online e-courses presenting the basics of plasma consumables, designed for plasma operators, distributor sales and service personnel, etc. Visit www.hyperthermcuttinginstitute.com.

Crane and Hoist Training. Safety courses and operator training for users of overhead cranes and hoists. For schedules, contact Konecranes Training Institute, Springfield, Ohio; (262) 821-4001; or visit www.konecranesamericas.com.

EPRI NDE Training Seminars. EPRI offers NDE technical skills training in visual examination, ultrasonic examination, ASME Section XI, and UT operator training. Call Sherryl Stogner (704) 547-6174, e-mail stogner@epri.com.

Environmental Online Webinars. Free, online, real-time seminars conducted by industry experts. For topics and schedule, visit www.augustinack.com.

Essentials of Safety Seminars. Two- and four-day courses are held at numerous locations nationwide to address federal and California OSHA safety regulations. Call American Safety Training, Inc. (800) 896-8867, or visit www.trainsosha.com.


Firefighter Hazard Awareness Online Course. A self-paced, ten-module certificate course taught online by fire service professionals. Fee is $195. Call Industrial Scientific Corp. (800) 338-3287, or visit www.indsci.com.

Gas Detection Made Easy Courses. Online and classroom courses for managing a gas monitoring program from gas detection to confined-space safety. Call Industrial Scientific Corp. (800) 338-3287, or visit www.indsci.com.

Heller NDT Courses. Heller, 277 W. Main St., Ste. 2, Niantic, CT 06257; (860) 739-8950; FAX (860) 739-6732.

Inspection Courses on ultrasonic, eddy current, radiography, dye penetrant, magnetic particle, and visual at Levels 1–3. Meet SNT-TC-1A and NAS-410 requirements. Call TEST NDT, LLC, (714) 255-1500, or visit www.testndt.com.


NACE Intl Training and Certification Courses. Call National Assoc. of Corrosion Engineers (281) 228-6223, or visit www.nace.org.
## Certified Welding Inspector (CWI)

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SEMINAR DATES</th>
<th>EXAM DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami, FL</td>
<td>EXAM ONLY</td>
<td>Jul. 15</td>
</tr>
<tr>
<td>New Orleans, LA</td>
<td>Jul. 11-16</td>
<td>Jul. 17</td>
</tr>
<tr>
<td>Phoenix, AZ</td>
<td>Jul. 11-16</td>
<td>Jul. 17</td>
</tr>
<tr>
<td>Orlando, FL</td>
<td>Jul. 18-23</td>
<td>Jul. 24</td>
</tr>
<tr>
<td>Milwaukee, WI</td>
<td>Jul. 18-23</td>
<td>Jul. 24</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>Jul. 18-23</td>
<td>Jul. 24</td>
</tr>
<tr>
<td>Sacramento, CA</td>
<td>Jul. 18-23</td>
<td>Jul. 24</td>
</tr>
<tr>
<td>Kansas City, MO</td>
<td>Jul. 25-30</td>
<td>Jul. 31</td>
</tr>
<tr>
<td>Cleveland, OH</td>
<td>Jul. 25-30</td>
<td>Jul. 31</td>
</tr>
<tr>
<td>Louisville, KY</td>
<td>Jul. 25-30</td>
<td>Jul. 31</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>Aug. 1-6</td>
<td>Aug. 7</td>
</tr>
<tr>
<td>Philadelphia, PA</td>
<td>Aug. 1-6</td>
<td>Aug. 7</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>Aug. 8-13</td>
<td>Aug. 14</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>Aug. 8-13</td>
<td>Aug. 14</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Aug. 8-13</td>
<td>Aug. 14</td>
</tr>
<tr>
<td>Charlotte, NC</td>
<td>Aug. 15-20</td>
<td>Aug. 21</td>
</tr>
<tr>
<td>San Antonio, TX</td>
<td>Aug. 15-20</td>
<td>Aug. 21</td>
</tr>
<tr>
<td>Bakersfield, CA</td>
<td>Aug. 15-20</td>
<td>Aug. 21</td>
</tr>
<tr>
<td>Rochester, NY</td>
<td>EXAM ONLY</td>
<td>Aug. 21</td>
</tr>
<tr>
<td>Portland, ME</td>
<td>Aug. 22-27</td>
<td>Aug. 28</td>
</tr>
<tr>
<td>Salt Lake City, UT</td>
<td>Aug. 22-27</td>
<td>Aug. 28</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>Aug. 22-27</td>
<td>Aug. 28</td>
</tr>
<tr>
<td>Corpus Christi, TX</td>
<td>EXAM ONLY</td>
<td>Sept. 4</td>
</tr>
<tr>
<td>Pittsburgh, PA</td>
<td>Sept. 12-17</td>
<td>Sept. 18</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Sept. 12-17</td>
<td>Sept. 18</td>
</tr>
<tr>
<td>Minneapolis, MN</td>
<td>Sept. 12-17</td>
<td>Sept. 18</td>
</tr>
<tr>
<td>St. Louis, MO</td>
<td>Sept. 19-24</td>
<td>Sept. 25</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Sept. 19-24</td>
<td>Sept. 25</td>
</tr>
<tr>
<td>New Orleans, LA</td>
<td>Sept. 19-24</td>
<td>Sept. 25</td>
</tr>
<tr>
<td>Anchorage, AK</td>
<td>EXAM ONLY</td>
<td>Sept. 25</td>
</tr>
<tr>
<td>Nashville, TN</td>
<td>Oct. 3-8</td>
<td>Oct. 9</td>
</tr>
<tr>
<td>Tulsa, OK</td>
<td>Oct. 3-8</td>
<td>Oct. 9</td>
</tr>
<tr>
<td>Long Beach, CA</td>
<td>Oct. 3-8</td>
<td>Oct. 9</td>
</tr>
<tr>
<td>Newark, NJ</td>
<td>Oct. 3-8</td>
<td>Oct. 9</td>
</tr>
<tr>
<td>Portland, OR</td>
<td>Oct. 17-22</td>
<td>Oct. 23</td>
</tr>
<tr>
<td>Roanoke, VA</td>
<td>Oct. 17-22</td>
<td>Oct. 23</td>
</tr>
<tr>
<td>Cleveland, OH</td>
<td>Oct. 17-22</td>
<td>Oct. 23</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>EXAM ONLY</td>
<td>Oct. 28</td>
</tr>
<tr>
<td>Corpus Christi, TX</td>
<td>EXAM ONLY</td>
<td>Oct. 30</td>
</tr>
<tr>
<td>Atlanta, GA</td>
<td>Nov. 14-19</td>
<td>Nov. 20</td>
</tr>
<tr>
<td>Dallas, TX</td>
<td>Nov. 14-19</td>
<td>Nov. 20</td>
</tr>
<tr>
<td>Sacramento, CA</td>
<td>Nov. 14-19</td>
<td>Nov. 20</td>
</tr>
<tr>
<td>Spokane, WA</td>
<td>Nov. 14-19</td>
<td>Nov. 20</td>
</tr>
<tr>
<td>St. Louis, MO</td>
<td>EXAM ONLY</td>
<td>Dec. 4</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>Dec. 5-10</td>
<td>Dec. 11</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Dec. 5-10</td>
<td>Dec. 11</td>
</tr>
<tr>
<td>Syracuse, NY</td>
<td>Dec. 5-10</td>
<td>Dec. 11</td>
</tr>
<tr>
<td>Reno, NV</td>
<td>Dec. 5-10</td>
<td>Dec. 11</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Dec. 5-10</td>
<td>Dec. 11</td>
</tr>
<tr>
<td>Corpus Christi, TX</td>
<td>EXAM ONLY</td>
<td>Dec. 18</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SEMINAR DATES</th>
<th>EXAM DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Diego, CA</td>
<td>Jul. 12-17</td>
<td>NO EXAM</td>
</tr>
<tr>
<td>Orlando, FL</td>
<td>Aug. 23-28</td>
<td>NO EXAM</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>Sept. 20-25</td>
<td>NO EXAM</td>
</tr>
<tr>
<td>Dallas, TX</td>
<td>Oct. 4-9</td>
<td>NO EXAM</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Nov. 29-Dec. 4</td>
<td>NO EXAM</td>
</tr>
</tbody>
</table>

For current CWIs and SCWIs needing to meet education requirements, the exam can be taken at any site listed under Certified Welding Inspector.

## Certified Welding Supervisor (CWS)

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SEMINAR DATES</th>
<th>EXAM DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minneapolis, MN</td>
<td>Jul. 15-23</td>
<td>Jul. 24</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Sept. 13-17</td>
<td>Sept. 18</td>
</tr>
<tr>
<td>Norfolk, VA</td>
<td>Oct. 4-8</td>
<td>Oct. 9</td>
</tr>
</tbody>
</table>

CWS exams are also given at all CWI exam sites.

## Certified Radiographic Interpreter (CRI)

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SEMINAR DATES</th>
<th>EXAM DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami, FL</td>
<td>Jul. 26-30</td>
<td>Jul. 31</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Oct. 18-22</td>
<td>Oct. 23</td>
</tr>
</tbody>
</table>

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

## Certified Welding Sales Representative (CWSR)

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

## Certified Robotic Arc Welding (CRAW)

- **Wolf Robotics, Ft. Collins, CO**
  - Location: Wolf Robotics, Ft. Collins, CO
  - Exam Date: Jul. 19
  - Contact: (970) 225-7736

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Jul. 26
  - Contact: (563) 445-5688

- **ABB, Inc., Auburn Hills, MI**
  - Location: ABB, Inc., Auburn Hills, MI
  - Exam Date: Aug. 2
  - Contact: (248) 391-8421

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Aug. 9
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Aug. 16
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Aug. 23
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Aug. 30
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Sep. 13
  - Contact: (563) 225-7736

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Sep. 27
  - Contact: (563) 445-5688

- **ABB, Inc., Auburn Hills, MI**
  - Location: ABB, Inc., Auburn Hills, MI
  - Exam Date: Oct. 4
  - Contact: (248) 391-8421

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Oct. 11
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Oct. 18
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Oct. 25
  - Contact: (216) 383-8542

- **ABB, Inc., Auburn Hills, MI**
  - Location: ABB, Inc., Auburn Hills, MI
  - Exam Date: Nov. 1
  - Contact: (248) 391-8421

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Nov. 15
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Nov. 29
  - Contact: (563) 445-5688

- **ABB, Inc., Auburn Hills, MI**
  - Location: ABB, Inc., Auburn Hills, MI
  - Exam Date: Dec. 6
  - Contact: (248) 391-8421

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Dec. 6
  - Contact: (563) 445-5688

- **Genesis-Systems, Davenport, IA**
  - Location: Genesis-Systems, Davenport, IA
  - Exam Date: Dec. 13
  - Contact: (563) 445-5688

## International CWI Courses and Exams

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

For information on any of our seminars and certification programs, visit our website at [www.aws.org/certification](http://www.aws.org/certification) or contact AWS at (800) 443-9553, Ext. 273 for Certification or Ext. 455 for Seminars. Please apply early to save Fast Track fees. This schedule is subject to change without notice. Please verify the dates with the Certification Dept. and confirm your course status before making final travel plans.
This conference will explore many topics, including the important aspects of coal-powered plants, the present and future states of nuclear power, activities in pipeline construction, land-based and offshore work in liquefied natural gas (LNG), solar energy, and wind power. Metals will be emphasized, especially Grade 91 steel, 2205 and the many other duplex stainless steels, and nickel-based alloys. New welding processes are already playing major roles in these arenas and cladding is becoming more important than ever. Some of the world’s largest operations, like the $10-billion, 3000-MW solar-powered facility in India and the expansive Gorgon gas fields in Australia, are expected to be on the agenda. Much of welding’s future depends on industry’s ability to adapt and promote its technologies.

### What’s New in Weld Consumables? November 2

A low-hydrogen weld deposit is obviously the result of proper use of low-hydrogen filler metals. Much has been done and is still being done in the development of low-hydrogen manual arc electrodes. It has become imperative that the relatively new Grade 91 steel be welded using low-hydrogen filler metals, and work is under way to develop new chemistries for these electrodes. Many of the gas metal arc welding technologies also produce low-hydrogen weld deposits, as does submerged arc welding. Industry still has to learn to store these electrodes in rod ovens when not in use, a practice not always observed in fabricating plants throughout America. The main thrust here is in ASME code work, shipbuilding, off-highway equipment, and in the chemical industry and power plants. The introduction of duplex stainless steels and the higher-strength versions of same require new filler metals to answer the needs of many plants that weld these corrosion-resistant materials. The roles of heat treatment and shielding gases will also be discussed.

### Weld Repair and the Strengthening of Welded Structures November 3

Two of the most important concerns in welding are the repair of faulty welds and the prevention of failures from occurring in the first place. These topics will be featured at one of the most important conferences at FABTECH.

Duane K. Miller of The Lincoln Electric Co. will be the keynoter. He will discuss the new AWS D1.7, Guide for Strengthening and Repairing Existing Structures. Other speakers will include Bob Ferrell of the National Board of Boiler and Pressure Vessel Inspectors, who will describe what is needed to obtain an “R” certificate; David J. Barton of PCI/WEC, who will comment on weld repairs in the nuclear industry; and Brent M. Williams of Miller Electric, who will discuss the use of GTAW inverter technology for aircraft engine repair work.

### New Developments in Thermal Spray Coatings, Processes, and Applications November 3

This one-day event, organized by the American Welding Society and the International Thermal Spray Association, will introduce the thermal spray process and its uses to new users with sessions focusing on actual applications and new developments in thermal spray technology. It will include a half-day tutorial on thermal spray fundamentals titled “What Is Thermal Spray” sponsored by the International Thermal Spray Association.

### The Welding and Cutting of Pipe and Tubing November 4

Highlighting the conference on pipe and tubing will be Ian D. Harris of the Edison Welding Institute, who will discuss three processes: DeepTig™, narrow groove tandem GMAW-P, and hybrid laser welding. Robert J. Pistor of Liburdi Automation will discuss the role of orbital welding in the new combined-cycle gas turbine power plants in Canada, and Eric Carson of CRC-Evans will talk about the past and present in automatic pipeline welding.

From the standpoint of cutting, Jeff Bennett of Vernon Tool will discuss the benefits and considerations via automating pipe and tube cutting and profiling processes. Joe Sorvaag of ESAB will also be on hand with a comparison of thermal cutting options.

For more information, please contact the AWS Conferences and Seminars Business Unit at (800) 443-9353, ext. 462. You can also visit the Conference Department at www.aws.org/conferences for upcoming conferences and registration information.
AWS Nominates National and District Officers for 2011

The 2009–2010 Nominating Committee has announced its slate of candidates who will stand for election to AWS national offices for the 2011 term, which begins January 1, 2011.

Nominated are the following candidates: John L. Mendoza, for president; William A. Rice Jr., Nancy C. Cole, and Dean R. Wilson for vice presidents; and Tony Anderson and David L. McQuaid for directors-at-large. Three vice presidents and two directors-at-large are to be elected.

The National Nominating Committee was chaired by Past President Gene E. Lawson. Serving on the committee with Lawson were H. R. Castner, D. A. Flood, R. A. Harris, D. C. Howard, J. F. Key, R. C. Lanier, T. M. Mustaleski, R. L. Norris, R. G. Pali, W. R. Polanin, D. D. Rager, N. S. Shannon, and G. D. Uttrachi. G. Manalich served as Secretary. The Nominating Committees for Districts 2, 5, 8, 11, 14, 17, and 20 have selected the following candidates for election/reelection as District directors for the three-year term Jan. 1, 2011, through Dec. 31, 2013. The nominees are H. W. Thompson, District 2; S. Mattson, District 5; J. A. Livesay, District 8; R. P. Wilcox, District 11; R. L. Richwine, District 14; J. Jones, District 17; and W. A. Komlos, District 20.

Nominated for President
John L. Mendoza

Mendoza, currently completing his third term as an AWS vice president, is with Lone Star Welding in San Antonio, Tex. He is a Certified Welding Inspector, Certified Welding Educator, and a journeyman welder qualified to ASME Section IX in SMA and GTA welding. He has extensive experience with power plant maintenance and training welders for CPS Energy, San Antonio, Tex. In 1996, he earned his Craft Instructor certification from the National Center for Construction Education and Research and was hired as a welding instructor at Texas A&M University. In 2005, he was elected to the State of Texas board of directors for the SkillsUSA college/postsecondary division. He chaired the Texas SkillsUSA welding competition; is a 34-year member of the International Brotherhood of Electrical Workers, Local 500; a past chair of the St. Philip’s College welding advisory committee; and has received the District Dalton E. Hamilton Memorial CWI of the Year Award.

Nominated for Vice President
William A. Rice Jr.

Rice, an AWS member for more than 25 years, is currently completing his second term as a vice president. He serves as CEO for OKI Bering Supply, president of Dadco of West Virginia, president of West Side Real Estate, and is on the boards of trustees for several health and financial organizations in West Virginia. Rice worked for Airgas from 1993 to 2001, where he served as its president and COO. From 1971 to 1992, he was president of Virginia Welding Supply Co. and president of several other welding-related companies, which he later sold to Airgas. He served as chairman of the state VICA welding contests from 1979 to 1983. Rice holds a degree in business marketing with postgraduate work in journalism, psychology, and labor relations. He also has completed numerous welding-related courses presented by AWS and other organizations.
Nominated for Vice President

Nancy C. Cole

Cole is completing her first term as a vice president. She is an AWS Fellow, a Life Member, and a registered Professional Engineer in the state of Tennessee. She has been a member of the Northeast Tennessee, Chattanooga, and Northeast Florida Sections. She served as chair of the AWS Technical Activities, Fellows, and C3 Brazing and Soldering Committees, and has served on the International Standards, Awards, Research and Development, Technical Paper Selection, and National Nominating Committees. Cole also served on the Welding Research Council Brazing Research Committee, Materials Advisory Group, Marine Board, National Research Council, Advanced Joining Committee, and National Materials Advisory Board. She has received the Wasserman Award, McKay-Helm Award, AWS Honorary Member Award, and outstanding Alumni Award from University of Tennessee. She holds three brazing-related patents. Cole worked at ABB Combustion Engineering where she developed welding electrodes, fluxes, and flux cored wires, and wrote computer programs for the process. Before forming her own company, she was program manager and contract manager at Oak Ridge National Laboratories.

Nominated for Vice President

Dean R. Wilson

Wilson is completing his first year as a director-at-large. He is vice president, welding business development, at Jackson Safety Products where he has worked since 2007. From 1987 to 2007, he served as president, CEO, and owner of Wilson Industries, Inc., in Pomona, Calif., a manufacturer of industrial safety-related products. He has completed graduate studies in business at San Diego State University and at Stanford University in executive management. Wilson is a Laser Institute of America director-at-large, and a member of Gases and Welding Distributors Assn., Industrial Fabrics Assn., Specialty Tools & Fasteners Distributors Assn., and Safety Equipment Distributors Assn.

Nominations Sought for National Officers

AWS members who wish to nominate candidates for President, Vice President, and Director-at-Large on the AWS Board of Directors for the term starting Jan. 1, 2012, may:

1. Send their nominations by Sept. 22, 2010, to Gricelda Manalich, gricelda@aws.org, c/o Victor Y. Matthews, chairman, National Nominating Committee or
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. 2, 2010, at the Georgia World Congress Center, Atlanta, Ga., during the 2010 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.

AWS Bylaws Article IX, Section 3. Nominations.

Nominations, except for Executive Director and Secretary, shall proceed as follows:

(a) Nominations for District Directors shall be made by the District Nominating Committees [see Article III, Section 2(c)]. The National Nominating Committee shall select nominees for the other offices falling vacant. The names of the nominees for each office, with a brief biographical sketch of each, shall be published in the July issue of the Welding Journal. The names of the members of the National Nominating Committee shall also be published in this issue of the Welding Journal, along with a copy of this Article IX, Section 3.

(b) Any person with the required qualifications may be nominated for any national office by written petitions signed by at least 200 members other than Student Members, with signatures of at least 20 members from each of five Districts, provided such signatures are delivered to the Executive Director and Secretary before August 26 for the elections to be held that year. A biographical sketch of the nominee (and acceptance letter) shall be provided with the petition. Any such nominee shall be included in the election.

Nominated for Director-at-Large

David L. McQuaid

McQuaid, an AWS member since 1975 and a past chair of the Pittsburgh Section, is presently completing his first three-year term as a director-at-large. He has been an AWS member since 1977, and is a past chair of the D1 Structural Welding Committee and the Technical Activities Committee (2002–2004). He received his civil engineering degree from West Virginia University in 1964 then joined the American Bridge Division of U.S. Steel Corp. where he held various positions in the Construction Department including senior welding engineer and corporate applications engineer. He received the prestigious American National Standards Institute 2009 Finegan Standards Medal that “honors an individual who has shown extraordinary leadership in the actual development and application of voluntary standards.” Currently, he heads D. L. McQuaid and Associates, Inc., a consulting company he formed in 1999 to serve the steel construction industry.

Nominated for District 2 Director

Harland W. Thompson

Currently vice chairman for the Long Island Section, Thompson is senior project engineer and welding supervisor for Underwriters Laboratories (UL), Inc., in Melville, N.Y. He received his degrees in business management at Lyndon State College, and industrial engineering from the University of Vermont. Prior to joining UL in 2006, he worked in engineering and quality assurance positions at Belle Transit Div., Bohemia, N.Y.; the Long Island Rail Road; Breda Transportation, Inc., San Francisco, Calif.; Thompson Transit Services, Inc., Ronkonkoma, N.Y.; and LTK Engineering Services in Blue Bell, Pa.

Nominated for District 5 Director

Steve Matteo

Mattson is currently completing his first term as District 5 director. He began his career in the welding industry in 1986 after serving in the military. He started a welding equipment service and repair facility...
business in Jacksonville, Fla., that has operated for more than 20 years. Mattson has been active in the North Florida Section for more than 20 years where he has served in all executive positions. Currently, he serves as its chairman and secretary.

**Nominated for District 8 Director**

**Joe A. Livesay**

Livesay is currently completing his first term as District 8 director. In the U.S. Navy, he served as a hull technician, then continued his studies at Tennessee Technological University and worked as a welder at the Hartsville, Tenn., nuclear power plant. He later worked as a fitter-welder in Louisiana offshore operations, then served 13 years at Crossville Ceramic as a maintenance welder. During this time he became an AWS Certified Welding Educator. Livesay taught evening welding classes at the Tennessee Technology Center and later became the full-time instructor. He has been active in AWS and has helped implement the welding accreditation program for the state of Tennessee. He has hosted numerous welding competitions and his teams have ranked high in the SkillsUSA contests.

**Nominated for District 11 Director**

**Robert P. Wiicox**

An AWS member since 1974, Wiicox has served in many Detroit Section officer positions including chair. He received his bachelor's degree at Spring Arbor College and a MS at Central Michigan University. He has worked in the automobile industry as a cost estimator, buyer, and quality manager. Wiicox serves on the advisory committees for William D. Ford Vocational High School and Schoolcraft Community College where he received his early education in industrial welding and fabrication technology. Currently, he owns and operates Warriors of Faith Martial Arts Academy where he conducts classes in self-defense.

**Nominated for District 14 Director**

**Robert L. Richwine**

An AWS Distinguished Member, active in the Indiana Section, Richwine has served as assistant District 14 director for the past three years. In 1994, he joined Ivy Tech State College teaching courses in welding, plumbing, pipefitting, print reading, and metallurgy. He was promoted to program chair in 1997. Among his many District awards are CWI of the Year, Meritorious, Private Sector Educator, and the District Director Award. He has received the Ivy Tech Technology Division Advisor of the Year in 2006 and 2008, the Mid-West Team Welding Tournament’s Clifford Hunt Award for his work in education, and was appointed to the Honorable Order of Kentucky Colonels.

**Nominated for District 17 Director**

**J. J. Jones**

Jones, currently completing his first term as District 17 director, has worked 26 years as a welding instructor with industry, secondary, and higher-education institutes. He is currently a technical sales manager for Region 300 of Thermadyne Industries. At the age of 12, Jones was introduced to welding by his father. He pursued metalworking and welding in high school and then went on to earn an AAS degree in welding technology from Eastfield College where he became an AWS Student Member in 1982. He later received a bachelor’s degree and his Texas Lifetime Teaching Certificate in vocational trades. He contributed to the AWS Welding Handbook, ninth edition, where he authored welding processes. He has held all of the Section officer positions, and worked on the 2005 AWS Welding Show Committee.

**Nominated for District 20 Director**

**William A. Komios**

An AWS member since 1979, Komlos is currently completing his first term as District 20 director. He is a Senior Certified Welding Inspector and a Certified Welding Educator. Komlos is president of Arc Tech, LLC, Salt Lake City, Utah, providing project support to manufacturing and steel-erection companies. Earlier, he worked as a welding engineer with Autoliv ASP, and as project manager and quality assurance manager for Mark Steel Corp. From 1980 to 1985, he served as a welding instructor at Salt Lake Community College and worked from 1985 to 1991 at United Precision Machine and Engineering Co. in Salt Lake City. Komlos served on the AWS B1 Committee on Nondestructive Examination of Welds as first vice chair for four years. He holds a MBA and a master’s in civil engineering.
Tech Topics

Two Official Interpretations: D1.1, Structural Welding Code — Steel

Subject: Pipe diameters qualified for fillet welds
Code Provision: Tables 4.9, 4.10
AWS Log: D1.1-04-I06

Inquiry: [Question not provided in the text]
Response: The term “fillet welds of all diameters and thicknesses” is commonly known as a “Record of Welder Performance.” [D17.1, 4.2.3.2] require that each “application normally welded” [D17.1, 4.2.3.2] for the purpose of meeting the Extended Validity requirements has to “meet prescribed standards” as implied by the A3.0 definition of “welder performance qualification” [D17.1/D1.1M:2004, Table 4.10, the qualified production material thickness is ½ in. [3 mm] to unlimited and the diameter is unlimited for fillet welds on tubular connections (Clause 4.28).]

Subject: Threaded stud and torque testing
Code Provision: 7.6.5, 7.7.1.4
AWS Log: D1.1-06-I14

Inquiry: Do all threaded studs have to be torque tested and cannot be tested by the bend test technique?
Response: Clause 7.6.5 deals specifically to Application Qualification test requirements for special cases as noted. It is a procedure test and not conducted on production work. The clause is not specific to threaded studs or non-threaded studs. When invoked by the position of stud application the qualification studs may be tested by any suitable means to achieve the Application Qualification. Clause 7.7 deals with production control of stud application using the procedure developed by 7.6.5. Its purpose is to verify the procedure developed elsewhere will produce sound stud attachment. Bending the threaded stud for production testing on fabricated parts may distort the threads to the point that the thread will not engage properly. Therefore, for production testing under Clause 7.7.1.4, bend testing of threaded studs is prohibited.

Bend testing is allowed for Stud Application Qualification testing per 7.6.5. Bend testing is prohibited for Production Control testing of applied threaded studs per 7.7.1.4.

Four Official Interpretations: D1.5, Bridge Welding Code

Subject: Butt joint welds in girder webs
Code Edition: D1.5M/D1.5:2008
Code Provision: Subclauses 6.11, 6.26.3
AWS Log: D1.5-08-I01

Inquiry: [Question not provided in the text]
Response: Yes, unless the region is specifically shown on the design drawings as subject only to compressive stress (see 6.26.2, 2).

Subject: Welder operator requirements
Code Edition: D1.5M/D1.5:2008
Code Provisions: 5.2.1.2, 5.23.1.2, 5.23.1.5
AWS Log: D1.5-08-I05

Inquiry: [Question not provided in the text]
Response: Yes, unless the region is specifically shown on the design drawings as subject only to compressive stress (see 6.26.2, 2).

Subject: Fracture-critical weld size and heat input
Code Edition: D1.5M/D1.5:2002
Code Provision: Clause 12 and Table 12.3
AWS Log: D1.5-02-I08

Inquiry: The heat input ranges identified in Table 12.3 start at 30 to 50 kJ/in. Does this mean that a minimum weld pass of 30 kJ/in. is all that can be made?
Response: The code does not provide preheats for fracture-critical welding using a heat input of less than 30 kJ/in. Welding outside of the parameters of Table 12.3 would require agreements of required preheat between the Contractor and Engineer.

Subject: Maximum heat input
Code Edition: D1.5M/D1.5:2002
Code Provisions: 5.12.1, 5.12.3.2
AWS Log: D1.5-02-I09

Inquiry: What is the intent of the wording in 5.12.1 in regard to the “highest heat input” requirement?
Response: Individual weld passes on a PQR test plate should be made at the same specific welding variables (i.e., volts, amps, travel speed, which will produce the maximum heat input) given due consideration for normal process variation. Increased variability can be anticipated for root and cap passes.

Two Official Interpretations: D17.1, Specification for Fusion Welding for Aerospace Applications

Subject: Extended validity and disqualification
Code Provision: Paragraphs 4.2.3.2, 4.2.3.3
AWS Log: D17.1-01-I02

Inquiry: 1. Does the phrase “...to document welder performance.” [D17.1, 4.2.3.3(2)] require that each “application normally welded” [D17.1, 4.2.3.2] for the purpose of meeting the Extended Validity requirements has to “meet prescribed standards” as implied by the A3.0 definition of “welder performance qualification”? Does this mean that a minimum weld pass of 30 kJ/in. is all that can be made?
Response: The code does not provide preheats for fracture-critical welding using a heat input of less than 30 kJ/in. Welding outside of the parameters of Table 12.3 would require agreements of required preheat between the Contractor and Engineer.

2. Can the Engineering Authority specify its “prescribed standards” for the “application normally welded” in lieu of the “criteria for Class A welds” [D17.1, 4.3.8.1]?
Response: Yes, unless the region is specifically shown on the design drawings as subject only to compressive stress (see 6.26.2, 2).

3. Is it required that the “application normally welded” meet the “prescribed standards” prior to any rework or repair, i.e., at its soonest planned inspection?
Response: Yes, unless the region is specifically shown on the design drawings as subject only to compressive stress (see 6.26.2, 2).

4. Does the “auditable record” [D17.1, 4.2.3.2] need to include evidence of conformance to the “prescribed standards” in addition to the evidence that the individual “used the process”? [D17.1, 4.2.3.2]?
Response: Yes, unless the region is specifically shown on the design drawings as subject only to compressive stress (see 6.26.2, 2).
welder performance”. Otherwise, the “individual’s performance required by 4.2.3.2” [4.2.3.3(2)] would contradict “welder performance” as implied by the definition of “welder performance qualification” in A30.1.

b) A reply of “Yes” to Question 1 would mean that each “application normally welded” for the purpose of Extended Validity in a six-month period would be purposely equivalent to an initial qualification test, including its inspection and evidence of conformance to prescribed standards, and invokes the prospect of Disqualification. A “Yes” to Questions 2–4 would logically follow. Consequently, this would require an expanded system for acquiring and maintaining inspection records from sources that are not common to qualification test records, e.g., from manufacturing records of delivered hardware (paper or electronic), with the added outlay of time and money to do so.

Response: No.

Subject: Qualification limitations

Official Interpretation: D15.1, Railroad Welding Specification for Cars and Locomotives

Subject: Technique

Inquiry: Form D-11 and Form D-13A: Under Technique where it states Welding Current, it covers Amperes and Volts. Shouldn’t this be designated as Electrical Characteristics instead of Welding Current?

Response: No. Paragraph 4.3.7.6 is not a requirement for special applications. Yes. 4.3.7.5 is a stand-alone paragraph.


AWS was approved as an accredited standards-preparing organization by the American National Standards Institute (ANSI) in 1979. AWS rules, as approved by ANSI, require that all standards be open to public review for comment during the approval process. Draft copies may be obtained from R. O’Neill, ext. 451, roneill@aws.org.

ISO Draft Standards for Public Review
ISO/DIS 12932, Welding — Laser-arc hybrid welding of steels, nickel and nickel alloys — Quality levels for imperfections
ISO/DIS 15609-6, Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 6 Laser-arc hybrid welding

Copies of the above draft standards are available for review and comment through your national standards body, which in the United States is ANSI, 25 W. 43rd St., Fourth Fl., New York, NY 10036; (212) 642-4900. Any comments regarding ISO documents should be sent to your national standards-preparing body. In the United States, contact Andrew Davis, ext. 466, adavis@aws.org.

New Standards Projects
Development work has begun on the following revised standards. Affected individuals are invited to contribute to their development. To participate, contact the staff engineer listed with the document.

A5.34/A5.34M:20XX, Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding. The composition, soundness, and properties of weld metal from ten grades of flux cored electrodes are specified. Standard electrode sizes together with their package forms and package sizes are detailed. This specification makes use of both U. S. customary units and the International System of Units (SI). Stakeholders: Welding industry. R. Gupta, ext. 301.

D9.1M/D9.1:20XX, Sheet Metal Welding Code. This code covers the arc and braze welding requirements for nonstructural sheet metal fabrications using the commonly welded metals available in sheet form. Requirements and limitations governing procedure and performance qualification are presented, and workmanship and inspection standards are supplied. The informative annexes provide useful information on materials and processes. Stakeholders: Those involved in the production and qualification of nonstructural sheet metal applications such as heating, ventilating, and A-C systems. Call A. Alonso, ext. 299.

D14.4/D14.4M:20XX, Specification for Welded Joints in Machinery and Equipment. This specification establishes common acceptance criteria for classifying and applying carbon and low-alloy steel welded joints used in the manufacture of machines and equipment. It covers weld joint design, workmanship, quality control requirements and procedures, welding operator and welding procedure qualification, weld joint inspection (visual, radiographic, ultrasonic, magnetic particle, liquid penetrant), repair of weld defects, and heat treatment. Stakeholders: Machinery and equipment industry. Call A. Alonso, ext. 299.


D16.2M/D16.2:20XX, Guide for Components of Robotic and Automatic Arc Welding Installations. This guide provides performance recommendations for evaluating components of a typical robotic or automatic welding installation. Emphasis is placed on the role of the welding interface. A pin arrangement and specific pin function for each location in a standardized 37-pin connector are proposed. Stakeholders: Robotic welding industry. Call M. Rubin, ext. 215.

G2.5/G2.5M:20XX, Guide for the Fusion Welding of Zirconium and Zirconium Alloys. This guide provides instructions for the welding of zirconium and zirconium alloys. It explains processes, equipment, materials, workshop practices, joint preparation, welding techniques, tests, and the repair of defects. Stakeholders: Equipment fabricators worldwide, engineering companies, maintenance welders, chemical companies using zirconium equipment, repair welders, etc. Call S. Borrello, ext. 334.

Technical Committee Meetings
Aug. 11, 12. Technical Activities Committee. Chicago, III. Contact J. L. Gayler, ext. 472.
Weldmex Was a Great Show

John Bruskotter, American Welding Society president, is shown presenting his speech welcoming the attendees to the 2010 AWS Weldmex exhibition. The event was held May 11–13, at the Centro Banamex exhibition hall in Mexico City, Mexico.

Weldmex now is colocated with Metalform Mexico, COA Tech, and FABTECH Mexico. The exhibition space totaled 44,000 sq ft, with the AWS Weldmex contributing 20,000 sq ft and 140 welding-related exhibitors. More than 7900 visitors attended the exhibition. The combined show has grown to the point where it is now the largest annual metalworking event in Latin America.

The next Weldmex combined show is scheduled for May 11–13, 2011, at Cintermex, Monterrey, Mexico.

Candidates Sought for M.I.T. Award

November 2, 2010, is the deadline for submitting nominations for the 2011 Prof. Koichi Masubuchi Award, sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology (M.I.T.).

This award, including an honorarium of $5000, is presented each year to one person who has made significant contributions to the advancement of materials joining through research and development. The candidate must be 40 years old or younger, may live anywhere in the world, and need not be an AWS member.

The nomination package should include the candidate’s background, experience, publications, honors, and awards, plus at least three letters of recommendation from fellow researchers.

The award was established to recognize Prof. Koichi Masubuchi for his numerous contributions to the advancement of the science and technology of welding, especially in the fields of fabricating marine and outer space structures. Send your nominations to Prof. John DuPont at jnd1@lehigh.edu.

District Director and Student Chapter Awards Announced

District 22 Director, Dale Flood, nominated the following members for this award: Tom Smeltzer (San Francisco), Tom Erichsen (Santa Clara), Charles Bookout (Fresno), Matt Wysoczki and Melvin Johnson (Sacramento), Randy Naylor, Gaylord Rodeman, and Scott Holcomb (Sierra Nevada). The District Director Award provides a means for District Directors to recognize individuals who have contributed their time and effort to the affairs of their local Section and/or District.

The AWS Sierra College Student Chapter, Sacramento Section, District 22, and Robert Purvis, Student Chapter Advisor, have selected Russell Jordan to receive the Student Chapter Member Award. Jordan, with the Sierra College Student Chapter, is finishing his second year at the college, served this year as the Chapter chairman, and is qualified to weld pipe on the 6G position. He enthusiastically volunteered to repair bicycles, lawn mowers, and other items, during the recent open house.

Technical Committees Seek Your Expertise

Surfacing Industrial Mill Rolls


Robotic and Automatic Welding


Thermal Spraying


Labeling and Safe Practices


Magnesium Alloy Filler Metals

ASL Subcommittee on Magnesium Alloy Filler Metals. This subcommittee is responsible for updating AWS A5.19-92 (R2006), Specification for Magnesium Alloy Welding Electrodes and Rods. Contact R. Gupta, gupta@aws.org, ext. 301.

Welding Sales Representatives

Volunteers are invited help set the qualification requirements in AWS B5.14, Specification for the Qualification of Welding Sales Representatives. Contact J. Gayler, gayler@aws.org, ext. 472.
Shanghai Welding Society Representative Visits Miami

Ding Fubao, general secretary, The Shanghai Welding Society (SWS), visited AWS headquarters May 7. The SWS administers AWS certification programs in Shanghai, China. It is an AWS Accredited Test Facility that became an AWS International Agent in August 2008. Shown above are (from left) Melissa Gomez, senior coordinator, international certification programs; Cassie Burrell, deputy executive director; Secretary Ding Fubao; Priti Jain, director, international business and certification programs; Peter Howe, managing director, Certification Dept.; Donald Llopis, coordinator, international business and certification programs; and Emil Pagoaga, senior coordinator for Accredited Test Facilities.

Israeli Certification Secretary Visits AWS Headquarters

Chaim Daon, a member of the Israeli Examination and Certification Committee for Welding Inspectors and secretary of the Israeli National Welding Committee (INWC), an AWS International Section, visited AWS headquarters in May. Business included discussion about reciprocity for Israelis holding AWS CWI certifications to gain INWC certification. Shown are (from left) Priti Jain, director, international business and certification programs; Cassie Burrell, deputy executive director; Secretary Chaim Daon; Peter Howe, managing director, Certification Dept.; and Rhenda Kenny, director, Member Services Department.

AWS Foundation Visits PSEG Fossil Training Center in Bridgeport, Conn.

Shown at the PSEG Welding Lab in Bridgeport, Conn., are (front, from left) Monica Pfarr, corporate director, solutions opportunity squad (SOS); and Elizabeth Fray; (back, from left) Sam Gentry, executive director, AWS Foundation; and welding students Jennifer Martin, Emery Labertrandle, and Justine MacLean. The group visited with District 2 Director Ken Stockton, then toured the training center. The center presents an eight-week course stressing welding safety and troubleshooting submerged arc welding machines. It offers certification in submerged arc pipe welding. Fray is an AWS Foundation donor who is interested in welder education and development programs in the state of Connecticut.
New Sustaining Companies

Alta Vista Solutions, Inc.
6475 Christie Ave., Ste. 425
Emeryville, CA 94608
Representative: Jinesh Mehta
www.altavistasolutions.com
Alta Vista Solutions is a specialty engineering firm that provides construction engineering and inspection services for infrastructure projects. Its offices in California, Europe, and Asia have highly skilled technical staffs to bring cost-effective construction support to speed project delivery.

Bucyrus International
1100 Milwaukee Ave.
South Milwaukee, WI 53172
Representative: Dale A. Gilbertson
www.bucyrus.com
Bucyrus International designs and manufactures high-productivity mining equipment for surface and underground mining. Its surface equipment is used for mining coal, copper, iron ore, oil sands, and other minerals. Its underground equipment is used primarily for mining coal. It also manufactures high-quality OEM parts and provides world-class support services for its equipment.

Supporting Companies

Campbell’s Welding & Machinery, Inc.
PO Box 8555
Landing, NJ 07850

Davlans Engineering
3644 Scarlett Oak Blvd.
St. Louis, MO 63122

Diamond Ground Products, Inc.
2550 Azurite Cir.
Newbury Park, CA 91320

Penn Iron Works, Inc.
700 Old Fritztown Rd.
Sinking Spring, PA 19608

Rai Industrial Fabricators, LLC
199 Paradise Valley Rd.
Athens, GA 30607

Wearexst technologies Pvt. Ltd.
749/9 G.I.D.C., Makarpura
Vadodara, Gujarat 390010
India

World International Testing, Inc.
2228 Sunset Blvd., Ste. One
Steubenville, OH 43952

Affiliate Companies

Calhoun Super Structures
7453 Willington Rd. 18
RR 1 Elora, ON N0B1S0, Canada

Hersherger Bros. Welding
PO Box 9736
Las Vegas, NV 89193

Interra Inc.
6501 E. Greenway Pkwy, # 527
Scottsdale, AZ 85254

Rowe Inspection Services and Consulting, LLC
17775 W. Columbine Dr.
Surprise, AZ 85388

R Z Contractors, Inc.
PO Box 726, Condo Los Pinos 108
Caguas, PR 00726

Educational Institutions

American Technical Publishers
10100 Orland Pkwy.
Orland Park, IL 60467

Denison High School
1901 S. Mirick Ave.
Denison, TX 75020

Erie Institute of Technology
940 Millcreek Mall
Erie, PA 16565

Floyd County High School
721 Baker St.
Floyd, VA 24091

Garden City Community College
801 Campus Dr.
Garden City, KS 67846

Inland Empire Job Corps Center
3173 Kerry St.
San Bernardino, CA 92407

Los Fresnos High School
1 Mile N. Arroyo Blvd.
Los Fresnos, TX 78566

Meridian PTC Meridian High School
1900 W. Pine
Meridian, ID 83642

Metropolitan Community College
Business and Technology
1775 Universal Ave.
Kansas City, MO 64120

North Pole High School
601 NPHS Blvd.
North Pole, AK 99705

Palo Duro High School
1400 N. Grant
Amarillo, TX 79106

Pusan National University
Jangjeon Dong
Kumjeong Ku
Pusan 609735, Korea

Royal High School
Welding Dept.
34499 Royal Rd.
Brookshire, TX 77423

South West I.S.D.
11914 Dragon Ln.
San Antonio, TX 78252

Spring Hill High School
Welding Program
3101 Spring Hill Rd.
Longview, TX 75605

The Steel Yard
27 Sims Ave.
Providence, RI 02909

Western Nevada College
2201 W. College Pkwy.
Carson City, NV 89703

AWS Mission Statement

The mission of the American Welding Society is to advance the science, technology, and application of welding and allied processes, including joining, brazing, soldering, cutting, and thermal spraying.
District 1
Thomas Ferri, director
(508) 927-1884
tferri@thermadyne.com

BOSTON
May 3
Activity: The Section members met at Assabet Valley Regional Technical School in Marlboro, Mass., for a demonstration of the safe use of industrial abrasives. Pferd Abrasives representatives Phil Benincaso, Jim Ballou, Christian Hansen, and Bill Fahlin performed the demos.

BOSTON AND CENTRAL MASS./R.I.
April 12
Activity: The two Sections met for a tour of Pierce Aluminum Co. in Franklin, Mass., to study its metal processing, waterjet cutting, and welded fabrication of aluminum components. Jim Pringle, vice president, conducted the program.

CONNECTICUT
April 20
Activity: The Section held an executive board meeting to plan for the upcoming CWI seminar in Hartford, Conn., the June District 1 conference, and future events. Attendees included District 1 Director Tom Ferri, Vice Chair Bob Cullen, Chairman Al Moore, Secretary Joe McGloin and Treasurer Walter Chojnacki.

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

LONG ISLAND
May 13
Activity: The Section discussed the welding of structures for the MTA tunnel and 2nd Avenue station. The meeting was held at The Nook Restaurant in Wantagh, N.Y.

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

Presenters at the Boston Section program are (from left) Phil Benincaso, Christian Hansen, Jim Ballou, and Bill Fahlin.

Shown are (from left) District 1 Director Tom Ferri, Pierce Aluminum Vice President Jim Pringle, and Doug Desrochers, chairman, Central Massachusetts/Rhode Island Section.

Shown at the Connecticut Section board meeting are (from left) Bob Cullen, Chairman Al Moore, Joe McGloin, District 1 Director Tom Ferri, and Walter Chojnacki.
Shown at the Long Island Section meeting are (from left) Tom Garland, Harland Thompson, Barry McQuillen, Ray O'Leary, Alex Duschere, and Brian Cassidy, chairman.

Reading Section second-level welding contest winners included (from left) Jake Watson, Alan Millinder, Zachary Shippling, and Cory Stuebner.

Shown at the Southwest Virginia Section fish fry outing are (from left) Ted Alberts, Tom Wenrich, and Chairman Wayne Johnson.

Reading Section first-level welding contest winners included (from left) Shantilly Smith, Frank Mohr, and Wesley Hess.

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

Southwest Virginia
May 1
Activity: The Section hosted its annual fish fry outing at Green Hill Park in Salem, Va. Tom Wenrich was presented his Silver Membership Certificate Award for 25 years of service to the Society by Section Chairman Wayne Johnson.

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

Florida West Coast
May 1
Activity: The Section hosted its annual Shrimp-A-Roo outing at Sons of Italy Lodge in Tampa, Fla., for nearly 100 members and guests. Scholarship Chair Alan Shissler presented Section scholarships for $750 each to Richard Perkins and Shane Holland, welding students at Traviss Career Center in Lakeland, Fla. Robert Brewington received his past chairman’s plaque from Steve Mattson, District 5 director.

North Florida
April 16
Speaker: Leo Herns, Scientia Solutions
Topic: Hexavalent chromium exposure limits
Activity: The program was held in Jacksonville, Fla. Attending were Jerry Thomas, director, Plumbers Pipe Fitters Training Facility; and Steve Mattson, District 5 Director.

Reading Section first-level welding contest winners included (from left) Shantilly Smith, Frank Mohr, and Wesley Hess.

Reading Section second-level welding contest winners included (from left) Jake Watson, Alan Millinder, Zachary Shippling, and Cory Stuebner.

Shown at the Southwest Virginia Section fish fry outing are (from left) Ted Alberts, Tom Wenrich, and Chairman Wayne Johnson.

Reading Section first-level welding contest winners included (from left) Shantilly Smith, Frank Mohr, and Wesley Hess.

Reading Section second-level welding contest winners included (from left) Jake Watson, Alan Millinder, Zachary Shippling, and Cory Stuebner.

Shown at the Southwest Virginia Section fish fry outing are (from left) Ted Alberts, Tom Wenrich, and Chairman Wayne Johnson.

Reading Section first-level welding contest winners included (from left) Shantilly Smith, Frank Mohr, and Wesley Hess.

Reading Section second-level welding contest winners included (from left) Jake Watson, Alan Millinder, Zachary Shippling, and Cory Stuebner.

Shown at the Southwest Virginia Section fish fry outing are (from left) Ted Alberts, Tom Wenrich, and Chairman Wayne Johnson.
Shown at the Florida West Coast Section outing are (from left) Alan Shissler, scholarship recipient Richard Perkins, and Edwin Harrell, welding instructor at Traviss Career Center.

Jolene Molitoris discussed transportation issues at the Columbus Section program in March.

Speaker Leo Herns (left), District 5 Director Steve Mattson (center), and Jerry Thomas participated in the North Florida Section program.

SOUTH CAROLINA
April 15
Activity: The Section held its annual Pig Pickin’ Social at Haselden Co., Inc., in Wando, S.C. Incoming officers were installed and Ben Magrone, outgoing chair, received a plaque of appreciation. Attending were Gale Mole, vice chair; and Steve Mattson, District 5 director.

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

District 7
Don Howard, director
(814) 269-2895
howard@ctc.com

COLUMBUS
March 23
Speaker: Jolene Molitoris, director
Affiliation: Ohio D.O.T., Columbus

Robert Brewington (left) is shown with Steve Mattson, District 5 director, at the Florida West Coast Section Shrimp-A-Roo.

Topic: Transportation and rail development in Ohio
Activity: Members of the local chapters of SWE, ASME, ASM International, IIE, AIAA, ISA, and NACE attended the program, held in Columbus, Ohio.

April 22
Activity: The Columbus Section joined members of the local chapters of SWE, ASME, ASM International, IIE, AIAA, ISA, and NACE to tour the facilities of the National Board of Boiler and Pressure Vessel Inspectors in Columbus, Ohio. The guides were engineering staff members Robert Schueler, James Keenan, Francis Brown, and Robert Ferrell.

MAY 6
Speaker: Robert Zimmerman, author
Topic: Stories of the early American and Russian space programs
Activity: The Columbus Section met with members of the local chapters of SWE, ASME, ASM International, IIE, AIAA, ISA, and NACE, at Arlington Banquets in Columbus, Ohio.

DAYTON
May 11
Speaker: Edd Turner, senior sales representative
Affiliation: Nelson Stud Welding
Topic: Advances in stud welding
Activity: The meeting was held at Amber Rose Restaurant in Dayton, Ohio.
Shown at the Pittsburgh Section executive board meeting are (from left) Tom White, Dave Daugherty, George Kirk, Carl Spade, Roger Hily, and Brad King.

Speaker Edd Turner (right) is shown with Steve Whitney, Dayton Section chair. Speaker Craig Eppley (left) chats with Buster Hales at the Chattanooga Section program.

Winners in the Holston Valley welding contests included (from left) John King, Jordan Lawson, Paul Brandon, and D. J. Littlefield.

The Nashville Section presented scholarships to (from left) Barry Paul, Bruce Threet, Les Cornet, Ryan Boyd, and Sean Jones.

PITTSBURGH
July 13, 2009
Activity: The Section held an executive board meeting to plan for the upcoming year's programs.

District 8
Joe Livesay, director
(931) 484-7502, ext. 143
joe.livesay@ttcc.edu

CHATTANOOGA
April 20
Speaker: Craig Eppley
Affiliation: The Lincoln Electric Co.
Topic: Controlling weld fumes
Activity: The program was held at Komatsu America Corp. in Chattanooga, Tenn.

GREATER HUNTSVILLE
April 20
Activity: The Section members met to discuss the national SkillsUSA contest, Section scholarship program, and the District conference. The meeting was held at Marshall Technical School in Huntsville, Ala. Chair Rayburn Johnson conducted the meeting.

HOLSTON VALLEY
April 13
Activity: The Section hosted its fifth annual students' night program at Tennessee Technology Center in Surgoinsville, Tenn. Welding instructor Jerry Sullivan presented a talk and also cooked the barbecue dinner. The welding skills contest included 20 students. The two top winners received $100 savings bonds, the runners-up received $50 bonds.

NASHVILLE
April 8
Speaker: John Kahl
Affiliation: The Lincoln Electric Co.
Topic: The services Lincoln provides for industrial robots and power sources
Activity: The Section presented $500 scholarships to welding students Barry Paul, Bruce Threet, Les Cornet, Ryan Boyd, and Sean Jones. Dave Brumley demonstrated a virtual reality welding simulator. Everyone enjoyed experimenting with the new training technology. Forty-one members and guests attended the meeting and barbecue dinner.

District 9
George D. Fairbanks Jr., director
(225) 473-6362
fits@bellsouth.net
New Orleans Section past chairs are (from left) James Watts, Travis Moore, Paul Hebert, Matthew Howerton, Tony DeMarco, AWS President John Bruskotter, and Bruce Halilla.

NEW ORLEANS
MAY 18
Speaker: Matthew Howerton
Affiliation: The Lincoln Electric Co.
Topic: Welding engineering for non-welding engineers
Activity: The Section hosted its past chairmen’s night program at Boomtown Casino in Harvey, La., for 70 attendees. Wesco Gas and Welding Supply hosted the meeting. Todd Taranto of Wesco and Chairman Donald Berger organized the event. Student Elliot Hardin, Local 58, was recognized for attending the most meetings.

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

District 10 DRAKE WELL
MAY 11
Activity: The Section members met to discuss plans for the upcoming year’s activities. The meeting was held at Cozumel Mexican Restaurant in Cranberry, Pa.

MAHONING VALLEY
District 10 Conference
MAY 6
The Mahoning Valley Section hosted the District 10 conference at Youngstown Historical Center in Youngstown, Ohio, presided by District 10 Director Richard Harris. Past AWS President Victor Matthews presented the Life Membership Award to Ray DeBonis for 35 years of service to the Society, and a chairman’s appreciation award to Huck Hughes. The AWS staff representative was Brian McGrath.

District 11
Efthimos Siradakis, director
(989) 894-4101
ft.siradakis@airgas.com

At the District 10 conference, Ray DeBonis receives the Life Membership award from past President Victor Matthews. Shown in the back, from left, are Kenny Jones, Chuck Moore, District 10 Director Richard Harris, and Brian McGrath, AWS staff representative.
District 12
Sean P. Moran, director
(920) 954-3828
sean.moran@hobartbrothers.com

District 12 Conference
May 7
Activity: The Milwaukee Section hosted the meeting chaired by District 12 Director Sean Moran. Participating were Theresa Wiles, Dave Ramseur, Dan Crefasse, Karen Gilgenbach, Chuck Frederick, Cory Satka, Ken Karwowsk, Gerald Blaski, Ben Newcomb, Craig Wentzel, Bob Bruss, Sue Silverstein, Randall Conselman, Dan Roland, and Steve Hedrick, AWS manager, safety and health. The event was held at Graingers Pub and Grill in Milwaukee, Wis.

MADISON-BELOIT
April 14
Activity: The Section members toured the Kuhn North America facilities in Brodhead, Wis., to study the manufacture of industrial agricultural equipment. The dinner and meeting were held at Silver Dollar Steakhouse and Saloon. Chair Ben Newcomb presented Rob Stinson the District Director’s Award, District Meritorious Award, and his Life Member Certificate for 35 years of service to the Society. David Diljak presented Ben Newcomb an award for his services as chairman.

MILWAUKEE
April 22
Activity: The Section sponsored a vendors’ night program at Milwaukee Area Technical College in Oak Creek, Wis., titled Latest Trends in Technology. Participating companies included Eutectic, Lincoln Electric, Miller Electric, Fronius, Panasonic, Mavrix, IGM Roboties, Walter, Norton Abrasives, and Airgas. A full-size robot performed for the 74 attendees. John Hinrichs was presented the District Meritorious Award by Sean Moran, District 12 director.
Shown at the Milwaukee Section program are (from left) Brion Kluge, Terry Kitzrow, Joe Villa, Bryan Hackbarth, Dale Gilbertson, and Anni Quackenbush.

Jim Renner (left) receives the Private Sector Instructor Award from Dale Lange, Upper Peninsula Section chair.

RACINE-KENOSHA
MAY 19
Speaker: Damian J. Kotecki, a past AWS president
Affiliation: Damian Kotecki Welding Consultants, Inc., president
Topic: How to turn good filler metal into poor welds
Activity: The program was held at Cardinal Ale House and Bowl in Columbus, Wis.

UPPER PENINSULA
APRIL 13
Activity: The Section members toured Verso Paper in Iron Mountain, Quinnesec, Mich. Karl Bauman, maintenance specialist, conducted the tour. Following the tour, the members held a business meeting to determine officer nominations and section award candidates. Chair Dale Lange received an appreciation certificate for his services. Jim Renner, a weld instructor at Marinette Marine Corp., received the Private Sector Instructor Award.

District 13
W. Richard Polanin, director
(309) 694-5404
rpolanin@icc.edu

Shown at the Racine-Kenosha Section program are (from left) Chair Daniel Crifase, Mike Kessel, speaker Damian Kotecki, and Ken Karwowski.

The sponsors for the J.A.K. welding rodeo were (from left) Mark Stevenson, John Willard, Fred Mancuso, Justin Tibbetts, and Will Hemphill.

Participants in the J.A.K. welding rodeo included (from left) Ian Walton, Alex Yarno, Spencer Blum, Clayton McDowell, Tony Szygus, Justin Tibbetts, and Mark Stevenson.
Shown at the Peoria Section welding contest are (from left) instructor Shane Seals with SkillsUSA welding participants Jimmy Baxter, Nick Deig, and Shane Markham.

First-place team members at the Indiana Section’s Mid-West Team Welding Tournament are (from left) Aaron Hopt, Dan Kreilein, Zack Wood, Devin Tegmeyer, and Kory Voelkel.

J.A.K.
APRIL 17
Activity: The Joliet-Aurora-Kankakee Section hosted a welding rodeo at Kankakee Community College in Kankakee, Ill. Josh Karalevicz turned in the best performance for the day. Others participating were Ian Walton, Alex Yarno, Spencer Blum, Clayton McDowell, Tony Syrgas, and sponsors Mark Stevenson, John Willard, Fred Mancuso, Justin Tibbetts, and Wil Hemphill.

PEORIA
APRIL 10
Activity: The Section joined with Illinois Central College to present an artists’ showcase at the college. Nine artists displayed their works, and Tom and Vicky Schertz demonstrated their blacksmithing talents.

APRIL 16
Activity: The Peoria Section sponsored contestees for the Illinois SkillsUSA contest. Shane Seals is the welding instructor. Jimmy Baxter placed fifth in the state post-secondary class, Nick Deig placed fourth, and Shane Markham placed seventh.

District 14
Tully C. Parker, director
(618) 667-7795
tullyparker@charter.net

INDIANA
APRIL 13–15
Activity: The Section hosted its 32nd annual Mid-West Team Welding tournament at new Castle High School in New Castle, Ind. Twenty-six teams competed for trophies, $8000 in prizes, and a $6000 scholarship to Ohio Technical College. Pike Central High School, Petersburg, Ind., won the team title. The runner-up teams were Kentucky Tech, Nelson County, Ky.; Fountain Central, Veedersburg, Ind.; New Castle Career Programs, New Castle, Ind.; and Franklin County High School, Frankfort, Ky. Tully Parker, District 14 director, received the Clifford Hunt Award for his “outstanding contributions to the Mid-West Team Welding Tournament.”

APRIL 17
Activity: The Indiana Section conducted the Indiana SkillsUSA welding contest at Walker Career Center in Indianapolis. Aaron Hopt, Pike Central High School, Petersburg, Ind., won the secondary contest. Greg Carper, Ivy Tech C. C., Anderson, Ind., won the postsecondary event.

APRIL 24
Activity: The Indiana Section conducted the first Indiana SkillsUSA fabrication welding contest at J. Everett Light Career Center in Indianapolis. Dave Koutz of Lincoln Electric chaired the event. The top teams were New Castle High School, Pike Central, and Whitewater Career Center. The winning team members were Zach Cheesman, Logan Pool, and Brandon Johnson.

LEXINGTON
APRIL 22
Activity: Incoming Chair Tim Pinson pre-
Shown at the St. Louis Section students’ night program are (from left) speaker Gailyn Cornell, Mark Borchardt, Jessica Gourley, Michael Hawks, Geordi Sievert, Lewis Green, Robert Lipscomb, Chris Newton, and Nick Wiltsee.

Chair Jason Miles (left) presents a speaker award to Howard Rinne at the Kansas City Section tour.

Presented James Mattox with an appreciation award for serving as chairman. The winners in the recent SkillsUSA welding contest were presented.

ST. LOUIS
APRIL 8
Speaker: Gailyn Cornell, branch services director
Affiliation: ILMO Products Co.
Topic: The welding career tree
Activity: The Section hosted a students’ night program at Granite City, Ill. Awards and scholarships were presented to outstanding students.

District 15
Mace V. Harris, director
(612) 861-3870
macevh@aol.com

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

KANSAS
APRIL 15
Activity: The Section hosted the state SkillsUSA welding competition at Wichita Area Technical College in Wichita, Kan. Thirty-five Section members participated and 54 secondary and postsecondary school students competed.

Incoming Lexington Section Chair Tim Pinson (right) is shown with James Mattox, chairman.

The first-place welding team poses with their trophies at the Lexington Section program.

Diane Steadham and Marc Childs are shown at the Kansas Section baseball event.

May 18
Activity: The Kansas Section members met with family and friends for a picnic lunch then attended the season game opener of the Wichita Wingnuts baseball team in Wichita, Kan. Chairman Diane Steadham was presented an appreciation award for her services.
Kansas Section members and guests are shown at the Wingnuts baseball game outing in May.

Central Arkansas Section members working the SkillsUSA contest are, from left, (front row) Jim Ryan, Matt Fair, Dennis Pickering, and Chuck LeBlanc; (back row) James Templet, George Seahorn, Jimmy Brewer, and Chris Newell.

The Kansas City Section members pose at SPX Cooling Towers in April.

KANSAS CITY
April 8
Activity: The Section toured SPX Cooling Towers in Olathe, Kan. Howard Rinne discussed cooling tower fabrication and led the program. Following the tour, the incoming slate of officers was announced: Jason Miles, chairman; Mike Vincent and Michael Williams, vice chairs; Joey Bleam, secretary; and Brian McKee, treasurer.

MID-PLAINS
April 7
Activity: The Section members toured Troyer Enterprises in North Platte, Neb., to learn about and see demonstrations of plasma arc cutting. The presenters were Kyle Troyer and Bob Hardy.

District 17
J. Jones, director
(940) 368-3130
jjones@thermadyne.com
Win Great Prizes in the 2010-2011 AWS Member-Get-A-Member Campaign*

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

**TO RECRUIT NEW MEMBERS, USE THE APPLICATION ON THE REVERSE, OR VISIT WWW.AWS.ORG/MGM**

**PRIZE CATEGORIES**

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

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

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

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

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

**SPECIAL PRIZES**

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

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

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

The AWS Member who sponsors the most Student Members will receive a free, one-year AWS Membership, an AWS polo shirt, hat and an AWS Sportpack bag.

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

**LUCK OF THE DRAW**

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

**Prizes Include:**

- Complimentary AWS Membership renewal
- AWS t-shirt
- AWS hat

**SUPER SECTION CHALLENGE**

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

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

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

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

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

TOTAL PAYMENT $135

TWO-YEAR AWS INDIVIDUAL MEMBERSHIP

Welding Journal $50  (Optional)

Yes  New Member?

One-Year AWS Individual Membership $80

Two-Year AWS Individual Membership $100 $135

New Member? Yes  No

If yes, add one-time initiation fee of $13

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

Domestic Members add $25 for book selection ($192 value)

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

TOTAL PAYMENT

AWS STUDENT MEMBERSHIP

Domestic (Canada & Mexico incl.) $15

International $50

TOTAL PAYMENT

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

Optional Book/CD-ROM Selection

Welding Journal (9th Ed., Vol. 1) $25

Welding Journal (9th Ed., Vol. 2) $25

Welding Journal (9th Ed., Vol. 3) $25

Cost-Effective Welding $25

BOOK/CD-ROM SELECTION

(For only $25. up to a $192 value)

New Member  Renewal

A free local Section Membership is included with all AWS Memberships.

Section Affiliation Preference (if known):

Type of Business (Check ONE only):

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

Job Classification (Check ONE only):

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

Technical Interests (Check all that apply):

O  Ferrous metals
B  Aluminum
C  Nonferrous metals except aluminum
D  Advanced materials/Intermetallics
E  Ceramics
F  High energy beam processes
G  Arc welding
H  Brazing and soldering
J  Resistance welding
K  Thermal spray
L  Cutting
L  NDT
M  Safety and health
N  Bending and shaping
O  Roll forming
P  Stamping and punching
Q  Aerospace
R  Automotive
S  Machinery
T  Marine
U  Piping and tubing
V  Pressure vessels and tanks
W  Sheet metal
X  Structures
Y  Other
Z  Automation
2  Robotics
2  Computation of Welding
The participants in the East Texas Section welding and cutting contest are shown in April.

British Columbia Section members pose at the Covanta Energy facility.

CENTRAL ARKANSAS
APRIL 12
Activity: The Section participated in the state SkillsUSA competition. The event was held at Hot Springs Summit Arena.

EAST TEXAS
APRIL 17
Activity: The Section hosted a welding and cutting contest at Tyler Junior College in Longview, Tex. The top performers were Martin Toppia, Brent Jonson, and Colton Clark.

TULSA
APRIL 27
Speaker: Paul Wittenbach, principal metallurgical and welding engineer
Affiliation: ConocoPhillips
Topic: Welding challenges faced when jacking up the Ekofish offshore North Sea oil platform
Activity: The program was held in Tulsa, Okla.

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

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

BRITISH COLUMBIA
APRIL 29
Activity: The Section members toured Covanta Energy, Inc., in Delta, B.C., Canada. Tim Benko and Helmut Bott presented an overview of the incinerator and how it works before conducting tours of the facility.

Tulsa Section Vice Chair David Gilliam (left) is shown with speaker Paul Wittenbach.
Presenters at the Puget Sound Section program are (from left) William Vossler, Yim Mens, Bryan Hayes, Philip Obers, Derric Fotherhill, instructor Ken Johnson, Steve Gaworski, Starr Gaworski, Tom Ferguson, and instructor Dan Aragon.

Shown at the Puget Sound Section program are speaker Mike Weaver (left) and Vice Chair Ken Johnson.

Awardees are shown at the Colorado Section program.

OLYMPIC
APRIL 20
Speaker: Ken Alrick, application specialist
Affiliation: Thermadyne-Thermal Arc
Topic: Plasma arc welding
Activity: Following the talk, Alrick held a question-and-answer session then offered the students hands-on demonstrations of the equipment.

PUGET SOUND
MAY 6
Activity: The Section hosted a students’ day program at Stanwood High School in Seattle, Wash. Mike Weaver of Weaver Engineering, discussed stress analysis of welds, and several students presented talks. Darryl Main received the Educator of the Year award.

SPOKANE
APRIL 27
Speaker: Rick Pfeifer
Affiliation: Pfeifer Sales, Inc.
Topic: Autodarkening welding hoods
Activity: The program was held at Oxarc Training Center in Spokane, Wash.

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

ALBUQUERQUE
APRIL 29
Speaker: Fred Hooper, owner
Affiliation: Speed of Light
Topic: Laser beam welding
Activity: Following the talk, Hooper demonstrated laser beam welding. Scholarships were presented.

COLORADO
MAY 13
Speaker: Glenn Washer, assistant professor
Affiliation: University of Missouri
Topic: Nondestructive evaluation of highway bridges
Activity: Jay Voth, Lynn Sturgill, Alan Barber, and Dave Murphy received Private Instructor Awards, Wade Lutz and Mike Rinow received CWI of the Year Awards, and John Steele received the Instructor of the Year Award.

Rick Pfeifer demonstrated autodarkening welding hoods at the Spokane Section event.
Albuquerque Section members pose for a group shot in April.

AWCIWT Student Chapter presenters pose with District 21 Director Nanette Samanich at the Green Welding symposium.

UTAH
April 27
Activity: The Section honored Mason Winters for earning the silver medal win in the SkillsUSA 2009 competition and his winning the Donald and Shirley Hastings Scholarship.

District 21
Nanette Samanich, director
(702) 429-5017
Nan07@aol.com

AWCIWT Student Chapter
February 5
Activity: The Arizona Western College Institute of Welding Technology (AWCIWT) Student Chapter hosted the Region 1 SkillsUSA welding competition in Yuma, Ariz. Thirty-five students from area high schools participated in the event.

March 10
Activity: The AWCIWT Student Chapter hosted its annual welcome back welders torch cutting skill competition for 75 attendees. Featured was a regional SkillsUSA welding competition.

March 18
Activity: The Student Chapter members toured the Free-McMoRan Copper and Gold Mine in Bagdad, Ariz., to study extractive metallurgy and see the heavy equipment in action.

March 30-April 1
Activity: The Student Chapter hosted the tenth anniversary Welders without Borders event titled Green Welding: The Future Is Now. Running from 8 a.m. to 5 p.m. daily, the activities included welding contests, robotic welding, 3-D virtual weld simulation and many welding processes sponsored by Miller, Lincoln, MK Products, ESAB, Thermadyne, Hobart, Stoody, Victor, Tweco, and others.

April 12, 13
Activity: Students from the college competed in Phoenix, Ariz., at the SkillsUSA state competitions for extemporaneous speaking and welding fabrication.
The Arizona Western College Institute of Welding Technology Student Chapter members are shown at the Green Welding event.

Welding students and instructors are shown at the Los Angeles/Inland Empire Section program in April.

The Sacramento Section event in April produced a big turnout.

L.A./INLAND EMPIRE
APRIL 28
Activity: The Los Angeles/Inland Empire Section hosted a students’ night activity in Los Angeles, Calif.

District 22
Dale Flood, director
(916) 288-6100, ext. 172
flashflood@email.com

SACRAMENTO
APRIL 21
Speakers: John Madri, ordinance welding instructor, U.S. Army; and Lincoln Electric sales representative David Kilburn.
The Sierra Nevada Section members are shown during their May tour.

Sam Cophrun detailed off-road vehicle construction at the Sierra Nevada Section event.

Shown at the Sacramento Section event are (from left) Trevor Robinson, Emmanuel Ezenwa, Mark Feuerbach, District 22 Director Dale Flood, Mark Reese, and Chair Matt Wysocki.

Speaker Jeff Hicks is shown with Tom Erichsen, Santa Clara Section chairman.

Shown at the Santa Clara Section program are (from left) Tony DeSousa, District 22 Director Dale Flood, and Alex Gutierrez.

Speaker Jimmy Hollison (right) is shown with Tom Smeltzer, San Francisco Section chairman.

Topic: Flame spraying tungsten carbide and use of hardfacing electrodes
Activity: Madri presented a demonstration of flame spraying for the 105 attendees. District 22 Director Dale Flood presented achievement awards to Section officers Trevor Robinson, Emmanuel Ezenwa, Mark Feuerbach, Mark Reese, and Chair Matt Wysocki. The Sierra College Student Chapter sponsored the event.

SANTA CLARA
May 11
Speaker: Jeffrey Hicks, principal scientist
Affiliation: Exponent, Inc.
Topic: Hexavalent chromium in weld fume
Activity: Chair Tom Erichsen, Vice Chair Alex Gutierrez, and Secretary Tony DeSousa received plaques in appreciation for their services.

SIERRA NEVADA
May 13
Activity: Following a pizza repast, the Section members toured SamCo Fabrication in Sparks, Nev., to study the manufacture of off-road race cars, trucks, and rock crawlers. Sam Cophrun, founder and owner, and David Kilburn, technical sales representative, conducted the program.

SAN FRANCISCO
May 5
Speaker: Jimmy Hollison, QA manager
Affiliation: Performance Mechanical, Inc.
Topic: Details about the certified fabricator designation
Activity: Sixty-eight members attended this final meeting for the season. The program was held at Spenger's Restaurant in Berkeley, Calif.

How to Order Copies of AWS Publications

Contact Rhonda Brown, Foster Printing Services, rhondab@fosterprinting.com, for electronic and printed Welding Journal articles in quantities of 100 or more.

Contact Ruben Lara, rlara@aws.org, for copies of Welding Journal articles.

Purchase American Welding Society standards, books, and other publications from WEX (World Engineering Xchange). Place your orders online at www.awspubs.com; call (888) 935-3464, (305) 824-1177; FAX (305) 826-6195; e-mail orders@awspubs.com.
Listed below are the AWS members who are participating in the 2009–2010 MGM campaign. See page 81 in this Welding Journal or visit www.aws.org/mgm for the rules and prize list.

The following standings are as of May 17, 2010. Call the AWS Membership Dept. (800/305) 443-9353, ext. 480, for information on your member-proposer status.

**Winner’s Circle**
Sponsored 20+ new members.
The superscript indicates the number of times the member has achieved Winner’s Circle status since June 1, 1999.

- J. Compton, San Fernando Valley
- J. Barber, Connecticut
- J. Rodenbarger, Nebraska
- J. Fitzpatrick, Arizona
- J. Hope, Puget Sound
- J. Ciaramitaro, N. Central Florida
- J. Price, Detroit
- J. Hennessy, Fox Valley
- T. Bridigum, Northwest
- M. Stevenson, J.A.K.
- T. Thomas, St. Louis

**4+ Student Member Sponsors**
- D. Saunders, Lakeshore
- C. Rogers, San Antonio
- G. Kirk, Pittsburgh
- H. Hughes, Mahoning Valley
- D. Berger, New Orleans
- J. Morash, Boston
- S. Miner, San Francisco
- C. Hardbarger, Mid-Ohio Valley
- R. Durham, Cincinnati
- G. Gammill, NE Mississippi
- D. Keller, Willamette Valley
- C. Lindquist, Central Michigan
- D. Zabel, SE Nebraska
- T. Palmer, Columbia
- J. Carney, West Michigan
- M. Anderson, Indiana
- D. Kowalski, Pittsburgh
- D. Pickering, Central Arkansas
- A. Stute, Madison-Beloit
- R. Hutchinson, Long Beach/Orange Cty.
- M. Boggs, Stark Central
- A. Duron, New Orleans
- S. Siviski, Maine
- D. Aragon, Puget Sound
- A. Baughman, Stark Central
- R. Wahrmann, Triangle
- T. Gerber, Allegheny
- T. Geisler, Pittsburgh
- S. Burdige, Stark Central
- R. Evans, Siouxland
- E. Norman, Ozark
- G. Marx, Tri-River
- K. Rawlins, Columbia
- B. Suckow, Northern Plains
- R. Cook, Utah
- C. Donnell, NW Ohio
- J. Durbin, Tri-River
- V. Facchiano, Lehighton
- W. Galvery, Long Beach/Orange Cty.
- W. Harris, Pascagoula
- J. Theberge, Boston
- M. Arand, Louisville
- J. Boyer, Lancaster
- R. Boyer, Nevada
- W. Davis, Syracuse
- J. Fox, NW Ohio
- J. Gerdin, Northwest

**President’s Club**
Sponsored 2–3 new members.

- S. Keskar, India
- E. Young, Tri-River
- J. Hennessy, Fox Valley
- J. Price, Detroit
- D. Berger, New Orleans
- J. Ciaramitaro, N. Central Florida
- E. Ezzell, Mobile
- J. Hope, Puget Sound
- G. Baldivis, Rio Grande Valley
- B. Cebry, Fox Valley
- J. Fitzpatrick, Arizona
- R. Eavelo, International
- J. Rodenbarger, Nebraska
- D. Scott, Mobile
- S. Singh, Indian
- T. Baber, San Fernando Valley
- G. Burrier, S. Florida
- T. Morris, Tulsa
- P. Newhouse, British Columbia
- M. Pelegrino, Chicago

**President’s Honor Roll**
Sponsored 2 new members.

- J. Barber, Connecticut
- T. Blakeney, Green & White Mts.
- C. Bridwell, Ozark
- G. Callender, San Fernando Valley
- K. Carter, Tri-River
- J. Cooley, Birmingham
- R. Davis, Utah
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 C. Bruskotter
jbruskotter@eplweb.com
Bruskotter Consulting Services
14254 Hwy. 23, Belle Chasse, LA 70037

ADMINISTRATION
Executive Director
Ray W. Shook, rshook@aws.org ............(219)
Deputy Executive Director
Cassie R. Burrell... cburrell@aws.org ............(253)
Senior Associate Executive Director
Jeff Weber, jweber@aws.org ............(246)
Associate Executive Director Accounting
Gesana Villegas... gvillegas@aws.org ............(252)
Administrative Assistant for Board Services
Gracielia Manalich... gracielia@aws.org ............(294)

Administrative Services
Managing Director
Jim Lankford... jilank@aws.org ............(214)
IT Network Director
Armando Campana... acampana@aws.org ............(260)
Director
Hidal Nuiez... hidual@aws.org ............(287)
Database Administrator
Natalia Swahn... nswahn@aws.org ............(245)
Human Resources
Director, Compensation and Benefits
Luisa Hernandez... luisa@aws.org ............(266)
Director, Human Resources
Dora A. Shada... dshada@aws.org ............(235)

INT’L INSTITUTE OF WELDING
Senior Coordinator
Sissibeth Lopez... slopez@aws.org ............(319)

GOVERNMENT LIAISON SERVICES
Hugh K. Webster... hwebster@wc-b.com
Webster, Chamberlain & Bean, Washington, D.C.,
(202) 785-9500, FAX (202) 835-0243.
Monitor federal issues of importance to the industry.

CONVENTION and EXPOSITIONS
Senior Associate Executive Director
Jeff Weber... jweber@aws.org ............(246)
Director, Convention and Meeting Services
John Osphina... josphina@aws.org ............(402)
Brazing and Soldering
Jeff Weber... jweber@aws.org ............(246)

GAWDA — Gases and Welding Distributors Association
Administrative Manager
Natasha Alexis... nal@aws.org ............(401)

RWMA — Resistance Welding Manufacturing Alliance
Manager
Susan Hopkins... susan@aws.org ............(295)

WEMCO — Welding Equipment Manufacturers Committee
Manager
Natalie Tapaney... tapaney@aws.org ............(444)

PUBLICATION SERVICES
Department Information ............(275)
Managing Director, Publication Services
Andrew Cullison... culcullison@aws.org ............(249)
Welding Journal
Publisher
Andrew Cullison... culcullison@aws.org ............(249)
Editor
Mary Ruth Johnson... myjohnson@aws.org ............(238)
National Sales Director
Rob Saltstein... rsaltstein@aws.org ............(245)
Society and Section News Editor
Howard Woodward... hwoodward@aws.org ............(244)
Welding Handbook
Editor
Annette O’Brien... aoobrien@aws.org ............(303)

MARKETING COMMUNICATIONS
Director
Ross Hancock... rhancock@aws.org ............(226)
Public Relations Manager
Cindy Weihl... cweihl@aws.org ............(416)
Webmaster
Jose Salgado... jsalgado@aws.org ............(456)

MEMBER SERVICES
Department Information ............(480)
Deputy Executive Director
Cassie R. Burrell... cburrell@aws.org ............(253)
Director
Rhenda A. Kenny... rhenda@aws.org ............(280)

CERTIFICATION SERVICES
Department Information ............(273)
Director Certification Operations
Terry Perez... tpeerez@aws.org ............(470)
Managing Director, Technical Operations
Peter Howe... phowe@aws.org ............(309)
Manages and oversees the development, Integrity, and technical content of all certification programs.
Director, Int’l Business & Certification Programs
Pritt Jain... pjain@aws.org ............(288)
Directs all Int’l business and certification programs, is responsible for oversight of all agencies handing AWS certification programs.

EDUCATION SERVICES
Director, Operations
Martica Ventura... mmviventura@aws.org ............(224)
Senior Manager, Education Development
David Henderson... dhenderson@aws.org ............(219)

AWS AWARDS, FELLOWS, COUNSELORS
Senior Manager
Wendy S. Reeve... wreeve@aws.org ............(293)
Coordinates AWS awards and AWS Fellow and Counselor nominees.

TECHNICAL SERVICES
Department Information ............(340)
Managing Director
Andrew R. Davis... adavis@aws.org ............(466)
Int’l Standards Activities, American Council of the Int’l Institute of Welding (IIW)

DIRECTOR, NATIONAL STANDARDS ACTIVITIES
John L. Gayler... jlgayler@aws.org ............(472)

Manager, Safety and Health
Stephen P. Hedrick... shedrick@aws.org ............(305)

Senior Manager, Technical Publications
Rosalinda O’Neill... rooill@aws.org ............(451)

Staff Engineers/Standards Program Managers
Annette Alonso... aalon@aws.org ............(299)
Automotive Welding, Resistance Welding, Oxy-fuel Gas Welding and Cutting, Definitions and Symbols, Sheet Metal Welding

International Welding, Brazing, and Soldering
Stephan Borrero... sborrero@aws.org ............(334)

Rakesh Gupta... rgupta@aws.org ............(301)
Filler Metals and Allied Materials, Int’l Filler Metals, Instrumentation for Welding, UMS Numbers Assignment

Brian McGrath... bmcgrath@aws.org ............(311)
Methods of Inspection, Measurement Testing of Welds, Welding in Marine Construction, Piping and Tubing

Selvis Morales... smorales@aws.org ............(313)
Welding Qualification, Structural Welding

Matthew Rubin... mrubin@aws.org ............(215)
Aircraft and Aerospace, Machinery and Equipment, Robotics Welding, Arc Welding and Cutting Processes

Reino Starks... rstarks@aws.org ............(304)
Welding in Sanitary Applications, High-Energy Beam Welding, Friction Welding, Railroad Welding, Thermal Spray

Note: Official interpretations of AWS standards may be obtained only by sending a request in writing to Andrew R. Davis, managing director, Technical Services, adavis@aws.org.

Oral opinions on AWS standards may be rendered, however, oral opinions do not constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

AWS Foundation
Chairman, Board of Trustees
Gerald D. Utrachti
Executive Director, AWS
Ray Shook, ext. 230, rshook@aws.org
Executive Director, Foundation
Sam Grayton, ext. 331, sgrayton@aws.org
Solutions Opportunity Squad (SOS)
Corporate Director
Monica Pfarr, ext. 561, mpfarr@aws.org
General Information
(800) 443-9353, ext. 689; wps@aws.org

AWS Foundation, Inc., is a not-for-profit corporation established to provide support for educational and scientific endeavors of the American Welding Society. Further the Foundation’s work with your financial support. Call for information.
Gas Equipment Presented in New Literature

The new 140-page, full-color *Industrial Gas Equipment Catalog* includes the recently introduced Professional Edge™ series regulators with high and medium capacity; the Journeyman®, Journeyman II, Contender®, Contender AF, and Performer® outfits incorporating the new Edge series regulators; and the Edge series medium-capacity flow gauge. The catalog features product images, reference sheets, selection guides, as well as special features and comparative benefits. Download the catalog from the Literature section of the Website, or call for a hard copy.

Victor® Equipment Co.
www.thermadyne.com/victor
(800) 426-1888

**Book Details Design of Welded Structures**

*Design, Fabrication, and Economy of Welded Structures* covers the fields of different materials and fatigue of welded joints, thin-walled structures, tubular structures, frames, plates, and shells. Also incorporated are special optimization problems, fire- and earthquake-resistant designs, special applications, and applied mechanics. It is intended to be an important reference for civil and mechanical engineers, architects, designers, and fabricators. Index topics include structure optimization, fatigue design, frames, hollow sections, plated structures, residual stresses and distortions, static stresses in welded connections, application, welding technology, and applied mechanics. The list price is $123. To order online, visit the Web site, then type “Welded Structures” in the search window.

Research and Markets
www.researchandmarkets.com
(646) 607-1907

**Production Machinery Pictured in Catalog**

A full-color, well-illustrated catalog details the company’s lines of machinery for rolling, bending, and forming. Featured are the CPHV double-pinch hydraulic angle-roll series, profile benders, A31 and LS series single-pinch plate rolls, Hi-Tech series of automatic high-speed four-roll double-pinched plate rolls, vertical benders, rebar benders and shears, ornamental bar working machines, horizontal presses, corner notchers, and manual benders. Call for a hard copy, or visit the Web site to download PDF editions of this and other catalogs.

Carell Corp.
www.carellcorp.com
(251) 937-0948

**Laser Hazard Standard Issued**

The standard Z136.4-2010, *Recommended Practice for Laser Safety Measurements for Hazard Evaluation*, provides
Companion D1.1 Standards Document Published

The 565-page, ASTM Standards for Welding, second edition, includes the 60 ASTM standards referenced by the latest edition of the American Welding Society, D1.1/D1.1M:2010, Structural Welding Code — Steel. These documents provide the practical information needed for welding any type of structure constructed from the commonly used carbon- and low-alloy steels. The included resources can assist quality professionals, inspectors, supervisors, as well as quality-conscious engineers and managers with interpretation of specifications and the test methods used every day in the field. The volume is available on CD or soft-cover edition for $475.

ASTM International
www.astm.org
(610) 832-9585

PMA Launches Improved Web Site

Metal-forming technology news is now easier to access at the company’s redesigned Web site. Notable improvements include enhanced navigation to Hot Off the Press features, new product announcements, and exclusive online articles. The updated multimedia center features editorial videos prepared by the staff to help illustrate the print articles...continued on page 94
TRUMPF Fills Two Sales Posts

TRUMPF Inc., Farmington, Conn., has named Mike Morissette finance manager for TRUMPF Finance. Chris McMillin replaces him as regional sales manager, based in Arizona. Morissette has been with the company for 15 years serving in various managerial positions. McMillin previously was a salesman for Icon Machine Tool, a distributor of fabrication equipment.

Thermadyne Adds to Its Sales Force

Thermadyne Industries, Inc., St. Louis, Mo., has appointed Tony Coco director of channel marketing and national accounts for North and South America. Bill Wehrman joins the company in support of Coco to define and direct the marketing communication strategy for the Americas. Vickie Marshall, working for Wehrman, is responsible for the visual design, layout, interface, and graphic production for Web-based products within the company. Coco previously worked for Honeywell Analytics as vice president of sales. Wehrman most recently was director of marketing and corporate communications for American Express Incentive Services. Marshall previously was the marketing communications specialist in the Biosystems division of Leica Microsystems, Inc.

Lincoln Electric Promotes Two to Global Positions

The Lincoln Electric Co., Cleveland, Ohio, has named Peter Fletcher director, global consumable development, and Ferry Naber director, global machine development. Fletcher, based in Cleveland, previously served as business director, offshore. Naber will continue to be based at Smitweld, Nijmegen, The Netherlands.

Genesis Names Two Execs

Genesis Systems Group, Davenport, Iowa, has named Chuck Keibler executive vice president—business development, and Patrick Pollock chief operating officer. Keibler is responsible for all aspects of business development, client discovery, service, and training. The position includes administering the company’s web of domestic partner relationships with supplier partners, original equipment manufacturers, and distributors.

MetalForming Names Publisher

Precision Metalforming Assn., Cleveland, Ohio, has named Andy Flando publisher of its official publication, MetalForming magazine. Flando previously served as associate publisher of Cleveland magazine and publisher of Pulse magazine, both published by Great Lakes Publishing in Cleveland, Ohio.

Northwire Technical Cable Names Business Leader

Northwire, Inc., Technical Cable, Osceola, Wis., a manufacturer of technical and retractile cables, has appointed Louis Garriga III industrial business unit leader. Since 1998, Garriga has served the company as director of manufacturing.

Scott Process Systems Appoints President

Scott Process Systems, Inc., Hartville, Ohio, a wholly owned subsidiary of the CIC Group, Inc., has named Thomas E. Bach president. Scott Process is a fabricator of process, power, and nuclear piping systems used primarily in the power-generation industry. Bach, a 30-year veteran of the fabrication, erection, and construction industry, most recently served as director of operations for the CIC Group.

Wittke Recognized by Cambridge Who’s Who

Phillip Wittke, director of marketing, The Lincoln Electric Co., Cleveland, Ohio, has been recognized by Cambridge Who’s Who for “demonstrating dedication, leadership, excellence in general, and marketing management.” Wittke, a member of the AWS Cleveland Section since 1996, previously served the company as managing director Greater China, based in China. He has been honored with a number of awards from the welding industry, including the Australian Metal Trades Person of the Year.

Human Resource Manager Named at Harris Products

The Harris Products Group, Mason, Ohio, a Lincoln Electric company, has appointed Cathey Sexton human resource manager at its Gainesville, Ga., facility. Previously, Sexton worked for auto parts supplier Unisia Steering Systems, a wholly owned subsidiary of Hitachi.

Brooks Receives SME’s Highest Honor

Rodney Brooks, chairman and chief technology officer of Heartland Robotics, Inc., has received Honorary Membership in the Society of Manufacturing Engineers (SME). In presenting the society’s highest award, Mark C. Tomlinson, SME executive director and general manager, said, “The society reserves this recognition for those who have exhibited professional eminence in our industry. Brooks’s work in robotics has achieved international promi-
nence and his passion and genius are known throughout the science, engineering, and manufacturing worlds.” Brooks was a former director of both the Massachusetts Institute of Technology (MIT) Artificial Intelligence Laboratory and the MIT Computer Science and Artificial Intelligence Laboratory, and held research and faculty positions at Carnegie Mellon and Stanford Universities. Brooks also founded iRobot Corp., manufacturer of the consumer-oriented Roomba® robot.

Single Source Appoints President

Single Source Technologies (SST), Mississauga, Ont., Canada, has appointed Juergen Moeglich president of SST Canada. The company is a distributor of machinery brands such as Makino, Muratec, Cinetic Lands, and Metris.Previously, Moeglich served as director of the Canadian Machine Tool Dealer Association for more than ten years.

Obituaries

Mike Harris

Mike Harris, 77, died May 15 in Uxbridge, Ont., Canada. Born in Letchworth, England, he immigrated to Canada in 1953. Associated for many years with Gullco International, he was a long-time member of the Welding Equipment Manufacturers Committee (WEMCO), and was an icon in the welding industry. Harris is survived by his wife, Ann, a daughter, a sister, and several grandchildren.

Frederick J. Winsor

Frederick J. Winsor, 88, an AWS Life Member, died at his home in Fanwood, N.J., May 25 following a long illness. Born in the Mohawk River Valley in upstate New York, he earned his PhD in metallurgical engineering at Rensselaer Polytechnic Institute. He was a Professional Engineer in the states of Delaware, Illinois, and New Jersey. He worked as a welding engineer and metallurgist for Armour Research Foundation, Standard Oil of Indiana (Amoco), DuPont, and Foster Wheeler. At Foster Wheeler he was director of welding engineering during the era of nuclear power plant construction for utilities and the U.S. Navy. As an adjunct professor, he taught courses in welding technology at Kean University in New Jersey and in welding metallurgy at the New York Polytechnic Institute graduate school. Winsor served as chairman of the AWS New Jersey Section and worked on the education committee supervising Certified Welding Inspector examinations. He also chaired a subcommittee of the AWS A5 Committee on Filler Metals and Allied Processes. He was an active member of the Welding Research Council and ASM International. AWS recognized his contributions with the Samuel Miller Memorial Medal in 1991, and the District Meritorious Award in 2007. He is survived by his wife Gertrude, four children, four grandchildren, and many nephews and nieces.

Bruce Dean Weisman

Bruce Dean Weisman, 68, died May 1 in Anchorage, Alaska. He was a member of the American Welding Society for 33 years and served several terms as chairman of the Alaska Section. Born in Los Angeles, Calif., he served in the U.S. Navy Seabees from 1960 to 1963. He was a self-taught welder who owned Ornamental Iron and Welding and taught welding at Lake Tahoe, Nev., before moving to Alaska in 1977. He was employed by Welding and Testing Institute of Alaska, Veco, and CH2M Hill as an instructor, shop foreman, Certified Welding Inspector, and quality assurance expert. He was also a member of BP’s emergency response team, the Porsche Club of Alaska, and the Petroleum Club. He was a founding member of the Mat-Su Borough School District Welding Advisory Board. His involvement and commitment resulted in the creation of a modern welding lab and certification program for the students and summer welding and certification classes for Alaska instructors. Weisman is survived by a daughter, a brother, a nephew, and several cousins.

T. J. (Jim) Snow

T. J. (Jim) Snow, 90, died May 27 in Chattanooga, Tenn. Snow was born in Searles, Ala., where his father was a foreman working for the coal mines. He was ten years old when the mines played out and his family moved to Whitwell, Tenn., where mining remains the main industry. After graduating from Whitwell High School as president of his class, he studied pre-med at the University of Tennessee, Knoxville, before World War II disrupted his studies. He worked many years for the Chattanooga Armature Works and Jones-Sylar Supply. In 1963, he founded the T. J. Snow Co., Inc., that continues today, selling resistance welding equipment. In 2003, the Resistance Welder Manufacturers Assoc. honored him with its Elihu Thompson Award to recognize his contributions to the industry. He was a member of the Chattanooga Yacht Club and was a longtime Shriner. He is survived by a son, two daughters, seven grandchildren, and four great-grandchildren.
published in MetalForming magazine. Other additions include podcasts, downloadable white papers, and an archive of sponsored Webinars. The site will be of particular interest to personnel concerned with precision metal forming, stamping, fabricating, spinning, slide- and roll-forming technologies, and other value-added processes.

**Precision Metalforming Assn.**
www.metalfomingmagazine.com
(216) 901-8800

**Hazardous Pollutants Chart Offered**

A 12-page, pocket-size Hazardous Air Pollutants (HAPS) monitor chart provides details on the chemical abstracts service (CAS) registry numbers, corresponding HAPS compounds, and the calibration gases the company can provide for accurately monitoring emissions of those compounds. The chart will be of value to regulators and owners of HAPS-emitting facilities to help them easily determine whether a calibration gas can be produced for measuring a specific pollutant to avoid using a surrogate chemical for calibration. The technique can save considerable time and expense in complying with Title V emissions permits. Call the phone number for a copy of the chart.

Airgas
www.airgas.com
(610) 675-6854

**Plasma Arc Technology Curriculum Developed**

Plasma Cutting Technology: Theory and Practice includes lessons, exercises, interactive presentation slides, comprehensive facilitator’s guide, and models of real plasma torches and consumables. It is designed for implementation in high schools, colleges, unions, the military, in-house training departments, and welding and cutting distributors who want to offer value-added customer training. The ten-hour course incorporates multimedia platforms with hands-on exercises and training to accommodate students with a range of learning styles. The course covers common industrial uses for plasma systems, differences among the various cutting methods, proper setup and operation, proper installation and use of consumables, how to evaluate cut quality, and how to execute a variety of cuts and gouges. The list price is $449, with special discounts available. Visit the Web site or call for more information.

**Hypertherm**
www.hypertherm.com
(603) 643-3441

**Fundamentals of Tool Design Updated**

The sixth edition of Fundamentals of Tool Design includes revised geometric dimensioning and tolerancing information to include ASME Y14.5-2009, an instructor’s guide with answers to the review questions in the book and information on how to incorporate the DVDs into classroom or online instruction. It includes expanded broaching examples and concepts, revised tool material and mechanical definitions and reference tables, an in-depth review of brushing applications, new appendices that provide sources for tool design components, related Web sites and reference charts, and more review questions at the end of each chapter. The 464-page textbook and nine DVDs are available as a package or individually. The book lists for $110, $90 for SME members.

**Society of Manufacturing Engineers**
www.sme.org
(800) 733-4763

**Laser Marking in Colors Demonstrated in Video**

An online five-minute-long tutorial video demonstrates the company’s process for laser beam marking aluminum and stainless steel with logos, designs, identification numbers and other markings in gold, black, violet, green, and many other colors. The process uses a precisely controlled laser beam to create the proper interference color patterns for each color. Additional videos are scheduled for release on laser beam welding, cutting, and engraving of handset metals.

**Laird Technologies**
www.lairdtech.com
(636) 898-6100

**Construction Estimating Handbook Published**

The Construction Estimating Complete Handbook is designed for building and construction professionals. It covers all aspects of the construction estimating process and is useful for both experienced professionals and students studying construction management. The guide covers key industry profit-making factors, including bidding, scope review, quantity take-off for all trades and divisions, cost analysis, value engineering, and Excel spreadsheet estimating tutorials. The book focuses on construction estimating how-to essentials for those who need straightforward answers to on-the-job problems. It includes tips, checklists, worksheets, and data tables that provide the tools needed to effectively navigate the estimating process risk assessment and mitigation, mark-up analysis, increasing bit-hit success ratio, value engineering, reducing estimating mistakes, meeting project management turnover, and improving labor productivity. Purchase of the book includes access to online resources.

**DeWALT®**
www.dewalt.com/guides
(603) 643-3441

**Dear Readers:**

The Welding Journal encourages an exchange of ideas through letters to the editor. Please send your letters to the Welding Journal Dept., 550 NW LeJeune Rd., Miami, FL 33126. You can also reach us by FAX at (305) 443-7404 or by sending an e-mail to Kristin Campbell at kcampbell@aws.org.

**Change of Address? Moving?**

Make sure delivery of your Welding Journal is not interrupted. Contact the Membership Department with your new address information — (800) 443-9353, ext. 217, smateo@aws.org.
AUDITORS WANTED

The American Welding Society is looking for auditors experienced in ISO 3834 quality management systems. If you reside in the USA and have direct experience in conducting audits to ISO 3834, we would like to talk with you.

Please e-mail your CV and relevant audit history to:

hufsey@aws.org

DIRECTOR OF QUALITY
BRIDGE DIVISION

Directly supervises the activities of the Bridge Division Quality Department and personnel. Maintains Quality programs and manuals. Writes weld procedures for internal and external needs. Establishes QC and QA systems. Manages continuous improvement efforts. Establishes goals and metrics to measure shop performance and costs.

Qualifications: 5+ years of management experience. Excellent written and verbal communication skills. Understanding of welding requirements in AWS D1.5, AREMA, AASHTO, AISC and AWS specifications and some state bridge specifications.

Employer confidential.
Located in Northwest Indiana.
Email resumes to:
humanresources46404@yahoo.com

RESEARCH WELDING ENGINEER AND
RESEARCH WELDING ANALYST

Candidates must have welding backgrounds, experience in cutting techniques, and be prepared to work in a team-based environment in a state-of-the-art R&D facility. The research engineer must possess an advanced degree from an accredited college or university, whereas the research analyst must possess an associate’s degree and a minimum of five years experience.

SSAB is a global leader in value added, high strength steel and offers products developed in close cooperation with its customers to reach a stronger, lighter and more sustainable world. SSAB employs 8,700 people in over 45 countries around the world and operates production facilities in Sweden and the U.S. To learn more, go to www.ssab.com.

Construction is near completion for SSAB America’s new R&D Facility adjacent to its steel mill in Montpelier, Muscatine County, Iowa. This $11 million investment includes a new building and a variety of specialized testing, simulation and metallurgical equipment. The 25,000 square-foot facility is environmentally designed and constructed to obtain Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ certification, and is expected to be completed by mid-summer 2010.

If you are a reliable, self-motivated individual who wants to join a strong, growing company, you owe it to yourself to check out this opportunity. Only candidates legally eligible to work in the United States need apply. Only those being actively considered for employment will be contacted.

Send your resume to:
paula.schmitt@ssab.com

AWS JobFind
Post Jobs. Find Jobs.
@www.aws.org/jobfind

Job categories for welders, engineers, inspectors, and more than 17 other materials joining industry classifications!
JOE FULLER LLC
We manufacture tank turning rolls
3–ton through 120–ton rolls
www.joefuller.com
email: joe@joefuller.com
Phone: 979-277-8343
Fax: 281-290-6184
Our products are made in the USA

markingpen depot.com
Paint markers for professionals
ArroMark, Artline
Dixon, Dykem
Markal, Posca
Sakura, Sharpie
SKM, UniPaint.
The worlds best
selection of markers!

Red-D-Arc
Welderentals
When you’re ready to weld.
Rentals, Lease and Sales
Welders, Weld Positioning Equipment,
Welding-Related Specialty Equipment,
Diesel-Powered Electric Generators
1-866-733-3272
reddarc.com

MITROWSKI RENTS
Made in U.S.A.
Welding Positioners
1-Ton thru 60-Ton

Used Equipment for Sale
www.mitrowskiwelding.com
sales@mitrowskiwelding.com
800-218-9620
713-943-8032

VERSATIG™
MULTIPLE TIG TORCH
SELECTORS
www.versa-tig.com

Place Your Classified Ad Here!
Contact Frank Wilson,
Senior Advertising
Production Manager
(800) 443-9353,
ext. 465
fwilson@aws.org
CERTIFICATION & TRAINING

The world’s first and only completely online NDT & CWI training program!
NDT Training to meet global standards including SNT-TC-1A, ISO 9712, etc.
Visit www.worldspec.org today and save $100 instantly by entering the discount code: aws59c2
Call toll free: 1-877-506-7773

AISC Training & Assistance

Visit www.worldspec.org today and save $100 instantly by entering the discount code: aws59c2
Call toll free: 1-877-506-7773

Place Your Classified Ad Here!
Contact Frank Wilson, Senior Advertising Production Manager
(800) 443-9353, ext. 465
fwilson@aws.org

SERVICES

Construction Technical Services, Inc.
Providing AWS Certified Welding Fabricator and Accredited Welder Testing Facility training/Consulting - AWS B5.17, AWS QC4, QC7
• In-house welding program audits and program recommendations at your facility
• Subsea welding consulting for overlay, Flow lines, Risers, Phased Array-AUT
• CWI Inspections * Certification Training
• Auditing * Weld Procedures, NDT
• Quality Systems
Call Today: (281) 578-6810 or (504) 931-9567
Steven T. Snyder,
SCWI/CWE/CQA/ASNT IID, CSWIP-AUT-PA
Ctsi7@swbell.net
www.ctsisite.com

WANT MORE FROM YOUR MEETINGS AND TRADESHOWS?
Take your events to the next level – partner with a dynamic, experienced meeting architect!
Strategic planning and attention to detail will enable you to exceed your goals and expectations.
Put our experience to work for you!
• Jeannie Battin, CMM, CMP
jeannie@meetingwoo.com
www.meetingwoo.com
(303) 229-3550

Got Clean Welds?

www.weldhugger.com
Visit Our Interactive Ad Index: www.aws.org/ad-index
Effects of Nb, V, and W on Microstructure and Abrasion Resistance of Fe-Cr-C Hardfacing Alloys

Various alloying elements were added to a self-shielded flux cored welding wire to determine their influence on the formation of wear-resistant weld metal

BY QINGBAO WANG AND XIAOYAN LI

ABSTRACT

The morphology of Nb, V, and W in Fe-Cr-C hardfacing alloy microstructure has been investigated with optical microscope (OP) and scanning electron microscope (SEM). The strengthening mechanism of the three alloying elements in the cladding metal has been analyzed. The causes for different hardnesses and abrasion resistances have been studied. The following is exhibited from the experiment: 1) with addition of around 6% Nb, the hardness and wear resistance of the cladding metal increased; 2) with a small addition of V and W, the hardness increased and the wear resistance improved more noticeably; and 3) with a further slight increase in the content content of V and W, the hardness of the cladding metal increased in some sort, but had no further significant effect on the wear resistance. The optimization of the alloying elements is required to obtain good wear resistance and economic efficiency by strengthening matrix and carbides simultaneously.

Introduction

Thanks to their high volume fraction of hard carbide fibers, Fe-Cr-C hardfacing alloys are used extensively in the mining and mineral processing industries where high wear and abrasion resistance are required. By depositing self-shielding flux cored welding wire, cladding metal with high-chromium content (up to 30%) and carbon content (up to 6%) can be obtained. Water cooling during welding will promote the formation of monocristalline $M_7C_3$ (where M represents the alloying element) carbide rods of irregular hexagonal cross section in a metastable matrix of austenite. These $M_7C_3$ carbide rods play an important role in improving the wear resistance of the material. Modern Fe-Cr-C wear-resistant material has been studied based on tough austenite matrix with dispersion of hard carbide particles. In this investigation, the alloying elements of Nb, V, and W were added and varied in a self-shielded flux cored welding wire to determine the influence of the alloying elements on the formation of abrasion-resistant skeletal carbide particles and the matrix (austenite and its transformation product). The abrasive testing result is discussed with the intention to provide a theoretical foundation for future investigations and applications of the Fe-Cr-C wear-resistant material (Refs. 1–9).

Experimental Methods and Procedures

Selection of Alloying System

From the Fe-Cr-C phase diagrams (Figs. 1, 2) (Refs. 10, 11), it is known that in order to obtain sufficient wear-resistant fibers — primary $M_7C_3$ carbides — C content should be more than 4.2% and Cr content more than 10%.

High C content will lead to the formation of primary chromium carbide, which will consume the Cr content in the matrix. The reduction of Cr content will in turn weaken the matrix's hardenability and corrosion resistance. To overcome this weakness, the content of Cr shall be increased. It is pointed out that increasing Cr content in the high-chromium white iron can reduce the eutectic carbon content (Ref. 12). For example, the alloys with Cr concentrations of 5, 13, 17, and 25% have carbon contents of 4.0, 3.7, 3.5, and 3%, respectively, at the eutectic point. In other words, increasing the Cr content and without changing the C content will shift the eutectic point to the left, and more chromium carbides will be formed. Thus, it is not necessary to increase the C content to get more chromium carbide, and therefore the toughness of the deposited weld metal will not be compromised (Ref. 12).

In this experiment, the welding deposit of the Fe-Cr-C self-shielded flux cored welding wire has been designed as 4.7% C and 23% Cr, which is a common commercial embodiment of a primary chromium carbide hardfacing alloy. It can be seen from Fig. 2 that with these chemical compositions, it is easy to form sufficient hard primary $M_7C_3$ fiber at high temperature.

The welding wire was made of 0.3 x 17 mm steel strip with extra-low carbon. The diameter of the wire was 3.2 mm and the weight proportion was 50±1.5%.

With the same contents of C and Cr in the welding deposit, the microstructures and mechanical properties of the cladding metal were investigated by adding different amounts of alloying ele-
Experimental Procedures

Microstructures of the welding deposit were observed with the Neophot 21 microscope. The samples were also examined by using a scanning electron microscope (JSM-6500F).

The macrohardness of the welding deposit samples was measured with an H-100 Rockwell hardness machine (1470 kN load). Nine measurements were made on each sample, with the highest and the lowest values omitted, and an average of the remaining seven numbers was calculated and recorded. The microhardness of the welding deposit was measured (on both carbides and matrix) with an HXD-1000 Vickers hardness machine (0.98 N load).

Abrasion-resistant tests were performed on a MLS-225 wet sand rubber wheel AR testing machine, according to the procedure ASTM G105. The specimen size was 57.9 x 25.4 x 11 mm. After the specimen was cut, it was ground using No. 600 SiC paper to remove the rough surface layer then polished so that the testing surface was parallel to the base surface. The rotating speed of the rubber wheel was 245 rev/min, its diameter was 178 mm, and the hardness was 60 HA (Shore hardness). Wet sand was made of 1-kg water and 1.5-kg abrasion SiO₂ round sand (50~70 mesh). The applied load was 10 kg. The total revolution of the rubber wheel was 1000. Before and after each test, the specimen was ultrasonically cleaned in acetone, blown dry with warm air, and then weighed to determine the weight loss by using an electronic balance that has an accuracy of 0.1 mg. The working theory of the testing machine is shown in Fig. 3. The abrasion testing equipment is shown in Fig. 4.

The wear resistance of Sample No. 1 is set as 1. Other samples are compared with

Table 1 — Welding Parameters

<table>
<thead>
<tr>
<th>Welding Current (I/A)</th>
<th>Welding Voltage (V)</th>
<th>Welding Speed (v/(mm.s⁻¹))</th>
<th>Stick out (l/mm)</th>
<th>Interpass Temperature (t/°C)</th>
<th>Welding Wire Diameter (Φ/mm)</th>
<th>Depositing Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>480–520A</td>
<td>34–38 V</td>
<td>800–850 mm/min</td>
<td>20–35 mm</td>
<td>&lt;200°C</td>
<td>3.2</td>
<td>6 Layers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 Beads</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 — Chemical Compositions of Experimental Samples (wt-%)

<table>
<thead>
<tr>
<th>Samples</th>
<th>C</th>
<th>Cr</th>
<th>Nb</th>
<th>V</th>
<th>W</th>
<th>Mn+Si</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>4.74</td>
<td>23.56</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Sample 2</td>
<td>4.81</td>
<td>22.98</td>
<td>6.12</td>
<td>0</td>
<td>0</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Sample 3</td>
<td>4.72</td>
<td>23.72</td>
<td>6.03</td>
<td>0.21</td>
<td>0.23</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Sample 4</td>
<td>4.69</td>
<td>22.57</td>
<td>6.21</td>
<td>0.39</td>
<td>0.42</td>
<td>&lt;0.2</td>
</tr>
</tbody>
</table>

Sample 1 is a Fe-Cr-C alloy without adding any other alloying elements and is used as the reference sample. Sample 2 adds 6.12% Nb on the basis of Sample 1. Sample 3 adds a small quantity of V and W on the basis of Sample 2. Sample 4 adds a comparatively large quantity of V and W on the basis of Sample 2.
Sample 1 and get a relative wear resistance coefficient \( \varepsilon \) (\( \varepsilon = \frac{w_1}{w_2} \), where \( w_1 \) is the weight loss of Sample No. 1 and \( w_2 \) the weight loss of the other sample). The larger the value of \( \varepsilon \), the more wear resistant is the sample. Five testing specimens were made from each sample and were tested separately. The highest and the lowest weight loss numbers were omitted, and an average of the remaining three numbers was calculated and recorded.

Results and Discussion

Morphology of Nb, V, and W under Optical Microscope

It is stated by G. Powell (Ref. 8) that in a Fe-Cr-C alloy with hypereutectic compositions, the as-solidified microstructure is one of long parallel aligned primary carbides in a eutectic matrix of carbide rods in austenite, or short randomly orientated primary carbides in a eutectic matrix.

In this experiment, metallographic specimens were prepared for Samples 1-4. The specimens were ground, polished, and etched by Picral-Nital solution. The specimens were examined using Neophot 21 microscopy. The microstructures are shown in Fig. 5.

It is shown that all of the four samples have a typical hypereutectic microstructure, which consists of hypereutectic (primary) \( M_7C_3 \) and matrix. The matrix is composed of mainly austenite and some ledeburite transformed from austenite. There is a large quantity of monocristalline \( M_2C \) fibers, which have a hexagonal cross section consistent with the pseudo hexagonal crystal structure of \( M_7C_3 \) carbide. The primary \( M_7C_3 \) carbide is the first phase to form on cooling. The residual liquid then decomposes into austenite, or short randomly orientated primary carbides in a eutectic matrix due to the fact that \( V \) and \( W \) were added.

The Morphology of Nb, V, and W under SEM

Figure 6 shows the SEM-EDS compositional maps of the deposits of Samples 2, 3, and 4, in which it is possible to identify the carbide types present in the microstructures. Figure 6H shows that V exists in three forms: 1) some solved in the matrix; 2) some solved in the primary and eutectic carbides; and 3) the others (in a small amount) formed fine carbides with \( W \) and \( Cr \). Therefore, \( V \) can strengthen the matrix and the carbides, and in the meantime it can form the primary carbides directly.

There are three formations of \( W \), which include: 1) dispersion in the matrix; 2) dispersion on the carbides, where it has strong ability to form primary carbide with \( Nb \), which can be seen from Fig. 6F and G; and 3) the formation of fine carbides with \( V \) and \( Cr \). Tungsten not only reinforces the matrix and carbide, but also forms skele-
Fig. 5 — Microstructures of four samples and the etchant is Picral+Nital solution. A — Sample No. 1; B — Sample No. 2; C — Sample No. 3; D — Sample No. 4.

tal primary carbide, which is the main force to fight abrasion.

The matrix surrounding the large primary particles was analyzed by SEM and the energy spectrum analysis. It is shown from Fig. 6C, D, I, and J that in both Samples 2 and 4, it is always Fe-rich and Cr-lean around the primary carbides.

In Sample 2, the formation of primary carbide consumes C and Cr, and during the fast cooling, there is no sufficient time for C and Cr in the austenite to migrate; hence, a low-Cr, low-C austenite transformation zone was formed surrounding the primary carbide. The hardness of this layer is measured by HXD-1000 as HV1360.

In Sample 4, with the addition of V and W, the eutectic point of Fe-C diagram drifted to the left. The carbon content in the austenite matrix decreased and thus the amount of the carbides increased. With the increasing quantity of carbides, the growth of austenite dendrite was hindered, and therefore, a finer austenite matrix was formed. There existed carbonitride of V and W in the iron liquid between the austenite dendrites, which worked as the nuclei during the solidification. That is why there formed a substantial amount of fine carbide in the austenite matrix.

### Table 3 — Energy Spectrum Analysis of Sample 4

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>V</th>
<th>Cr</th>
<th>Fe</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Fine primary carbide</td>
<td>21.01</td>
<td>0.53</td>
<td>24.89</td>
<td>51.91</td>
<td>1.67</td>
</tr>
<tr>
<td>B Blade-like carbide</td>
<td>14.97</td>
<td>0.12</td>
<td>6.64</td>
<td>76.59</td>
<td>1.86</td>
</tr>
</tbody>
</table>

### Table 4 — Hardness and Relative Wear Resistance of Samples 1–4

<table>
<thead>
<tr>
<th>No.</th>
<th>Weight Loss of 3 Specimens after 1000 Revolutions (mg)</th>
<th>Average Weight Loss (mg)</th>
<th>Relative Wear Resistance Ratio $\varepsilon$</th>
<th>Hardness (HRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>171.3, 189.3, 178.5</td>
<td>179.7</td>
<td>1</td>
<td>61.2</td>
</tr>
<tr>
<td>Sample 2</td>
<td>132.9, 118.3, 134.0</td>
<td>126.4</td>
<td>1.40</td>
<td>62.8</td>
</tr>
<tr>
<td>Sample 3</td>
<td>96.5, 110.3, 98.6</td>
<td>101.8</td>
<td>1.77</td>
<td>63.6</td>
</tr>
<tr>
<td>Sample 4</td>
<td>102.7, 99.5, 94.5</td>
<td>98.9</td>
<td>1.82</td>
<td>64.1</td>
</tr>
</tbody>
</table>
From Table 3 and Fig. 7 (both for the energy spectrum analysis of Sample 4), it can be seen that around the large hexagonal primary carbide, there exist two forms of carbides: fine primary carbides and larger blade-like carbides. The isolated fine carbides have plenty of C and Cr, and also accumulate abundant V and W. During the metallurgical reaction, the primary carbides formed with V and W working as the nuclei. The larger blade-like carbides are mainly composed of Fe, and some Cr, V, and W solved on the surface. It can be deduced from the compositions (Table 3) that the blade-like carbides are eutectic ones.

The Effects of Nb, V, and W on Hardness and Wear Resistance

Figure 8 shows the surface morphology of Samples 1, 2, and 3 after the abrasion test. The fine checking cracks on the specimens are caused by the stress relief during the fast cooling. The fine checking crack, which often runs vertically from the surface of the deposit to the substrate, is one of the characteristics of the chromium carbide overlay plate. In the wear and abrasion application, this stress-relief cracking is tolerated for the improved wear resistance. Table 4 shows the hardness and relative wear resistance of Sample 1–4.

The Effect of Nb, V, and W on Hardness

The basic factors that decide the macro-hardness of Fe-Cr-C hardfacing alloy include the matrix microstructure and the...
volume fraction of hard carbide particles. The most important factor that affects the austenite formation and the volume fraction of carbide is the carbon content.

In this experiment, there is little difference in the carbon content for the four samples. The matrix microstructures look similar and the volume fractions of the carbide are about the same for all samples. For general reference, the microhardness for various carbides and other hard substances is shown in Fig. 9.

In this study, the carbides in the microstructure were big enough to measure the microhardness with a load of 0.98 N. In the Nb-, V-, and W-free alloy Sample 1 (4.74C-23.56Cr), the chromium carbides had an average hardness of 1410 HV with a standard deviation of 220 HV. In Sample 2, the addition of around 6% Nb results in the formation of harder primary niobium carbide in the cladding metal. Therefore, the macrohardness of Sample 2 is higher than Sample 1. In Sample 2, the average hardness of chromium carbides showed a very high average hardness value of 2550 HV, as it is known of pure NbC — Fig. 9. While the chromium carbides showed an average hardness of 1410 HV, which means that the chromium carbide is not alloyed with Nb. The niobium in the melts has been bound in the NbC.

In Samples 3 and 4, fortifying elements V and W were added. Microhardness tests showed that the added V and W were dissolved in chromium carbide and increased the hardness of the M$_7$C$_3$ carbides by solid-solution hardening. Vanadium and W dispersed in the matrix and carbides, thus reinforcing the matrix and eutectic carbide simultaneously. Vanadium and W also agglomerate and form primary carbides. Therefore, the cladding metal with addition of V and W was harder than Sample 2. With the increase of V and W, the extent of reinforcement increased. But in Table 4, it does not show a considerable macrohardness increase from Sample 3 to Sample 4. The main reason is probably that V and W are strong elements in forming carbides, and consume more carbon, which probably leads to the reduction of carbon content in the matrix and, therefore, the hardness of the matrix. High hardness requires a combination of fortified carbides and reinforced matrix, as stated by Askeland (Ref. 14), “The strength of a fiber-reinforced composite depends on both the strength of the raw fiber and bonding between the fibers and the matrix.”

The Effect of Nb, V, and W on Wear Resistance

Comparing the relative wear resistance in Table 4, it is found that Sample 1 without any addition of alloying elements has the most inferior wear resistance. Sample 2 with the addition of 6% Nb has a relative wear resistance coefficient of 1.40 compared to Sample 1, and the coefficient of Sample 3 is 1.77, while Sample 4 with higher quantity of V and W has a relative wear resistance coefficient of 1.82.

Sample 2 has a good wear resistance because of the formation of hard primary niobium carbide NbC. The coarse M$_7$C$_3$ carbide particles provided a barrier against microgouging and microcutting. This beneficial effect is reinforced by the NbC particles, which prevent the detachment of M$_7$C$_3$ carbides due to their finely dispersed distribution in the matrix, as shown by Chen and Chang (Ref. 15). The experimental result shows that the wear resistance of Sample 2 is 1.4 times better than Sample 1. Sample 3 adds matrix-fortifying elements V and W, which not only fortifies the matrix but also the carbide, thus a good combination of hard carbides and tough matrix is obtained. The experimental result shows that the wear resistance of Sample 3 is 1.26 times better than Sample 2. Sample 4 adds slightly more V and W, which leads to formation of more vanadium and tungsten carbides. But the formation of these vanadium and tungsten

---

**Fig. 7** — SEM image of the matrix around the large primary carbide (Sample 4): (A) fine primary carbides and (B) larger blade-like carbides.

**Fig. 8** — Abrasion surface morphology of Samples 1, 2, and 3 after the abrasion test. A — Sample 1; B — Sample 2; C — Sample 3.

**Fig. 9** — Hardness of various carbides and other hard substances (Ref 13).
carbides reduces the carbon content and hardness in the matrix. In this experiment, adding slightly more V and W did not get a good combination of hard carbides and tough matrix, therefore the wear resistance of Sample 4 did not improve much, compared to Sample 3. The experimental result shows that the wear resistance of Sample 4 is 1.02 times of Sample 3.

The erosive weight loss of high-chromium white irons is a combination of the weight loss due to matrix removal and carbide removal. Large quantity of carbides shortens the distance between each carbide particle, and reduces the area of matrix between them. Hence the matrix can be protected well. On the other hand, the matrix can in turn support the primary and secondary carbides. The key is to obtain a good combination of tough matrix and hard carbide particles. In high-chrome cast iron, in order to obtain good wear resistance, it is required to optimize the alloying elements so that both the matrix and carbide will be reinforced.

Conclusions

1) With the addition of around 6% Nb in the cladding metal, the hardness increases and the wear resistance increases. With the slight addition of W and V in the cladding metal, the hardness increases to some extent and the wear resistance increases. With a further slight addition of W and V, the hardness increases further, but there is not much difference in wear resistance.

2) In the cladding metal, Nb increases the hardness of carbides by forming primary carbide, while V and W reinforce both matrix and carbides, and also form primary carbides.

3) In order to obtain good wear resistance, it is required to optimize the alloying elements and get a good combination of hard carbides and tough matrix.

References


Good News:

I’m glad to announce that peer review of research papers is now managed through an online system using Editorial Manager software. Papers can be submitted into the system directly from the *Welding Journal* page on the AWS Web site by clicking on “submit papers.” You can also access the new site directly at *www.editorialmanager.com/wj/*.

Follow the instructions to register or login, and make sure your information is up to date. This online system will streamline the review process, and make it easier for authors to submit papers and track their progress. If you have any questions or encounter problems, please click on “help” or “contact us” in the main navigation bar.

Best Regards,

Andrew Cullison
Publisher
*Welding Journal*
Hybrid Laser Arc Welding Process Evaluation on DH36 and EH36 Steel

This study characterizes the effects laser power, arc power, and laser-arc separation on weld macrostructure, microstructure, and welding arc

ABSTRACT

The effects of laser power, arc power, and laser-arc separation on the macrostructure, microstructure, and welding arc were characterized in hybrid laser arc welds on DH36 and EH36 steels. Experiments were done to study a range of arc and laser powers at a constant laser-arc separation and a range of laser powers and laser-arc separation at a constant arc power. High-speed video captured images of the welding in process, and arc voltage and current were also measured. Two distinct weld macrostructure morphologies were observed. The first had a uniform fusion zone, and the second had a two-part fusion zone with an upper laser and arc combined region and a lower laser-only penetration region at the root. This two-part fusion zone was only observed for partial joint penetration welds. The arc voltage is lowered and with reduced fluctuation. Melting efficiency is increased, and the arc contracts to a smaller radius, and the cathode spot is fixed to the point of laser incidence (Refs. 6–9). In the laser plus arc welding category, a high-power laser, typically greater than 1 kW, is used so that a keyhole is formed and the arc and laser have similar power levels. Neither power source dominates the welding process. The laser provides improved penetration, and the arc allows root opening bridging ability. In addition, the welding speed is increased over arc welding, and the weld quality is improved over laser beam welding (Refs. 1–4). This research work used a high-power laser and while the process falls into the latter category of laser plus arc welding, the rest of this paper discusses this category of hybrid laser arc welding. There are many process variables associated with hybrid laser arc welding, and it is important to understand how they affect the welding process. In hybrid laser arc welding, the arc power controls the weld width and root opening bridging ability, and the laser power controls the penetration (Refs. 10–14). Modeling work (Ref. 15) also verifies these results. The laser-arc separation can also be optimized to increase the penetration (Refs. 10, 11); however, laser-arc separation also greatly influences the stability of the process (Refs. 11, 16, 17). Hybrid laser arc welding has an increased melting efficiency, as measured by the weld cross-sectional areas, over the sum of the individual processes (Ref. 16). Laser focal position can also influence penetration greatly; it should be slightly below the base metal surface such that the laser is focused on the surface of the depressed weld pool (Refs. 11, 14).

The microstructural development of hybrid laser arc welds is an important research interest. Steel weld metal microstructure depends on the following important parameters: chemical composition, nonmetallic inclusions, solidification structure, prior austenite grain size, and the thermal cycle (Ref. 18). These parameters may be significantly different in hybrid laser arc welds over other more conventional processes and need to be studied in addition to the resultant weld metal microstructure to ensure the viability of the process.

KEYWORDS

Laser Power
Arc Power
Laser-Arc Separation
Hybrid Laser Arc Welding
DH36 and EH36 Steels

C. ROEPKE and S. LIU (sliu@mines.edu) are with Center for Welding, Joining and Coatings Research, Colorado School of Mines, Golden, Colo. S. KELLY and R. MARTUKANITZ are with Applied Research Laboratory, Pennsylvania State University, State College, Pa.
ity of hybrid laser arc welding as an industrial process. The size distribution of nonmetallic inclusions is very important in controlling weld metal microstructure. Acicular ferrite is observed to nucleate on inclusions, and a high content of acicular ferrite is associated with inclusions greater than 0.2 μm, more specifically between 0.4 and 0.6 μm (Refs. 19–21). These inclusions are typically oxides of manganese, aluminum, and titanium, and are formed during deoxidation of the weld pool by the alloy additions of the filler material (Refs. 20, 21). Oxygen potential of the weld system during welding and solidification has an important effect on the type and size of the inclusions that result. Higher oxygen content and short solidification time both promote smaller inclusions (Refs. 19, 22). It is well established in low-carbon structural steel welds that high contents of acicular ferrite generally exhibit high toughness and strength; consequently, acicular ferrite is a preferred weld metal microstructure for good mechanical performance (Refs. 18–22).

There have been several studies focused on the weldment microstructure and mechanical properties of hybrid laser arc welding of steel (Refs. 23–33). Hybrid laser arc welds on DH36 steel using either CO2 or Nd:YAG lasers with conventional GMAW produced a weld metal microstructure high in acicular ferrite. The hybrid welds also had better weld metal impact toughness, 53 to 64 J at −20°C, than a comparison submerged arc weld (SAW), 49 J at −20°C (Ref. 23). The weld metal hardness of hybrid laser arc welds on DH36 and A36 steel have been reported to be acceptable for arc and laser welding (Refs. 23, 24). Hybrid laser arc welding can be used to weld a variety of pipeline steels (Ref. 26). Hybrid laser arc welding is an important influence on the type and size of the inclusions, and a high content of acicular ferrite can form in hybrid laser arc welds of these steels. It is also expected that the weld metal microstructure will not be influenced by the change in base material between DH36 and EH36 steels. This is because the chemical compositions of the two steels are very similar (they are designated differently because of different impact toughness requirements), and the weld metal is predominately influenced by the filler material, which remains constant for both base materials. Consequently, DH36 and EH36 steels have been used interchangeably in this study, and no comparison is made between the hybrid laser arc welds made on them.

This research work will have application to the shipbuilding, pipeline, heavy-equipment, and other heavy construction industries. Hybrid laser arc welding allows welding to be done at higher travel speeds, with greater penetration, reduced distortion compared to conventional arc welding (Refs. 34, 35), and improved root opening tolerance over laser beam welding. Understanding the effects of the major hybrid variables on the welding process will be critical to the implementation of hybrid laser arc welding in these industries.

**Research Objectives**

The main objective of this research was to characterize the effects of the following major hybrid laser arc welding parameters: laser power, arc power, and laser-arc separation on the macrostructure, microstructure, and the welding arc.

**Experimental Procedures**

The hybrid laser arc welding system consisted of a continuous-wave 14-kW CO2 laser with an F/# (ratio of raw beam diameter to focal length) of 5.2 and a focused beam diameter of 0.8 mm, and a constant voltage gas metal arc welding power source. The electrode was 0.045-in.- (1.1-mm-) diameter ER70S-6 wire, fed using a conventional wire feeder and GMAW gun. The shielding gas used was 50%He-50%Ar-5%CO2 (after the work of A. Fellman and V. Kujanpaa (Ref. 36)) and was fed solely through the GMAW gun. Two different base materials were used, 5-mm-thick ABS Grade DH36 steel for welds made with laser powers of 4 and

---

**Table 1 — Measured Base Material Chemical Composition as Determined by Direct Reading Atomic Spectroscopy (wt-%)**

<table>
<thead>
<tr>
<th>Material</th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Al</th>
<th>Nb</th>
<th>V</th>
<th>Ti</th>
<th>Cu</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>Fe</th>
<th>Carbon Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH36</td>
<td>0.06</td>
<td>1.39</td>
<td>0.19</td>
<td>0.011</td>
<td>0.004</td>
<td>0.025</td>
<td>0.010</td>
<td>0.06</td>
<td>0.01</td>
<td>0.25</td>
<td>0.11</td>
<td>0.14</td>
<td>0.03</td>
<td>bal</td>
<td>0.39</td>
</tr>
<tr>
<td>EH36</td>
<td>0.06</td>
<td>1.38</td>
<td>0.25</td>
<td>0.010</td>
<td>0.004</td>
<td>0.024</td>
<td>0.004</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>bal</td>
<td>0.35</td>
</tr>
</tbody>
</table>

(a) Under minimum specification requirement of 0.02%.
6 kW, and 10-mm-thick ABS Grade EH36 steel for welds made with laser powers of 8 and 9 kW (note the steel grade here is specified in the commercial standard ASTM A131, Standard Specification for Structural Steel for Ships). The chemical compositions of these steels are given in Table 1. The reason for selecting the two thicknesses was the need for a thicker material to prevent melt-through at the higher laser powers. At the time of the experiment, only DH36 steel was available in 5 mm thickness and EH36 steel in 10 mm thickness. The base material was cut into 5 cm × 30 cm coupons, and bead-on-plate welds were made. Welding was done with the laser leading the arc. Contact tip-to-work distance and welding angles were all held constant throughout the experiment as shown — Fig. 1. All the constant processing parameters are shown in Table 2.

An experimental matrix was developed to test the following three major hybrid laser arc welding variables: laser power, arc power, and laser-arc separation. The first experimental matrix used a constant laser-arc separation of 4.5 mm and tested three levels of arc power, 3.4, 6.3, and 8.5 kW, plus four levels of laser power, 4, 6, 8, and 9 kW. The three arc parameters were chosen to produce a change in the dominant metal transfer mode. The 3.4-kW parameter (20 V and 170 A with 200 in./min or 85 mm/s wire feed speed (WFS)) produced predominately short circuiting transfer; the 6.3-kW parameter (28 V and 225 A with 250 in./min or 106 mm/s WFS) was predominately globular transfer; and the 8.5-kW parameter (32 V and 265 A with 300 in./min or 127 mm/s WFS) was predominately spray transfer. The second experimental matrix used a constant arc

**Table 2 — HLAW Processing Constants**

<table>
<thead>
<tr>
<th>Welding Position</th>
<th>Flat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Orientation</td>
<td>Laser leading arc</td>
</tr>
<tr>
<td>Laser Focus</td>
<td>At workpiece surface</td>
</tr>
<tr>
<td>Laser Orientation</td>
<td>Perpendicular to work</td>
</tr>
<tr>
<td>GMAW Polarity</td>
<td>DCEP-CW</td>
</tr>
<tr>
<td>Contact Tip-to-Work Distance</td>
<td>0.75 in.</td>
</tr>
<tr>
<td>Laser-Arc Angle</td>
<td>15 deg (from laser beam)</td>
</tr>
<tr>
<td>Shielding Gas</td>
<td>50% He-45% Ar-5% CO₂</td>
</tr>
<tr>
<td>Shielding Gas Flow Rate</td>
<td>150 fl/h</td>
</tr>
<tr>
<td>Electrode</td>
<td>ER70S-6, 0.045 in. diameter</td>
</tr>
<tr>
<td>Travel Speed</td>
<td>30 in./min</td>
</tr>
</tbody>
</table>
Results and Discussion

Macrostructure

When examining the macrostructure of the hybrid laser arc welds, it was immediately apparent that there were two distinct types of morphologies — Fig. 2. The first morphology has a uniform fusion zone (the microstructure is the same everywhere in the fusion zone), much like a conventional gas metal arc weld but with increased penetration. The second morphology has a two-part fusion zone consisting of an upper, laser and arc penetration region (similar to a conventional gas metal arc weld) and a lower, laser-only penetration region (similar to a laser beam weld). This second morphology has been previously observed by power of 8.5 kW (the spray arc parameter as above) and tested four levels of laser power, 4, 6, 8, and 9 kW, plus four levels of laser-arc separation, 2.0, 4.0, 6.0, and 12.0 mm. In addition to the two matrices, arc-only welds were made at the three arc power levels tested, and laser-only welds were made at the four laser power levels tested.

During welding, a LabVIEW based data-acquisition system was used to monitor arc voltage and current at a 10-kHz sampling rate. Additionally, a high-speed video system was used to capture images of the welding arc, laser plume, and welding pool. The high-speed video camera was filtered with a shade 11 welding lens, and the capture rate was 600 frames/s with an exposure time of 8 μs/frame. The arc voltage and current were analyzed using an IGOR Pro program that computed the average voltage, current, and power, and used a Fast Fourier Transform (FFT) to output the voltage and current frequency spectra. From these frequency spectra, the major voltage and current frequencies could be determined.

Transverse samples for macrostructure and microstructure analysis were sectioned from the center portion of the weld length. The samples were mounted in Bakelite, ground down to 600 grit, and then polished with a diamond suspension down to 1 μm. The welds were etched with a 2% Nital solution for 10 s. Macrographs of the welds were then taken using a stereomicroscope at 10x. The weld morphology was observed, and characterizing dimensions were measured. Multiple micrographs of each of the welds were taken throughout the fusion zone using a light optical microscope at 200x. The weld microstructures were observed and characterized according to the IIW system for the classification of weld metal microstructures (Ref. 37).
Fig. 8 — Macrographs showing the morphology changes due to the laser-arc separation in the partial penetration welds with a two-part fusion zone. From left, the laser-arc separation is 4.5, 6.0, and 12.0 mm. Laser power and arc power are constant for all welds at 8 and 8.5 kW, respectively.

Fig. 9 — Schematic macrograph showing the penetration measurements of the laser and arc region, and the laser-only region.

Fig. 10 — Total penetration and the penetration of the two distinct fusion zone regions as a function of the laser-arc separation in-partial penetration bead-on-plate welds. Laser power and arc power are constant for all welds at 8 and 8.5 kW, respectively.

Fig. 11 — Macrographs showing the morphology changes due to the laser-arc separation in the welds with a uniform fusion zone. From left, the laser-arc separation is 4.5, 6.0, and 12.0 mm. Laser power and arc power are constant for all welds at 4 and 8.5 kW, respectively.

the authors (Ref. 28) and by several other researchers (Refs. 29, 30, 33, 38, 39). The two regions in the second morphology not only appeared different at low magnification but also at high magnification. The microstructure of the upper, laser, and arc penetration region is mostly acicular ferrite with some grain boundary ferrite whereas the lower, laser-only penetration region is mostly ferrite with second phases and only a small amount of acicular ferrite — Figs. 3, 4. These differences were also reported by other researchers (Refs. 29, 30). It is likely that this second morphology is the result of incomplete mixing of the filler material from the gas metal arc welding part of the hybrid process to the root of the weldment. The lower, laser-only penetration region is basically an autogenous laser beam weld in the base material. In addition, the lower, laser-only penetration region may actually be solidifying before mixing can occur because of high cooling rates at the root of the weldment. Real-time X-ray transmission imaging of hybrid laser arc welding with tungsten tracers by Naito et al. (Ref. 39) has shown a dual-flow convection pattern in welds with a 5-mm laser-arc separation that would produce this second type of morphology. This dual-flow convection pattern consists of one flow from the bottom of the keyhole up along its sides and another from the center of the arc at the surface down and...
away from the arc. This creates a region at the bottom of the keyhole that flow from the arc never reaches. In general, for hybrid laser arc welding, this second morphology would be undesirable because it has a region that is unalloyed by the filler material from the gas metal arc welding part of the process, and the alloying addition from the gas metal arc welding component is a key advantage of the hybrid laser arc welding process. Hardness traverses measured across both regions show no major difference in weld metal hardness between the two regions — Fig. 5. This behavior is expected because DH36 and EH36 steels both have low hardenability. However, if this morphology were present in a more hardenable steel, it is likely that the laser-only penetration region would have a much higher hardness than the laser and arc penetration region, and this would be undesirable. Much of the rest of this macrostructure discussion focuses on how to eliminate or avoid this laser-only penetration region that creates the second type of fusion zone morphology. A process map laser power and arc power at a laser-arc separation of 6 mm was developed to show the processing windows where the two different morphologies would result — Fig. 6. The figure shown includes data from previous work by authors (Ref. 28), which help define the boundary between the two morphologies. Low laser powers and high arc powers promoted a uniform fusion zone, the first morphology. Welds made with a high laser power and low arc power will have a two-part fusion zone, the second morphology. Work done by Gao et al. (Ref. 33) also shows that increasing the arc power promotes the uniform fusion zone. It is important to note that this process map was made for partial-penetration welds.

Complete-joint-penetration welds were always observed to have a uniform fusion zone, the first morphology. The microstructure in these complete penetration welds was the same throughout the fusion zone. However, it is possible that there may be some small compositional changes in the fusion zone of these welds; the fluctuation in weld metal composition has not been measured and will be the subject of future work by the authors. Even when a complete penetration weld was achieved by increasing the laser power, such that the weld would now fall in the processing window for the two-part fusion zone morphology as defined on the previous map, a uniform fusion zone was observed. This is believed to be due to the base metal being sufficiently thin to result in complete penetration and partially altering the flow characteristics. This is illustrated in Fig. 7. It is likely that the fluid flow in a complete penetration weld promotes better mixing in the fusion zone and consequently does not have the laser-only penetration region. Additionally, a complete penetration weld changes the heat flow conditions of the weld and, as a consequence, the cooling rate at the root of the weldment will be much slower than in a partial-penetration weld allowing more time for mixing to occur to the root of the weld before solidification. When making complete penetration hybrid laser arc welds, the two-part fusion zone morphology with a laser and arc upper penetration region and a lower laser-only penetration region was not observed.

The laser-arc separation also plays a major role in modifying the hybrid laser arc weld morphology. Considering partial-penetration welds made with 8 kW of laser power and 8.5 kW of arc power as shown in the macrographs, decreasing the laser-arc separation decreased the weld width and reduced the size of the laser-only penetration region — Fig. 8. It may be advantageous to quantitatively describe the changes in the size of the two fusion zone regions as a function of the processing conditions. To do this, the penetration of the laser and arc region, DlA, the penetration of the laser-only region, Dl, and the total penetration, Dl, are defined, and these penetrations are plotted — Figs. 9, 10. The total penetration remained relatively constant over the range of laser-arc separation tested. The penetration of the laser and arc region increased with decreasing laser-arc separation, resulting in a smaller laser-only penetration region. As the spatial separation of the heat sources is reduced, the thermal gradient behind the laser keyhole is also reduced. Consequently, the solidification rate behind the laser keyhole is reduced, allowing greater time for weld metal mixing. It is also likely that the fluid flow pattern in the molten weld pool changes with changing
Fig. 14 — Micrographs showing the effect of laser power. From left, the laser power is 4 and 8 kW. Constants include arc power, 8.5 kW, and laser-arc separation, 4.5 mm.

Fig. 15 — Weld metal microstructural content as a function of laser power. Arc power and laser-arc separation were constant at 8.5 kW and 4.5 mm, respectively.

Fig. 16 — Micrographs showing the effect of arc power. From left, the arc power is 3.4, 6.3, and 8.5 kW. Constants include laser power, 8.0 kW, and laser-arc separation, 4.0 mm.

Fig. 17 — Weld metal microstructural content as a function of arc power. Laser power and laser-arc separation were constant at 8.0 kW and 4.0 mm, respectively.

Laser-arc separation (Ref. 39), and this may also contribute to the reduced fraction of laser-only penetration. While the fraction of laser-only penetration was reduced by decreasing the laser-arc separation, it was not completely eliminated in the range of laser-arc separation (4.5–12.0 mm) and plate thickness (10 mm) tested. However, extrapolation of the graph shows that it may be possible to produce the uniform fusion zone morphology with no laser-only penetration region if the laser-arc separation is less than 2.0 mm. Consequently, laser-arc separation would be a third variable in creating a boundary on the process map for partial penetration uniform fusion zone welds.

Laser-arc separation also plays a significant factor in hybrid welds with a uniform fusion zone. Figure 11 shows macrographs of welds made with 4 kW of laser power and 8.5 kW of arc power; these parameters produced welds with a uniform fusion zone. Decreasing the laser-arc separation dramatically increased the penetration of these welds. There is also a corresponding decrease in width as laser-arc separation is decreased. From these results, it is clear that reducing the laser-arc separation is advantageous because it promotes higher penetration in the uniform fusion zone welds and reduces the size of the laser-only region in the two-part fusion zone welds.

Microstructure

For microstructural comparison to the hybrid laser arc welds, representative micrographs from a GMA weld made with 8.5-kW arc power and a LBW weld made with 8-kW laser power are provided — Fig. 12. The microstructural content of these welds is shown in Fig. 13. The microstructure of the GMA weld is predominantly acicular ferrite (AF) with a small amount of primary ferrite (PF). The microstructure of the laser beam weld is predominantly ferrite with second phases (FS) and a small amount of acicular ferrite (AF) and primary ferrite (PF).

First, the effect of laser power on the microstructure of hybrid laser arc welds in the laser and arc region was examined. Figure 14 shows representative micrographs of the hybrid laser arc welds made with 4 and 8 kW of laser power with constant arc power, 8.5 kW, and constant laser-arc separation, 4.5 mm. The welds had very similar microstructures. The microstructural content of these welds is shown in Fig. 15. The hybrid laser arc weld made with 4 kW of laser power was predominantly acicular ferrite (AF) with a significant amount of primary ferrite (PF) and some ferrite with second phases (FS). The hybrid laser arc weld made with 8 kW of laser power was predominantly acicular ferrite (AF) with a significant amount of primary ferrite (PF) and some ferrite with second phases (FS). The change in laser power from 4 to 8 kW did not produce any major changes in the microstructure of the hybrid laser arc welds. This observation is likely because the major factor in controlling weld metal microstructure is the filler material added, and this did not change when changing laser power.

Next, the effect of arc power on the microstructure of hybrid laser arc welds was examined. Figure 16 shows representative micrographs of the hybrid laser arc welds made with 3.4, 6.3, and 8.5 kW of arc power with constant laser power, 8.0 kW, and constant laser-arc separation, 4.0 mm.
The microstructural content of these welds is shown in Fig. 17. The hybrid laser arc weld made with 3.4 kW of arc power was predominantly ferrite with second phases (FS) with some acicular ferrite (AF) and a small amount of primary ferrite (PF). The hybrid laser arc weld made with 6.3 kW of arc power was mostly ferrite with second phases (FS) with a significant amount of acicular ferrite (AF) and a small amount of primary ferrite (PF). The hybrid laser arc weld made with 8.5 kW of arc power was predominantly acicular ferrite (AF) and a small amount of primary ferrite (PF). The change in arc power produced significant changes in the microstructure of the hybrid laser arc welds. Increasing the arc power increased the amount of acicular ferrite and decreased the amount of ferrite with second phases. This observation is likely because increasing the arc power increases the total heat input of the process, and the arc power is increased by increasing the wire feed speed, which adds additional filler metal to the weld pool. Both of these effects of increasing the arc power would cause a decrease in the amount of ferrite with second phases and an increase in acicular ferrite. It is also important to note that the filler wire used has been designed to produce a high content of acicular ferrite in conventional GMAW. Because HLAW has increased penetration over GMAW, there is higher base metal dilution in HLAW. This may require higher wire feed rates to be used to counteract the increased penetration in HLAW or new filler wires to be designed specifically for HLAW.

Finally, the effect of laser-arc separation on the microstructure of hybrid laser arc welds was examined. Figure 18 shows representative micrographs of the hybrid laser arc welds made with 4.5, 6.0, and 12.0 mm of laser-arc separation with constant laser power, 4.0 kW, and constant arc power, 8.5 kW. The microstructural content of these welds is shown in Fig. 19. The hybrid laser arc weld made with 4.5 mm of laser-arc separation was predominantly acicular ferrite (AF) with a significant amount of primary ferrite (PF) and some ferrite with second phases (FS). The hybrid laser arc weld made with 6.0 mm of laser-arc separation was predominantly acicular ferrite (AF) and a small amount of primary ferrite (PF). The hybrid laser arc weld made with 12.0 mm of laser-arc separation was predominantly acicular ferrite (AF) and a small amount of primary ferrite (PF). The change in laser-arc separation produced significant changes in the microstructure of the hybrid laser arc welds. Increasing the laser-arc separation increased the amount of acicular ferrite in the welds and promoted a microstructure very similar to the GMAW comparison weld. This is likely because increasing the laser-arc separation decreased the penetration and consequently decreased the dilution of the welding wire.

Welding Arc

The welding arc was observed with high-speed video, and the arc current and voltage were monitored to look for changes in the properties of the arc that may have been caused by the three major hybrid laser arc welding variables. When the arc power was increased in the hybrid laser arc welding process the arc current increased, the predominance frequency in
The arc voltage and current signals corroborated well with the visual observation of the arc behavior. At the low laser-arc separations, 2.0 and 4.5 mm, a new low-frequency (−10 Hz) peak was observed in the voltage FFT that was not observed in the GMA weld — Fig. 21. This voltage frequency would correspond to the large globular/short circuiting transfer that was observed visually with the high-speed video. When the laser-arc separation was increased to 6.0 and 12.0 mm, this low-frequency peak was no longer observed; however, a new mid-frequency (−70 Hz) peak was observed. This peak likely corresponds to the small globular transfer that was visually observed in the welds at these laser-arc separations. In addition to these voltage frequency changes caused by the laser-arc separation, there was also a change in the arc current — Fig. 21. Increasing the laser-arc separation increased the arc current. However, it did so in a stepwise function that seemed to correlate with the observed changes in the voltage frequency and metal transfer mode. The lowest currents, −250 A, were associated with the low voltage frequency peak and the large globular/short circuiting transfer, while the mid current levels, −265 A, were associated with the mid voltage frequency and the small globular transfer. The highest current, 281 A, was only observed in the GMA weld that only exhibited high voltage frequencies and pure spray transfer.

To observe the effect of the laser power on the welding arc, welds were made using an arc power of 8.5 kW, which produced pure spray transfer, and a laser power of 4 kW. Figure 20 shows selected high-speed video frames highlighting the differences caused by changing the laser power. Red triangles indicate the position of the laser beam.

The arc voltage and current signals corroborated well with the visual observation of the arc behavior. At the low laser-arc separations, 2.0 and 4.5 mm, a new low-frequency (−10 Hz) peak was observed in the voltage FFT that was not observed in the GMA weld — Fig. 21. This voltage frequency would correspond to the large globular/short circuiting transfer that was observed visually with the high-speed video. When the laser-arc separation was increased to 6.0 and 12.0 mm, this low-frequency peak was no longer observed; however, a new mid-frequency (−70 Hz) peak was observed. This peak likely corresponds to the small globular transfer that was visually observed in the welds at these laser-arc separations. In addition to these voltage frequency changes caused by the laser-arc separation, there was also a change in the arc current — Fig. 21. Increasing the laser-arc separation increased the arc current. However, it did so in a stepwise function that seemed to correlate with the observed changes in the voltage frequency and metal transfer mode. The lowest currents, −250 A, were associated with the low voltage frequency peak and the large globular/short circuiting transfer, while the mid current levels, −265 A, were associated with the mid voltage frequency and the small globular transfer. The highest current, 281 A, was only observed in the GMA weld that only exhibited high voltage frequencies and pure spray transfer.
but at both of these low laser powers, the large metal globular formation that violently transferred/short circuit was observed. When the laser power was increased to 8 kW the keyhole was observed to be much larger and more stable, and the ejected laser plasma remained more separate from the arc plasma than with the welds made with lower laser powers. The metal transfer was again predominately spray, but the large globular/short circuiting transfer was not observed, and instead a small globular free flight transfer was detected.

These visual observations of the arc and metal transfer correlated well with the arc voltage and current signals. The relationship between metal transfer, voltage frequency, and current was the same as what was observed in the effect of laser-arc separation even though the changes were caused by laser power level. The effect of laser power on the major arc voltage frequencies and arc current is shown in Fig. 23. The low laser powers, 4.0 and 6.0 kW, that produced the large globular/short circuiting transfer had a low-frequency (~10 Hz) peak observed in the voltage FFT, and the lowest current levels, ~245 A. Other production work (Ref. 40) has shown that the introduction of the laser beam reduces the arc current. When the laser power was increased to 8.0 kW, the small globular free flight transfer was produced, the mid frequency (~70 Hz) voltage peak replaced the low frequency peak, and the current increased to 270 A. Again, this current was still less than the GMAW current, 281 A, that was associated with only the high frequency voltage peaks and a pure spray transfer.

Conclusions

- Partial-joint-penetration hybrid welds should be made within a processing window, defined by a maximum laser power for a given arc power and laser-arc separation, for a uniform fusion zone to prevent laser-arc penetration at the root.
- Complete-joint-penetration hybrid welds always had a uniform fusion zone macrostructure and microstructure regardless of the laser power.
- Decreasing the laser-arc separation increased the penetration of the laser and arc region in the two-part fusion zone welds and increased the total penetration in the uniform fusion zone welds.
- Increasing the arc power and increasing the laser-arc separation both promoted the formation of acicular ferrite in the weld metal microstructure. Changes in laser power did not produce a major change in the weld metal microstructure.
- Small laser-arc separations introduced a low frequency large globular/short circuiting transfer in the arc. Larger laser-arc separations produced a mid frequency small globular free flight transfer.
- Low laser powers produced the large globular/short circuiting transfer in the arc, while high laser powers produced the mid frequency small globular free flight transfer.

Acknowledgments

The authors would like to thank Ed Good at the Applied Research Laboratory, Pennsylvania State University, for his help making the welds, and Scott Mitzen at CSM-CWJCR for his help with the preliminary metallographic work. C. Roepke and S. Liu would also like to thank Matt Johnson and Pat Hochinadel at the Los Alamos National Laboratory for their financial support of the graduate research program at the Colorado School of Mines.

References

An Important Event on Its Way?

Send information on upcoming events to the Welding Journal Dept., 550 NW LeJeune Rd., Miami, FL 33126. Items can also be sent via FAX to (305) 443-7404 or by e-mail to woodward@aws.org.

Preparation of Manuscripts for Submission to the Welding Journal Research Supplement

All authors should address themselves to the following questions when writing papers for submission to the Welding Research Supplement:

1) Abstract. A concise summary of the major elements of the presentation, not exceeding 200 words, to help the reader decide if the information is for him or her.
2) Introduction. A short statement giving relevant background, purpose, and scope to help orient the reader. Do not duplicate the abstract.
3) Experimental Procedure, Materials, Equipment.
4) Results, Discussion. The facts or data obtained and their evaluation.
5) Conclusion. An evaluation and interpretation of your results. Most often, this is what the readers remember.
6) Acknowledgment, References and Appendix. Keep in mind that proper use of terms, abbreviations, and symbols are important considerations in processing a manuscript for publication. For welding terminology, the Welding Journal adheres to AWS A3.0:2001, Standard Welding Terms and Definitions.

Papers submitted for consideration in the Welding Research Supplement are required to undergo Peer Review before acceptance for publication. Submit an original and one copy (double-spaced, with 1-in. margins on 8 ½ x 11-in. or A4 paper) of the manuscript. A manuscript submission form should accompany the manuscript.

Tables and figures should be separate from the manuscript copy and only high-quality figures will be published. Figures should be original line art or glossy photos. Special instructions are required if figures are submitted by electronic means. To receive complete instructions and the manuscript submission form, please contact the Peer Review Coordinator, Erin Adams, at (305) 443-9353, ext. 275; FAX 305-443-7404; or write to the American Welding Society, 550 NW LeJeune Rd., Miami, FL 33126.

Effect of Continuous Cooling Transformation Variations on Numerical Calculation of Welding-Induced Residual Stresses

Three continuous cooling transformation (CCT) diagrams for S355J2 steel were employed to study the effect of CCT variations on calculated residual stresses

BY J. CARON, C. HEINZE, C. SCHWENK, M. RETHMEIER, S. S. BABU, AND J. LIPPOLD

ABSTRACT

Continuous cooling transformation (CCT) behavior affects the transient state of material properties employed in a numerical welding simulation, having a direct influence on the developing stress state. Three different CCT diagrams for S355J2 steel were employed to understand the influence of variations in CCT behavior on the numerical calculation of welding-induced residual stresses. The CCT diagrams were constructed from transformation data contained in the Syweld software database, measured dilatometric data from Gleeble experiments, and transformation data calculated from the JMatPro software. The calculated transverse and longitudinal residual stress distributions provided a qualitative correlation only in comparison to experimental measurements, with the largest deviation occurring near the weld interface. Overall, the results indicate a weak dependency of the calculated residual stresses due to anticipated CCT variations. The most significant effect on the calculated residual stresses was shown to be related to the proportion of formed martensite. It is suggested that CCT data of approximate accuracy is sufficient for reliable calculation of welding-induced residual stresses.

Introduction

During welding, residual stresses are developed due to the local plastic deformations created by the steep thermal gradient that occurs in the weld zone from localized heating and cooling (Ref. 1). Phase transformation strains, which are created from differences in crystal structure and mechanical properties, also contribute to the evolution of residual stresses during welding (Ref. 2). Both the diffusive and displacive phase transformation mechanisms are often accompanied by substantial strains, which greatly exceed elastic strain values (Ref. 1). Residual tensile stresses result in unwanted deformations of the welded component, increase the susceptibility to hydrogen-induced cold cracking, and also combine with tensile stresses experienced during service to promote brittle fracture, fatigue failure, and stress corrosion cracking (Ref. 3).

An historical account of research relating to residual stresses and distortions is provided by Dong (Ref. 4). One of the initial studies to use the finite element (FE) method to study welding-induced residual stresses dates back to Ueda et al. in 1977 (Ref. 5). In recent years, the on-cooling phase transformation behavior has been integrated in FE simulations of steel (Refs. 6–10). These studies have all shown the strong effect of the austenite to martensite transformation on the final residual stress state. The influence induced by the volume expansion has been found to be more significant than that due to the yield strength change (Refs. 7, 10). Ferro et al. (Ref. 8) isolated the effects of volume change and transformation plasticity in a numerical simulation of laser beam welding of steel plate. The overall effect of phase transformations was to generate compressive longitudinal stresses in the fusion zone and to shift the location of the maximum tensile stress in the heat-affected zone (HAZ). In an investigation of the influence of thermophysical and thermomechanical material properties on the numerical calculations, thermal expansion was shown to have the most significant influence; giving a direct proportional variation of the calculated distortions in both the longitudinal and transverse directions (Ref. 11). In addition to the simulation results, experimental development of new filler metal compositions has demonstrated that a lower martensitic transformation temperature reduces residual stresses by allowing the expansion associated with the martensite transformation to compensate for the accumulated thermal contraction strains (Ref. 12). A review of the metallurgical issues and modeling challenges associated with calculation of welding-induced residual stresses, with respect to ferritic power plant steels, is given by Francis et al. (Ref. 13).

While the effect of on-cooling phase transformations and material properties variations have been established, information regarding the effect of variations in CCT behavior has not yet been considered. Given the relatively wide composition ranges specified for certain alloys and the heat-to-heat composition variations that do occur, significant differences in CCT behavior can be expected. In steels it is well known that the martensite start (Mₜ) temperature is a strong function of the carbon content, and that the ferrite and bainite transformation kinetics are known to be

KEYWORDS

Continuous Cooling Transformation Diagrams
Residual Stresses
Gas Metal Arc Welding
C-Mn Steels
Welding Simulation
sensitive to alloying elements that decrease the driving force for austenite decomposition, particularly carbon, manganese, nickel, and chromium (Ref. 14). Also contributing to variability are the different experimental and computational methods that are used to determine CCT diagrams.

In welding, austenite inhomogeneity often occurs due to the inability of alloying elements and precipitates to completely solutionize during the rapid weld thermal cycle. Thus, CCT diagrams constructed from short-time holds at high temperatures in the austenite region are more appropriate for determining HAZ CCT behavior than the conventional CCT procedure of holding on the order of an hour at a temperature slightly above the fully austenite (\(A_c^3\)) temperature (Ref. 15).

Knowledge of the effect of CCT variations on the numerical calculation of residual stress would enable an estimation of the deviations in the calculated results that can be expected when using phase transformation data of unknown or reduced accuracy. Furthermore, a detailed knowledge about the important aspects of the CCT behavior helps to define the quality and the suitability of a CCT diagram with respect to the calculation of welding-induced residual stresses. This information would allow an estimation of the required accuracy of CCT data and is also necessary to benchmark the quality of the numerically calculated residual stresses when considering phase transformation effects.

**Experimental Procedure**

The steel used for the welding experiments was S355J2 (1.0577), a German standardized plain-carbon fine-grained construction steel with a minimum yield strength of 355 MPa (51 ksi). The chemical composition and specified minimum mechanical properties for S355J2 plate material thicknesses ≤ 16 mm (0.63 in.), as specified in the German DIN EN 10025 standard (Ref. 16), are provided in Tables 1 and 2, respectively.

The chemical composition of the plate material used in the welding experiments was determined through spark emission spectroscopy. The average composition from three analyses is provided in Table 3. A tensile test conducted on the base plate confirmed the yield strength and ultimate tensile strength to be 363 MPa (53 ksi) and 488 MPa (71 ksi), respectively. The average hardness of the as-received material was determined to be 144 HV10.

A stress-relief heat treatment, consisting of heating to 570°C (1058°F) at 5°C/min, holding at temperature for 3.5 hours, and furnace cooling to ambient temperature, was applied to the plate material before welding to reduce any preexisting residual stresses. Figure 1 shows the microstructure of the experimental plate material following the stress-relief heat treatment, which consisted of ferrite and pearlite with an average hardness of 138 HV10, with no noticeable differences in microstructure compared to the as-received material.

### Table 1 — Nominal Chemical Composition of S355J2 Plate Material according to DIN EN 10025-2:2004 (values in wt-%)

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤0.20</td>
<td>≤0.55</td>
<td>≤1.60</td>
<td>≤0.035</td>
<td>≤0.035</td>
</tr>
</tbody>
</table>

### Table 2 — Specified Minimum Mechanical Properties of S355J2 Plate Material according to DIN EN 10025-2:2004

<table>
<thead>
<tr>
<th>Yield Strength (MPa)</th>
<th>Tensile Strength (MPa)</th>
<th>% Elongation</th>
<th>V-Notch Impact Energy (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>355</td>
<td>470–630</td>
<td>17</td>
<td>27 (at -20°C)</td>
</tr>
</tbody>
</table>

### Table 3 — Measured Chemical Composition of S355J2 Plate Material (values in wt-%)

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>Al</th>
<th>Nb</th>
<th>Ti</th>
<th>V</th>
<th>W</th>
<th>Co</th>
<th>B</th>
<th>N</th>
<th>Cu</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.14</td>
<td>0.20</td>
<td>0.67</td>
<td>0.00823</td>
<td>0.012</td>
<td>0.033</td>
<td>&lt;0.01</td>
<td>0.0354</td>
<td>0.0354</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.005</td>
<td>0.0023</td>
<td>0.00393</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.0003</td>
<td>0.007</td>
<td>0.0221</td>
<td>balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
received material.

The individual plate dimensions for the welding experiments were 500 mm (19.7 in.) length, 100 mm (3.93 in.) width, and 5-mm (0.197 in.) thickness containing a 60-deg V-groove with joint edges milled. A single-pass complete-penetration gas metal arc (GMA) weld was conducted with G3Si1 filler metal wire of 1.2-mm (0.05-in.) diameter, in accordance with DIN EN ISO 14341 (Ref. 17), using a shielding gas mixture of 82% Ar and 18% CO₂ at a flow rate of 18 L/min (4.76 gal/min), in accordance with DIN EN ISO 14175 (Ref. 18). Welding conditions consisted of 261 A welding current, 30.4 V average arc voltage, 8.5 m/min (27.9 ft/min) wire feed rate, and 0.4 m/min (15.7 in./min) travel speed. This resulted in an approximate net heat input of 1 kJ/mm (25.4 kJ/in.).

Type-K thermocouple wires with a diameter of 0.5 mm (0.02 in.) were used to acquire the temperature at positions on both the top and bottom of the welded plate directly adjacent to the weld joint. The experimental configuration provided a force-free support of the plate, permitting free shrinkage during the welding process and subsequent cooling. Additionally, a ceramic weld backing was used for all conducted weld experiments.

The residual stresses before and after welding were measured using an Xstress 3000 Goniometer G3 X-ray diffractometer. A 2-mm (0.08-in.) aperture was used, which provided a suitable balance between time, costs, and results (Ref. 19). The line of measurement across the weld region is represented schematically in Fig. 2.

**Experimental Results**

Figure 3 shows the experimental weld macrosection with the weld pool area outlined, microstructures at the weld interface, and the HAZ microstructure from a location that experienced a peak temperature of 1159°C (2118°F) and at t₄/₅ time of 30.0 s, where t₄/₅ is the cooling time from 800°C to 500°C. The experimental thermal cycles as measured on both the top and bottom of the welded plate are provided in Fig. 4A. A summary of the individual parameters for each measured thermal cycle is provided in Table 4.

The transverse hardness distribution across the weld region is shown in Fig. 5. The peak hardness of 172 HV10 was found to occur in the weld metal, with a microstructure consisting of mainly Widmanstätten ferrite with aligned second phase — Fig. 3B. The HAZ microstructure shown in Fig. 3C has a hardness of 162 HV10 and consists of a mixture of grain boundary ferrite, polygonal ferrite, Widmanstätten ferrite with aligned second phase, and ferrite-carbide aggregate. The minimum hardness values, which were below 140 HV10, were found to occur in the base metal region.

The average residual stresses of the plate material after heat treatment were

---

**Table 4 — Summary of Individual Parameters for the Measured Thermal Cycles**

<table>
<thead>
<tr>
<th>Measurement Location</th>
<th>Distance from Weld Centerline (mm)</th>
<th>Peak Temperature (°C)</th>
<th>t₄/₅ Cooling Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of Plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.4</td>
<td>953</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>8.9</td>
<td>795</td>
<td>36³</td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>765</td>
<td>39³</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>1159</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>1007</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>6.8</td>
<td>937</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Bottom of Plate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Extrapolated t₄/₅ cooling times.
The hardness measurements taken along the top and bottom of the experimental weld plate are shown in Fig. 6. Residual stress measurements of experimental weld plate according to line of measurement shown in Fig. 2.

Fig. 4 — Measured thermal cycles adjacent to the weld joint. A — Top of plate; B — bottom of plate.

Fig. 5 — Hardness measurements taken along the top and bottom of the experimental weld plate.

Fig. 6 — Residual stress measurements of experimental weld plate according to line of measurement shown in Fig. 2.

The residual stress was measured to be 21 ± 47 MPa (3.0 ± 6.8 ksi) in the longitudinal direction and 11 ± 45 MPa (1.6 ± 6.5 ksi) in the transverse direction, obtained from 15 measurements. Measurements of both the longitudinal and transverse residual stresses after welding are given in Fig. 6. While a qualitative trend in residual stress is realized, the relatively high error of measurement of each of the points and the differences in the measured values between opposite points equidistant from the weld centerline are noted. The maximum longitudinal residual stress of 333 ± 109 MPa (48.3 ± 15.8 ksi) was measured at a distance of 12.5 mm (0.5 in.) from the weld centerline. At an increasing distance from the weld, the longitudinal residual stresses decrease monotonically down to a stress-free range. The transverse residual stress is compressive in all locations and is mainly constant toward the outer plate region with a minimum stress of −176 ± 64 MPa (−25.5 ± 9.3 ksi) occurring at a distance of 12.5 mm (0.5 in.) from the weld centerline.

**Numerical Simulation Procedure**

A complete, self-consistent welding simulation that includes all relevant physical aspects is not yet available. Many couplings are still unknown or not described mathematically, and incorporation of all aspects would result in a very complicated model that is not realistically solvable. Furthermore, the available computational abilities would be limiting for such a complex and demanding task. However, not all aspects need to be known with absolute certainty for reliable calculation and clarification of individual effects (Refs. 20, 21). Welding FE simulations have the ability to separate the influence of the various metallurgical parameters and their effect on the calculated results.

All numerical simulation calculations in this study were performed with the commercial FE software “Sysweld” Version 2008 on a standard PC with a Linux operating system. The most important simplifications and assumptions of the simulation are as follows:

- Temperature-dependent, homogenous, and isotropic material properties with consideration of phase transformations.
- A solidus temperature of 1440°C (2624°F) for validation of the weld joint geometry.
- No consideration of preceding process steps; the specimen is assumed to be geometrically ideal and totally stress free, and the weld reinforcement on the top and bottom side are considered.
- Phenomenological temperature field calibration using a combination of a double-elliptical Goldak (Ref. 22) and a 3D-conical Gauss heat source with time-independent volumetric heat flux density and no consideration of weld pool convection.
- Unified heat transfer on all outer surfaces with temperature-dependent radiative heat transfer.
losses according to Stefan-Boltzmann, a constant emission coefficient of \( e = 0.8 \), constant convective losses of \( 4 \text{ W/mm}^2 \) (1.27 \( \times \) 10\(^6 \) Btu/h-ft\(^2 \)), and an ambient temperature of 20°C (68°F).

• Idealized clamping of the specimen using elastic constraints of 10\(^3\) N/mm (5715 lbf/in.) for a force-free support.

### Finite Element Model

The FE model of the flat plates was meshed as a 3D model corresponding to the experimentally determined temperature gradients. The minimum element length in the weld joint area was 0.37 mm (0.015 in.) in the Z-X plane and 3 mm (0.12 in.) in the welding direction. The full model used for both the thermal and mechanical simulation consisted of approximately 90,000 nodes and 94,000 elements with a linear basis function. Figure 7 exhibits the FE model geometry used in the thermal welding simulation and the positions and directions of the locked degrees of freedom for the force-free support. The influence of the mesh density on the stiffness of the model was checked in advance. Consequently, in order to obtain an improved bending behavior of the mesh, an increase in the element size further from the weld was not applied.

### Thermal Analysis

For the thermal analysis, the experimentally determined data were used to calibrate the heat source of the simulation. Two aspects were considered in the temperature field adjustment. First, the cross-section geometry of the simulated weld pool was correlated with both the size and shape of the experimental macrosection of the weld joint. Second, the corresponding temperature cycles in the HAZ were correlated with the experimental measurements, with emphasis given to peak temperature and cooling time. Each of the simulations was performed with an identi-

### Table 5 — Characteristic Phase Transformation Parameters for Each CCT Diagram

<table>
<thead>
<tr>
<th>CCT Diagram</th>
<th>Phase Transformation Temperatures (°C)</th>
<th>Martensite Temp. Range (°C)</th>
<th>KM Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ferrite/Pearlite Start(^{(a)})</td>
<td>Bainite Start(^{(a)})</td>
<td>Martensite Start(^{(a)})</td>
</tr>
<tr>
<td>Sysweld</td>
<td>730</td>
<td>630</td>
<td>420</td>
</tr>
<tr>
<td>Gleeble</td>
<td>800</td>
<td>672</td>
<td>508</td>
</tr>
<tr>
<td>JMatPro</td>
<td>847/714</td>
<td>634</td>
<td>451</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Represents the highest temperature at which the phase is permitted to form.
physical and thermomechanical properties. The thermophysical and thermomechanical data in the Sysweld database were acquired at various temperatures by previous researchers (Ref. 23). For each of the simulations, an \( A_\text{c1} \) temperature of 727°C (1341°F) and an \( A_\text{c3} \) temperature of 867°C (1593°F) were employed, as stated in the Sysweld material database for S355J2. The residual stresses in the weld metal were not considered in the analysis due to measurement uncertainties, the direct energy input in the respective elements, and the negligence of heat convection in the weld pool.

### Metallurgical Model

The general phase transformation model incorporated in the Sysweld software is derived from the Leblond model (Ref. 24) and generalized to account for Johnson-Mehl-Avrami kinetics (Refs. 25-28). The semi-empirical model allows for direct introduction of CCT and TTT data and is represented by the following general equation for transformation of phase \( i \) to phase \( j \):

\[
\frac{dP_j}{dt} = \frac{n(T)}{\tau(T)} \left( \frac{P_j}{P_{j,eq}(T)} - \frac{P_i}{P_{i,eq}(T)} \right) \left( \frac{\ln \left( \frac{P_{i,eq}(T)}{P_{j,eq}(T)} \right)}{\ln \left( \frac{T}{T_0} \right)} \right)
\]

(1)

### Table 6 — Calculated Phase Percentages and Vickers Hardness Values for Each CCT Diagram, Referring to a Node with a Peak Temperature of 1300°C and \( t_{B5} = 28 \) s

<table>
<thead>
<tr>
<th>CCT Diagram</th>
<th>Ferrite, wt-%</th>
<th>Bainite, wt-%</th>
<th>Martensite, wt-%</th>
<th>Calculated Vickers Hardness*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sysweld</td>
<td>0.2</td>
<td>96</td>
<td>3.4</td>
<td>207</td>
</tr>
<tr>
<td>Gleeble</td>
<td>6.7</td>
<td>91</td>
<td>2.3</td>
<td>202</td>
</tr>
<tr>
<td>JMatPro</td>
<td>5.4</td>
<td>45.5</td>
<td>49</td>
<td>281</td>
</tr>
</tbody>
</table>

(a) Equations provided in Ref. 40.
where 
\[ P_{j,eq} = \text{equilibrium fraction of phase } j \text{ obtained after an infinite time at temperature } T; \]
\[ \tau = \text{characteristic time constant for the reaction at temperature } T; \]
\[ n = \text{variable illustrating the reaction rate at temperature } T; \text{ and} \]
\[ F = \text{parameter representing cooling rate dependence.} \]

When temperature varies in time, Equation 1 expresses that \( P_j \) exponentially approaches \( P_{j,eq} \) with time constant equal to \( \tau \). The metallurgical parameters \( \tau \) and \( n \) are modeled as piecewise linear functions. For incorporation of experimentally determined CCT data, \( n \) is given a nominal value of 1 in the transformation temperature range and Equation 1 simplifies to

\[
\frac{dP_j}{dt} = F(T) \left( [P_{j,eq}(T) - P_j(T)] / \tau(T) \right) \tag{2}
\]

The parameters \( \tau \) and \( F \) are then manually adjusted to align the predicted phase fraction values with those determined from the experimental CCT data. For introduction of TTT data, parameters \( \tau \) and \( n \) are extracted for various temperatures and incorporated directly into the metallurgical model.

The martensitic transformation is modeled using the Koistinen-Marburger equation (Ref. 29):

\[
P(T) = 1 - \exp\left( -KM \left( M_s - T \right) \right) \tag{3}
\]

where
\[ P = \text{proportion of martensite; } \]
\[ T = \text{temperature; } \]
\[ M_s = \text{martensite start temperature; } \]
\[ KM = \text{Koistinen-Marburger coefficient related to martensitic reaction rate.} \]

The \( M_s \) and \( M_f \) temperatures are considered to be 0.01 and 0.99 phase fraction transformed, respectively.

Four phases are given consideration in the model: austenite, ferrite-pearlite, bainite, and martensite. The finish temperature of the phase transforming at higher temperature coincides with the start temperature of the phase transforming at a lower temperature.

### Metallurgical Model Inputs

Rather than performing an arbitrary adjustment of CCT behavior, three justifiable data sets were used as input to the numerical calculation: data available in the Sysweld database, experimental data acquired through Gleeble dilatometry tests, and TTT/CCT predictions calculated from the JMatPro software. The thermo-physical and thermomechanical properties were identical for the three simulations; only the metallurgical phase transformation parameters were adjusted.

#### Sysweld Database

The CCT information available in the Sysweld database for S355J2 was derived from an experimentally determined welding-related CCT diagram (Ref. 30). The CCT diagram was determined by heating samples to a peak temperature of 1350°C (2462°F) and cooling linearly to 850°C (1562°F) before applying different cooling rates to ambient temperature. The composition stated in the Sysweld metallurgical file is the nominal composition for S355J2 as given in the DIN EN 10025-2 standard and presented in Table 1 previously. The CCT diagram implemented in the Sysweld metallurgical file is based on the chemical composition given in Ref. 30 for the S355J2 CCT diagram. It is noted that there is no direct composition adjustment available in the Sysweld software to account for differences in CCT behavior due to compositional differences.

#### Gleeble Dilatometry Experiments

A set of dilatometry experiments were conducted for S355J2 using a Gleeble 3800 thermal-mechanical simulator. A dilatometer was used to extract dilatation vs. temperature data for several cooling rates. Solid cylindrical samples of diameter 5 mm (0.2 in.) and length 100 mm (3.9 in.) were machined from the experimental S355J2 base plate material. Samples were heated to a peak temperature of 1300°C (2372°F) at 100°C/s (180°F/s) and held at the peak temperature for 1 s before being cooled to 950°C (1742°F) at a rate of 25°C/s (45°F/s). The peak temperature of 1300°C (2372°F) was selected in order to allow for austenite grain growth, promoting a fully martensitic phase transformation.

---

**Table 7 — Residual Stress Values at Ambient Temperature for Each CCT Diagram, Referring to a Node with a Peak Temperature of 1300°C and \( t_{\text{eq}} \) = 28 s**

<table>
<thead>
<tr>
<th>CCT Diagram</th>
<th>Transverse (MPa)</th>
<th>Longitudinal (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sysweld</td>
<td>-175</td>
<td>434</td>
</tr>
<tr>
<td>Gleeble</td>
<td>-224</td>
<td>436</td>
</tr>
<tr>
<td>JMatPro</td>
<td>-130</td>
<td>511</td>
</tr>
</tbody>
</table>

---
tion to occur at the fastest cooling rates achievable. Cooling to 950°C (1742°F) was necessary in order to perform a helium gas quench without destroying the sample. The samples were quenched from 950°C (1742°F) at various linear cooling rates. The range of 10s times achieved was 2.1–23.8 s, with the fastest cooling rates repeated to achieve an average value of transformation temperatures. The CCT determination was made in direct reference to the dilatation data, microstructural evidence, hardness measurements, and to published CCT data for S355J2 (Refs. 30, 31). Following the testing, the dilatation data was analyzed using a linear least squares fitting routine to determine the transformation temperatures and phase fractions. The phase fraction values determined from the dilatation data for individual cooling rates were then used to calibrate the metallurgical model parameters in the Sysweld software.

**JMatPro TTT/CCT Calculations**

JMatPro is a commercially available software designed to calculate the properties and behavior of multicomponent alloys (Ref. 32). One feature of JMatPro is the calculation of TTT and CCT diagrams of steels, Al alloys, Ni-based superalloys, and Ti alloys. The predicted TTT diagrams for steels are derived from the chemical composition, austenitization temperature, and austenite grain size (Refs. 33, 34). The incorporated phase transformation model is based on the model of Kirkaldy (Ref. 35) and validated with experimentally determined TTT and CCT diagrams (Refs. 36–38). For the TTT calculation, inputs were the composition of S355J2 experimental plate material, as provided in Table 3, an austenitization temperature of 1300°C (2372°F) and an austenite grain size of 50 μm (0.002 in.), which was selected as an approximate value for the CGHAZ region (Ref. 39). The specific effect of peak temperature and austenite grain size is considered for evaluation in subsequent research. Consistent with the numerical determination of metallurgical parameters outlined in Sysweld, parameters τ and n were determined from the numerical data and directly incorporated in the Sysweld metallurgical model. Since the predicted phase fractions were not directly available from the JMatPro data, Johnson-Mehl-Avrami calculations consistent with the Sysweld metallurgical model were performed for individual cooling rates to obtain the phase fractions. The calculation employed an additivity principle whereby continuous cooling rates were divided into a series of discrete isothermal steps, with the inclusion of a Scheil incubation period (Ref. 40). The calculated phase fraction values for individual cooling rates were then used to calibrate the metallurgical model parameters.

**Summary of CCT Diagrams**

The three CCT diagrams generated from the mathematically formalized metallurgical data are presented in Fig. 8. From an analysis of the three CCT diagrams, variations are evident in the phase transformation temperatures, the location of the phase transformation regions, and the predicted phase fractions for individual cooling rates. The characteristic phase transformation parameters for the three diagrams are presented in Table 5. The higher Mₜ temperatures of the Gleeble and JMatPro data may be attributed to the lower level of carbon (0.14 wt-%) in the experimental steel compared to the carbon concentration (0.18 wt-%) of the S355J2 material that was used to determine the Sysweld CCT diagram by previous researchers (Ref. 30).

For the fastest cooling rates > 100°C/s (180°F/s), all three CCT data sets predict a fully martensitic transformation. Bainite is predicted to begin forming at cooling rates below 100°C/s (180°F/s), with the nose of the bainite curve similarly located in each diagram. However, the bainite transformation kinetics and predicted bainite phase fraction values differ greatly for the three diagrams. For a cooling rate of 60°C/s (108°F/s), the Sysweld database predicts the formation of 47% bainite, while the Gleeble and JMatPro data predict only 2% and 6% bainite, respectively. For a cooling rate of 10°C/s (18°F/s), there is good agreement in the predicted phase fractions between the Sysweld (89% bainite, 8% martensite) and Gleeble (9% ferrite, 85% bainite, 3% martensite) data, with the JMatPro data predicting significantly more martensite (5% ferrite, 29% bainite, 65% martensite). Whereas ferrite-pearlite is predicted to begin forming at cooling rates in the 30°–60°C/s (54°–108°F/s) range for the Gleeble and JMatPro data, the formation of ferrite-pearlite is suppressed to cooling rates below 10°C/s (18°F/s) for the Sysweld data. It is felt that the overall variability of the CCT diagrams investigated is sufficient to reveal the effect of anticipated CCT variations on the calculated residual stresses.

**Numerical Simulation Results**

Validation of the numerical simulation with experimental data is a necessary requirement to ensure the quality of the calculated results. Figure 9A represents the comparison of a measured and calculated thermal cycle, with the macrosection and
temperature field also shown. The peak temperatures of the simulation thermal cycles were interpolated to exactly match the experimental peak temperatures. As a result, there is some deviation in the exact distances from the weld centerline between experiment and simulation; however, this deviation is in the range of the temperature measurement uncertainty. The experimental $\frac{1}{2} \text{sec}$ cooling time was approximately 36 s for a peak temperature of 795°C (1463°F). In comparison, the calculated thermal cycle for a peak temperature of 795°C (1463°F) provided a $\frac{1}{2} \text{sec}$ time of 32 s. The difference of 4 s represents a 12.5% deviation. Regarding the assessed CCT diagrams, no significant microstructural differences are expected for this deviation. Additionally, Fig. 9B shows the calculated weld pool outline in comparison to experimental macrosections of the weld pool shape observed at 35-, 150-, and 265-mm (1.4-, 5.9-, and 10.4-in.) distances from the beginning of the weld joint. The deviation between the average area of the experimental weld pool shape, represented by the area surrounded by the weld interface, and the calculated weld pool outline, represented by the area exceeding the solidus temperature of 1440°C (2624°F), is approximately 9%. This deviation is within the range of deviation of the experimental weld pool macrosection measurements. The validation of the numerically calculated temperature field represents both a good qualitative and quantitative correspondence between the experimental and simulation results. Furthermore, negligible differences were found for both the maximum temperature and temperature gradient of the thermal cycles. Hence, the temperature field provided ensured input data for the subsequent calculation of residual stresses.

Table 6 shows the calculated phase percentages and Vickers hardness values after complete cooling to ambient temperature for a HAZ node nearest to the weld interface experiencing a peak temperature of approximately 1300°C (2372°F). The calculated hardness values were obtained from equations provided in Ref. 41. The phase percentages listed are valid for the weld metal and a major portion of the HAZ, as shown in Fig. 10. This kind of qualitative distribution applies for all three investigated cases because of the identical temperature field that was employed.

Figure 11 exhibits the calculated transverse and longitudinal residual stress distributions for each of the three CCT diagrams considered in the numerical simulation. For all three cases, the transverse residual stresses reach a maximum compressive stress at a distance of 10 mm (0.39 in.) from the weld centerline, with the Gleeble CCT data resulting in the largest compressive stresses exceeding −250 MPa (−36 ksi). The deviation between the Sysweld and Gleeble results are less than 20 MPa (3 ksi), except for the values directly adjacent to the weld interface where larger deviations occur. The calculations based on the JMatPro CCT data result in the highest longitudinal residual stresses, reaching a peak above 500 MPa (73 ksi) near the weld interface. At distances of 10–30 mm from the weld centerline, a plateau of approximately 300–350 MPa (44–51 ksi) is noted, followed by a monotonic decrease to a stress-free level. Table 7 provides a summary of the calculated residual stress values for a node adjacent to the weld interface.

Discussion

Comparing the experimental measurements and calculated residual stresses, a qualitative correlation only was realized in both the transverse and longitudinal directions, with the largest deviation occurring in the HAZ region nearest to the weld interface. The JMatPro CCT exhibited the best agreement with the measured transverse residual stress distribution — Fig. 12A. Considering the longitudinal residual stresses, the Gleeble CCT provided the best agreement with the experimental values — Fig. 12B. The discrepancy in stress values may be attributed to the uncertainty associated with the residual stress measurements as noted previously, simplifying assumptions of the numerical simulation, and significant differences between the phase percentages of the experimental microstructures and those predicted by the CCT data, as discussed in the following paragraph.

Referring to Table 6, it can be seen that the calculated Vickers hardness values are higher than the experimental measurements as shown in Fig. 5. The Sysweld and Gleeble CCT resulted in calculated hardness values slightly above 200 HV, while the calculated hardness of the JMatPro CCT was found to be 281 HV. The average measured hardness of the experimental microstructures in the weld metal and CGHAZ regions was found to be 166 HV10. Using the equations in Ref. 41 as a guide, the experimental microstructure with this hardness value is estimated to consist of approximately 50% ferrite and 50% bainite, assuming a negligible amount of martensite. Overall, the lower hardness of the experimental microstructure can be attributed to a higher proportion of ferrite, as evidenced in Fig. 3B and C. Due to its lower yield strength, a higher proportion of ferrite in the experimental microstructure would contribute to lowering the longitudinal residual stresses measured near the weld interface in comparison to the calculated stress values. The higher yield strength associated with a higher proportion of martensite would contribute to increasing the maximum potential residual stresses.

Notwithstanding the noted differences between the experimental and calculated residual stress values, a determination of the effect of CCT variations on the calculated residual stresses is the main point of investigation. As shown in Fig. 11, the calculated residual stresses exhibit a similar qualitative distribution for each of the three CCT diagrams investigated. The largest deviation between the three cases was found to occur in the HAZ region nearest to the weld interface. Referring to Table 7, the stress values calculated for a node nearest to the weld interface vary from −224 to −130 MPa (−32 to −19 ksi) in the transverse direction and 434 to 511 MPa (63 to 74 ksi) in the longitudinal direction. This represents a relatively small deviation between the three cases, and suggests that only minimal losses in accuracy are to be expected for the level of CCT variations investigated in this study.

A microstructural comparison shows the most significant effect on the calculated residual stresses to be related to the proportion of formed martensite. The small deviation between the Sysweld and Gleeble stress distributions correlates with the microstructural similarity between the two cases (Table 6), where less than 5% martensite is predicted to form in each case. For the JMatPro CCT case, 49% martensite is predicted to form in the microstructure, which supports the larger deviation in stress distribution in comparison to those calculated with the Sysweld and Gleeble CCT data. The higher martensite proportion for the JMatPro CCT was shown to decrease the compressive transverse stresses and increase the tensile longitudinal stresses throughout the HAZ region. Specific investigation regarding the influence of the martensite transformation on the calculated residual stresses is planned for future work.

Conclusions

1. A qualitative correlation only was realized between the experimental residual stress measurements and the calculated residual stresses in both the transverse and longitudinal directions. The discrepancy in stress values is attributed to residual stress measurement uncertainty, simplifying assumptions of the numerical simulation, and significant differences between the phase percentages of the experimental microstructures and those predicted by the CCT data.

2. For the S355J2 steel investigated and the employed numerical simulation approach, there was shown to be an overall weak dependency of the calculated residual stresses due to anticipated variations
in CCT behavior. The maximum deviation in the calculated stresses for the three CCT diagrams investigated was −224 to −150 MPa (−32.5 to −19 ksi) in the transverse direction and 434 to 511 MPa (−63 to −74 ksi) in the longitudinal direction. These results suggest that CCT data of approximate accuracy, in combination with detailed material property data, is sufficient for reliable calculation of welding-induced residual stresses.

3. The most significant effect of CCT variations on the calculated residual stress distributions was related to the proportion of martensite. A higher martensite proportion was shown to decrease the compressive transverse stresses and increase the tensile longitudinal stresses throughout the HAZ region.

Acknowledgements

The authors gratefully acknowledge the financial support for this research from the German Federal Ministry of Economics and Technology (BMWi) within the framework program of the “Innovation with Norms and Standards (INS)” coordinated and conducted by the German Institute for Standardization (DIN). The respective INS-project, “Draft guideline for a structured approach for the execution, analysis and post-processing of a numerical simulation of welding induced distortions and residual stresses,” was coordinated by the DIN Welding Standards Committee (NAS).

References


Welding Research
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**
One Arcos Drive • Mt. Carmel, PA 17851
Phone: (570) 339-5200 • Fax: (570) 339-5206

For Info go to www.aws.org/ad-index
Now It's Easier Than Ever to Get Things Done . . .

With a factory rebate from Lincoln Electric.

Purchase any of the five products listed above from a participating Money Matters™ program distributor, submit your proof of purchase online, and the check will be mailed to you. It's that simple.

Visit www.lincolnelectric.com to locate a participating distributor near you.