Understanding Weld Flaws
Welding’s Role in Our Lives
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NAME: Rob Christerson
PROFESSION: Welder
COMPANY: TQ Constructors, Inc.

Job Experience: Though he’s been welding for much longer, Rob Christerson has worked at TQ Constructors, Inc. for the last 13 years. On the job he creates Skid prototypes, which involves a great deal of custom fitting and redesigning. Customization has always been a hobby of Christerson’s. So in his free time he does custom work on his truck and those of his friends.

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Why the Thermal Arc 201TS Portable DC Welder? “The small size of the 201TS lets me fit into tight areas much easier than any other machine ever could, and it runs so much smoother than older units. No wasting time fine tuning. Plus the trigger isn’t bulky or cumbersome at all.”

“This is one really comfortable machine”

Rob carries the torch... will you?

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When you’re doing work for one of America’s most hallowed grounds, you tend to feel differently. Fabricating 24-foot columns and column base plates using 4-inch thick high-performance steel brought a heightened sense of pride in our shop. From fracture-critical work done to rebuild NYC’s World Trade Center complex to other projects that require big and heavy capability, people turn to Greiner. Why? Because we have the facilities, the people and the certifications to deliver a job well done – time after time. We’re proud of the work we do, and especially proud when it’s for one of America’s most iconic construction projects.

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On the cover: Randy Jennings performs gas metal arc welding using a 0.045-in. wire to create yard ramps. (Photo courtesy of Bluff Manufacturing, Inc., Fort Worth, Tex.)
How Does Basketball Relate to Welding Standards?

Recently, the Lakers’ Ron Artest received a slap on the wrist for his flagrant fourth-quarter “clothesline” foul of J. B. Barea. It had been an exciting game up to that point, as it always is when two powerhouse teams meet in the playoffs. We were all watching the final minutes of play, then bam! In half a second, Artest put two years of charitable work into the garbage by reminding us of his violent past. How serious was his transgression? We have rules to determine these things, and although some will say the referees are under huge pressure to look the other way on controversial plays and bend the rules to protect star players, in this case, the referees did take action. The foul, however, does remind us of why there are rules.

Now you may be asking yourself, “What does this have to do with welding?” Standards are rules intended to help everyone play on a level playing field. The fact is, though, in reality it is seldom a level field. Our lives are not static like the basketball regulations. James Naismith, the Canadian inventor of the game, laid down 13 rules of basketball in 1891 that determined what constituted a foul, and the rules have stayed essentially the same ever since. This is not the case in international trade, or in the standards and rules that govern trade. The USA and Canada face increasing global competition, intractable social problems, changing products and technologies, as well as evolving priorities in safety and in the management of our environment. Nor do other countries necessarily play by the same rules we do.

Every time we pick up a newspaper, we see that important trading partners are following different rules than we are. A country that does not let its people demonstrate or worship freely is not likely to encourage fair and transparent standards-setting in private. And if we are going to buy an increasing number of products from them, and use them in our homes with our children nearby, how such standards are determined may be rather important.

Our system, under the umbrella of the American National Standards Institute (ANSI), is a consensus process that endeavors to weigh the differing interests of the manufacturer, user, educator, and others. Parties work together, openly, to form rules and standards that theoretically balance everyone’s interests. Some other countries use a different system to set national standards; in some cases, an interested party, such as a manufacturer, may buy their way into the standard by paying for a seat on the committee writing the national standard. It is naïve to think other countries have our interests at heart.

We frequently read about how we are losing our influence internationally, and how our share of international trade is decreasing in the face of other countries’ growth. So, if others’ standards are potentially suspect, having come through a system that is flawed, and since national standards frequently become international standards, it is more likely that we will have less influence on international standards in the future.

This is particularly galling to those of us who are devotees of the American Welding Society, as the AWS wrote many of the original standards for welding. Our standards are timely, market-driven, sector-specific standards that enhance the competitiveness of our industry. They are cost-effective standards that improve safety and protect the environment, promoting a worthwhile legacy for those who come behind us. The AWS is part of a unique process of private-sector developers in a private-public partnership developing standards in America. Our standards are routinely revised to reflect developments and new discoveries, reflecting changes in technology, industry practice, and hazards. If you look around, and consider the challenges we face, this process needs our support and involvement as technologies and products change. Can you help by getting involved in our standards-setting process? Much needs to be done, from helping write new standards to ensuring regulations reflect changes in current products.

It is easy to get involved. Contact your AWS Section, or the AWS Technical Department, and join an AWS committee. It costs nothing, you can participate as little or as much as you like, and it will definitely increase your own knowledge. You might even have some fun discussing the Lakers…

Nigel Scotchmer
Chair, AWS International Standards Activities Committee
Looking for a welding machine that’s as portable as it is productive? Meet the Caddy line of portable MIG welders by ESAB. Weighing only 26 pounds, these machines offer superior arc performance similar to machines three times their size. The CaddyMig 160i is capable of welds over 1/8 inch thick, while the CaddyMig 220i welds up to 1/4 inch thick. Plus, both machines are incredibly easy to set up – meaning you’ll be ready to weld in minutes, no matter where the job takes you.

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President Obama Announces Student Credentialing Initiative that Partners with AWS

President Barack Obama has announced a partnership with industry groups, including the American Welding Society (AWS), Miami, Fla., that plans to provide 500,000 community college students with industry-recognized credentials to help secure jobs in manufacturing.

Speaking at Northern Virginia Community College in Alexandria, Va., on June 8 to an audience of education and industry leaders, including AWS Executive Director Ray Shook, the president noted that the manufacturing sector has led the economic recovery, adding 230,000 jobs since the beginning of 2010. However, progress in education is needed to bring the country back to full employment and global competitiveness.

“The goal is not just to make sure you have a diploma,” Obama said. “The goal is to make sure your degree helps you to get a promotion or a raise or a job.”

He also pointed out that curriculum and credentials need to match employers’ needs.

The White House said that a standardized credentialing system is crucial to the country’s ability to have the most productive manufacturing workers in the world.

“The irony is even though a lot of folks are looking for work, there are a lot of companies that are actually also looking for skilled workers. There’s a mismatch that we can close. And this partnership is a great way to do it,” Obama said.

“If you’re considering attending a community college, you’ll be able to know that the diploma you earn will be valuable when you hit the job market.”

The Manufacturing Skills Certification System, designed by the Manufacturing Institute of the National Association of Manufacturers in partnership with AWS and other industry associations, is being established via programs at community colleges in 30 states.

The White House pointed out that “2.7 million manufacturing employees are 55 years of age or older and likely to leave the labor force in the next 10 years.”

“Welders are retiring twice as fast as new welders are entering the profession,” said Shook. “AWS is providing curriculum and credentialing standards that will help community colleges graduate welders and welding technicians who are ready to be productive on Day One.

“We are pleased to be working with the Manufacturing Institute and its partners from other manufacturing disciplines on an initiative that will help new workers compete in the global marketplace,” he added.

Nominations Sought for AWS Image of Welding Awards

July 31 is the deadline to submit your nominations for the Image of Welding Awards. These awards recognize outstanding public contributions that have promoted the image of welding and the welding industry as a whole.

The awards are presented by the American Welding Society (AWS), Miami, Fla., and the Welding Equipment Manufacturers Committee (WEMCO), an AWS standing committee. All individuals, organizations, and groups may be nominated for multiple categories. Self-nominations are also acceptable.

Achievement is recognized in the following categories: Individual, Educator, Educational Facility, Small Business, Large Business, Distributor, and Section Award.

To see past winners and submit a nomination, visit www.aws.org/awards/image.html. For your application to be considered, complete the nomination form and return via e-mail to image@aws.org, FAX to (305) 443-1552, or mail to AWS Image of Welding Awards, 550 NW LeJeune Rd., Miami, FL 33126.

Winners will be presented their awards at a ceremony to be held during the FABTECH Show, Nov. 14-17, at McCormick Place, Chicago, Ill. ◆
If you always call it quits when you're faced with a task that seems impossible, you'll never achieve great things. This is the crucial point where we simply keep going. As a worldwide technological leader and European market leader, we work day-in, day-out, on realizing our vision: to «decode the DNA of the arc». So as to make impossible weld-joints possible – like steel to aluminum. Today we can say with complete conviction: We have full mastery of the arc. A mastery which ensures higher welding speeds, zero spatter and excellent gap bridgeability. Since 1950, this is how we have kept coming up with innovative total systems for arc welding and resistance spot welding. Want to know more? Check out www.fronius-usa.com
GE Transportation Plans to Open New Locomotive Plant in Texas

GE Transportation plans to open a new 900,000-sq-ft locomotive manufacturing facility in Fort Worth, Tex. It will invest up to $96 million in the plant and will create more than 500 high-tech manufacturing jobs. Production is scheduled to start by 2012. The company will also expand its manufacturing workforce at its Erie, Pa., plant by hiring an extra 250 workers.

“GE Transportation is experiencing strong U.S. and global growth because of its technical leadership, and we need to increase our manufacturing capacity and flexibility,” said GE Chairman and CEO Jeffrey Immelt.

“Texas continues to attract employers of all sizes that are looking to create jobs and grow their business thanks to our low taxes, reasonable and predictable regulatory climate, fair legal system, and skilled workforce,” said Texas Governor Rick Perry.

Later this year, GE anticipates launching its formal hiring process for both salaried employees and production workers for the Texas facility. Production workers include welders, assemblers, painters, and related skilled labor.

The proposed location in Fort Worth will become final upon conclusion of pending local approval. The state of Texas will commit up to $4.2 million in incentives toward the project through the Texas Enterprise Fund.

GE Transportation has recalled approximately 800 production workers at its Erie manufacturing facility since late 2010 and announced 450 new jobs since April.

Shown is the Evolution® Series locomotive, GE’s most technologically advanced, fuel-efficient, and low-emissions locomotive, along with a company worker welding a traction pin to a locomotive platform. (Photos courtesy of GE Transportation.)

AWS Welding Sales Representative Certification Available Online

The American Welding Society (AWS), Miami, Fla., launched the first-ever online certification program for welding sales professionals this spring.

“The AWS Welding Sales Representative Certification sets apart the elite sales professionals from the rest of the pack,” said Cassie Burrell, AWS deputy executive director. “Being able to take the course and test online will make it more convenient for sales reps to obtain the certification and will show their commitment to helping customers find new solutions and ways to improve their welding quality and productivity, as well as help provide a safe workplace.”

The seminar will be available through AWS’s new online welding university, American Welding Online, located at www.americanweldingonline.com. Currently, the site houses the Online Certified Welding Sales Representative seminar and exam, allowing participants access to the course materials and exam 24 hours a day, seven days a week.
Sales professionals who meet the program’s requirements may take the 20+ hour, self-paced, online seminar, then complete a two-hour exam to establish credentials. Seminar and exam topics will establish the sales person’s level of knowledge concerning five arc welding processes; brazing and soldering; cutting; safety in process and gas cylinder handling; AWS filler metal classifications; shielding gas applications; welding terminology; ventilation; electrical requirements for power sources; and welding procedures and their qualification.

Prerequisites for the AWS Certified Welding Sales Representative online program include a high school diploma or equivalent and at least five years’ experience in an occupational function in direct relation to the sales of welding and cutting equipment, and supplies of other related services; or at least two years of experience plus a training certificate of completion for welding processes. Completion of the seminar fulfills this training certificate requirement.

For those wishing to take the seminar and test in person, exam dates are scheduled throughout the country. The seminar can even be taken at your workplaces for groups of sales personnel.

**MesoCoat Breaks Ground on New Facility**

MesoCoat, Inc., recently celebrated the groundbreaking of its new, 11,000-sq-ft plant in Euclid, Ohio. The well-attended event attracted about 100 individuals.

The plant will be built with a single CermaClad™ production line — a high-speed cladding process that utilizes a high-intensity light source — to manufacture around 10,000-sq-m per year of corrosion- and wear-resistant clad tubes, pipes, and plates. The process can increase the longevity of components in deep-sea oil and gas, oil sands production, mining and mineral processing, and nuclear power generation.

The facility will employ blasting, application, and testing equipment to make these products. Also, the company will equip the plant with a thermal spray system to commercialize its PComP™ nanocomposite cermet products and qualify them for...

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This unique product's optical and magnetic arc detection systems ensure that the filter will never open even if the sensors are blocked. With a redundant magnetic arc detection system, the lens will stay dark as long as there is an arc present. The opto-magnetic sensing system is fully adjustable so that you can fine tune the system to the ambient conditions. This is the perfect auto-darkening welding filter for all welding processes including TIG and TIG pulsing. Great in production applications where lighting issues, close proximity to other welders, smoke, or reflections can render standard auto-darkening filters useless.

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use in the aerospace, oil and gas, mining, and chemical processing industries.

“This facility is the first in a series of six manufacturing plants scheduled over the next four to five years in the U.S., Canada, South America, and Asia,” said MesoCoat CEO Andrew Sherman.

The company expects to finish construction in September. Installation and setup of production equipment will take an extra two months. Full-scale production is expected to be underway by the start of 2012.

McDermott Wins Pipeline Installation Project in Gulf of Mexico

A subsidiary of McDermott International, Inc., Houston, Tex., has been awarded a contract by Pemex Exploración y Producción for the procurement, construction, and installation of three oil and gas pipelines ranging from 8 to 20 in. in diameter, in Mexico’s Bay of Campeche. The contract is valued at more than $50 million.

“Our installation solution for this project will be supported by our subsea engineering design group in Houston and fabrication work from our construction yards in Altamira, Mexico,” said Stephen M. Johnson, McDermott’s chairman, president, and chief executive officer.

Pipeline installation engineering is expected to begin in the second quarter of this year, with subsequent fabrication of the risers, clamps and guards, subsea tie-in assembly, and other platform piping and structural items from Altamira. The work will be performed using a DB16 shallow and deepwater combination barge with completion expected by the end of 2011.

The DB16 features five pipelay automatic welding stations. The vessel’s underwater block is also capable of lifting large amounts of tonnage into deepwater.

McDermott’s DB16 barge (shown above) is equipped with five pipelay welding stations. The pipeline installation work will be performed for Pemex in Mexico’s Bay of Campeche.

The field development in the Gulf of Mexico sits in about 170 ft of water. The pipelines will run from the Kambesah Wells Recoverer Structure to the Kutz TA and Ixtoc-A platforms.

General Dynamics Awarded $1.2 Billion for Second FY11 Virginia-Class Submarine

The U.S. Navy has released $1.2 billion for constructing the 14th Virginia-class submarine, SSN-787, to General Dynamics Electric Boat, Groton, Conn. This marks the start of production of two submarines per year on the Virginia-class program.

— continued on page 94
What’s a hero without a trusty sidekick?

Reliable, powerful, hard-working under extreme conditions ... and that’s just our service team.

These courageous colleagues can combat any welding crisis!

Steve and Wes — an unstoppable pair

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Kobe Steel Establishes Welding Company in India

Kobe Steel, Ltd., Tokyo, Japan, has established a company to sell welding consumables and provide sales support and maintenance services for welding robot systems in India. The new company is named Kobelco Welding India Pvt. Ltd. (KW1) and is based in Gurgaon, Haryana state, which is about 30 km southwest of New Delhi.

The company is capitalized for $112,000. Kobe Steel will hold an 80% share and Kobe Welding (Singapore) Pte. Ltd. and Tiseto Co., Ltd., will each hold 10%. The company has a staff of five people.

Demand for welding consumables is growing significantly in India. Because construction of a number of power plants is expected, demand for welding products in the energy field is expected to grow.

Machine-Vision-Aided Heavy Robot Welding Station Delivered to China

Pemamek Oy Ltd., Loima, Finland, has delivered a portal-type machine-vision-aided robotic heavy welding station for the Chinese Jiangsu Rainbow Heavy Industries Co., Ltd. The station will be used to tack-weld end and side plates of MacGregor hatch covers for cargo ships.

The products come from the company’s PEMA Welding Automation division. Products include a PEMA VRWP-5500/1 vision robot welding portal, including a Yaskawa-Motoman MH6 welding robot with a DX100 controller and a Lincoln Electric PowerWave 455M GMAW power source. The VRWP portal consists of a robot welding gantry with 3 external robot axes, 6-axis welding robot, and patented Vision System robot programming, as well as a PEMA fume-extraction system, rails and gear racks, welding programs, and an installation, startup, training, and service package.

“We consider this a major breakthrough in our effort on the Chinese heavy metal industry market,” said Jukka Rantala of PEMA. “Improvements in cost effectiveness usually call for more automation.”

Auctioneers to Liquidate Odense Steel Shipyard

Maynards Europe GmbH and Hilco Industrial Europe (Hilco) recently took title to the Odense Steel Shipyard (OSS) assets in Denmark. A wholly owned subsidiary of AP Moller Maersk, OSS was the largest shipyard in Europe and for decades built some of the world’s largest container vessels, oil tankers, and other ships.

“The sale of the Odense yard has valuable equipment of interest to the shipbuilding industry around the world,” stated Daniel Kroger, managing director of Maynards Europe. “The facility offers machinery that can be used in a variety of industries. We expect strong purchase interest from a wide range of end-users.”

The 92-year-old shipyard announced its imminent closure in August 2009, citing competitive market pressure from the Far East, particularly China, and considerable annual deficits. Maynard’s European office took note, and approached OSS with an offer to liquidate the 1.1 million-sq-m facility.

Worthington Industries Launches Joint Venture in China for Housing

Worthington Industries, Columbus, Ohio, recently announced a joint venture to manufacture light-gauge steel framing products, and to design, engineer, and supply light-gauge, steel-framed, mid-rise residential buildings in five central Chinese provinces. The 40/60 venture, which will be called Worthington Modern Steel Framing System Co., Ltd., is with Hubei Modern Urban Construction & Development Group Co., Ltd., of China.

The company will operate in the Chinese provinces of Hubei, Hunan, Jiangxi, and Anhui, which have a combined population of 300 million.

“This joint venture is a great example of our global strategy for our mid-rise system as we introduce steel framing to new markets. We have identified several attractive and developing worldwide markets with strong demographics that have the potential to provide a magnitude of scale,” Worthington Industries Chairman and CEO John McConnell said. “We have invested resources in China over the past five years to pursue this market, and those efforts are starting to pay off. Our Shanghai design office has been engaged in trial steel-framed, mid-rise buildings for several months with the Ministry of Construction as China focuses on national building codes that promote steel framing.”

Austrian Welding Academy Awarded Accreditation

The South African Institute of Welding (SAIW) and the International Institute of Welding (IIW) recently awarded Authorized Training Board status to the Austrian Welding Academy Trust (AWA).

“The accreditation positions the AWA high in welding training in terms of facilities, range of courses, and instructors in both regional and international welding skills training,” said AWA Manager Tom Rice.

The academy opened in 2008 and is based in Isando, Johannesburg, South Africa. It caters to anyone wishing to begin or improve their welding skills to a level of certification recognized locally by professional organizations, industry, and the SAIW and the IIW.

In addition to receiving the accreditation, the academy has also increased the range of courses, from basic practical welding in fillet, plate, and pipe in the most widely used processes and positions to the SAIW/IIW international courses that include international practitioner, technologist, and specialist courses.◆
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For decades, Multiquip dual purpose welding/generator products have been exceeding the expectations of professional welders worldwide. Whatever the job, MQ Welders perform, quietly and confidently. Features like a superior arc characteristic, engineered safety components and a proprietary operating system that provides both significant energy-savings and quiet operation, deliver under the toughest conditions. And it's all backed by our industry-leading worldwide service network.

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Q: We are being requested to supply E308H-16 electrodes with both a measured (on a standard weld pad as given in AWS A5.4) Ferrite Number of 3 to 8 FN and a FN, calculated by the WRC-1992 Diagram as given in the ASME Code, Section III, Division 1, Figure NB-2433.1-1, also in the range of 3 to 8 FN. We are finding that a number of lots of electrodes do not satisfy both requirements. Is it reasonable to expect to satisfy both requirements?

A: In a word, no. A measured Ferrite Number is reality. A calculated Ferrite Number is merely a prediction, every bit analogous to a prediction of the weather. We should not be surprised when either prediction is not quite right.

There is uncertainty or variability built into every prediction. In the case of FN predictions, uncertainty includes, but is not limited to, uncertainties in the predicting diagram itself, variability in FN sample preparation (if you weld several test pads from the same lot of electrodes, the average FN will vary somewhat from sample to sample), and variability of chemical analysis.

The role of variability in chemical analysis is not well appreciated by those who predict FN using a constitution diagram. That variability includes biases within any single laboratory, as well as variability among various laboratories performing chemical analysis. No laboratory will get exactly the same results when it analyzes a given sample a number of times. And when round-robin chemical analyses are performed, it is normally found that each individual participant’s data will have a certain bias for each chemical element analyzed. The Schaeffler and DeLong diagrams were constructed using chemical analysis data developed almost entirely within a single laboratory in each case, so each of those diagrams includes the analytical bias of the originating laboratory. The WRC-1992 diagram, on the other hand, is based on pooled data from a number of laboratories, so this diagram at least eliminates the single-lab bias effect. But the WRC-1992 diagram’s predicting accuracy is still affected by the accuracy of the chemical analyses used in developing the diagram, as well as by the accuracy of the chemical analysis for the given sample for which a prediction of FN is desired.

Seven chemical elements are necessary to make a FN prediction with the WRC-1992 diagram. These elements are carbon, chromium, nickel, molybdenum, niobium, copper, and nitrogen. With uncertainty in each of these elements, it should not be surprising that there is uncertainty in FN prediction. The International Institute of Welding, Commission II, has run a round-robin of FN measurement and prediction on five stainless steel weld samples, including an E308H-16 deposit (Ref. 1, 2). Sixteen laboratories around the world participated. Table 1 summarizes the observations of that round-robin. It is quite clear that the measured results are much more reproducible than the predictions of the WRC-1992 diagram.

The predicting accuracy of the WRC-1988 diagram, which is the precursor of the WRC-1992 diagram, was tested against the predicting accuracy of the older DeLong diagram, by the Welding Research Council (Ref. 3). It should be noted that, prior to 1995, the DeLong diagram was the preferred method of predicting ferrite in the ASME Code, and that diagram appeared in the Code as Figure NB-2433.1-1. A database of some 200 compositions and measured Ferrite Numbers that was independent of the database used in developing the diagram was used for this comparison, covering the range of 0 to 18 FN. Figure 1 shows the error histogram obtained as a result of that comparison. It can be seen that the center of the distribution of errors is closer to zero for the WRC-1988 diagram than it is for the DeLong diagram, and the spread of errors for the WRC-1988 diagram is about half the spread of errors for the DeLong diagram. It is noteworthy that the spread of errors for the WRC-1988 diagram looks virtually identical to the range of the 95% confidence interval observed in Table 1 for predicted Ferrite Numbers, on the order of plus or minus 4 FN.

It should be noted that a neural network for predicting FN has also been proposed by Vitek et al. (Ref. 4-7). Better predicting accuracy is claimed for the neural network than for the WRC-1992 diagram. However, the neural network includes assumptions about levels of vanadium, titanium, and cobalt in the weld metal which, at least in the writer’s opinion, are not justified. The interested reader can access the neural network online at http://calculations.ewi.org/vjp/secure/FNPLots.asp.

This Web site allows readers to evaluate the predictions of the neural network for themselves. However, in view of the observations above with regard to the ability to accurately determine chemical analysis, better accuracy in FN prediction than that of the WRC-1992 diagram seems to the writer to be an unrealistic expectation.

Returning to the original question, requiring both a measured FN and a pre-

![Fig. 1 — Error histogram comparing the predicting accuracy of the WRC-1988 diagram with that of the DeLong diagram.](image-url)

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<th>Table 1 — IIW Commission II Round-Robin Results</th>
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<td><strong>Average FN</strong></td>
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<td>Standard Deviation, FN</td>
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<td>95% Confidence Interval, FN</td>
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<td>Max. FN</td>
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Q&A: BY DAMIAN J. KOTECKI
dicted FN to be within a narrow range seems analogous to requiring both one’s observation of the current weather conditions and the weather forecast in the morning newspaper to agree on dry conditions before deciding to mow the lawn today. An observation that weather conditions are dry is alone sufficient for mowing the lawn, and a measured FN which complies with a specified range is alone sufficient for demonstrating suitability of a given filler metal for its intended application.

References


DAMIAN J. KOTECKI is president, Damian Kotecki Welding Consultants, Inc.; treasurer and a past vice president of the International Institute of Welding; a member of the AWS ASD Subcommittee on Stainless Steel Filler Metals and DIT Subcommittee on Stainless Steel Structural Welding; a member and past chair of the Welding Research Council Subcommittee on Welding Stainless Steels and Nickel-Base Alloys; a past chair of the A5 Committee on Filler Metals and Allied Materials; and was president of the American Welding Society (2005–2006). To contact Dr. Kotecki, e-mail your questions to damian@damiankotecki.com, or mail to Damian Kotecki, c/o Welding Journal Dept., 550 NW LeJeune Rd., Miami, FL 33126.

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For info go to www.aws.org/ad-index
Q: My company welds a lot of galvanized steel parts. The electrodes have to be cleaned every 100 welds to keep weld quality reasonable, and electrode life is very low, and the surface appearance of the weld area is rough. Is there a technique that we can use to extend the time between electrode dressings to possibly 300 or so welds and get more welds out of the electrodes?

A: Yes. In fact, you can actually make about 3000 good welds between electrode dressings and also drastically increase electrode life.

**The problem:** Galvanized steel has a layer of zinc on both sides of the metal. This can be deposited by moving the steel through a zinc bath or by electro-deposit technology. In either case, this layer will be in contact with the electrodes.

Zinc melts at about 787°F (420°C). Steel melts at about 2700°F (1492°C). This means that at the beginning of each weld sequence, the zinc will melt and then overheat, producing zinc oxide. The zinc oxide gets trapped between the sheets being welded, and also under the electrodes.

At the same time, this liquid zinc alloys with the copper electrode to form a layer of brass on the electrode face (brassing) causing the gold color you typically see on these electrodes after use. The trouble here is that this brass layer continues to build up and spread out to effectively increase the contact surface area between the electrode and the steel being welded. The electrodes shown in Fig. 1 illustrate this problem.

At the same time, the natural contact face of the electrodes increases in diameter due to mushrooming of the copper itself. Because the contact surface of the electrode has increased, the current density through the weld decreases and the welds lose strength and fail.

Below are some of the things you can do to solve this problem.

**Water Cooling:** Pulling heat out of the electrode rapidly will keep the temperature at the contact face of the electrodes lower. Proper water temperature and reasonable flow are key here. It is also critical that the cooling water makes contact at the bottom of the cooling hole inside the electrode.

The electrodes shown in Fig. 1 illustrate the different wear patterns using higher- and lower-temperature water at two different flow rates. The electrode faces started at 3/4 in. in diameter.

**Heat/Cool/Weld Schedule:** A major improvement can be made if the zinc layer can be moved away from the weld zone before welding temperatures are achieved on the steel. This can be done using some preheat at the start of the weld to liquefy the zinc. Then, by turning off the heat for a short time (cool time), the electrode force will force the liquid zinc to move to the outer edges of the electrode contact area and between the sheets.

The actual weld can now proceed through a very thin zinc layer. The resultant welds will be clean and strong. This also cuts down on the brassing, greatly increasing electrode life.

A typical heat/cool/weld cycle is shown in Fig. 2.

**Heat Stepper:** The most important factor in making a large number of welds on galvanized steel is using a heat stepper function. Heat stepper programs increase the welding current to compensate for electrode face diameter increase caused by the factors explained previously.

Figure 3 shows weld tensile strength when welding without the use of a heat
stepper and with various water temperatures and flow rates.

With higher cooling water temperatures, the weld strength drops starting at about 300 welds. Even with cold water and good flow, weld strength drops off at about 1400 welds.

Figure 4 shows what happens when an aggressive heat stepper program is used on the same material. With colder water, weld strength actually increases during the first 2000 welds and goes back to the original tensile strength at 3000 welds. While welding could continue past 3000 welds, it is more practical to dress the electrodes here and start the heat stepper over.

Because electrode dressing is done a fraction of times during production, electrode life is greatly increased. This increases production output by keeping the welding machines making spot welds rather than their being down for excessive tip dressing.

ROGER HIRSCH is immediate past chair of the RWMA, a standing committee of the American Welding Society. He is also president of Unitrol Electronics, Inc., Northbrook, IL. Send your comments and questions to Roger Hirsch at roger@unitrolelectronics.com, or mail to Roger Hirsch, c/o Welding Journal, 550 NW LeJeune Rd., Miami, FL 33126
This double-barreled two-day conference in Charlotte will be something a little different in AWS conferences.

**Day one** will be all about the newer corrosion-resistant alloys and will cover such materials as the growing body of duplex stainless steels, the nickel-base alloys, and titanium. The duplex grades are beginning to replace the austenitic stainless steels in some instances, so there is much to learn in terms of how to weld these grades. Newer is the introduction of less expensive duplex alloys, so much needs to be learned here as well. There’s a new titanium alloy which could very well replace the popular 6Al-4V grade. It, too, will be on the program. Cladding is also playing an increasingly important role in the whole matter.

**Day two** will be devoted to another hot topic in welding, the new chrome-moly steels such as the 91, 92, and 911 grades. There are benefits here, but there is still much to learn. It’s a market cut out for the low-hydrogen consumables. Fabrication is tricky. Great attention must be paid to heat treat and dissimilar metal welding. Although not new but still a problem to many, there will even be discussion on that old nemesis, to some, 4130.

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Gary Coates, Nickel Institute

What’s Next After 2205 Duplex Stainless Steel?
Gary M. Carinci, TMR Stainless

Applications for 16-8-2 Stainless Steel Weld Metal
William F. Newell, Jr., Euroweld Ltd.

Hastelloy® Alloys: Solutions to Severe Wet Flue Gas Desulfurization Environments
Henry J. White, Haynes International

Material and Process Considerations for Corrosion-Resistant Weld Overlay
Ben Fletcher, Chicago Bridge & Iron Co.

Super Duplex Welding
David Riley, Westinghouse

Welding of ATI 425® Alloy
Luis J. Ruiz-Aparicio, ATI Allegheny Ludlum

Additive Manufacturing of Corrosion-Resistant Alloys and AMC
Ian D. Harris, Edison Welding Institute

A Highly Corrosion-Resistant High Molybdenum
Samuel D. Kiser, Special Metals WPC

P91 and Beyond
William F. Newell, Jr., Euroweld Ltd.

Life Management of Creep Strength Enhanced Ferritic Steels
Kent Coleman, EPRI

The First Commercial Use of Filler Metal EPRI P87 in AEP’s Turk Plant
John A. Siefert and Dave Bauer, Babcock & Wilcox Research Center

Use of Welding Program Management Software for Power Plant Construction Applications
Shane Findlan, Shaw Power Group

Variability in Field Post Weld Heat Treatment
Kent Coleman, EPRI

Experience with the Welding of Grade 23 and 24, Including a New Approach to Dissimilar Chromium-Molybdenum Welds
Russel Fuchs, Bohler Welding Group

The Benefits of Using Flux in the Development of New Weld Metals for Use on P91 Steel
Brian Gaal, Electrode Engineering

Tubular Wire Alternatives for P91 and P92 Chrome-Moly Steels
Keith Packard, Hobart Brothers Company
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offer operational tips and support resources once they’ve purchased the equipment. The barcodes encode text, URLs, or other data and are readable by most camera phones. Users can pull up operational help tips and videos, product specification sheets and comparisons, instruction manuals, related articles, and company contact information. The company will begin including the codes on a few of its machines, including the POWER MIG® 140, 180, and 216 models, along with the Square Wave™ TIG 175 and Outback® 145 and Ranger® 225 engine-driven welding/generator machines. The company is looking to implement this program across all product lines. To get the mobile application for your phone, visit http://gettag.mobi.

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--- continued on page 93 ---

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Mark Burk, Indalco Alloys

Aluminum Welding Metallurgy
Bruce Anderson, Maxal

Metal Preparation for Aluminum Welding
Frank Armao, Lincoln Electric

Filler Alloy Selection Primary Characteristics
Tony Anderson, ITW

Gas Metal Arc Welding of Aluminum Alloys
Mark Burk, Lincoln Electric

Increasing Performance & Production in Aluminum GMAW
Thom Burns, AlcoTec

Aluminum Weld Discontinuities: Causes and Cures
Kyle Williams, Alcoa Technical Center

Design and Performance of Aluminum Welds
Bruce Anderson, Maxal

Application of the AWS D1.2 Structural Welding Code—Aluminum
Kyle Williams, Alcoa Technical Center

Overview of Solid-State Welding Processes for Aluminum
Donald J. Spinella, Alcoa Technical Center

Friction Stir Welding and Processing of Aluminum Alloys
John Hinrichs and Chris Smith, Friction Stir Link Inc.

The Use of Automation in the Aluminum Welding Industry
John W. Smith, Panasonic Welding Automation

Resistance Spot Welding of Aluminum
Donald J. Spinella, Alcoa Technical Center

The Fundamentals of GTAW Welding of Aluminum
Brent Williams, Miller Electric Mfg. Co.

Aluminum Extrusions for Joining and Welding
Nick Parson, Rio Tinto Alcan

Welding Aluminum for Marine Applications
Jerry Mirgain, AlcoTec

The Functionality of Feeding Aluminum Wire in GMAW Systems
David B. Veverka, ESAB Welding and Cutting Products
New Wire an Advancement in Self-Shielded Flux-Cored Arc Welding

Flux cored wires have long been a popular choice for steel fabrication. New advancements in steel fabrication, however, have increased the demand for more robust welding performance, and therefore, higher mechanical property requirements from the wires to satisfy new procedure qualification record (PQR) and welding procedure specification (WPS) developments. In particular, steel fabricators are moving toward higher-strength steels and more critical applications requiring low-weld-metal diffusible hydrogen contents for better cold-cracking resistance.

Self-shielded flux cored wires differ from gas shielded flux cored wires in that they expose the welding arc to the air instead of shielding it with an inert gas. As a result, nitrogen, oxygen, and hydrogen invasion in the arc and weld pool are inevitable. To overcome this negative impact from the atmosphere, deoxidizers and denitrifiers, such as aluminum, must be used in the flux formula to produce a sound weld. Traditional self-shielded flux cored wires have their limits, however, in handling the hydrogen from the atmosphere.

In fact, it was believed no low-hydrogen self-shielded flux-cored wires could meet the stringent 5 mL/100 g \([H]_{\text{diff}}\) maximum requirement (H5) until the recent introduction of a new AWS A5.29 E71T-8Ni1J (ISO 17632-A T4241NiYN1H5) product commercially named Coreshield 8Ni1H5.

Both \(\%\)-in. (2.0-mm-) and \(\%\)-in. (1.6-mm-) diameter wires were designed to control the diffusible hydrogen level in welds to less than 5 mL/100 g. Using well-controlled welding parameters, the \(\%\)-in. wire can achieve a diffusible hydrogen content less than 4 mL/100 g. The following are typical diffusible hydrogen levels using AWS A4.3 procedures:

- \(\%\)-in. 4.5 mL/100 g  [220 A, 19.5 V, 14 in./min travel speed (TS), and 1-in. contact tip to work distance (CTWD)]

<table>
<thead>
<tr>
<th>Diameter</th>
<th>AWS</th>
<th>ABS 4YSA (open root)</th>
<th>ABS 4YSA (AWMT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% in.</td>
<td>% in.</td>
<td>1G</td>
<td>3G down</td>
</tr>
<tr>
<td>C</td>
<td>0.04</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>1.21</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>Si</td>
<td>0.28</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.005</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.003</td>
<td>0.004</td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>0.05</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>0.98</td>
<td>0.96</td>
<td>N/A</td>
</tr>
<tr>
<td>Mo</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Al</td>
<td>0.80</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>0.00</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>H diff</td>
<td>3.3 mL/100 g</td>
<td>4.3 mL/100 g</td>
<td>34 mL/100 g</td>
</tr>
<tr>
<td>Yield Strength</td>
<td>65.8 ksi</td>
<td>66.6 ksi</td>
<td>65.0 ksi</td>
</tr>
<tr>
<td>Ultimate Tensile Strength</td>
<td>78.8 ksi</td>
<td>79.9 ksi</td>
<td>75.7 ksi</td>
</tr>
<tr>
<td>Elongation</td>
<td>33%</td>
<td>30%</td>
<td>31%</td>
</tr>
<tr>
<td>CVN, –20°F</td>
<td>113 ft-lb</td>
<td>118 ft-lb</td>
<td>N/A</td>
</tr>
<tr>
<td>CVN, –40°F</td>
<td>70 ft-lb</td>
<td>100 ft-lb</td>
<td>123 ft-lb</td>
</tr>
<tr>
<td>Face Bend</td>
<td>N/A</td>
<td>Pass</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Fig. 2 — A 6GR pipe joint welded with the new E71T-8NilJ.

Fig. 3 — This photograph shows slag detachability on a 6GR pipe joint.

Table 2 — Typical Welding Procedure for 6GR

<table>
<thead>
<tr>
<th>Pass</th>
<th>Process</th>
<th>Filler Metal</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FCAW-SS, up</td>
<td>CS8-NiH5</td>
<td>% in.</td>
</tr>
<tr>
<td>2</td>
<td>FCAW-SS, up</td>
<td>CS8-NiH5</td>
<td>% in.</td>
</tr>
<tr>
<td>3A</td>
<td>FCAW-SS, up</td>
<td>CS8-NiH5</td>
<td>% in.</td>
</tr>
<tr>
<td>3B</td>
<td>FCAW-SS, up</td>
<td>CS8-NiH5</td>
<td>% in.</td>
</tr>
<tr>
<td>4A</td>
<td>FCAW-SS, down</td>
<td>CS8-NiH5</td>
<td>% in.</td>
</tr>
<tr>
<td>4B</td>
<td>FCAW-SS, down</td>
<td>CS8-NiH5</td>
<td>% in.</td>
</tr>
<tr>
<td>4C</td>
<td>FCAW-SS, down</td>
<td>CS8-NiH5</td>
<td>% in.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current (A)</th>
<th>Voltage (V)</th>
<th>Polarity</th>
<th>H.I. (kJ/in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>130–165</td>
<td>18–20</td>
<td>DCEN</td>
<td>66</td>
</tr>
<tr>
<td>170–190</td>
<td>18–20</td>
<td>DCEN</td>
<td>71</td>
</tr>
<tr>
<td>185–210</td>
<td>18–20</td>
<td>DCEN</td>
<td>61</td>
</tr>
<tr>
<td>195–250</td>
<td>18–20</td>
<td>DCEN</td>
<td>41</td>
</tr>
<tr>
<td>195–250</td>
<td>18–20</td>
<td>DCEN</td>
<td>43</td>
</tr>
<tr>
<td>195–250</td>
<td>18–20</td>
<td>DCEN</td>
<td>46</td>
</tr>
</tbody>
</table>

%-%. 4.2 mL/100 g [215 A, 20.5 V, 12 in./min TS, and 1-in. CTWD]

Such low diffusible hydrogen levels minimize most of the "fish-eyes" (the diffusible hydrogen-induced round white spots on a fracture surface) found in self-shielded welds. Figure 1 shows the fracture surface of a nick-break that was done one day after welding. Except for a few tiny fish-eyes, smaller than 1 mm in diameter, the new E71T-8NiH5 product showed no fish-eyes. On the other hand, another commercial E71T-8NiH8 type wire showed large fish-eyes associated with the brittle fracture — Fig. 1B. This test demonstrated the advantage of this improved self-shielded cored wire on welding applications requiring good resistance to cold cracking, which is highly desirable for critical structures fabrication.

In addition to the low diffusible hydrogen levels, this new flux formulation is balanced to provide arc and slag performance with stable weld metal mechanical properties. The welding voltage and current can be as low as 18 V and 128 A, and as high as 25 V and 280 A. Such a wide operating window offers an advantage in manipulating the heat input specified by PQRs and WPSs. For example, on TKY pipe joints of offshore steel structures, the new E71T-8NiH5 product can weld uphill and downhill to suit various types of groove configurations. Typical welds are shown in Figs. 2 and 3.

Traditional self-shielded flux cored wires often experience an abrupt drop in Charpy V-notch (CVN) weld metal impact toughness from more than 200 ft-lb (270 J) to single-digit ft-lb at low testing temperatures. This is called a clink. Even though the averaged CVN impact toughness value can meet requirements, the clink projects a shadow of uncertainty on the engineering application. To achieve robust mechanical properties, the new E71T-8NiH5 employs an alloying strategy to ensure the weld metal not only has a reliable chemical composition but also stable CVN impact toughness at -20°F (-29°C) and -40°F (-40°C) with a tensile strength greater than 70 ksi (480 MPa). Welding performance, low weld metal diffusible hydrogen levels, and robust mechanical properties enabled this improved self-shielded cored wire to pass welding qualifications including ABS 4YSA. In particular, it is capable of passing ABS 4YSA in the uphill and downhill welding positions. Typical weld metal mechanical properties and chemical composition are presented in Table 1.

Successful qualification tests were also completed for a 6GR WPS on X65 pipe. Typical welding procedure and testing results are shown in Tables 2 and 3.

As a low-hydrogen self-shielded fluxcored wire, this new E71T-8NiH5 (ISO 17632-A-T4241NiYN1H5) product sets a trend for self-shielded flux cored wire manufacturing.

WESLEY WANG and STANLEY FERRER (sferree@esab.com) are with ESAB Welding & Cutting Products, Hanover, Pa.
The Roles Welding Plays in Our Lives

Many practical, day-to-day objects are welded such as bicycles and lockers as well as not-so-common items like piano plates and gates for protecting bats.

BY KRISTIN CAMPBELL

Whether most people realize it or not, welding really does play an important role in their lives; it’s one of, if not the most, effective ways to join metal.

Just think about it — the frame that supports the structure where you work is welded. So are the planes, trains, or automobiles that you travel in; pipelines that carry essential water and fuel; housewares ranging from kitchen tools to furniture. The list goes on.

Skilled, knowledgeable welders and automated/robotic machines are relied upon to create these objects.

Described below are a few welded items — some perhaps more familiar than others — that help fulfill important purposes.

Going ‘Batty’ with Creating Gates for a Good Cause

Kristen Bobo (kristenbobo.com), an independent contractor from Cookeville, Tenn., builds steel gates to protect bats in both caves and mines across the eastern United States (see lead photo).

She became interested in caves after marrying a former cave enthusiast nearly 14 years ago — Fig. 1. “The cave environment felt like home,” Bobo said.

Previously, she had worked as a seamstress for more than five years in New Orleans, La., then in Jamestown, Tenn.

When Roy Powers, an engineer and cave gate builder, visited her at Wolf River Cave in Tennessee, she believed in his cause. After discovering bats killed by vandals, she wanted to join in his conservation work. She enrolled in Tennessee Technical Institute’s welding fabrication program in the fall of 2000.

“Caves and mines are dangerous and fragile environments with sensitive ecosystems. The gates protect the caves from vandalism, the cave life from being disturbed or harmed, cultural resources from being looted, and the general public from being injured.

“Bats are especially sensitive to change or disturbance, so the gates must be ‘bat friendly,’ using all the latest research to assure the current design is,” Bobo said.

These gates are usually funded by state and federal wildlife agencies or nonprofit organizations. Bobo uses shielded metal arc welding to build a small gate at Devilstep Hollow, a state-owned cave with prehistoric art, in Cumberland County, Tenn. (Photo courtesy of Kristen Bobo.)

Fig. 1 — Kristen Bobo, pictured here attached to a rope while exploring the Youngs Pit Cave in Tennessee, has a passion for protecting biological and cultural cave resources. (Photo courtesy of Dr. Joe Douglas.)

KRISTIN CAMPBELL (kcampbell@aws.org) is associate editor of the Welding Journal.
groups, but sometimes private owners will pay for one.

As gate engineer, Bobo decides the final design and placement of each gate she creates. Engineering plans can take months and require return trips to the site before work begins, but once those are completed, most gates take less than a week to construct with the crew working 10–12-hour days.

The gates are field engineered to fit the irregular entrances and internal passage walls. They range from only a few feet to 40 ft wide.

“Many cave openings tend to be small and obscure. The confined spaces are more difficult to work in than the massive openings. Also, the deeper in a cave or mine, the more hazardous it is and fumes can build to dangerous levels,” Bobo said.

Mild steel is used in 20-ft lengths that may be reinforced with smaller pieces of angle iron or cut to fit smaller spaces. For fabrication work, she uses shielded metal arc welding with a portable machine, 6013 electrodes that are kept sealed to stay dry, and an oxyacetylene torch.

Some gate aspects are uniform, such as bar spacing and material shape. Prior to construction, a cross section is put together and trigonometry is applied for figuring material requirements.

In addition, the gates feature zero-airflow reduction, incorporating an angle within angle design. “This has proven to smooth out air currents indicated by wind tunnel research using mock gates made of different-shaped materials,” Bobo said. It’s critical for bats who use echolocation to maneuver with maximum shielding.

Bat gates for endangered species must meet current U.S. Fish and Wildlife Service requirements or the engineer/welder may be held liable,” Bobo added. Gates with improper bar spacing or airflow caused by incorrect material shape may result in the species abandoning what would have been an ideal habitat. “Also, gates should not take up more than a third of the entrance or passage space,” she said.

Some of Bobo’s adventures include replacing the 25-year-old gate at Big Bone Cave, Van Buren County, Tenn.; creating an updated gate with a large swinging door at Dunbar Cave State Natural Area, Clarksville, Tenn.; building three gates to cover entrances for the Chickamauga Cave in Georgia; and making a gate for Gibson Frazier Cave in Virginia — Fig. 2.

Bobo believes in her work and has seen large populations of endangered bats return to an abandoned site just one season after a habitat was gated. She has also noticed a general increase in the animals, most of which are invertebrates, living in the cave. Bobo pointed out that just because the importance of a particular animal may not be known yet, it could hold the cure for a disease or answer a mystery. Less vandalism and trash dumping in the gated caves has been achieved, too.

**Forklifts Help Clean Debris after Japan Earthquake**

Mitsubishi Heavy Industries, Ltd. (MHI), the parent company of Mitsubishi Forklift Trucks (www.mihift.com), Houston, Tex., recently developed two heavy-duty forklifts — Fig. 3. They feature radiation-shielded cabins to handle and dispose of contaminated rubble at the Fukushima Daiichi Nuclear Power Station following the March 11 earthquake and tsunami in Japan.

The two units have been delivered to a joint venture formed by Taisei Corp., Kajima Corp., and Shimizu Corp., which is handling the site cleanup.

Developed and manufactured within one month, MHI incorporated its expertise in heavy plate welding, vehicle systems, filtering, and radiation shielding and management into the unit based on the company’s 15-ton, heavy-duty forklift.

The first radiation-shielded cabin forklift contains a sealed cabin constructed using 100-mm-thick steel plates and 230-mm-thick lead glass, with all sides gas metal arc welded to enable the operator to maneuver with maximum shielding.
at Wilford Young Piano Tuning, a 100-year-old piano awaits restoration. Its interior cast-iron plate can also be viewed. (Photo courtesy of Wilford Young.)

Fig. 5 — At Wilford Young Piano Tuning, a 100-year-old piano awaits restoration. Its interior cast-iron plate can also be viewed. (Photo courtesy of Wilford Young.)

Fig. 6 — This close-up shot of a piano plate reveals a crack. (Photo courtesy of Wilford Young.)

Fixing Piano Plates Brings Music to Welder’s Ears

Wilford Young (wilfordyoung@comcast.net) of Ogden, Utah, enjoys tuning, repairing, and performing specialized piano services — Fig. 4.

At almost 88 years old, he stays busy bringing his piano-repairing expertise to clients within a three-county area.

Young has a 30 x 40 ft repair shop at his home. Part of the work he does there is welding broken piano plates, the cast-iron frame that holds internal parts in a rigid configuration — Fig. 5.

“If the plate in a piano breaks, the piano will not hold its tuning tension,” Young explained.

He first saw cast iron being welded while helping his uncle repair machinery on construction sites. By using a portable welding machine and specially designed welding rod, they would do on-site repairs.

Sixty years ago, when a neighbor was going to throw his piano away due to a broken plate, Young received permission to try fixing it. Those efforts paid off, and that piano is still in use today.

“A broken plate is a relatively rare happening, considering how many pianos there are in the world. In the state of Utah, I might hear of one or two a year,” he said.

Pianos vary in size from small, upright versions to large concert grands whose plates can weigh nearly 1000 lb.

A cast-iron plate will break because of accidental dropping/tipping over, defects in the casting, or a poor design with flimsy struts — Fig. 6. “The age of a piano seems to have little to do with frequency of plate breakage,” Young added.

To fix breaks, he typically removes the plate out of the piano and puts it on a workbench, at which point the plate will revert to its original configuration because there’s no string tension stress.

He grinds a V-groove along the crack line, uses arc welding with a ½-in. nickel electrode for cast iron, and lays in metal at the groove’s base, keeping heat input to a minimum. He doesn’t progress until the metal cools to a hand-held temperature, taking about 20 min.

“To speed up the process is to invite disaster as cracks will appear elsewhere in the casting. Cast iron is unforgiving when it comes to heat expansion,” he said.

After completing the weld on one side of the strut, he does the same thing to the other side. Then, he smoothes the weld using a grinding tool. For added strength, he welds a 2 x 6-in. steel plate on top of the previously made weld.

“I do this since I do not know what the cause of the original break was, and I do not want to take a chance that it will ever happen again,” Young emphasized.

Finishing work is done with a filler material, sanding, polishing, and applying a primer paint followed by a coat of gold-color lacquer — Fig. 7.

“In the 60 years I have been doing arc welding of broken plates, I have not had a single failure,” Young said.

Welding a plate that’s inside the piano can be done if extra care is used to not damage the surrounding parts.

For this, Young releases the tension from all the strings. Those close to the break are removed for about 6 in. on each side of the broken strut. Using a jig brings the warped plate back into its original shape. The welding process is the same as with plates outside the piano, but to protect other parts from sparks and possibly starting a fire, Young uses damp towels and strips of sheet metal.

“If there are several breaks in the plate, the process can take up to several weeks to complete due to the cooling/waiting period involved,” Young said.

Recently, clients in Portland, Ore., transported their piano 1000 miles by van to Young’s shop. He spent six weeks working on the project, and after putting the piano back together, it played again with a gorgeous tone.

“The family deemed the restoration to be worth the expense in bringing back to life such a beautiful instrument,” he said.

Young likes his job so much that as long as he stays healthy, he’s not slowing down.

“Restoring a piano to its original specifications and seeing the delight in the owner’s smile is what it’s all about,” he said.

Bicycles Feature Durable, Stainless Steel Tubes

KVA Stainless™ (www.kvastainless.com), San Diego, Calif., recently launched MS2™ at the North American Handmade Bicycle Show. The material is made from domestic stainless steel alloys using forming, welding, and thermal processing technology to produce custom tubing — Figs. 8, 9.

The company’s patented weld processing technology eliminated difficulties such as cold cracking of the heat-affected zone under mechanical straining and forming, resulting in high-strength martensitic stainless steels. Decades of metallurgical and thermal processing research and development by company founder, Ed McCrink, as well as development staff, have made this possible.
Gas tungsten arc welding is used to fabricate MS2 stainless steel on KVA’s production tube mill. (Photo courtesy of KVA Stainless.)

Cory Rosene of Tucson, Ariz., built this bicycle that features KVA’s new MS2 stainless steel tubing. At the 2011 North American Handmade Bicycle Show, this bike won the rookie of the year award in the mountain bike category. (Photo courtesy of KVA Stainless.)

The weld technology does the following: improves ductility, enhances toughness, enables high-speed welding of high-carbon alloys, is compatible with all welding methods, reduces the hardness of the weld in the fusion and heat-affected zones, and does not limit the part from transforming into a homogenous, uniform microstructure after solution heat treatment.

“Bike builders have been very generous with their ideas and thoughts, as well as extremely supportive. Cyclists should expect excellent ride characteristics, outstanding durability, and toughness from our new MS2 bicycle tubing,” said Douglas Gore, vice president of sales and business development.

Over the last three years, production manager, Joe McCrink, and director of engineering, Danny Codd, manufactured and tested numerous road bike frames using this tubing. “We are aware of a growing interest in stainless steel frames; riders reportedly like the look and feel of stainless steel,” McCrink added.

In addition, the tube is capable of allowing automakers to improve their vehicles’ crashworthiness while reducing overall curb weight and increasing gas mileage. It’s also used to manufacture wheelchairs and is under consideration for a new style of golf shaft along with baseball bats, ice skates, and automotive components.

The company’s yard ramps, also called portable loading ramps/docks, allow passage from the ground to a truck bed or the dock level to the ground — Fig. 10. The height of the dock and weight of the product dictate its load capacity.

Additionally, the high-strength steel yard ramps are welded to handle size and strength requirements — Fig. 11. They range in widths from 70 to 84 in., lengths from 30 to 36 ft, weigh up to 7000 lb, and handle capacities in excess of 30,000 lb.

The heavy-duty steel sides provide the yard ramp’s main load-bearing capacity. These are welded to multiple steel Z cross members to form an understructure frame. Then, the steel grating is welded to the Z members to form a one-piece unitized yard ramp. The sides provide the strength capacity and incorporate an 8-in. curb for run-off safety. If necessary, 6-ft
level offs are built into the ramp.

Bluff’s dock plates are rectangles of steel or aluminum containing a type of locking leg attached with a butt joint weld. They’re ideal for light dock loading activity applications and use with hand trucks and pallet jacks.

The company’s dock boards feature the addition of structural components above the plate called “curbs” that are usually 3–4 in. high, help maintain power equipment alignment, and provide runoff protection. They have an all-welded steel construction and weight-bearing capacities from 15,000 to 40,000 lb. Steel curbs are welded onto the steel plates, which vary in thickness from ⅛ to 1 in. They also have 6- and 10-in. understructures.

The Speedy Board® dock board has a cut-out feature that allows the fork lift operator to retrieve, place, and store the board without leaving the driver’s cage.

Bluff’s rail boards are dock boards with specific application to railcars — Fig. 12. They offer capacity ranges from 15,000 up to 90,000 lb; are designed/built to match specific conditions; have locking rings on each side, fabricated by cutting and welding ½ x ½ in. flat bar, to secure the board against a dock; and custom fabrication includes welding the curbs to the steel plate as well as the box understructure. Heavy-duty span members are deep-penetration welded and gusset reinforced at critical points to absorb impact and stress loads of railcar forklift service.

Welding Process Makes Conveyor Belts Stronger

Ashworth Bros., Inc. (www.ashworth.com), Winchester, Va., has been granted U.S. patent 7,735,637 for manufacturing Omni-Pro® conveyor belts featuring zero-tension, 360-deg smooth welds — Fig. 13.

These welds are produced with an automated process that positions the electrode and welds the links together, creating strong, smooth welds. In addition, this weld is free from surface imperfections and crevices, improving cleaning characteristics by eliminating bacteria entrapments.

Each link is manufactured with a patented coining process to prevent break-in wear and reduce belt elongation.

The stainless steel belt is used in spiral conveyors, typically a part of cooling and freezing systems for food, and can be used in proofers and cookers. It’s also capable of carrying products ranging from meat and poultry to baked goods.

The belt is offered in ⅜, 1, 1.2, and 1½ in. pitch options with turn ratios from 1.6 to 2.8 and widths from 12 to 60 in. It withstands spiral/turn-curve tensions up to 400 lb for 100,000 cycles.

Tall Lockers House Clothing, Equipment

The TA50 army lockers, carried by A Plus Warehouse (www.apluswhs.com), Lynn, Mass., are used by the military as well as firehouses and corporations — Fig. 14. TA50 is a military term for army-issued field clothing and equipment.

“Our TA50 lockers are all-welded, with 16-gauge diamond-perforated sides, 18-gauge backs, and 14-gauge doors,” said Ed Stairman, president of A Plus Warehouse. “We also include a stainless steel coat rod and two back hooks under the top shelf to keep your uniform wrinkle-free and ready for inspection.”

They have 16-gauge shelves, 12 in. from its top and 18 in. from its bottom; a rust-resistant finish; three-point locking handle (lock not included); welded wire mesh at each intersection; and stand 42 x 24 x 84 in. for storing military equipment ranging from personal items to heavier gear.

“These lockers aren’t just for soldiers, however,” said Stairman. “If these lockers are good enough for Uncle Sam, they’re good enough to hold anything civilians can throw at them. Their large size makes them great for multipurpose storage in the garage or sports equipment storage, and their high-security factor makes them ideal for storing expensive equipment at the office.” ♦

Fig. 12 — A rail board (center) gets placed between a warehouse’s interior and a railcar. (Photo courtesy of Bluff Manufacturing.)

Fig. 13 — Omni-Pro’s patented link assembly features zero-tension, 360-deg smooth welds that are strong and easy to clean. (Photo courtesy of Ashworth Bros.)

Fig. 14 — The TA50 army all-welded locker features a stainless steel coat rod and 16-gauge shelves. It stands tall at 42 x 24 x 84 in. (Photo courtesy of A Plus Warehouse.)
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Properly identifying the cause of weld flaws and implementing corrective measures can help welding operators minimize downtime and its associated costs.

Weld flaws come in all shapes, sizes, and degrees of severity. Yet one thing holds true regardless of the application or material on which they occur: They are a common, and costly, cause of downtime and lost productivity. They are also an occurrence that even the most skilled welder can experience.

In the gas metal arc welding (GMAW) process, specifically, there are several typical weld flaws that can transpire. From porosity to undercut and melt-through, each has multiple causes. Fortunately, there are also numerous cures that can help welding operators minimize their frustration over weld flaws and get back to work faster.

**Porosity**

When gas becomes trapped along the surface or inside of the weld metal, porosity occurs — Fig. 1. Like other weld flaws, porosity results in a weak weld that should be ground out and reworked.

**Causes:** Typically, inadequate or contaminated shielding gas is the culprit of porosity. Using a nozzle that’s too small for the application, or a nozzle full of weld spatter, can also cause this weld flaw. Having a dirty base metal and/or extending the welding wire too far beyond the nozzle is an additional cause. Air currents from cooling fans can disrupt the shielding gas envelope around the weld pool creating this problem. Another common cause is a poor seal or a loose fitting in the shielding gas channel through the welding gun. Any gas leaks have the potential to aspirate air into the gas flow and cause porosity.

**Cures:** To correct porosity, ensure that there is adequate gas flow (increasing it as needed), and replace any damaged gas hoses or GMAW gun components that may be causing leaks. Also, place a welding screen around the work area if welding outside or in an area inside that’s particularly drafty. Check that...
Several solutions are provided for reducing porosity, melt-through, incomplete joint penetration, undercutting, and hot cracking

BY VIC LUBINEIECKI

the nozzle used is large enough for the application and replace with a larger one if it's not. Remove any spatter buildup in the nozzle. Extend the welding wire no more than ¼ in. beyond the nozzle and make certain that the base metal is clean prior to welding. Slowing travel speed to gain greater shielding gas coverage can also combat porosity.

Melt-Through

Just as its name implies, melt-through results when the weld metal penetrates fully through the base metal, essentially "melting through" it. It's most common on thin materials, particularly those that are ¼ in. or less.

Causes: Excessive heat is the primary cause of melt-through. Having too large of a root opening on the weld joint can also result in melt-through.

Cures: If melt-through occurs, lowering the voltage and/or wire feed speed can help rectify the problem. Increasing travel speed helps, too, especially when welding on aluminum, which is prone to heat buildup. If a wide root opening is the suspected cause of melt-through, increasing the wire extension and/or using a weaving technique during welding can help minimize heat input and the potential for melt-through.

Incomplete Joint Penetration

Incomplete joint penetration results when there's shallow fusion between the weld metal and the base metal, rather than complete joint penetration of the joint — Fig. 2. It can often lead to weld cracking and joint failure.

Causes: Insufficient heat input and improper joint preparation are the main causes of incomplete joint penetration. The shielding gas mixture, wire diameter, and incorrect gun angle can also be factors.

Cures: There are several cures for incomplete joint penetration, including using higher wire feed speed and/or voltages. Reducing travel speed also allows more weld metal to penetrate the joint, as does preparing and designing the joint properly. The joint should allow the welding operator to maintain the proper welding wire extension (no more than ¼ in. beyond the nozzle) and still access the bottom of the weld joint. Make sure that the shielding gas or gas mixture, wire type, and diameters are recommended for the application.

Undercutting

Undercutting is a groove or crater that occurs near the toe of the weld. When this weld flaw occurs, the weld metal fails to fill in that grooved area, resulting in a weak weld that's prone to cracking along the toes.

Causes: Excessive heat, as well as poor welding techniques, can lead to undercutting on a weld joint.

Cures: Reducing the welding current and voltage is the first step to rectifying undercutting. Using a weaving technique in which the welding operator pauses slightly at each side of the weld bead can also help prevent this weld flaw. Additional cures include reducing travel speed to a rate that allows the weld metal to fill out the joint completely and adjusting the angle of the GMAW gun to point more directly toward the weld joint.

Hot Cracking

Hot cracking typically appears along the length of a weld or directly next to it almost immediately after the weld pool solidifies. This weld flaw occurs at temperatures greater than 1000°F (538°C). There are multiple variations of hot cracking including centerline, bead shape, and crater cracks.

Causes: Hot cracking can result from several factors. These include poor fitup or joint design, creating too thin of welds and welding at too high of voltages. High levels of base metal impurities can also cause this weld flaw. In some cases, high levels of specific alloys (boron, for example) in filler metals can cause the problem.

Cures: Having the proper joint design and good part fitup is one way to help prevent hot cracking, as it keeps the weld pool the appropriate size and minimizes the chance of the throat of the weld being too thin. In the case of crater cracking, in par-

VIC LUBINEIECKI (info@bernardwelds.com) is an account manager for the Bernard (www.bernardwelds.com) and Tregaskiss welding equipment companies.
Incomplete Fusion

When the weld metal fails to completely fuse with the base metal or with the preceding weld bead in multipass applications, incomplete fusion can occur — Fig. 3.

Causes: Most often the cause of incomplete fusion is an incorrect gun angle, although contaminants on the base metal can also cause this weld flaw. In some instances, insufficient heat can be the culprit.

Cures: First, clean the base metal properly prior to welding, making sure it’s free of dirt, oil, grease, or other debris. Next, welding operators should place their GMAW gun at an angle of 0 to 15 deg to access the groove of the weld joint fully and keep the arc on the leading edge of the weld pool. Increase travel speed as necessary to keep the arc from getting too far ahead of the weld pool. For joints requiring a weaving technique, holding the arc on the sidewall for a moment can help prevent incomplete fusion. Make certain, too, that there’s enough heat input to fuse the weld metal and base metal fully. Increase the voltage range and adjust the wire feed speed as necessary to complete the weldment.

Conclusion

Remember, even the most skilled welders can experience weld flaws. The key to keeping them from affecting productivity and increasing costs in the welding operation is to identify and rectify the problems as quickly as possible. Proper maintenance of the welding equipment is also imperative. Repair or replace any worn or defective items.

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Understanding Stress Corrosion Cracking of Welds in Nuclear Reactors

BY JOSE RAMIREZ

The most critical corrosion problem in pressurized water reactors is primary water stress corrosion cracking of nickel-based alloys

Aging of water-cooled nuclear reactors and increasing demand for energy are likely to raise the severity of service of structural materials and their susceptibility to failure in nuclear plants. Figure 1 shows a schematic of a pressurized water reactor (PWR) and of a PWR nuclear plant. Different structural materials are used in the primary and secondary sides of pressurized water reactors (PWRs) in nuclear power plants (Ref. 1). Nickel-based alloys are used because they offer better resistance to chloride stress corrosion cracking (SCC) than stainless steels and have a coefficient of thermal expansion similar to the low-alloy steels used for reactors. The Ni-based alloys used in PWRs are listed in Table 1. Durability of Ni-based alloy welded joints and their susceptibility to PWSCC (Ref. 7) has been observed in several primary circuit welds (Ref. 7). It has been observed preferentially in weld repairs made to eliminate hot cracking, which may have induced high residual stresses (Ref. 1). Some cracking has been observed in surface cold-worked areas and the cracks seem to start earlier in the base metal (BM) than in the weld metal (WM) (Ref. 8). This has triggered further in-service crack monitoring and experimental investigations. This article presents a general summary of metallurgical factors influencing PWSCC of Ni-based alloy welded joints, as well as some aspects of PWSCC control.

PWSCC of Welded Joints

There are some unique characteristics of Ni-based alloy welded joints and their susceptibility to PWSCC (Ref. 4), including high yield strength, which produces high residual stresses and high stress intensity factors (K), making them more susceptible to SCC. Postweld heat treatments (PWHT) normally required for low-alloy steels can induce some increase in yield strength, potentially exacerbating chromium (Cr) depletion, while reducing peaks in residual stresses. Additionally, hot cracking or other defects may occur in some Alloy 182 heats and welds. These cracks may affect weldment integrity, eliminate the crack nucleation phase, and accelerate SCC by increasing the stress intensity if part of the crack front is hot cracked. Finally, chemical composition at weld metal grain boundaries (interdendritic) may be different than for wrought materials and contribute to SCC. Figure 3 shows some of the microstructural characteristics observed in Ni-based alloy welded joints used in nuclear applications.

Cracking Susceptibility of Heat-Affected Zones

The microstructure of Alloy 600 or 690 in the mill-annealed or heat-treated conditions may be classified into two groups: 1) structures in which precipitates M7C3 are intergranular; and 2) structures in which precipitates are mainly intragranular. The microstructural development is mainly dependent on carbon content, thermomechanical history, and heat treatment. The SCC susceptibility is associated with the microstructure type, where intergranular precipitation is preferred (Ref. 9).

The effect of carbide precipitation on SCC in a deoxygenated environment can be interpreted in different ways, most of which assume that intergranular precipitation affects microdeformation behavior and the resultant crack tip strain rate. Grain boundary (GB) precipitates seriously slow down intergranular slip. On the other hand, intragranular precipitation increases intergranular slip by passing on creep strain to the grain boundaries. Additionally, GB precipitates may act as low-

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energy dislocation sources, thereby producing more homogeneous plastic deformation at the crack tip. This plastic deformation may relieve stresses and may lead to blunting that slows down crack progress.

Another important metallurgical factor is the degree of plastic deformation applied or induced in the welded joint, which increases the PWSCC crack growth rate (CGR) (Ref. 10). Cold work larger than 2% has a strong influence on CGR (Ref. 11). The most significant influence of cold work on CGR occurred in the first 5% of deformation, increasing less rapidly with increased cold work. There are several sources that can cause plastic deformation in plant components before service, such as surface finishing, fabrication, installation, welding, etc.

During welding, thermal cycles can change the material properties in the heat-affected zone (HAZ) and dissolve carbides, produce high localized residual stresses and strains, and promote SCC in the HAZ. However, contradictory results have been reported regarding the relative susceptibility to SCC of different regions of welded joints.

Some studies have shown that SCC growth rates in Alloy 600 HAZs are about 30× faster than in Alloy 600 base metals under the same testing conditions, which is attributed to fewer chromium-rich intergranular (IG) carbides and to increased plastic strain in the HAZ (Ref. 12). Additional reported experimental work indicated that the higher CGR in the HAZ was due mainly to induced plastic deformation. Weld residual strains represent the equivalent to that of 20–30% room-temperature tensile strength, with the highest strain forming at the root of the weld near the weld interface (Refs. 13–15).

On the other hand, testing of specimens machined from 600-EN82H-600 narrow groove welds at 360°C (680°F) in hydrogenated deaerated water unexpectedly showed SCC initiation was observed in the BM, rather than the HAZ or WM in most samples (Ref. 12). Cracking in the HAZ was observed only in samples that had been pretrained before testing. Therefore, it was hypothesized that the observed results were due to differences in the level of strain imposed in the different areas of the weld during testing. However, strain analysis showed the Von Mises strain was consistently highest in the weld region; differences were not observed between Alloy 600 and the HAZ region before and after the loading cycle.

The reported results suggest that SCC initiation resistance of welded Alloy 600 joints follows this order: EN82H > Alloy 600 HAZ > Alloy 600, which is unexpected based on the microstructure of the HAZ vs. BM and on prior SCC growth rate studies. The observed behavior may be related to the intragranular microstructure and creep resistance of the various regions of the welded joint, differences in the exposed area of each region (random event), or differences in the film stability due to the higher Cr content in the weld metal.

### Cracking Susceptibility of Weld Metals

Experimental work has shown that initiation of PWSCC in Ni-based weld metals appears to be strongly related to the weld microstructure. Crack growth rate in Alloys 82/182/132 is strongly affected by the orientation of the crack growth with respect to the microstructure (dendrite orientation) (Refs. 16, 17). Cracking has been observed to propagate faster along

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**Table 1 — General Chemical Composition of Nickel-Based Alloys Used in Pressurized Water Reactors (PWRs)**

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Ni</th>
<th>Cr</th>
<th>Fe</th>
<th>Ti</th>
<th>Al</th>
<th>Nb+Ta</th>
<th>Mo</th>
<th>C</th>
<th>Mn</th>
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<td>600</td>
<td>&gt;72.0</td>
<td>14–17</td>
<td>6–10</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>182</td>
<td>Bal</td>
<td>13–17</td>
<td>≤10.0</td>
<td>≤1.0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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</tr>
<tr>
<td>82</td>
<td>Bal</td>
<td>18–22</td>
<td>≤3.00</td>
<td>≤0.75</td>
<td>—</td>
<td>2.0–3.0</td>
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<tr>
<td>690</td>
<td>&gt;58.0</td>
<td>28–31</td>
<td>7–11</td>
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<td>—</td>
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<tr>
<td>152</td>
<td>Bal</td>
<td>28–31.5</td>
<td>8–12</td>
<td>≤0.50</td>
<td>—</td>
<td>1.2–2.2</td>
<td>≤0.50</td>
<td>≤0.045</td>
<td>≤5.0</td>
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<tr>
<td>52</td>
<td>Bal</td>
<td>28–31.5</td>
<td>8–12</td>
<td>≤1.0</td>
<td>≤1.10</td>
<td>≤0.10</td>
<td>≤0.05</td>
<td>≤0.040</td>
<td>≤1.0</td>
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<tr>
<td>800</td>
<td>30–35</td>
<td>19–23</td>
<td>&gt;39.5</td>
<td>0.15–0.60</td>
<td>0.15–0.60</td>
<td>—</td>
<td>—</td>
<td>≤0.10</td>
<td>≤1.50</td>
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<td>&gt;70.0</td>
<td>14–17</td>
<td>5–9</td>
<td>2.25–2.75</td>
<td>0.4–1.0</td>
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<td>—</td>
<td>≤0.08</td>
<td>≤1.0</td>
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<tr>
<td>718</td>
<td>50–55</td>
<td>17–21</td>
<td>Bal</td>
<td>0.65–1.15</td>
<td>0.2–0.8</td>
<td>4.75–5.50</td>
<td>2.8–3.3</td>
<td>≤0.08</td>
<td>≤0.35</td>
</tr>
</tbody>
</table>
the dendrites than across them. Cracking is interdendritic and/or intergranular and the crack path is clearly related to the crystallographic misorientation of the dendrite packets. In the weld metal, the dendrites form long columnar packets mainly along the <001> crystallographic axis in each weld pass that solidifies (Ref. 16). In general, the CGRs of Alloy 182 are higher than those of Alloy 82.

The interface between crystallographic structures with different orientations can be classified into three groups: 1) grain boundaries with misorientation between two adjacent grains greater than 15 deg (these are high-energy GBs and are the most likely to initiate SCC); 2) GBs with misorientation greater than 15 deg but having specific orientation relationships between the two crystallographic lattices, thus resulting in low-energy grain boundaries (these are known as coincident site lattice (CSL)); and 3) boundaries with low angle dendrite packet interfaces with misorientation less than 15 deg.

Examination of welds by orientation image microscopy has showed that a large fraction (70%) of the grain boundaries are random or are grains with high-angle misorientation, which are more susceptible to cracking than those with specific orientation relationship (CSL) boundaries (Ref. 6). The misorientation may affect the strain compatibility across the GB, which may induce or increase the susceptibility to cracking. Additionally, high-angle boundaries may extend from the weld into the HAZ, which may form an easy path for crack propagation.

Primary water SCC initiation during testing has been associated with plastic deformation and high-energy GBs (16 to 40 deg misorientation) that were approximately perpendicular to the surface and, therefore, to the hoop stress imposed to test capsules (Ref. 16). Cracks typically initiated between two grains that did not deform in the same way under stress. This different plastic behavior was associated with the large heterogeneity of composition in the welds, particularly niobium content, between grains.

The only well-known effect of the compositional differences among weld alloys on PWSCC is the influence of Cr (Ref. 17). Reported experimental results indicate that weld metals with 30% Cr are resistant to cracking, with a threshold for PWSCC resistance being between 22 and 30% Cr (Ref. 17). Different weldable filler metals for use with Alloy 690 showed a dramatic decrease in the measured SCC rates with increase of Cr levels from about 20 to >24% (Ref. 18). Depending on the welding conditions, the weld metal adjacent to the weld interface may have lower chemical composition due to base metal weld dilution, and may affect SCC susceptibility.

In operating plants, weld metal Alloys 82 and 182 are used with Alloy 600 and appear to be more resistant to SCC than wrought alloys. It has been reported that using all-weld-metal EN82H, SCC initiation was not observed in specimens loaded to about 30% plastic strain at 360°C and 30 cc/kg H2 after exposure longer than 4000 h. However, Alloy 600 in the annealed condition exhibited SCC after only 1000 h under the same testing conditions. Laboratory CGR testing of Alloy 182 (shielded metal arc welding) showed that the SCC of Alloy 182 was close to the average behavior of Alloy 600 in PWR environments (Ref. 6). Stress corrosion CGR in EN82H weld metal is accepted to be between those of the HAZ and Alloy 600 (Ref. 12).

Cracking Behavior

Observed cracks in weld metals tend not to extend laterally, which is different than cracking observed in base metals such as Alloy 600, which tend to be semi-elliptical in shape (Ref. 16). The unusual shape of PWSCC in Alloy 182 may be linked to the strong microstructural texture of the weld. Weld texture induces many low-energy grain boundaries or portions of GBs with low energy, which are sufficiently distributed in the structure so as to limit the lateral surface extension of the crack propagation. Additionally, uneven cracking is caused when the most susceptible GBs readily separate, producing SCC fingers. The most resistant boundaries do not separate, thereby causing unbroken lattices in the wake of an advancing crack front. Finally, variation in cracking resistance may also be associated with differences in GB structure (mismatch, precipitation, segregation) or the
relative orientation of the GBs to the applied stress. Uneven crack fronts and incomplete engagement of SCC cracks are sources of potential uncertainty in measurement of CGR of welds (Ref. 17).

Relatively large, sharp weld defects such as incomplete fusion could potentially promote PWSCC by acting as stress concentrators (Ref. 17). It has been reported that hot cracking and ductility dip cracking do not play a significant role in PWSCC initiation and propagation. There is no evidence of crack initiation at small acceptable weld flaws such as porosity or slag inclusions.

Control of PWSCC

As shown schematically in Fig. 4, SCC generally occurs after an incubation period as short cracks, starting from pitting or from corrosion at grain boundaries. After reaching a critical length, the cracks enter the SCC propagation stage, in which they grow rapidly. The material life ends as the cracks reach the limit of an allowed length. Different engineering approaches have been tried to control PWSCC including identification of threshold conditions of immunity, prediction of CGR curves, operation and fabrication techniques, and material selection.

There is consistent engineering pressure to control SCC and, therefore, to define threshold conditions below which immunity to SCC exists. However, engineering threshold should not be confused with a genuine regime of immunity to SCC (Refs. 13–15). In 2003, a CGR disposition curve for PWSCC of thick-section Alloy 600 material was reported. This curve has been incorporated into Section XI of the ASME Boiler and Pressure Vessel Code for flaw and integrity evaluation. Around 2004, the need for a similar equation for Alloy 82/182/132 weldments was identified for estimating the remaining life of components and to determine inspection intervals. An international panel of PWSCC experts supported this development, and deterministic CGR curves for Alloys 182/132 and 82 were developed and proposed (Refs. 17, 19).

Mitigation of PWSCC of Ni-based alloys has been tried with different operational and fabrication techniques including operation at reduced temperature, chemical or electrochemical potential control techniques, stress relief heat treatment for U bends, mechanical surface enhancement, and environmental barriers or coatings (Refs. 20–24). Additionally, stress corrosion cracks of IN182 in nuclear plants may be repaired with laser surface melting (Ref. 25). Optimization of repair procedures is required to achieve the right penetration without defects. Compared with gas tungsten arc welding repair techniques, laser beam welding offers high precision, reliability, efficiency, and productivity.

In addition to water chemistry control, the main remedy for SCC of Alloy 600 has been replacement with Alloy 690 and its compatible weld alloys (IN152 and 52), which have been resistant to SCC in primary water both in severe laboratory testing and after more than 17 years in service (Ref. 1). It has been reported that SCC cracks hardly propagate in either weld metal or base metal of Alloy 690 (Ref. 26).

Cold-worked (20 and 40%) Alloy 690 and as-deposited weld metal Alloys 152 and 52 (10 to 15% weld strain) have been tested in representative PWR primary water at 340° and 360°C (Ref. 27). Intergranular cracking was observed in Alloy 690 at constant K but no evidence of interdendritic cracking was observed in the weld metals. Even in the presence of various accelerants (elevated temperature, peak H2, cold work, and/or gentle cyclic loading, and moderately high K [27.5 to 38 MPa-m1/2]), CGRs in most cases were in the range of 1 to 10 x 10^-9 mm/s (Ref. 27). With these low CGRs, which are 100 to 400 times lower than industry standards for Alloy 600 and 182 weld metals and of little engineering significance, components would likely last hundreds of years.

One of the most important differences observed between Alloys 690 and 600 pertains to the intergranular carbides present (Ref. 26). Coherent Cr23C6, which is coherent to one side of the base lattice, is dominant in both weld metal and base metal of Alloy 690, while incoherent M7C3 is dominant in Alloy 600 base metals, and incoherent NbC is dominant in Alloy 600 weld metal. According to these results, it is considered that the effect of intergranular carbide on PWSCC is stronger than the other metallurgical factors such as GB character distributions and hardness. It seems that coherent Cr23C6 has the strongest effect on inhibiting PWSCC propagation.

Additionally, differences in depletion of Cr at the grain boundaries have been observed in Alloys 600 and 690 (Ref. 26). In the Alloy 600 system (BM and WM), the observed minimum Cr was between 10 and 15%, but in the Alloy 690 system (BM and WM), the observed minimum Cr was above 15%. Therefore, Cr depletion at GBs could be another factor in the intergranular character of SCC and the faster CGR observed in Alloy 600 as compared to Alloy 690.

Alloy 690 with a high fraction of special grain boundaries, achieved through thermomechanical treatment, has better resistance to SCC (Ref. 28). The special GBs (fraction of low angle boundaries and coincident site lattice boundaries) disturb the connectivity of the random high-angle boundary network.

Acknowledgment

This work was part of a state-of-the-art review on SCC in the nuclear industry supported by the Nuclear Fabrication Consortium (NFC) and its member companies as part of their support and dedication to reestablishing the North American nuclear supply base.

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How to Avoid Gas-Related Weld Flaws

On-site gas blending systems impact weld quality and profitability

BY RICHARD GREEN

A pinch of this and a little of that is how grandmother used to bake in the kitchen. While that loose type of recipe might have worked for Grandma, that system doesn’t cut it in today’s metal fabrication industry where repeatability plays an important role in weld quality and profitability.

Argon is a primary component in mild steel welding shielding gas. However, depending on factors like thickness, chemistry, position, deposition rate, and penetration requirements, components such as oxygen, helium, and carbon dioxide are added. The following discussion relates the gas component physical properties that the operator must consider to balance productivity gains while avoiding potential weld defects like undercut, incomplete joint penetration, and porosity.

These minor component gases can be supplied via premixed high-pressure cylinders or, if economics permit, an on-site shielding gas blending system. Factors such as blending technology, gas supply, and piping impact the repeatability of the on-site blending system.

Figure 1 illustrates a typical gas-blending system. There are two common types of blenders; both have advantages and disadvantages. The simplest is the proportional blender. This design maintains equal pressure into the mixing chamber by using the incoming supply of one gas component to pilot both inlet gas source regulators. The major advantage of the proportional blender is low cost and a nonelectric design.

The pressure differential gas mixer controls the pressure drop across the mixing chamber by adding a surge tank, electric pressure switch, and solenoid valve as illustrated in Fig. 2. The solenoid valve stops the gas flow out of the mixing chamber under low-use conditions. This prevents a poor mixture from filling the surge tank and pipeline. The pressure switch maintains the surge tank pressure between 58 and 72 lb/in.². The switch activates the solenoid valve to open and close, allowing gas from the mixing chamber to fill the surge tank. The surge tank provides a buffer while the mixing chamber replenishes the consumed mixed gas.

The pressure differential mixer requires an external electrical supply and periodic maintenance of the pressure switch and solenoid valve related to normal wear and tear.

The cumulative properties of the blended shielding gas directly impact weld quality. For instance, arc initiation impacts productivity and weld quality by the ease in which the shielding gas establishes a plasma or flow of free electrons from the workpiece to the electrode (direct current electrode positive (DCEP)). Arc initiation is influenced by the ionization potential of the gas. This is the energy required to remove the outermost orbiting electrons from the molecule. It takes less energy expressed in electron volts to remove the electrons from higher molecular weight gases like argon and oxygen. This is because of the greater distance of the outer orbit from the nucleus. Conversely, the power supply must provide greater energy by increasing arc voltage in order to overcome the attractive force of the smaller helium nucleus.

Blender inaccuracy can lead to a gas mixture rich in argon, which leads to undercuts. As the proportion of argon increases, the arc lengthens, which increases the voltage from the electrode tip to the weld joint. The energy across the arc fans out, increasing pool fluidity. As the base...
material flows, it leaves a concave (undercut) area around the weld bead edges as illustrated in Fig. 3. In some cases, 1–5% oxygen may be added to argon to achieve superior arc stability and better tie-in (wetting) at the weld edge without the undercut.

Gas density is the weight per unit of volume, which can be expressed as lb/ft³. The greater the density, the more effective the shielding gas displaces air around the molten weld pool as it solidifies. Heavy gases require less flow to cover the weld pool from the atmosphere, which minimizes consumption and cost.

Incomplete joint penetration can also result from an inaccurate blend, as illustrated in Fig. 4. Thermal conductivity is another property that affects shielding gas performance. Thermal conductivity depicts the molecule’s ability to conduct heat. Argon-based shielding gases produce narrow penetration profiles because of the heat distribution is less than with other mixtures. Oxygen tends to provide a wider but shallower penetration profile as compared to carbon dioxide mixtures because of its lower ionization and higher thermal conductivity properties. Oxygen additions tend to yield better toughness and yield strengths because of the absence of carbon retention associated with carbon dioxide mixtures. For instance, CO₂ with its low thermal conductivity constricts the energy across the arc, elevating the driving force and subsequent penetration. Helium has the highest thermal conductivity listed in Fig. 5. Molecules like helium conduct the most heat away from the plasma producing a wider and hotter arc with less penetration.

Carbon dioxide mixtures of 8–15% are flexible enough to facilitate both spray and short circuit transfer modes in gas metal arc welding (GMAW). Shielding gas development has led manufacturers to design three-component gas blends that offer the benefits of both carbon dioxide and oxygen additions to argon-based mild steel gas metal arc applications.

Undercut and incomplete joint penetration can also result from an undersized gas supply system. On-site mixers can be supplied by bulk tanks, micro-bulk, liquid cylinders, or high-pressure cylinders. The minimum usage threshold to convert from high-pressure cylinders to an on-site mixing system is usually 2200–3000 ft³ per week. The advantages are higher productivity and lower gas costs. Bulk tanks require an external vaporizer that converts liquid to gas. Micro-bulk and liquid cylinders offer both liquid and gas phase withdrawal. Problems can arise when the mixer demands higher input than what the cylinders internal gas vaporizing coils can generate. Ice then forms on the valves and sides of the liquid cylinder as illustrated in Fig. 1. As a result, the coils become saturated and the gas temperature falls below the 32°–100°F range for which the mixing valves are designed. The gas density increases, which causes an imbalanced mixture. As a result, the mixture will become richer in either component causing undercut or incomplete joint penetration for reasons similar to those described previously.

Gas consumption patterns will impact the on-site mixing system. As demand increases, the pressure differential mixer’s solenoid valve stops cycling on and off after 500 ft³/h for mixers under 1000 ft³/h capacity. This places a continuous demand on the supply system to maintain pressure to the mixture between 100 and 125 lb/in.². If one component drops out of this range, the mixture will vary. When using liquid cylinders, it is necessary to match the mixer’s maximum flow capabilities with the correct number of liquid cylinders. A standard liquid cylinder can deliver gas at up to 350–400 ft³/h for approximately 1–2 hours of continuous withdrawal. Beyond this, the cylinder’s outlet pressure begins to drop to the mixer. A manifold is required for supplying multiple cylinders to meet the mixer’s consumption. Unfortunately, each cylinder’s pressure-building circuit operates at different pressures allowing one to dominate and close the check valves of the others. Connecting the vents together causes the vent pressure to equalize, increasing the manifold gas with-
A fully automatic switchover optimizes the use of liquid or high-pressure cylinders. This flexibility enables the customer to reduce monthly cylinder rental costs by taking advantage of the best mode of supply for each gas component. A liquid argon can primary with a can in reserve provided the lowest cost position with minimal residual or vent losses. Economically, it makes more sense to use a liquid CO₂ cylinder as the primary with four 50-lb high-pressure CO₂ cylinders as a backup because of the minor component's low flow requirement.

Finally, a monthly gas consumption exceeding 75,000 ft³ necessitates the use of a bulk or micro-bulk tank. The main benefit of a bulk system is lower product cost and reduced handling. However, the total cost also involves high monthly facility fees, product vent loss, and delivery charges. Now that Grandma's recipe has been quantified, the operator can utilize physical gas properties to optimize arc initiation and productivity while minimizing defects such as undercut and inadequate joint penetration.

Couple the right gas ingredients with the proper mixing utensils such as an on-site gas-blending system, and you have a recipe for success.

Fig. 6 — A fully automatic switchover optimizes the use of liquid or high-pressure cylinders.
The BRAZIL WELDING SHOW 2011 is the first specialized trade show dedicated to welding technology in Brazil. It joins forces with the Corte & Conformação de Metais, the largest trade show for metal forming and fabricating in South America, which is being held concurrently with the BRAZIL WELDING SHOW. Show organizers Messe Essen and Aranda Eventos are supported by DVS – German Welding Society and the AWS – American Welding Society. AWS and Essen Trade Shows USA are jointly organizing a US Pavilion. For further information, please contact:

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For Info go to www.aws.org/ad-index
As locomotives increase in speed, many components need to be welded and repaired due to serious abrasion. Among them, the wheel flanges and core wheel from the engine are subject to intense wear (Ref. 1). Abrasion in the core wheel results in an undersized wheel, which becomes useless after it has been repaired several times. In this case, maintenance cost is obviously increased and its use is limited. The statistical data show that 60~70% need to be repaired because of excessive abrasion. The main welding (Refs. 4, 5) methods for the wheel flange and core wheel focus on gas metal arc welding with CO₂ (Refs. 2, 3) and submerged arc welding (Refs. 6, 7). Because of its simplicity of operation and stable weld quality, CO₂ welding is used the most for surface welding the flange and core wheel. But when the core wheel is welded in the vertical position, the welding efficiency is low, as is the weld quality. Moreover, the usual flat position welding process can't be directly adopted in welding repair because of the complicated surface wear in the core wheel (Ref. 8). In view of this situation, an automatic surfacing welding machine was developed — Fig. 1.

The Mechanical System of an Automatic Surface Welding Machine

Mechanical Structure

The mechanical parts of the welding machine mainly consist of the headstock, spindle and chuck, welding gun mobile mechanism, wire feeder, stand, and protective shield. The schematic diagram of the structure is shown in Fig. 2.

The rotary headstock consists of a DC servo motor, the annular encoder, pneumatic clutch, conduction mechanism, worm and worm wheel's rotary headstock, and spindle and chuck. This latter part is the key to controlling the core wheel mechanically. The spindle and chuck structure is shown in Fig. 3.

By rotating the workpiece vertically, the welding surface becomes horizontal to avoid the collapse of the molten metal. After changing speed through the planetary gearbox, the worm and worm wheel are rotated by the DC servo motor. The workpiece is clamped by a pneumatic clutch between the worm wheel and spindle, which is controlled by two cylinders controlled by a reversing valve. The worm and worm wheel rotate the spindle, chuck, and workpiece. Conductive copper loops and copper brushes are installed on the spindle to ensure the welding circuit reliability and to avoid inaccuracy of the spindle when welding current flows through the bearing part.

The chuck has a pair of V-shaped clamping jaws, and a large-diameter twin-thread screw across its middle. The workpiece can be clamped or unfastened by operating the V-shaped clamping jaw, which is controlled by a pneumatic wrench. The rigid ejector pin in the middle of the chuck is used to support an expanding arbor, and the two shrinkage pools beside the chuck are used for inserting the drive pin. The above equipment is usually used to weld the external face of the wheel flange — Fig. 4. Regulation of a stepless speed SCR can control the rotational velocity of the chuck. In order to adapt to welding different types of holes, one rotary encoder is installed at the end of the DC servo machine within the same axis. When the DC machine starts, the encoder sends out a synchronous pulse, and then the pulse is sent to the programmable logic controller’s high-speed counting apparatus.

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The movement of the welding gun is adjusted by calculating and counting the pulse. Here, the pulse of the encoder is 200 T/r. If the rated revolution of the servo motor is 3000 rpm, the pulse frequency of the encoder will be 3000 x 200 = 600,000 T/min, which equals 10 kHz. The encoder will send out 200,000 pulses after a rotation of the spindle.

The tailstock and expansion body are designed to weld the external face of the wheel flange. As shown in Fig. 5, the internal hole of the wheel is held by an expansion body, and the screw nut on the expansion body is tightened by a special wrench. Then the axis is fixed between the chuck center and tail center by the tailstock. The workpiece and chuck rotate together when the drive pin is inserted in the chuck. The machine is capable of multiple functions.

The movement of the welding gun is controlled mainly by a longitudinal and horizontal traveling mechanism — Fig. 6. The AC dynamo and the screw rod are installed at the top of the column. The welding gun's longitudinal and horizontal movement mechanism is installed on the horizontal arm. The two directions are transformed by a stepping motor. A ball screw and a linear guide ensure the smooth movement of the welding gun. The welding gun is fixed in a lever that can be folded, so welding can occur at any angle and position. The welding wire is placed in the wire feeder, which is at the back of the horizontal arm.

The Operating Principles of the Automatic Welding Machine

The principle of the mechanical parts of the machine is shown in Fig. 2. After the clutch is separated by the cylinder, which is controlled by a reversing valve, the workpiece is clamped and hoisted to the working position. The workpiece can be fastened by the V-shaped clamping jaw. The pneumatic wrench is used to spin a twin-thread screw. Then, the clutch is contacted by a manually operated reversing valve to control the cylinder. The welding gun can be moved to the initial position and the wire extension can be adjusted by the cross-shaped operation handle on the panel of the portable remote control box. According to the requirements of the welding procedure, the machine can set the rotation direction of the workpiece on the panel of the portable remote box. The current, voltage, and welding speed also can be preset on the panel. Depending on the length of the weld on the workpiece, the number of weld passes can be preset by operating the counter located in the middle of the panel's main control. Depending on the welding position of the workpiece, the movement direction of welding gun can be chosen by operating the horizontal/vertical option switch in the middle of the main control panel.
welding gun is displaced at the starting position by operating the cross-shaped operation handle. After the welding preparation process is finished, the automatic welding machine can be started. The welding arc stops automatically when the number of weld beads reaches the preset value.

The Control System

There are many control components in the main control cabinet, such as PLC, step motor driver, DC motor driver control panel, control transformer, AC contactor, and intermediate relay, and this machine can be operated manually and automatically. A weld switch button, emergency stop button, and vertical/horizontal option switch are set in the panel. Also, three numeral meters are set in the pane, which display the moving speed of the welding gun, the rotating speed of the spindle, and preset number of weld beads.

The programmable logic controller is the core of the whole control system. Partial functions are set through a preset procedure. The main control knobs include rotary table speed, which controls the rotational speed of the workpiece; welding gun speed; welding current; welding voltage; cross arm; welding wire; welding gun adjustment; and turntable.

The PLC control system has 16 input points and 10 output points depending on the specific case. Input points are both analogue value and switching value, while all the output points are switching value. The 8 input and 6 output points of switching value, can completely meet the input and output demands.

The Parameters of the Welding Machine

The main technical parameters of the machine are shown in Table 1. The welding parameters are shown in Table 2. The workpiece is large and its weight ranges from 500 to 800 kg, so the stand consists

Table 1 — The Main Technical Parameters of the Automatic Surface Welding Machine

<table>
<thead>
<tr>
<th>Name</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input power</td>
<td>30 kVA</td>
</tr>
<tr>
<td>Welding current</td>
<td>60~500 A</td>
</tr>
<tr>
<td>Welding voltage</td>
<td>15~40 V</td>
</tr>
<tr>
<td>Maximum OD of workpiece</td>
<td>1100 mm</td>
</tr>
<tr>
<td>Smallest ID of workpiece</td>
<td>200 mm</td>
</tr>
<tr>
<td>Length of workpiece</td>
<td>≤600 mm</td>
</tr>
<tr>
<td>Maximum weight of workpiece</td>
<td>≤800 kg</td>
</tr>
<tr>
<td>Horizontal arm upper-and-lower movement speed</td>
<td>1500 mm/min</td>
</tr>
<tr>
<td>Protective atmosphere</td>
<td>CO₂ or 70%Ar + 30% CO₂</td>
</tr>
</tbody>
</table>

Table 2 — Typical Specifications of Welding Wheel Flange and Core Wheel

<table>
<thead>
<tr>
<th></th>
<th>The welding process of repair welding wheel flange</th>
<th>The welding process of repair welding core wheel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding current</td>
<td>260~280 A</td>
<td>220~250 A</td>
</tr>
<tr>
<td>Welding voltage</td>
<td>25~28 V</td>
<td>23~26.5 V</td>
</tr>
<tr>
<td>Flow of protective atmosphere</td>
<td>25 L/min</td>
<td>23 L/min</td>
</tr>
<tr>
<td>Welding speed</td>
<td>500~550 mm/min</td>
<td>450~500 mm/min</td>
</tr>
</tbody>
</table>
of a steel H section. A shield can be set to protect the operator from the arc, and allow convenient observation. An observation window with eye protection can be opened at the front part of the protective shield. At the top of the protective shield, there is an exhaust opening to get rid of smoke and dust during welding.

Conclusion

The special automatic welding machine is successful in repairing the damaged surface of locomotive wheels. The results show that a smooth surface is obtained with the repair machine (Fig. 7), and welding can be performed with efficiency. At the same time, it reduces labor intensity and improves the operational environment. It satisfies the demand of work and has been successfully used at the Chengdu Locomotive Carriage Works of China since 2005.

Acknowledgments

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


China Aerospace & Aviation Technology Show (CAATS), Nov. 1–5. SNIEC, Shanghai, China; www.caats.aero/.


♦ FABTECH. Nov. 14–17. McCormick Place, Chicago, Ill. This exhibition is the largest event in North America dedicated to showcasing the full spectrum of metal forming, fabricating, tube and pipe, welding equipment, and myriad manufacturing technologies. Contact American Welding Society, (800/305) 443-9353, ext. 264; www.fabtechexpo.com or www.aws.org.


♦ 5th Int'l Brazing and Soldering Conf. April 22–25, Red Rock Casino Resort Spa, Las Vegas, Nev. A joint activity of the American Welding Society and ASM International®, it brings together scientists and engineers from around the world who are involved in the research, development, and application of brazing and soldering. www.asminternational.org/IBSC.

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Weld Smarter With Total Welding Management

Implementing the principles and concepts in this book could save you $15,000 to $25,000 annually per welder.

Drawing on more than 50 years of welding experience, author Jack R. Barckhoff, P.E., gives you a solid step-by-step plan to manage your welding operations for maximum productivity and cost efficiency. Specific recommendations and real-life production examples illustrate how your welding team can realize productivity gains of 20 percent to 50 percent. Total Welding Management explains the management principles, structure, and details you need to transform your welding operations from a cost center into a profit center. A must-read for supervisors, managers, and executives who seek to make their welding operations more efficient and more productive. 185 pages, 35 figures, 20 tables, hardbound.


Order code: AWS TWM, $49.50

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Educational Opportunities


Bridge Coating Inspector Training/Certifications. August 1–6, deadline to register is July 11. Pompano Service Plaza on Florida’s Turnpike, Pompano Beach, Fla. The Society for Protective Coatings, www.sspc.org; (877) 281-7772, ext. 2202.


Certified Welding Supervisor Preparation with Exam. Two-week-long class beginning Sept. 1. Hobart Institute of Welding Technology, Troy, Ohio; www.welding.org; hiwt@welding.org; (800) 332-9448.

Fundamentals of Brazing Seminar. July 26–28, Sheraton Chicago O’Hare Airport, Rosemont, Ill.; Sept. 27–29, Crowne Plaza Irvine, Orange County, Calif. For designers, processing, manufacturing, and quality engineers, managers, production supervisors, and brazing operations personnel with all levels of brazing experience. Lucas-Milhaupt, www.lucasmilhaupt.com; (800) 558-3856.


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

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


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### Seminars, Code Clinics, and Examinations

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

### Certified Welding Inspector (CWI)

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SEMINAR DATES</th>
<th>EXAM DATE</th>
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<tbody>
<tr>
<td>New Orleans, LA</td>
<td>July 10-15</td>
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<td>Phoenix, AZ</td>
<td>July 10-15</td>
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<td>Los Angeles, CA</td>
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<td>Sacramento, CA</td>
<td>July 17-22</td>
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<tr>
<td>Kansas City, MO</td>
<td>July 24-29</td>
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<td>Cleveland, OH</td>
<td>July 24-29</td>
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<td>Louisville, KY</td>
<td>July 24-29</td>
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<td>Denver, CO</td>
<td>July 31-Aug. 5</td>
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<td>Seattle, WA</td>
<td>Aug. 21-26</td>
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<td>Houston, TX</td>
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<td>Minneapolis, MN</td>
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<td>Tulsa, OK</td>
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<td>Long Beach, CA</td>
<td>Oct. 16-21</td>
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<td>Newark, NJ</td>
<td>Oct. 16-21</td>
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<td>Portland, OR</td>
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<td>Atlanta, GA</td>
<td>Oct. 30-31</td>
<td>Nov. 4</td>
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<td>Dallas, TX</td>
<td>Nov. 6-11</td>
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<td>Sacramento, CA</td>
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<td>Spokane, WA</td>
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<td>Nov. 17</td>
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<td>Syracuse, NY</td>
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<td>Houston, TX</td>
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<td>Reno, NV</td>
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<td>Los Angeles, CA</td>
<td>Dec. 4-9</td>
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<tr>
<td>St. Louis, MO</td>
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<tr>
<td>Corpus Christi, TX</td>
<td>Exam only</td>
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### Certified Welding Supervisor (CWS)

<table>
<thead>
<tr>
<th>LOCATION</th>
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<th>EXAM DATE</th>
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<tbody>
<tr>
<td>Minneapolis, MN</td>
<td>July 18-22</td>
<td>July 23</td>
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<tr>
<td>Miami, FL</td>
<td>Sept. 12-16</td>
<td>Sept. 17</td>
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<tr>
<td>Norfolk, VA</td>
<td>Oct. 17-21</td>
<td>Oct. 22</td>
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CWS exams are also given at all CWI exam sites.

### Certified Radiographic Interpreter (CRI)

<table>
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<tr>
<th>LOCATION</th>
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<th>EXAM DATE</th>
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<tr>
<td>Dallas, TX</td>
<td>July 18-22</td>
<td>July 23</td>
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<tr>
<td>Chicago, IL</td>
<td>Sept. 12-16</td>
<td>Sept. 17</td>
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<td>Pittsburgh, PA</td>
<td>Oct. 17-21</td>
<td>Oct. 22</td>
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<tr>
<td>Allentown, PA</td>
<td>Nov. 7-11</td>
<td>Nov. 12</td>
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The CRI certification can be a stand-alone credential or can exempt you from your next 9-Year Recertification.

### Certified Welding Sales Representative (CWSR)

<table>
<thead>
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<th>LOCATION</th>
<th>SEMINAR DATES</th>
<th>EXAM DATE</th>
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<td>Miami, FL</td>
<td>Aug. 24-26</td>
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<tr>
<td>Indianapolis, IN</td>
<td>Sept. 21-23</td>
<td>Sept. 23</td>
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</table>

CWSR exams will also be given at CWI exam sites.

### Certified Welding Educator (CWE)

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

### Certified Robotic Arc Welding (CRAW)

<table>
<thead>
<tr>
<th>WEEK OF</th>
<th>LOCATION</th>
<th>CONTACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 1</td>
<td>Wolf Robotics, Ft. Collins, CO</td>
<td>(970) 225–7736</td>
</tr>
<tr>
<td>Aug. 1</td>
<td>ABB, Inc., Auburn Hills, MI</td>
<td>(248) 391–8421</td>
</tr>
<tr>
<td>Sept. 19</td>
<td>Wolf Robotics, Ft. Collins, CO</td>
<td>(970) 225–7736</td>
</tr>
<tr>
<td>Oct. 24</td>
<td>Lincoln Electric Co., Cleveland, OH</td>
<td>(216) 383–8542</td>
</tr>
<tr>
<td>Nov. 7</td>
<td>ABB, Inc., Auburn Hills, MI</td>
<td>(248) 391–8421</td>
</tr>
</tbody>
</table>

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

### Senior Certified Welding Inspector (SCWI)

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

### Important:

This schedule is subject to change without notice. Please verify your event dates with the Certification Dept. and confirm your course status before making your travel plans. For information, visit www.aws.org/certification, or call (800/305) 443–9353, ext. 273, for Certification; or ext. 455 for Seminars. Apply early to avoid paying the $250 Fast Track fee.
Corrosion-Resistant Alloys and the New Chrome-Moly Steels
August 16, 17
Charlotte, N.C.

This double-barreled two-day conference in Charlotte will be something a little different in AWS conferences. Day one will be all about the newer corrosion-resistant alloys and will cover such materials as the growing body of duplex stainless steels, the nickel-based alloys, and titanium. The duplex grades are beginning to replace the austenitic stainless steels in some applications and there is much to learn about welding them. Even newer is the introduction of less-expensive duplex alloys; so much needs to be learned about those as well. There’s also a new titanium alloy that could replace the popular 6Al-4V grade. It too will be on the program. Cladding is also playing an increasingly important role in the industry.

Day two will be devoted to another hot topic in welding, the new chrome-moly steels such as the 91, 92, and 911 grades. There are benefits with those, but there is still much to learn. It’s a market cut out for the low-hydrogen consumables. Fabrication is tricky. Great attention must be paid to heat treating and dissimilar metal welding. Also discussed will be the material that to some is an old nemesis, 4130 chrome-moly steel.

14th Annual Aluminum Welding Conference
September 20, 21
Ft. Lauderdale, Fla.

Aluminum lends itself to a wide variety of industrial applications because of its light weight, high strength-to-weight ratio, corrosion resistance, and other attributes. However, because its chemical and physical properties are different from those of steel, welding aluminum requires special processes, techniques, and expertise.

A distinguished panel of aluminum-industry experts will survey the state of the art in aluminum welding technology and practice. The conference will also provide opportunities for you to network informally with speakers and other participants, as well as visit an exhibition showcasing products and services specifically for the aluminum welding industry.

2011 FABTECH Conference Schedule
Chicago, Ill.

National Welding Education Conference
November 13

Presented by the National Center for Welding Education and Training (Weld-Ed), this conference is designed to bring together educators for professional development and networking opportunities. Weld-Ed’s focus is on the preparation of welders, welding technicians, and welding engineers to meet the needs of industry. This conference will include presentations on topics such as Weld-Ed accomplishments in the last year, the partnership between Weld-Ed and AWS, welding industry workforce needs, recruitment tips and tools for educators, competency models, externship programs for educators, tips on partnering with other secondary and postsecondary schools, welding education trends, curriculums, materials science education and applications, distance learning updates, new technology applications, and presentations from welding educators who will share their best practices. For additional information, contact Monica Pfarr at mpfarr@aws.org.

Welding Technology to the Rescue
November 14

A number of major research efforts and technological wizardries are beginning to pay off in big ways throughout industry. The effects are numerous, including huge improvements in productivity, reduced costs, and improvements in quality. Solutions to lingering problems are also being discovered. The trend in new developments is bound to introduce more science into the overall welding scene.

8th Conference on Weld Cracking
November 15

The most perplexing problem in the welding industry has to be weld cracking. This conference is for those who want to get a handle on controlling weld cracking situations. The different types of cracking, their causes, and their solutions will be discussed. Learn how identify the types of cracks, and more importantly, what to do about them.

What’s New in Power Sources?
November 16

Learn about the advanced features and capabilities available on the latest welding power supplies, including multiprocess operation. Transformer-rectifiers and inverters are on a roll. Experts will be on hand to explain many of these innovations.

Thermal Spray Technology: High-Performance Surfaces
November 16

The International Thermal Spray Association (ITSA) and the American Welding Society have organized this one-day educational coatings conference to introduce and highlight various advantages of the thermal spray process. This program will benefit both potential users and those actively involved with thermal spray coatings as it will focus on actual applications and new developments in thermal spray technology. In addition, on Tuesday, Nov. 15, ITSA will sponsor a free half-day tutorial on thermal spray fundamentals titled Thermal Spray Basics: Putting Coatings to Work.
Don’t miss a beat. Don’t miss a sale.
Get certified on your own schedule and save!

New online training and testing for

AWS Certified Welding Sales Representatives

Through the *AWS Certified Welding Sales Representative* program, you can prove you are among the most valuable sales professionals in the welding industry. Train and test online at your convenience. Try a demonstration module right now at www.americanweldingonline.com

*Here’s what sales professionals are saying:*

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

“The AWS Certified Welding Sales Representative Program has provided another value added service for my internal and external customers.”  Greg Pierce, WESCO

“All of my customers have been *very impressed* with this certification due to the prestige and their faith in AWS and their certifications.”  Robert Koczur, Maine Oxy

“I consider myself one of the best in the industry. With this certification, I can tell everybody, ‘Here are my credentials. This is what I know. This is what I’m certified in.’ That gives me the ability to be one step above everybody else. *My competitors—none of them have that.*”  Gilly Burrell, Florida Gas Welding Supply

Free demo at www.americanweldingonline.com
Planning for Weld Repairs

Before starting a preventive maintenance or repair project, it is essential to plan a course of action to include the most appropriate welding repair procedures. After you establish a plan, you should analyze it to confirm the procedures and identify alternative actions before making a final decision. For example, welding on hardenable metals may require a high preheat temperature to avoid cracking; therefore, the effect of thermal expansion on distortion or on adjacent materials may be significant, and must be included as a variable.

Table 1 is a checklist that provides details that can be applied systematically to planning and evaluating welding repairs. The information and this systematic approach can be applied to any repair, whether the defect or damage is in a bridge, building, pressure vessel, or other equipment.

The checklist is not complete or inclusive of every situation, but can be used to supplement the experience of the repair team, which may include the welder, foreman, technician, engineer, superintendent, and owner.

Table 1 — Checklist for Planning Maintenance and Repair Welding

1. Base Metals
   - Is the component a welded fabrication?
   - What is the base metal?
     - Document sources for this information
     - Operating and maintenance manuals and drawings
     - Physical methods of determining the base metal chemistry, strength, and hardness
     - Heat-treated condition of the base metals
     - What are the limitations to weldability for the base metals?
     - Are dissimilar metals to be welded?

2. Defect Type, Location, and Method of Examination
   - Visual examination
   - Nondestructive examination
   - Destructive examination and defect removal
   - Metallurgical examination

3. Defect Repair and Service Conditions
   - Should the defect be repaired?
   - Does the type and nature of the defect permit repair?
   - Does service history preclude repair?
   - Will a repair increase the potential for future failure?
   - Should the component be replaced?
     - Is a replacement less expensive?
     - What is the effect of a replacement on the schedule?
     - Is the defect the result of a design flaw that will reoccur with a replacement?
     - Should the component be used as-is?
     - What is the basis for allowing return to service?
     - Are there specific limitations in service time or operation that must be followed?
     - Do the responsible design engineers and other interested parties accept the use-as-is disposition?

4. Preparation of the Defective or Worn Component
   - Is the area accessible for repair and inspection?
   - Are straightening or other operations required before weld repair?
   - Can a clean and safe working environment be ensured?
   - Can the defect be completely removed?

5. Distortion and Shrinkage
   - What are the structural and thermal restraints?
   - What are the process restraints?
   - What mitigations are necessary (e.g., preheat, postweld heat treatment, peening, or other)?

6. Codes, Standards, and Regulations
   - Industry codes and standards
   - Industry regulations, such as state or federal laws
   - Customer or original equipment manufacturer (OEM) specifications
   - Applicable welding codes, standards, and guidelines
   - Military specifications

AWS Nominates National and District Officers for 2012

William Rice Jr.  
president

Nancy Cole  
vice president

Dean Wilson  
vice president

David Landon  
vice president

The 2010–2011 Nominating Committee has announced its slate of candidates who will stand for election to AWS national offices for the 2012 term, which begins Jan. 1, 2012.

Nominated are the following candidates: William Rice Jr. for president; Nancy Cole, Dean Wilson, and David Landon for vice presidents; and Matthew Lucas and Thomas Siewert 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 Victor Matthews. Serving on the committee with Matthews were Bruce Albrecht, Alfred Fleury, J. Jones, Gene Lawson, Thomas Lienert, Joe Livesay, Steve Mattson, David McQuaid, Tully Parker, Nanette Samanich, Eftihios Siradakis, and Ken Stockton. Gricelda Manalich served as Secretary.

The Nominating Committees for Districts 3, 6, 9, 12, 15, 18, and 21 have selected the following candidates for election/reelection as District directors for the three-year term Jan. 1, 2012, through Dec. 31, 2014. The nominees are Mike Wiswesser, District 3; Ken Phy, District 6; George Fairbanks, District 9; Dan Roland, District 12; David Lynnes, District 15; John Bray, District 18; and Nanette Samanich, District 21.

Nominated for President  
William A. Rice Jr.

Rice, an AWS member for more than 25 years, is currently completing his third 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. Rice holds a degree in business marketing with postgraduate work in journalism, psychology, and labor relations.

Nominated for Vice President  
Nancy C. Cole

Cole is completing her second term as a vice president. She is an AWS Fellow, a Life Member, and a registered Professional Engineer in the state of Tennessee. She served as chair of the AWS Technical Activities, Fellows, and C3 Brazing and Soldering Committees, and has served on numerous technical committees. She has received the Wassermaun Award, McKay-Helm Award, AWS Honorary Member Award, and Outstanding Alumni Award from University of Tennessee, and 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.

Nominated for Vice President David J. Landon

Landon, currently District 16 director, a Senior Certified Welding Inspector, and an AWS member since 1983, is manager of welding engineering and missions support at Vermeer Mfg. Co. where he has worked since 1992. From 1985 to 1992 he operated Landon’s Welding Services performing failure analysis, welding inspections, and welder training. Earlier he worked as a welding engineer for Chicago Bridge and Iron Co. on a variety of projects. He has served on numerous AWS technical committees, as a Delegate to the IIW Commission XIV, Welding Education and Training, and member of the Planning and Zoning Commission for the city of Pella, Iowa.

Nominated for Director-at-Large Matthew J. Lucas Jr.

Lucas is an AWS Counselor, a Life Member, and a licensed welding engineer. He worked for ten years at Belcan Corp. until his retirement in 2004. Currently, he serves as a consultant with GE Aviation in the brazing, heat treating, and welding areas. During his long career he has worked for Union Carbide, Babcock and Wilcox, and 31 years for GE Brazing and Heat Treat Technologies Center. He holds patents for narrow groove welding, an automatic GMAW arc length control method, and an activated brazing system for joining titanium aluminide. He has chaired the AWS Technical Activities Committee, founded the D17 Aerospace Welding Committee, contributed to Brazing Handbook, Welding Handbook, and the ASM Welding and Brazing Handbook, and currently serves as a Welding Journal Peer Reviewer.

Nominated for Director-at-Large Thomas A. Siewert

Siewert, an AWS Fellow, most recently was leader of the Structural Materials Group at the National Institute of Standards and Technology in Boulder, Colo. During the past 25 years, his group has worked on projects such as investigations into the failures of pipelines and buildings (including the World Trade Center towers), as well as weld sensing and consumables issues. Earlier, he was manager of R & D at Alloy Rods. He has been a member of AWS since 1969, served as a Section chair, and has participated on both national and local committees for more than 30 years. Siewert is a frequent contributor to the Welding Journal, where he serves as a Peer Reviewer. He received his PhD in metallurgical engineering from the University of Wisconsin-Madison. He has received the McKay-Helm Award, R. D. Thomas Jr. International Lecture Award, R. D. Thomas Memorial Award, and the George E. Willis Award.

Nominated for District 3 Director Michael Wiswesser

Wiswesser has been nominated to his second term as District 3 director. After receiving his bachelor's degree in business administration from Kutztown University, he joined the Welder Training and Testing Institute (WTTI) in Allentown, Pa., as operations manager. He has directed the expansion of a number of educational programs, including welding and nondestructive testing.

Nominated for District 6 Director Kenneth A. Phy

Phy has been nominated to his second term as District 6 director. Phy has worked in the nuclear power industry since 1986. Currently, he is senior project manager at Entergy Nuclear Operations, Inc., James A. FitzPatrick Nuclear Power Plant in Lochville, N.Y. Earlier he worked for J. P. Bell & Sons, Rochester, N.Y., as a mechanical field engineer, and as a project piping engineer at Catalytic, Inc., in Philadelphia, Pa. He has been an AWS Certified Welding Inspector, and has performed welding engineering and inspection work to the ASME Boiler and Pressure Vessel Code, Section XI. He earned his degree in mechanical engineering from Spring Garden College.

Nominated for District 9 Director George D. Fairbanks Jr.

Fairbanks has been nominated to his sec-

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, 2013, may:

1. Send their nominations by Oct. 4, 2011, to Greicele Manalich, greicele@aws.org, c/o John C. Bruskotter, 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. 15, 2011, at McCormick Place, Chicago, Ill., during the FABTECH show. Nominations must be accompanied by biographical material on the candidate, including a written statement by the candidate as to his or her willingness and ability to serve if nominated and elected, letters of support, plus a 5- x 7-in. color portrait. Note: Persons who present their nominations at the show must provide 20 copies of the biographical materials and written statement.

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 filling 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 not less than 200 members other than Student Members, with signatures of at least 20 members from each of five Districts, provided such petitions 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 the election for such office.

A District Director may be nominated by written petitions signed by at least 10 members each from a majority of the Sections in the District, provided such petitions are delivered to the Executive Director and Secretary before August 26 for the elections to be held that year. A biographical sketch and acceptance letter of the nominee shall be provided with the petition. Any such nominee shall be included in the election.
ond term as District 9 director. Currently, he is principal owner and general manager of Fairbanks Inspection & Testing Services. Previously, he was senior welding inspector at Gonzales Industrial X-Ray. Earlier, Fairbanks worked 16 years as a CWI and an API 653 inspector in a metallurgical and testing lab. He joined the AWS Baton Rouge Section in 1980, where he has held many offices, including six terms as chairman. Currently, he is a CWI, CWE, API 653, NCCER Master Trainer, NCCER Welding Educator, VT Level III, RT Film Interpretation II, PT Level III, MT Level III, and UT Thickness III. In 2004, he received the National Dalton E. Hamilton CWI of the Year Award.

Nominated for District 12 Director
Daniel J. Roland

Roland, an AWS member since 1996, has been nominated to his first term as District 12 director. He is the quality technical coordinator at Marinette Marine Corp., where he has worked since 2001. Since 1997, he has also served as a welding instructor at Northeast Wisconsin Technical College and a member of the Welding Advisory Committee. From 1990 to 2001, he served as quality assurance manager at Silvan Industries. Roland is an AWS CWI, an NDT examiner, Level II certified to numerous testing methods. He has served as deputy District 12 director and as Section chair, vice chair, secretary, and education chair. He has received the AWS District Educator of the Year, District Private Sector Instructor Award, and the District Meritorious Award.

Nominated for District 15 Director
David E. Lynnes

Lynnes, an AWS member for 18 years, has been nominated to his first term as District 15 director. He is part owner of three companies, Wild Rice Mfg., Inc., and Lynnes Welding Training of Fargo and in Bismarck, N.Dak. He is an AWS CWI and CWE, and is also a CNB certified welding supervisor, and 6G certified pipe welder. He has been welding for more than 20 years. Lynnes has held all of the officer positions in the Northern Plains Section where he received the Section Meritorious award in 1997. He attended the AWS Leadership Symposium and Instructors Institute. Lynnes speaks to several student groups throughout the year promoting the Society and welding as a career.

Nominated for District 18 Director
John Bray

Bray, an AWS member since 1988, has been nominated to his second term as District 18 director. He served on the Houston Section board for 12 years, and as chairman in 1999. For the past 14 years, he has served as president of Affiliated Machinery, Inc. He started his welding career in 1968 as a repairman at Staples Welding Machine Repair. Following a tour of duty in the U.S. Army, he returned to Staples in 1972 as general manager. In 1975, he became service manager at Associated Equipment Co. until 1985. Then he moved to outside sales with Associated Welding Supply until 1996 when he joined Affiliated Machinery as president.

Nominated for District 21 Director
Nanette Samanich

Samanich has been nominated to a second term as District 21 director. Currently, she is the welding technologies instructor at Desert Rose High School and Adult Career Center in North Las Vegas, Nev. She began her welding career in 1994, attending the Community College of Southern Nevada and the Hobart Institute of Welding Technology. She is an AWS Certified Welding Inspector and a Certified Welding Educator. She is also a certified Spray-Applied Fireproofing Inspector by the International Code Council. Samanich has served AWS as Nevada Section chair (2001–2004), District 21 deputy director, and District 21 director from 2006 to the present. She has received the AWS District Meritorious, and Section and District CWI of the Year Awards. She has been featured in a women in welding article in the March 2002 Welding Journal and another story in Nevada Women magazine. Samanich is a member of the American Institute of Steel Construction and International Code Council.
Errata D1.1/D1.1M:2010
Structural Welding Code — Steel

The following errata have been identified and will be incorporated into the next reprinting of this document.

Page 152, Table 4.11: Under the Qualified Dimensions category for Production T-, Y-, or K-Connection CJP Groove Welds, correct “Nominal Wall or Plate Thickness” Qualified, in.” to “Nominal Wall or Plate Thickness” Qualified, in.”

Page 152, Table 4.11: Under the Qualified Dimensions category for Production T-, Y-, or K-Connection CJP Groove Welds, correct “Dihedral Angles Qualified” to “Dihedral Angles Qualified.”

Page 152, Table 4.11: Under the Qualified Dimensions category for Production T-, Y-, or K-Connection Fillet Welds, correct “Dihedral Angles Qualified” to “Dihedral Angles Qualified.”

Page 152, Table 4.11: Under the Qualified Dimensions category for Production T-, Y-, or K-Connection Fillet Welds, correct “Dihedral Angles Qualified” to “Dihedral Angles Qualified.”

New Standards Projects
B2.4:20XX, Specification for Welding Procedure and Performance Qualification for Thermoplastics. This specification provides the requirements for qualification of welding procedure specifications, welders, and welding operators for manual, semiautomatic, mechanized, and automatic welding. The processes included are electrofusion, hot gas, socket fusion, butt contact fusion, infrared, extrusion welding, flow fusion welding, and solvent cement welding. Base materials, filler materials, qualification variables, and testing requirements are also included. Stakeholders: Personnel involved in all aspects of thermoplastic welding.

Development work has begun on the above revised standard. Affected individuals are invited to contribute to its development. For information, contact secretary Alex Diaz, adiaz@aws.org, ext. 304.

Standards for Public Review
C3.7M/C3.7:20XX, Specification for Aluminum Brazing. Revised. $25.
C3.8M/C3.8:20XX, Specification for the Ultrasonic Examination of Brazed Joints. Revised. $25.

The above three standards were submitted for public review. Their reviews expired 6/27/2011. Draft copies may be obtained from R. O’Neill, roneill@aws.org, ext. 451.

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.

ISO Draft Standard for Public Review
ISO/DIS 15614-14, Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 14: Laser-arc hybrid welding of steels, nickels and nickel alloys

Copies of the above draft international standard are available for review and comment from your national standards body, which in the United States is ANSI, 25 W. 43rd St., 4th Fl., New York, NY, 10036; (212) 642-4900. Send comments regarding ISO documents to your national standards body. In the United States, if you wish to participate in the development of International Standards for welding, contact Andrew Davis, adavis@aws.org; (800/305) 443-9553, ext. 466.

Contribute Your Skills to These Technical Committees

Volunteer to serve on an AWS Technical Committee and help develop the documents that serve industry’s ever-changing needs. Currently, more than 1800 volunteers participate on the 160 AWS technical committees and subcommittees. Membership on AWS Technical Committees is open to everyone. Review the committee openings outlined here, then contact the committee secretary listed to learn more about the advantages and responsibilities for contributing to this work. E-mail the committee secretary listed, or call (800/305) 443-9553 at the extension shown.

Local Heat Treating of Pipe Work
The D10P Subcommittee for Local Heat Treating of Pipe to revise D10.10, Recommended Practices for Local Heating of Welds in Piping and Tubing, Contact B. McGrath, bmcgrath@aws.org; ext. 311.

Joining Wrought Nickel Alloys
The G2C Subcommittee on Nickel Alloys seeks volunteers to review G2.1M/G2.1, Guide for the Joining of Wrought Nickel-Based Alloys, and participate in the regular meetings and teleconferences. A. Diaz, adiaz@aws.org, ext. 304.

Oxyfuel Gas
C4 Committee on Oxyfuel Gas Welding to prepare C4.1, Criteria for Oxygen Cut Surfaces and Roughness Gauge; C4.2, Recommended Practices for Safe Oxyfuel Gas Cutting Torch Operation; C4.3, Recommended Practices for Safe Oxyfuel Gas Heating Torch Operation; C4.4, Recommended Practices for Heat Shaping and nical committees and subcommittees. Membership on AWS Technical Committees is open to everyone. Review the committee openings outlined here, then contact the committee secretary listed to learn more about the advantages and responsibilities for contributing to this work. E-mail the committee secretary listed, or call (800/305) 443-9553 at the extension shown.

Straightening with Oxyfuel Gas Heating Torches; C4.5, Uniform Designation System for Oxyfuel Nozzles; C4.6, Thermal Cutting — Classification of Thermal Cuts — Geometric Product Specification and Quality Tolerances; and C4.7, Recommended Practices for Safe Oxyacetylene Welding of Steel. E. Abrams, eaabrms@aws.org; ext. 307.

Thermal Spray

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

Surfaceing Industrial Mill Rolls
Mendoza Opens AWS Weldmex Show in Monterrey

The eighth annual Weldmex Show, held May 11–13 in Monterrey, Mexico, attracted 7086 attendees who experienced first-hand the latest welding, cutting, metal finishing, and safety technologies displayed by 241 vendors in 52,100 sq-ft of exhibition space.

AWS President John Mendoza (shown in the inset above) greeted the attendees at the show’s opening ceremony.

Mendoza said, “The American Welding Society is very proud to host AWS Weldmex this year in Monterrey, the industrial center of northern Mexico.

“The response to this show, both in the number of exhibitors and the number of show attendees, has shown steady growth over the past several years. Part of this growth has resulted from a growing interest in Mexico in the newest equipment for welding and cutting.

“Additional growth has resulted from linking forces with the Metalform Mexico show organized by the Precision Metalforming Association, and with the FABTECH Mexico show organized by the Fabricators and Manufacturers Association International, and the Society of Manufacturing Engineers. We especially thank all of the show visitors who have taken time in their busy week to view the latest technologies in welding, fabricating, and metalforming. We sincerely hope you enjoy the show.”

The record-setting attendance at this year’s event demonstrates that the manufacturing industry continues to strengthen in Latin America. Many exhibitors have responded enthusiastically about their satisfaction with the sales generated by the event each year.

Weldmex 2012 will be held May 2–4 in Mexico City, Mexico. Visit the Weldmex Web site, www.awsweldmex.com, for more information.

Errata AWS BRH:2007, Brazing Handbook

The following errata have been identified and will be incorporated into the next reprinting of this document.

Page 61, under Inspection, 3rd, 4th, and 5th paragraphs.

Replace the following:

“Class A joints are those joints subjected to high stresses, cyclic stresses, or both, the failure of which could result in significant risk to persons or property significant operational failure.

Class B joints are those joints subjected to low or moderate stresses, cyclic stresses, or both, the failure of which could result in significant risk to persons or property significant operational failure.”

With the following:

“Class A is typically chosen for joints subjected to high stresses, cyclic stresses, or both, the failure of which could result in significant risk to persons or property, or in significant operational failure.

Class B is frequently chosen for joints subjected to low or moderate stresses, cyclic stresses, or both, the failure of which could result in significant risk to persons or property, or in significant operational failure.

Class C is frequently chosen for joints subjected to low or moderate stresses, cyclic stresses, or both, the failure of which would have no significant detrimental effect.”
Cassie Burrell, AWS deputy executive director, was invited to address the attendees at the Annual International Sheet Metal Apprentice Competition held March 15–18 in Las Vegas, Nev. Burrell spoke to the apprentices (some are shown above) about career opportunities in welding. The event, hosted by the International Training Institute (ITI), attracted more than 325 sheet metal apprentices to vie for top spots in five categories: industrial/welding, HVAC, service, architectural discipline, and TAB (testing, adjusting, and balancing in heating and air-conditioning).

Ryan Burton, an apprentice from Sheet Metal Local #2 in Kansas City, won the industrial/welding category.

James Shoulders, ITI executive administrator, said, “The competition is challenging because those who make it in are the United States’ and Canada’s top apprentices. These men and women are dedicated to perfecting their craft.”

Six Members Recognized for Special Awards

Sean Bayes, Timothy Jones, Brandon Smith, and Christopher Wright were cited to receive Student Chapter Member Awards and Eleanor Ezell and Johnny Dedeaux received District 9 Director Awards for their outstanding services to their Student Chapter (SC) and Section.

Sean Bayes with the Whitmer Career & Technology Center SC (District 10) was selected by SC Adviser Craig Donnell for his 3.7 GPA in the welding program, serving on the varsity debate team, winning the local SkillsUSA welding competition, and participating in many school activities.

Timothy Jones with the Wake Tech Community College SC, Triangle Section, District 4, was selected by SC Adviser Russell Wahrman for serving as the SC chairman, receiving his diploma in welding technology, and his AWS D1.1 certification.

Brandon Smith with the Columbiana County Career and Technical Center SC (District 10) was selected by SC Adviser Huck Hughes for being a member of the National Technical Honor Society with a 3.9 GPA, serving as Chapter treasurer and chairman, participating in Mahoning Valley Section events and working as a community volunteer for Toys for Tots and a local food drive.

Christopher Wright with the Beaver Valley SC (District 7) was selected by Adviser Thomas Geisler. He is a ten-time high school honor roll member who worked his senior year at American Bridge Mfg. Co. while maintaining an A average. He has served as SC vice chair, organized SC events, and designed and built an auto-lifting machine.

Download the SC Member Award criteria and nomination form from www.aws.org/sections/awards/student_chapter.pdf or call (800) 443-9353, ext. 260.

Eleanor Ezell and Johnny Dedeaux, Mobile Section, were selected by George Fairbanks, District 9 director, to receive the District Director Award for their contributions of time and effort to the affairs of the Mobile Section and/or District 9.

AWS Foundation Awards

The AWS Foundation has given five Workforce Development Grant Awards to the following educational and industrial facilities. These funds are intended to provide welding skills upgrades and to recruit, train, and AWS-certify new welders for industry, issue certificates of completion, and offer new welders employment opportunities. Each award will be used to best suit the needs of the participants.

- Fulton County Area Technical Vocational School and Mellott Co., Pennsylvania — $18,394, (Mellott Co. has committed to add $7150.)
- Regional Technical Education Center and Kolberg-Pioneer, Inc., South Dakota — $12,850.
- Henderson Community College and Pittsburgh Tank & Tower Co., Ohio Valley Marine Services, Inc., and Alliance Coal, LLC, Kentucky — $19,095. (Alliance Coal has committed to add $9924.)
- Vermeer Corp., Iowa — $18,865. (Vermeer has committed to add $7546.)

For complete information about the AWS Foundation and its Workforce Development Grants program, contact Vicki Pinsky at vpinsky@aws.org, or call (800) 443-9353, ext. 212.
Win Great Prizes in the 2011-2012 AWS Member-Get-A-Member Campaign

GREAT PRIZES. GREAT CAMPAIGN. START SPONSORING MEMBERS TODAY!

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 2011-2012 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 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 Limited Edition T-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 Limited Edition T-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 2012).

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 2012 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 or Limited Edition T-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 2011, as well as in February and June 2012.

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 2012 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.


American Welding Society


Prizes are awarded at the close of the campaign.
**AWS MEMBERSHIP APPLICATION**

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

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

**Last Name** ___________________________ **Middle Initial** M. I. ___________________________

**Title** ___________________________ **Birthdate** ___________________________

Were you ever an AWS Member? ☐ YES ☐ NO If "YES," give year _____ and Member # _______.

**Primary Phone ( )** E-Mail ___________________________ **Secondary Phone ( )**

**FAX ( )** E-Mail ___________________________

Did you learn of the Society through an AWS Member? ☐ Yes ☐ No

If "YES," Member's name: ___________________________ Member's # (if known): _______.

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

**ADDRESS**

**NOTE:** This address will be used for all Society mail.

Company (if applicable) ___________________________

Address ___________________________

Address Con't. ___________________________

City ___________________________ State/Province ___________________________ Zip/Postal Code ___________________________ Country ___________________________

**PROFILE DATA**

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

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

**PAYMENT INFORMATION (Required)**

**ONE-YEAR AWS INDIVIDUAL MEMBERSHIP** $80

**TWO-YEAR AWS INDIVIDUAL MEMBERSHIP** $160 $135

**New Member? ☐ Yes ☐ No**

If "YES," add one-time initiation fee of $12 ___________________________

**International Members add $50 for optional hard copy of Welding Journal (note: digital delivery of WJ is standard) $50**

**SAVE $25**

**Individual Members add $25 for book selection** (up to a $192 value) $25

**Note:** $50 shipping charge applies to members outside of the U.S. $50

**TOTAL PAYMENT** $_________________________

**AWS STUDENT MEMBERSHIP** $15

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

**Domestic (Canada & Mexico incl.)** $15

**International** $50

**TOTAL PAYMENT** $_________________________

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

☐ Check ☐ Money Order

☐ American Express ☐ Diners Club ☐ Carte Blanche ☐ MasterCard ☐ Visa ☐ Discover ☐ Other

Your Account Number ___________________________ Expiration Date (mm/yy) ___________________________

Signature of Applicant: ___________________________ Application Date: ___________________________

**Office Use Only**

**Check #** ___________________________ **Account #** ___________________________ **Amount** $_________________________

**BOOK/CD-ROM SELECTION**

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

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

**ONLY ONE SELECTION PLEASE:**

- ☐ Jefferson's Welding Encyclopedia (CD-ROM only)
- ☐ Design & Planning Manual for Cost-Effective Welding
- ☐ Welding Metallurgy
- ☐ Welding Handbook (9th Ed., Vol. 4)
- ☐ Welding Handbook (9th Ed., Vol. 3)
- ☐ Welding Handbook (9th Ed., Vol. 2)
- ☐ Welding Handbook (9th Ed., Vol. 1)

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

Learn more about each publication at www.awspubs.com

☐ New Member ☐ Renewal

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

**Type of Business (Check ONE only):**

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

**Job Classification (Check ONE only):**

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

**Technical Interests (Check all that apply):**

☐ Ferrous metals
☐ Nonferrous metals except aluminum
☐ Advanced materials/intemetals
☐ Ceramics
☐ High energy beam processes
☐ Arc welding
☐ Braze and soldering
☐ Resistance welding
☐ Thermal spray
☐ Cutting
☐ NDT
☐ Safety and health
☐ Bending and shearing
☐ Roll forming
☐ Stamping and punching
☐ Aerospace
☐ Automotive
☐ Machining
☐ Marine
☐ Transportation
☐ Tubing and tubing
☐ Pressure vessels and tanks
☐ Sheet metal
☐ Structures
☐ Other
☐ Automation
☐ Robotics
☐ Computerization of Welding

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American Welding Society

550 N.W. LeJeune Rd
Miami, FL 33126

Telephone (800) 443-9353
Fax (305) 443-5647

Visit our website: www.aws.org
Middle East Executives Discuss Business Opportunities

Ibrahim I. Mohamed (far left), president, HEDO Group Int’l, and M-Yasser Fahmy (far right), HEDO’s international marketing executive, met with Cassie Burrell (left), AWS deputy executive director, and Priti Jain, director, AWS international business and certification programs, on May 3 to discuss expanding AWS programs in Egypt and the Middle East. Mohamed is the administrator of the Egyptian Welding Academy in Cairo.

Nominate Your Candidate for the M.I.T. Prof. Masubuchi Award

November 2, 2011, is the deadline for submitting nominations for the 2012 Prof. Koichi Masubuchi Award. It is presented each year to one person, 40 years old or younger, who has made significant contributions to the advancement of materials joining through research and development. Nominations should include the candidate’s experience, publications, honors, and awards, and at least three letters of recommendation from fellow researchers. E-mail your nomination package to Todd A. Palmer, assistant professor, The Pennsylvania State University, tapl03@psu.edu. Sponsored by the Dept. of Ocean Engineering at Massachusetts Institute of Technology (M.I.T.), this award includes a $5000 honorarium.

Honorary Meritorious Awards

The deadline for submitting candidates for these awards is December 31 prior to the year of the awards presentations. Send candidate materials to Wendy Sue Reeve, wreve@aws.org; 550 NW LeJeune Rd., Miami, FL 33126.

William Irgang Memorial Award

This award is given to the individual who has done the most over the past five years to enhance the Society’s goal of advancing the science and technology of welding. It includes a $2500 honorarium and a certificate.

National Meritorious Certificate Award

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

George E. Willis Award

This award is given an individual who promoted the advancement of welding internationally by fostering cooperative participation in technology transfer, standards rationalization, and promotion of industrial goodwill. It includes a $2500 honorarium.

Honorary Membership Award

This award acknowledges eminence in the welding profession, or one who is credited with exceptional accomplishments in the development of the welding art. Honorary Members have full rights of membership.

International Meritorious Certificate Award

This honor recognizes recipients’ significant contributions to the welding industry for service to the international welding community in the broadest terms. The award consists of a certificate and a one-year AWS membership.
New AWS Supporters

**Sustaining Members**

Fronius USA LLC  
10421 Citation Dr., Ste. 1100  
Brighton, MI 48116  
Representative: Stephanie Gibson  
[www.fronius-usa.com](http://www.fronius-usa.com)

Fronius manufactures, sells, and services welding equipment for manual and robotic applications. The company works with integrators and a dedicated sales force. It has more than 3000 employees worldwide with 12% of the staff dedicated to research and development activities. The company, noted for its many innovations, is ISO 9000 and CSA certified.

Lynnes Welding Training, Inc.  
2717 3rd Ave. N.  
Fargo, ND 58102  
Representative: Dave Lynnes  
[http://learn toweld.com](http://learn toweld.com)

Lynnes Welding Training, with locations in Fargo and Bismarck, N.Dak., offers courses for beginners and advanced welders, including cutting applications, applied metallurgy, blueprint reading, and safety. Students develop a working knowledge of welding techniques, equipment setup, and operations with an excellent instructor-to-student ratio and significant hands-on welding experiences in custom-designed welder training booths to become highly skilled employable welders. The company also provides training for businesses customized to their individual needs and specifications.

**Metalcraft, Inc.**  
1080 W. Amity Rd.  
Boise, ID 83705  
Representative: Ken Cortez  
[www.metalcraftidaho.com](http://www.metalcraftidaho.com)

Metalcraft’s fabrication services include CNC punching, forming, laser cutting and machining, hardware insertion; and welding. The company also has the ability to offer engineering, CAD/CAM programming, chromate conversion, wet painting, screen-printing, and a full prototype area.

**Patterson Pump Co.**  
2129 Ayersville Rd., PO Box 790  
Toccoa, GA 30577  
Representative: Clint Simmons  
[www.pattersonpumps.com](http://www.pattersonpumps.com)

Patterson Pump is a major supplier of products for enhancing safety and comfort in HVAC and fire-suppression technology, and for meeting pumping demands in water supply, irrigation, flood prevention, and wastewater treatment. It also provides industrial solutions to liquid transfer and process heating and cooling needs.

**Affiliate Companies**

A.R.E. Mfg., Inc.  
518 S. Springbrook Rd.  
Newberg, OR 97132

**Advanced Mechanical**  
217 SW 28th St. Ft. Lauderdale, FL 33315

**B & D Fabworks LLC**  
3137 Hwy. 36 N., Bldg. A #7  
Sealy, TX 77474

**Barras Inspection and Consulting LLC**  
1023 N. Monte Blanc Dr. Abbeville, LA 70510

**Best Fab, Inc.**  
204 Bartow Municipal Airport Barlow, FL 33830

**C. W. Shaw, Inc.**  
4400 60th Ave. N. St. Petersburg, FL 33714

**Deep Recycling Industries**  
Plot No. 773 Phase II GIDC, Dared Jamnagar Gujarat 361004, India

**Indium Corp. of America**  
80 Scott St. Elk Grove Village, IL 60007

**K Line Equipment Corp.**  
POB 698, Maxton, NC 28364

**Lift & Compactors Mexico**  
Km 69 5 A Carr Fed Col Sta Ma Ahuacatlan Cuernavaca Morelos 62100, Mexico

**Miami Machine Corp.**  
4251 Riverside Dr. Middletown, OH 45055

**Sedemi S.C.C.**  
Via Sangolqui Amaguaña Km 4½ Loozicuan El Carmen No 4 Sangolqui Pichincha, Ecuador

**Welding Distributors**  
Multiplaz North America  
1625 17th St., Ste. 5  
Santa Monica, CA 90404

**PT Freeport Indonesia**  
Lip – Kuala Kencana Timika, Papua, Indonesia

**Rolled Alloys**  
9944 Princeton-Glendale Rd. Cincinnati, OH 45246

**Supporting Companies**

Caguas Mechanical Contractor, Inc.  
Nebraska U-4, Caguas N. Caguas, PR 00725

**Elite Precision Fabricators, Inc.**  
2239 St. Beulah Chapel Rd. Montgomery, TX 77316

**Jones Metal Products, Inc.**  
3201 Third Ave., Mankato, MN 56001

**Primo Automation Systems**  
8, Multi Ind. Nagar, Gherugambakkam, Chennai, Tamil Nadu 602101, India

**Wilschur Design, Inc.**  
2619 S. Oak St., Santa Ana, CA 92707

**Educational Institutions**

Adano Engineering Co., Training Div.  
Flat 6 Jeffia Estate, 156 P.T. I. Rd. Effurun, Delta, Nigeria

**Big Spring High School**  
707 11th Pl., Big Spring, TX 79720

**Lutton Associates**  
973 Old Henderson Rd. Columbus, OH 43220

**National University**  
Polytechnic Institute  
3570 Aero Ct., San Diego, CA 92123

**AWS Member Counts**

**June 1, 2011**

**Grades**

Sustaining..........................504  
Supporting..........................306  
Educational..........................579  
Affiliate.............................461  
Welding Distributor...............49

**Total Corporate..................1,899**

Individual..........................56,637  
Student + Transitional............11,143  
Total Members......................67,780

**Actions of Districts Council**

On May 15, 2011, after due consideration, Districts Council approved the charter of the AWS West Zone India — Vadodara International Section. The name change from Albuquerque Section to New Mexico Section was approved.

Approved for Student Chapter (SC) charters were Great Oaks Career Campuses SC, Dist. 7; Tennessee Technical Center at Huntsville SC, Dist. 8; Coshocton County Career Center SC, Dist. 10; Logan SC, Dist. 14; Johnson County Community College SC, Dist. 16; and the CONALEP CAST NL SC, Dist. 18.

Approved for disbandment were Triangle Tech — Pittsburgh Campus SC, Westmoreland County Community College SC, and West Virginia University at Parkersburg SC, Dist. 7.
Shown at the District 1 conference are (from left) Geoff Putnam, Gil Trigo, Bob Lavoie, Jenifer Eastly, Walt Chojnacki, Scott Lee, Ross Hancock, Rick Moody, Phil Witteman, Jim Kein, Paul Mendez, Ray Hendersen II, Brandon Pequita, Doug Desrochers, Tim Kinnaman, District 1 Director Tom Ferri, Michel Marnier, Dick Gregoire, Warren Ballard, Rojean Roy, Dave Paquin, and Carl Richardson. Photo by Russ Norris.

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

District 1 Conference
May 7
Activity: District 1 Director Tom Ferri hosted the conference, sponsored by the Boston Section at Hampton Inn in West Yarmouth, Mass. Highlights included a seafood dinner on Cape Cod and Ferri’s reelection to serve a second three-year term as District 1 director.

District 2
Harland W. Thompson, director
(631) 546-2903
harland.w.thompson@us.ul.com

NMTCC Student Chapter
May 5
Speaker: Harland Thompson, District 2 director, senior project engineer
Affiliation: Underwriters Laboratories, Inc.
Topic: Careers in welding
Activity: The event was held at the North Montco Technical Career Center (NMTCC) in Lansdale, Pa.
Reading Section welding competition winners included (from left) Frank Mohr, Travis Chavous, Corey Appleby, Jamie Reichert, Ryan Achey, Jon Nace, Mike Hinds, and Andy Pownall.

Harland Thompson, District 2 director, poses with students at North Montco Technical Career Center.

Alan Shissler (left) is shown with Florida West Coast Section Chair Robert Brewington and his wife, Jan.

Florida West Coast Section chefs Charles Crumpton Sr. (right) and Charles Jr. cooked the key ingredient for the Shrimp-A-Roo awarded to Tom Davenport. The welding instructors attending were John Boyer, Sharon Bally, Dale Roberts, Brian Yarri son, and Daniel Milan. The contest judges were Randy Jacobs, Bryan Shenk, Rich Helsey, Riley Fus selman, Michael Brickel, and Austin Chavous.

YORK- CENTRAL PA.
APRIL 7
Speaker: John Mendoza, AWS president
Affiliation: Lone Star Welding
Topic: The value of AWS certification
Activity: The program was held at Heritage Hills Conference Center in York, Pa. Attending were District 3 Director Mike Wis wesser, York-Central Pa. Chair Jim Henry, and Michael S ebergandio, Lancaster Section chair.

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

READING
APRIL 28
Speaker: Mike Wiswesser, District 3 director
Affiliation: Welder Training and Testing Institute, vice president

Topic: The values of AWS membership and the AWS Foundation
Activity: The Section hosted its 34th annual welding competition awards banquet at Mt. Joy Career & Technology Center in Mt. Joy, Pa. About 60 people participated. Top scoring welders were Frank Mohr, Travis Chavous, Corey Appleby, Jamie Reichert, Ryan Achey, Randy Brightbill, Jon Nace, Mike Hinds, Tyler Kempt, and Andy Pownall. Merilyn McLaughlin and Danny Milan were recognized for their services by program emcee Tracy Davenport. The Section $750 scholarship was awarded to Tom Davenport. The welding instructors attending were John Boyer, Sharon Bally, Dale Roberts, Brian Yarri son, and Daniel Milan. The contest judges were Randy Jacobs, Bryan Shenk, Rich Helsey, Riley Fus selman, Michael Brickel, and Austin Chavous.

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

District 5
Steve Mattson, director
(904) 260-6040
steve.mattson@yahoo.com
From left, Nora Mendoza and AWS President John Mendoza receive a gift from York-Central Pa. Section Chair Jim Henry, Lancaster Section Chair Michael Sebergandio, and Mike Wiswesser, District 3 director.

Shown at the Florida West Coast Shrimp-A-Roo event are (from left), Alan Shissler, Walt Arnold, Damen Johnson, Bill Machnovitz, Al Sedor, Ray Monson, Charles Crampton, and Albert Carr.

**FLORIDA WEST COAST**

**May 14**
Activity: The Section held its annual Shrimp-A-Roo dinner and dance at Sons of Italy Hall in Tampa, Fla., for 75 attendees. Damen Johnson, with Tampa Steel Erecting Co., was elected chairman for the 2011–2012 term. Outgoing Chair Robert Brewington received recognition for his services. Charles Crampton Sr. and his son, Charles Jr., prepared the crustaceans for the event.

**NORTH FLORIDA**

**April 28**
Speaker: Phil Baker
Affiliation: Jax Certified Welding Services
Topic: How to become a certified welder
Activity: The program was held at Jax Certified Welding Services in Jacksonville, Fla.
Steve Mattson, District 5 director, attended the program.

**NORTH CENTRAL FLORIDA**

**May 10**
Speaker: Ray Monson, project manager
Affiliation: Bureau Veritas North America
Topic: Stuff breaks
Activity: This students’ night program included the presentation of student memberships and awarding copies of the Lincoln Welding Handbook and an AWS Welding Handbook volume. The event was held at Airgas Training Center in Ocala, Fla.

**SOUTH CAROLINA**

**April 20**
Speaker: Steve Mattson, District 5 director
Affiliation: Mattson Repair Service
Topic: Welding scholarship and employment opportunities
Activity: The Section hosted its annual Pig Pickin’ and installation of officers event at Haselden & Co., in Wando, S.C. Gale Mole was recognized for his services as chair.

Gale Mole (right), South Carolina Section chair, receives a plaque from Steve Mattson, District 5 director.

**District 6**
Kenneth Phy, director
(315) 210-5297
KAPhylnic@gmail.com

WELDING JOURNAL 71
Shown at the South Carolina Section Pig Pickin’ event are (from left) Marie Bruce, past Chair Howard Jones, Jim Bruce, and Dick Bruce.

Billy Joe Edwards (far left) led the Chattanooga Section members on the Gestamp tour.

辖区8

乔伊・莱思伊，总监
(931) 484-7502, ext. 143
joe.livesay@ttcc.edu

查塔努加

4月19日
活动：该会会员参观了位于田纳西州查塔努加的Gestamp公司，研究汽车部件的冲压和焊接。比利・乔・爱德华兹带领了这次参观。

霍斯顿山谷

2月17日
活动：该会会员参观了位于田纳西州克林顿的Sagebrush餐厅，研究汽车部件的冲压和焊接。比利・乔・爱德华兹带领了这次参观。

尼奥加的变迁

4月21日
演讲：哈里・卡尔森，CWI，自由职业教师
主题：焊接金属艺术的介绍
活动：该组织活动于质量技术培训学院在纽约州德皮举行。

7区

唐・霍华德，总监
(814) 269-2895
howard@ctc.com

更大的阿勒高职业和科技中心学生组织

3月
演讲：约翰・门多萨，AWS总裁
哲联：得克萨斯州立焊接
活动：唐・霍华德，7区总监和男讲师在威斯特摩群岛社区学院也说到了对焊接工人的需求。乔治・西思，学生章员，说他有42个学生在三年的基本焊接课程。他的以前班的学生现在就找到了工作，他希望他的学生能获得直接的职业工作。

东北密西西比州

2月17日
演讲：道格・贝克，地区经理
哲联：米勒电焊器公司
主题：焊接安全和脉冲焊接
活动：这次学生会晚上活动在密西西比州麦海举行。许多焊接头盔被颁发。

7月2011
Shown are the contenders in the high school class welding competition held by the Holston Valley Section.

NE Mississippi Section members visited Nucor Steel in April. Shown are (from left) Randy Perkins, Gary Gammill, Tavares Irions, David Carwyle, Teddy Lampard, Beau Riser, presenter Ed Russell, Kevin Reed, Frank Smith, Mitch Lovell, Zach Parchman, and Robbin Shull.

Adam Vest and Kourtney Wills took top honors at the Holston Valley adult-class welding competition.

April 21
Activity: The NE Mississippi Section members toured the Nucor Steel Jackson, Inc., facility near Jackson, Miss. Ed Russell conducted the program.

District 9
George Fairbanks Jr., director
(225) 473-6362
flts@bellsouth.net

Baton Rouge
New Orleans
April 21
Speakers: Jim Falgout, Jimmy Goodson; welding instructors
Affiliation: Louisiana Dept. of Education
Topic: Welding education and teaching methods

District 9 Director George Fairbanks (center) is shown with presenters Jim Falgout (left) and Jimmy Goodson at the joint Baton Rouge and New Orleans Sections’ meeting.

Welding students Zack Brown (left) and Cody Davis (center) are shown with instructor Dale Box at the Mobile Section program.
Shown at the joint Baton Rouge and New Orleans Sections’ program are (from left) George Fairbanks, District 9 director; Morgan City Chair Joey Rentrop; AWS President John Mendoza; and Acadiana Section Chair Mike Skiles.

At the Mobile Section program, outgoing Chair Jackie Morris is shown with Brenda Amos, incoming chair.

Detroit Section program presenters are Bradford Coons (left) and Brian Coons.

Shown at the Drake Well Section program are (from left) Ward Kiser, Chair Mike Owens, Jason Fry, and presenter Ron Stahura.

Activity: This joint meeting of the Baton Rouge and New Orleans Sections was hosted by Baton Rouge at the Madisonville Maritime Museum in Baton Rouge, La.

**MOBILE**

**MAY 12**

Activity: The Section elected its incoming slate of officer and recognized its past officers. The Section also provided funds to welding instructors to take students to the SkillsUSA competition.

**DISTRICT 10**

**Richard A. Harris, director**

(440) 338-5921

richaharris@windsnet.net

**DRAKE WELL**

**MAY 10**

Speaker: Ron Stahura, territory sales manager

Affiliation: ESAB Welding & Cutting Products

Topic: Welding cast irons

Activity: Jason Fry received the District Director Award. Ward Kiser was presented the District Meritorious Award and the CWI of the Year Award. The program was held at The Commons in Franklin, Pa.

**DISTRICT 11**

**Robert P. Wilcox, director**

(734) 721-8272

rmwilcox@wowway.com

**DETROIT**

**MAY 12**

Activity: The Section members hosted its awards-presentation program at BRICO Welding & Fab, Inc., in Chesterfield, Mich. The program included a tour of the facility led by Brian Coons, president and founder, and Bradford Coons, vice president. Mike Karagoulis, awards committee chair, presented Section recognition certificates to Dave Kelly, Rod Bereznicki, Shirley Kowalski, Fred Ellicott, Dietrich Roth, and Efthios Siradakis. Sixty members and guests attended the event.

**DISTRICT 12**

**Daniel J. Roland, director**

(715) 735-9341, ext. 6421
daniel.roland@us.fincantieri.com

**LAKESHORE**

**APRIL 8**

Activity: The Section sponsored a students’ career day program in conjunction with Lakeshore Technical College in Cleveland, Wis. Featured were demonstrations, and hands-on activities with various welding and cutting processes. The event attracted 105 students. Welding student Chris Richmond coordinated the event.
Shown at the Detroit Section program are (from left) Dave Kelly, Mike Karagoudis, Rod Bereznicki, Shirley Kowalski, Fred Ellicott, Vice Chair Don Maatz Jr., Dietrich Roth, and Efthios Siradakis.

Shown at the Lakeshore Section career day event are from left Tim Echan (Lincoln Rep), Darbie Magray, Ryan Dahm, Jason Domra, Chris Sanders, Jennifer Kozaczuk, Courtney Savage, Mitchell Schmidt, Kenric Hietala, Tony Bulitz, Samuel Johnson, Troy King, Daniel Sennzel, Chris Richmond, Jeff Tischel, James Lucz, Brett Damrow, John Brandt, Jesse Huettl, David Guillette, and Brian Strebe.

MAY 12
Activity: The Lakeshore Section members toured D&S Machine Services in Luxemburg, Wis. Russ Novak, president and owner, conducted the program. The dinner and business meeting were held at nearby Northbrook Country Club. Treasurer Nick Freiberg presented Chuck Frederick a plaque recognizing his services as chairman for the past year.

MILWAUKEE
APRIL 21
Activity: The Section members attended a seminar on failure analysis of welds conducted at Stork Technimet in New Berlin, Wis. The leaders were Craig Brown, principal metallurgical engineer; Dale Loiselle, welding project manager; and Tom Augustin, sales manager. Professional development credit hours were given to attendees.

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

CHICAGO
APRIL 13
Speaker: John Mendoza, AWS president

Craig Tichelar (left) receives his Silver Member certificate from AWS President John Mendoza at the Chicago Section program.

Affiliation: Lone Star Welding
Topic: The AWS certification programs
Activity: Craig Tichelar received his Silver Member certificate for 25 years of service to the Society. Rick Polanin, District 13 director, and Jim Greer, a past AWS president, attended the program. The event was held at Bohemian Crystal Restaurant in Chicago, Ill. Twenty-two members attended the event.

Lakeshore Section Chair Chuck Frederick (left) is shown with Treasurer Nick Freiberg.

Presenters at the Milwaukee Section program were (from left) Tom Augustin, Dale Loiselle, and Craig Brown.
Attending the Chicago Section meeting are (from left) Tim and Marcia Donovan, Nick and Lisa Moran, George Nowak, Craig Tichelar, John and Nora Mendoza, Pete Host, John Louis, Rich Gawel, and Marty Vondra.

Shown at the Chicago Section April 13 event are from left (front row) Craig Tichelar, Nora and John Mendoza, AWS president; (back row) Jim Greer, AWS past president; and Rick Polanin, District 13 director.

Working at the Illinois SkillsUSA April 20 welding contest are (from left) Tully Parker, Dave Beers; Brian Muenchau; Eric Krauss; and Wayne Chuko.

AWS President John Mendoza (far right) presents the Mid-West Welding Tournament first-place trophy to the Kentucky Tech team members (from left) Trevor Osborne, Austin Nally, Brandon Mattingly, Shelby Frazier, and John Pyle.

Judging the Mid-West Welding Tournament were (from left) Dave Jackson, Mike Anderson, Bennie Flynn, Gary Dugger, Gary Tucker, Dick Alley; District 14 Director Bob Richwine, Josiah Miller, and Tony Brosio.
About half of the 125 Mid-West Welding Tournament contestants are shown at the Indiana Section-sponsored event.

Lexington Section Chair Tim Pinson (far left) is shown with the winners in the Regional VICA welding contests.

Incoming Lexington Section Chair Frank McKinley (right) is shown with outgoing Chair Tim Pinson.

Lexington Section Chair Tim Pinson (far left) is shown with the winners in the Regional VICA welding contests.

APRIL 20
Activity: Chicago Section members joined members of other AWS Sections to judge contestants in the Illinois SkillsUSA welding competition. The event was held at Capital City Career Center in Springfield, Ill. Judges included Eric Krauss with the Chicago Section, and District 14 director Tully Parker, Dave Beers, and Brian Muenchau (St. Louis Section), and Wayne Chuko (Peoria Section).

INDIANA
APRIL 20, 21
Activity: The Section hosted its 33rd Mid-West Welding Tournament for 125 students who competed for 30 trophies and $10,000 worth of prizes. Twenty-five five-student teams were coordinated to prove their skills at the New Castle Area Career Center in New Castle, Ind. Coordinating the event were Mike Anderson, Chair Gary Tucker, Tony Brosio, Bennie Flynn, Gary Dugger, Josiah Miller, Dave Jackson, District 14 Director Bob Richwine, past AWS President Dick Alley, Steve Houston from American Technical Publishing, Cliff Hart from Major Tool, and Devin Kernal from ESAB. AWS President John Mendoza presented the trophies to the winning teams.

LEXINGTON
APRIL 21
Activity: The Section presented awards to the winners of the Regional VICA welding contests. Incoming Chair Frank McKinley presented Tim Pinson an appreciation gift for his services as chairman. The program was held at Bluegrass Community and Technical College in Lexington, Ky., for 65 attendees.

ST. LOUIS
APRIL 20
Speaker: John Mendoza, AWS president Affiliation: Lone Star Welding Topic: The AWS CWI program Activity: The Section held its annual students’ night program at Ranken Technical College in St. Louis, Mo., hosted by Chair Victor Shorkey. The scholarship winners and their welding instructors were recognized.

District 14
Robert L. Richwine, director
(765) 378-5378
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INDIANA

District 15
Mace V. Harris, director
(612) 861-3870
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District 16
David Landon, director
(641) 621-7576
dlandon@vermeermfg.com
St. Louis Section Chair Victor Shorkey at the lectern poses proudly with the scholarship recipients.

Judges for the Iowa SkillsUSA welding competition are (from left) Brandon VanderLeest, Chair Rick Guffey, Michael Byerly, John Shaw, District 16 Director Dave Landon, Rick Cowman, Anthony Rudkin, and Tom Thompson.

Shown at the Lincoln College of Technology Student Chapter program are (from left) Paul Zimmerman, AWS President John Mendoza, and Donnie Williams, Chapter adviser.

District 16 Director Dave Landon (left) presents an appreciation award to Rick Guffey, Iowa Section chair.

Mark Ward (left) is shown with judges at the Kansas State SkillsUSA contest.

Nancy McDowell displays her welded sculpture at the Iowa Section program.

IOWA

APRIL 29

Activity: Section members judged and proctored the Iowa SkillsUSA welding contest held at Des Moines Area Community College in Ankeny, Iowa. Forty-six welders competed in the event. The judges included Chair Rick Guffey, District 16 Director Dave Landon, Brandon VanderLeest, Michael Byerly, John Shaw, Rick Cowman, Anthony Rudkin, and Tom Thompson. Nancy McDowell took top honors for her welding sculpture. Rick Guffey received an appreciation gift for his services as chairman. Richard Kacmarynski accepted an $18,865 AWS Foundation Workforce Development Grant on behalf of Vermeer Corp. Read the story on page 64 of this Welding Journal.

KANSAS

APRIL 28

Activity: The Section members participated in the Kansas State SkillsUSA welding competition at Wichita Area Technical College in Wichita, Kan. The co-chairs for the event were Chair Diane Steadham and Mark Ward.
Ron Theiss (far left) taught the six-day CWI seminar in Houston, Tex.

MID-PLAINS
MAY 17
Activity: Several Section members participated in the design and building of the new welding lab at McCook Community College Center for Applied Science and Technology in McCook, Neb. The members toured the facility, hosted by Michael Chips, college president.

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

Lincoln College of Technology Student Chapter
APRIL 29
Speaker: John Mendoza, AWS president
Affiliation: Lone Star Welding
Topic: The importance of AWS certifications
Activity: The program was held at the college in Grand Prairie, Tex.

TULSA
APRIL 1
Activity: The Section members participated in the Tulsa County Area School System's engineering competition for students from sixth grade through high school held at Riverside Vocational School. The Section distributed welding literature and displayed examples of welded products. Working the booth were Ray Wilsdorf, Jay Rufner, and Jerry Knapp.

APRIL 21
Speaker: Darren Gibson, SkillsUSA, state director
Affiliation: Oklahoma Dept. of Career and Technology Education
Topic: Strengthening partnerships between welding schools and industry
Activity: The Tulsa Section held its election of officers.

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

HOUSTON
Visit www.awshouston.org
MARCH 6–11
Activity: The Section sponsored a six-day CWI seminar for 38 attendees, including two students from Japan. Ron Theiss taught the course at the Sheraton Hotel in Houston, Tex. District 18 Director John Bray addressed the class and presented the Japanese attendees gifts for traveling the farthest to attend.

APRIL 20
Speaker: Abbe Doering, materials engineer
Affiliation: Wear & Friction Resources
Topic: Analyzing wear
Activity: The Section recognized the District 9 SkillsUSA welding winners Alex Li, Jake Hopkins, Daniel Broeckelmann, Trevor Gains, and Austin Holm. The Section presented the Ron VanArsdale Scholarship banner to his wife, Donna, and son, Kyle.

Shown at the Tulsa Section booth are (from left) Ray Wilsdorf, Jay Rufner, and Jerry Knapp.

Abbe Doering receives a speaker gift from John Husfeld, Houston Section chair.
District and Section officers are shown at the District 18 conference hosted by the Lake Charles Section.

Shown at the Houston Section are SkillsUSA welding winners Alex Li, Jake Hopkins, Daniel Broeckelmann, Trevon Gains, and Austin Holm.

Donna VanArsdale and son Kyle (far right) receive the Ron VanArsdale Scholarship banner from Terry Wells at the Houston Section meeting.

Louis Falgout (left) receives a speaker’s gift from Morris Weeks, Sabine Section vice chair.

Shown at the District 18 conference are (from left) John Bray, District 18 director; Ron Theiss; and Houston Section Chair John Husfeld.

SABINE
APRIL 19
Activity: Forty-two Section members and students toured Gulf Coast Fabricators in Beaumont, Tex. Louis Falgout, vice president, conducted the program, and presented a talk especially for the students.

District 19
Neil Shannon, director
(503) 201-5142
neilshnn@msn.com

SPOKANE
APRIL 20
Activity: The Section members participated in a students’ career night event held at Spokane Skills Center for more than 100 attendees. The speakers included Steve O’Connor (Wagstaff, Inc.), Ralph Christiansen (Energy Products), Phil Zammit (Brooklyn Iron Works), and Russ Lovehead (Western States Equipment Co.). The display tables were manned by representatives from local training facilities and the AWS Foundation. Art Sabiston moderated.

MAY 18
Activity: The Spokane Section members met at the Oxarc Training Facility in Spokane, Wash., for a show and tell session featuring various home and artistic projects the welding students and Section members had created.
District 20
William A. Komlos, director
(801) 560-2353
bkoz@arctechllc.com

COLORADO
APRIL 14
Speaker: Brian Heft
Affiliation: Petrogen, Inc.
Topic: The Petrogen oxygasoline technology for cutting steel
Activity: The program was held at Aims Community College welding shop in Greeley, Colo.

District 21
Nanette Samanich, director
(702) 429-5017
nan07@aol.com

District 22
Dale Flood, director
(916) 288-6100, ext. 172
d.flood@tritool.com

SACRAMENTO
APRIL 20
Activity: The Section held a board meeting at Fox & Goose Public House in Sacramento, Calif., to plan the upcoming fundraiser and slate of incoming officers. Dale Flood, District 22 director, recognized Ken Morris for his services as Section chair.

SAN FRANCISCO
MAY 4
Speakers: Una Gilmartin, Robert Bruce
Affiliation: Wiss, Janney, Elstner Assoc.
Topic: Renovation of the Sather Gate at University of California at Berkeley
Activity: Robert Bruce spoke about becoming an AWS Certified Welding Engineer (CWEng). Liisa Pine was recognized for her services as Section chair.

International Section
SAUDI ARABIA
Calendar
The 14th Middle East Corrosion Conference & Exhibition is scheduled for Feb. 12–15, 2012, at Gulf International Convention Center Gulf Hotel, Kingdom of Bahrain. Contact Dr. Moufaq Jafar, Chair, technical committee, moufaq.jafar@aramco.com; or visit www.mecconline.org.

Shown at the Aims Community College welding shop are presenter Brian Heft (far left) with Colorado Section members.

Shown at the Spokane Skills Center event are (from left) Steve O’Connor, Ralph Christensen, moderator Art Sabiston, Phil Zammit, and Russ Loveland.

Shown at the Sacramento Section meeting are (from left) Jason Rafter, Mark Reese, Bruce Tanner, District 22 Director Dale Flood, Melvin Johnson, Chair Ken Morris, Jerry Wentland, and David Kilburn.

Shown at the San Francisco Section program are (from left) Chair Liisa Pine, Elizabeth Moore, speakers Una Gilmartin and Robert Bruce, and Dale Flood, District 22 director.
Member-Get-A-Member Campaign

Listed below are the May 17, 2011, standings of the members participating in the 2010–2011 Member-Get-A-Member Campaign. For complete campaign rules and prize list, see page 65 of this Welding Journal, or visit www.aws.org/mgm. Call the Membership Department, (800) 443-9353, ext. 480, for questions concerning your member-proposer status.

**Winner’s Circle**
AWS Members who have sponsored 20 or more new Individual Members, per year, since June 1, 1999. The superscript denotes the number of years the member earned Winner’s Circle status, if more than once.

- J. Compton, San Fernando Valley
- J. Ezell, Mobile
- J. Merzthal, Peru
- G. Taylor, Pascagoula 2
- L. Taylor, Pascagoula 2
- B. Chiu, Auburn
- S. Esders, Detroit
- M. Haggard, Inland Empire
- M. Karagoulis, Detroit
- S. McGill, NE Tennessee
- B. Mikeska, Houston
- W. Shreve, Fox Valley
- T. Weaver, Johnstown/Altoona
- M. Seese, Johnstown-Altoona
- R. Evans, Siouxland

**President’s Club**
Sponsored 3-8 new members

- M. Tryon, Utah 8
- T. Crate, Drake Well 7
- I. Daubert, Northern New York 6
- C. Simmons, Atlanta 6
- D. Wright, Kansas City 6
- H. Rosario, Central Texas 5
- T. Baber, San Fernando Valley 4
- R. Dawson, Western Carolina 4
- J. Dolan, New Jersey 4
- D. Evancezyk, Louisville 4
- J. Hope, Puget Sound 4
- J. Hopwood, Iowa 4
- D. Sierer, Niagara Frontier 4
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- G. Bish, Atlanta 3
- H. Cable, Pittsburgh 3
- C. Crumpton, Florida W Coast 3
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- R. Hutchinson, Long Beach/O. Cty 3
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- W. Sartins, Long Beach/O. Cty 3
- G. Seese, Johnstown-Altoona 3

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

- M. Allen, Charlotte
- D. Berger, New Orleans
- J. Carney, West Michigan
- J. Fox, NW Ohio
- R. Fuller, Florida W. Coast
- J. Gerdin, Northwest
- G. Hamilton, Houston
- J. Hill, Nebraska
- A. Holt, St. Louis
- J. Kline, Northern New York
- A. Laabs, Lakeshore
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Sponsored 3+ Student Members

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- G. Seese, Johnstown-Altoona 38
- K. Steelman, Saginaw Valley 34
- V. Facchiano, Lehigh Valley 31
- R. Culbert, Inland Empire 28
- M. Anderson, Indiana 27
- J. Carney, West Michigan 27
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- M. Bogg, Stark Central 25
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- A. Baughman, Stark Central 19
- G. Smith, Lehigh Valley 19
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- E. Nurmi, Ozark 18
- A. Syder, Spokane 18
- J. Bruskotter, New Orleans 17
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- F. Oravets, Pittsburgh 16
- W. Wilson, New Orleans 16
- T. Crate, Drake Well 15
- C. Hobson, Olympic Section 15
- T. Shirk, Tidewater 15
- R. Evans, Siouxland 14

**President’s Roundtable**
Sponsored 9-19 new members

- G. Kirk, Pittsburgh 17
- M. Pelegrino, Chicago 15

**President’s Guild**
Sponsored 20 or more new members

- E. Ezell, Mobile 28

**Member-Get-A-Member Campaign**

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Welding Technology to the Rescue
Mon., Nov. 14 • 8:30-4:30
$345 members/$480 nonmembers
A number of major research efforts and technological wizardries are paying off in big ways throughout industry. The effects are numerous. Some are in huge improvements in productivity. Others are in quality. There are brand-new solutions to lingering problems. This trend in new developments is bound to introduce more science into the overall welding scene.

8th AWS Conference on Weld Cracking
Tues., Nov. 15 • 8:30-4:30
$345 members/$480 nonmembers
At AWS’s eighth conference on weld cracking, the different types of cracking, their respective causes, and their solutions will be thoroughly examined. No incident causes so much alarm as a weld crack. The different types of cracking, their causes, and their solutions will be discussed. This program will identify and analyze the types of cracks — and more importantly — what to do about them.

National Welding Education Conference
Tues., Nov. 15 • 9:00-4:00
$149 members/$149 nonmembers
Presented by the National Center for Welding Education and Training (Weld-Ed), this conference is designed to bring together educators for professional development and networking opportunities. Weld-Ed’s focus is on the preparation of welders, welding technicians, and welding engineers to meet the needs of industry. This conference will include presentations on topics such as Weld-Ed accomplishments in the last year, the partnership between Weld-Ed and AWS, welding industry workforce needs, recruitment tips and tools for educators, competency models, externship programs for educators, tips on partnering with other secondary and post-secondary schools, welding education trends, curriculum, materials science education and applications, distance learning updates, new technology applications, and presentations from welding educators who will share their best practices.

What’s New in Power Sources
Wed., Nov. 16 • 8:30-4:30
$345 members/$480 nonmembers
The latest welding machines are equipped with greatly improved capabilities, including multi-process operation. Meet the experts and understand the relative benefits of emerging power source technologies, for example, transformer-rectifiers and inverters. The experts will be on hand to compare these innovations.

Thermal Spray Technology: High-Performance Surfaces
Wed., Nov. 16 • 8:00-4:45
$345 members/$480 nonmembers
This joint conference of AWS and the International Thermal Spray Association (ITSA) will present the latest developments in thermal spray coating technologies and applications.

RWMA Resistance Welding School
Wed., Nov. 16 (7:45-5:30) — Thurs., Nov. 17 (8:00-3:45)
$475 members/$695 nonmembers
This intensive two-day course covers the basics of resistance welding. The school is designed to give operators, production supervisors, engineers, and others the opportunity to study, better understand, and further their knowledge in the theory, applications, and equipment used in the resistance welding process.
AWS Professional Program

Pick and choose between concurrent sessions on the latest in welding research and commercial developments. Pay by the day or register for the entire four-day program.

**Mon., Nov. 14**

**SESSION 1: International Trends in Welding Research**
Chair: Stephen Liu, Colorado School of Mines
State of the Welding Related Industries and Trends of Welding Research & Development in Singapore by Ang Chee Pheng, President of the Singapore Welding Society ......................................................... 8:00
International Topics in Welding Research ......................................................... 9:00

**SESSION 2: NSF I / UCRC Sponsored**
Chair: Stephen Liu, Colorado School of Mines
Separating the Good Welds from the Bad Welds by John P. H. Steele, Colorado School of Mines ........................................... 2:00
Development of a High-Chromium Nickel-base Filler Metal with Improved Weldability for Nuclear Power Plant Construction and Repair Applications by Adam T. Hope, Eric Furer and John C. Lippold, The Ohio State University, and Steve L. McCracken ........................................... 2:30
Weldability of A356+0.5Cu and Its Nanocomposites by Dake Wang, Hongseok Choi, Xiaochin Li and Sindo Kou, University of Wisconsin 3:00
Welding of Stainless Steel-Effect of Sulfur on Weld Pool Phenomena by Sindo Kou, University of Wisconsin, C. Limmagnevich, King Mongkut’s University of Technology-Thonburi, and P.S. Wei ........................................... 3:30
Newly Developed Low Transformation Temperature (LTT) Welding by Tariq Alghamdi and Stephen Liu, Colorado School of Mines ........................ 4:00
Weld Solidification Behavior of Ni-base Superalloys for Use in Advanced Supercritical Coal-fired Power Plants by David Tung and John C. Lippold, The Ohio State University ........................................... 4:30

**SESSION 3: Solid-State Processing**
Chair: Yoni Adonyi, LeTourneau University
Friction Stir Welding of ISO 3183 X80M Steel by Antonio J. Ramirez, Tahiana F. C. Hermenegildo and Tiago F. A. Santos, Brazilian Synchrontron Light Laboratory, and Conrado R. M. Afonso and Ricardo R. Marinho, Cenpes-Petrolbras ........................................... 2:00
Adaptation of Al-to-Steel FRW-I to Thick Sections by Wendell L. Johnson and Jerry E. Gould, Edison Welding Institute ........................................... 2:30
Solid-State Welding of High Performance Steels by Nathan Dix, Josh Hammond and Yoni Adonyi, LeTourneau University ........................................... 3:00
Friction Stir Welding of Lean Duplex Stainless Steel by Tiago F. A. Santos, Marina Magnani and Antonio J. Ramirez, Brazilian Synchrontron Light Laboratory ........................................... 3:30
Susceptibility of Carbon Steel Welds to Hydrogen Embrittlement by Wei Zhang, Zhi Li Feng, John Wang and Larry Anovitz, Oak Ridge National Laboratory ........................................... 4:00
Mechanical and Microstructural Evaluation of Friction Stir Processed Diffusion Bonded Magnesium and Magnesium Metal Matrix Composites by Scott Gordon and Stephen Liu, Colorado School of Mines ........................ 4:30

**Tues., Nov. 15**

**SESSION 4: Shipbuilding**
Chair: Maria Posada, Naval Surface Warfare Center - Carderock Division
Fracture Toughness of Welded NUCu-140 by Brett Leister, John DuPont and Jeffrey Farren, Lehigh University ........................................... 8:00
Microsampling of Friction Stir Welded Ti Alloys by Sal Nimer and Mark Zupan, UMBc-University of Maryland, and Jennifer Wolf, Naval Surface Warfare Center-Carderock Division ........................................... 8:30
Automated Welding Technology for VCS Submarines by Nancy C. Porter and Steve Massey, Edison Welding Institute, and Ned Kaminski, General Dynamics Electric Boat ........................................... 9:00
Ultrasound Impact Treatment of Aluminum 5456 Plate and Welds by Kim N. Tran and Caroline Scheck, Naval Surface Warfare Center Carderock Division, Lourdes Salamanca-Riba, University of Maryland – College Park, and Marc Zupan, University of Maryland ........................................... 9:30
Understanding the Effect of Tool Design in Friction Stir Welding of HSLA-65 Steels by David Lammlein and Maria Posada, Naval Surface Warfare Center - Carderock Division ........................................... 10:00
Fusion Welding Repair of SxxEx Series Aluminum Friction Stir Welds by Maria Posada, Naval Surface Warfare Center - Carderock Division .......................... 10:30
Underwater Friction Stir Welding of HY80 Steel by Terry R. McNeely, Sarah K. Menon, Garth W. Young and William C. Steward, Naval Postgraduate School, and Murray W. Mahoney, Consultant ........................................... 11:00
Nondestructive Testing False Positives on Friction Stir Weld Applications by Bruce H. Halverson, Marquette Marine Corporation ........................................... 11:30

**SESSION 5: Arc Welding Processes**
Chair: Daniel Hartman, Manufacturing Behavioral Science
Double Electrode GMAW with One Welding Power Supply by Jinsong Chen, Adaptive Intelligent Systems, and Yi Lu and YuMing Zhang, University of Kentucky ........................................... 8:00
Submerged Arc Welding of High Strength Steel by Cold Wire Feed by Biswajoti Basu, Naval Materials Research Laboratory, India, R. Rahul and E. Jeevarasan, National Institute of Technology, India, and S. Jerome and Arun Kumar Shah, Panipat Institute of Engineering Technology ........................................... 8:30
Welding Arc Interruptions in Tandem Pulsed GMAW by Ruhman Pablo Relis, Federal University of Rio Grande ........................................... 9:00
Study of Silicate Islands in GMAW by Richard Derrien, Stephen Liu, and Erik Lord, Colorado School of Mines ........................................... 9:30
Full Penetration Welding Using Laser Enhanced GMAW by Yi Huang and YuMing Zhang, University of Kentucky ........................................... 10:00
Submerged Arc Welding Line Pipe with Three Electrodes by Stephen Kenny, University of Alberta ........................................... 10:30
Residual Stress Analysis in Machining of Duplex Welds by Carolina Payares-Asprino and Patricia Muñoz-Escalona, Universidad Simon Bolivar, and Anamels Sanchez, Fundación Instituto de Ingeniería ........................................... 11:00
Selection of Welding Consumables for Metal Arc Welding Under Oil (MAW-UO) by Hamad H. Mostamee, Stephen Liu, and David L. Oleen, Colorado School of Mines ........................................... 11:30
Droplet Heat Content in Nickel Sheathed WC-Cored GMAW Wires by Kevin Scott and Patricio Mendez, University of Alberta ........................................... 12:00

**SESSION 6: NSF I / UCRC Sponsored**
Chair: John DuPont, Lehigh University
Corrosion Behavior of Nickel Based Alloy Coatings by Andrew W. Stockdale and John DuPont, Lehigh University ........................................... 2:00
Thermal Stir Welding of Steel by Feng Pan and Sindo Kou, University of Wisconsin, and R.J. Ding, Marshall Space Flight Center ........................................... 2:30
Preventing Dissimilar Metal Weld Failures by Gregory J. Brentrup, John DuPont, Brett M. Leister, Brett S. Snowden, and Joachim L Grenestedt, Lehigh University ........................................... 3:00
Hot Bending of Armor Alloys by Nicholas A Kullman and Boian T. Alexandrov, The Ohio State University ........................................... 3:30
Stress Rupture Evaluation of Steel Welding Consumables by Chai Xiao and Sindo Kou, University of Wisconsin ........................................... 4:00
Laser Impact Welding by Huimin Wang, The Ohio State University ........................................... 4:30

**SESSION 7: Weld Modeling**
Chair: Zhili Feng, Oak Ridge National Laboratory
Surface and Interface Phenomena in Thermoelectric Element Welding by Ithamar Glumac, Ben Sokolove, and Yoni Adonyi, LeTourneau University ........................................... 2:00
A Computational Modeling Tool for Welding Repair of Irradiated Materials by Zhili Feng, Oak Ridge National Laboratory, and Eric Willis and Ken Wolfe, Electric Power Research Institute ........................................... 2:30
3D Weld Pool Surface Characterization by XueWu Wang, YuMing Zhang and WeiJie Zhang, University of Kentucky ........................................... 3:00
Modeling and Microstructure Evolution Analysis of Friction Stir Processing of Magnesium Alloy by Zhenzhen Yu, Wei Zhang and Zhili Feng, Oak Ridge National Laboratory, and Hahn Choo, University of Tennessee ........................................... 3:30
SESSION 8: Laser Materials Processing
Chair: Tom Lietzert, Los Alamos National Laboratory
Characterization of a Materials Processing Laser by T.J. Lietzert, J.O. Sutton, M.S. Pitch and P. Burgardt, Los Alamos National Laboratory... 8:00
Issues with Laser Welding Through a Fused Silica Window by T.J. Lietzert, J.O. Sutton, M.S. Pitch, R.T. Forsyth and P.A. Papin, Los Alamos National Laboratory... 8:30
Reducing Alloying Element Vaporization from Stainless Steel Weld Pools Produced by Pulsed Laser Welding by T. DebRoy, Penn State University and T.J. Lietzert, Los Alamos National Laboratory... 9:00
Properties Variation in Stainless Steel Laser Welds by Charles V. Robino, Brad L. Boyce and Corbett C. Battle, Sandia National Laboratories... 9:30
Modeling of Laser Spot Micro-Welding of Silicon by Ashwin Raghavan, Penn State University... 10:00
Scaling Thermocapillary Weld Pool Shape by Peng S. Wei, C.L. Lin and H.J. Liu, National Sun Yat-Sen University, and T. DebRoy, Penn State University... 10:30
Comparing Laser and Resistance Interconnection Welds by Gerald A. Knorovsky, Danny O. MacCallum and Louis A. Malizia Jr., Sandia National Laboratories... 11:00

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

SESSION 10: Sensing and Control
Chair: YuMing Zhang, University of Kentucky
Computation of GMAW Pool Surface from Laser Reflection by Xiaojie Ma and YuMing Zhang, University of Kentucky... 2:00
Near-Infrared Vision System for Arc-Welding Monitoring by Carolina Pimenta Mota, Marcus Viniclus Ribeiro Machado, Lourenã³l Oliveira Vilarinho, and Roberto Mendes Finzi Neto, Federal University of Uberlandã­a... 2:30
Analytical Computation of GTAW Weld Pool Surface by Zhenzhao Wang, University of Kentucky... 3:00
Temperature Measurement of Low-Carbon Steel TIG Welding Heat Affected Zone Using Fiber Bragg Grating by Yulong Li, Harbin Institute of Technology, and Zhichao Jiang, Yanfeng and Hua Zhang, Nanchang University... 3:30
Machine-Human Cooperative Control of Welding Process by Weijie Zhang and YuMing Zhang, University of Kentucky... 4:00

SESSION 11: Joining Metallurgy
Chair: Suresh Babu, The Ohio State University
Ultrasonic Soldering for Dissimilar Material Joining by Shankar Sririvasan, Edison Welding Institute... 2:00
Au-Al Intermetallic Formation in a Resistance Weld by Donald F. Susan, Gerald A. Knorovsky and Paul T. Vianco, Sandia National Laboratories... 2:30
Constitution Diagram for Dissimilar Metal Welds by Elijah K. Gould, BP America, and John C. Lipold and Bolian T. Alexandrov, The Ohio State University... 3:00
Weid Behavior of Ultra-High Strength Eglin Steel by Daniel H Bechetti Jr. and John N. DuPont, Lehigh University... 3:30
Advanced Brazing Technologies for Nuclear Fuel Cladding by Edward D. Herderick, Kirk Cooper and Nale Ames, Edison Welding Institute... 4:00
Microstructure of Alloy 625 Weld Overlay by Clayton Carvalho Silva, Corrado R. M. Afonso, H‰lio Cordeiro de Miranda and Jesualdo Pereira Farias, Federal University of Cearã­, and Antonio J. Ramirez, Brazilian Synchrotron Light Laboratory... 4:30
Effect of Ti on Toughness of 700 MPa Weld Metal by Hee Jin Kim and Jun Seok Seo, Cheonan, and Changhee Lee, Hanyang University... 5:00

SESSION 12: Materials Weldability
Chair: Boian Alexandrov, The Ohio State University
Application of Cold Cracking Tests for Determining the Preheating Temperature in High Strength Steels by Mônica Zalazar, Universidad Nacional del Comahue, and Eduardo Asta, ESAB Argentina... 8:00
Hydrogen Assisted Cracking in Dissimilar Metal Welds by Boian T. Alexandrov, Jeffrey M. Rodelas and John C. Lipold, The Ohio State University, and Shu Shi, Shell International Exploration and Production... 8:30
Impermeable Low Hydrogen Covered Electrodes by Alexandre Queiroz Bracarense, Claudio Turani, Ezequiel Caires Pereira Pesssoa, and Ivanilza Fielzardo, Federal University of Minas Gerais... 9:00
Characterization of Grade 91 Steels to Tempering by Daniel Saltzmann, Boian T. Alexandrov and John C. Lipold, The Ohio State University... 9:30
Development of Welding Technology for Bicycle Frame by Mok-Young Lee and Wooong-Seong Chang, RIST, and Norman Zhou, University of Waterloo... 10:00
Effect of Oxide/Ferrite Phase on the Toughness of SDSS by Kim Dae Joo, Bae Sang Deock and Choi Jun Tae, Hyundai Heavy Industries... 10:30

SESSION 13: Industrial Technology
Chair: Joe Scott, Devasco International
Automated Narrow Gap GTAW by Barbara K. Henon, Arc Machines, and Jonathan T. Saflin, Arc Applications... 8:00
Green Stud Welding Technologies Save Energy and Labor by Chris Hsu, Nelson Stud Welding... 8:30
Welding 4130 Steels for Oil Field Equipment by Joe Scott, Devasco International, and David R. Berndt, CRA Technologies... 9:00
Arc Welding Ultra HSLA Steels by Joe Scott and Tomas Brashear, Devasco International... 9:30
Increase Joint Success with an Internal Groove by Larry Zinker, Marve Harker and Kyle Kolford, Idaho National Laboratory... 10:00
Product and Process Comparisons of Welding Fumes by Stanley E. Ferree and Frank Lake, ESAB... 10:30
Mechanization of Short Welds in Heavy Fabrications by Steve Massey and Nancy Porter, Edison Welding Institute... 11:00
Wrapped Textile Cord Process for Welding Wire Finish by Kai Boockmann, Michaela Boockmann and Gerhard Boockmann, Boockmann GmbH... 11:30
AWS Exam and Preparation Events

**D1.5 Bridge Code Clinic**
*Mon., Nov. 14 • 8:00-12:00*
Prepare for the Bridge Code exam option for CWI certification or endorsement.

**D15.1 Railroad Code Clinic**
*Mon., Nov. 14 • 1:00-5:00*
Prepare for the Railroad Code exam option for CWI certification or endorsement.

**ASME Section IX Code Clinic**
*Tues., Nov. 15 • 8:00-5:00*
Prepare for the ASME Section IX, B31.1 & B31.3 exam option for CWI certification or endorsement.

**D1.1 Road Map**
*Tues., Nov. 15 • 8:00-5:00*
$345 members/$480 nonmembers
Prepare for the D1.1 exam option for CWI certification or endorsement.

**Advanced Visual Inspection Workshop**
*Tues., Nov. 15 • Wed., Nov. 16 • 8:00-5:00*
$550 members/$685 nonmembers
Prepare for Part B of the CWI or recertification exam.

**Certification Examination**
*Thurs., Nov. 17*
Take your exam to certify as a CWI, CWE, CWS, CWSR, SCWI, CWEng, or test for endorsements. Advance application required to take exams. Call 1-800-443-9353 ext. 273, or go to http://www.aws.org/certification for details on certification and registration requirements.

**Other Seminars**

**Metallurgy Applied to Everyday Welding**
*Mon., Nov. 14 • 8:00-5:00*
$345 members/$480 nonmembers
Improve your understanding of the science behind good welding.

**The Why and How of Welding Procedure Specifications**
*Wed., Nov. 16 • 8:00-5:00*
$345 members/$480 nonmembers
A valuable seminar on qualifying and following procedures.

Free AWS Events at FABTECH

**Professional Welders Open Competition**
*Mon., Nov. 14 — Wed., Nov. 16*
Watch contestants compete for hard cash and the title of best welder in America. Awards presented Thurs., Nov. 17 at 11 a.m.

**Free Seminar Sample Sessions**
Attend a special one-hour portion of an AWS exam seminar.
*Mon., Nov. 14*
Certified Welding Sales Rep ........................................ 1:00-2:00
Certified Welding Inspector ....................................... 2:00-3:00
*Tues., Nov. 15*
Certified Welding Supervisor ................................... 8:00-9:00
Certified Radiographic Interpreter .............................. 9:00-10:00

**IIW and 2012 Annual Assembly Info Session**
*Mon., Nov. 14 • 11:30 - 1:00*
Everything you wanted to know about the American Council of the International Institute of Welding (IIW) and the 2012 IIW Annual Assembly in Denver. Lunch and refreshments will be provided.

**Thermal Spray Basics: Putting Coatings to Work**
*Tues., Nov. 15 • 1:00 – 5:00*
Presented by the International Thermal Spray Association (ITSA), this intro to the benefits of thermal spraying will cover processes, equipment, applications, and industry usage.

**Education Annual Program**
Valuable free programs for educators and trainers are held every day of the show.

**Career Counselor & Welding Educator Workshop**
*Mon., Nov. 14 • 10:30 – 5:00*
Representatives from AWS, the welding industry and trade unions will make short presentations on career paths, scholarships and job outlook. A walking tour of exhibits on the show floor will highlight high-tech topics in welding related to the most rewarding career opportunities.

**Topics in Welding Education**
*Mon., Nov. 14*
Using Practical Welding Metallurgy Object Lessons ................ 8:00-9:00
Common Errors in Applying AWS 2.4 Welding Symbols .......... 8:00-10:00

**Lectures in Welding Education**
*Tues., Nov. 15*
Plummer Memorial Award Lecture .................................. 10:30-12:00
Adams Memorial Membership Award Lecture ..................... 1:30-2:30
Howard E. Adkins Memorial Instructor Membership Award Lecture ....................................................... 2:30-3:30
Panel Discussion with Award Recipients ......................... 3:30-5:00

**Educators’ Program**
*Wed., Nov. 16*
Writing Engaging Lesson Plans Workshop ........................ 9:00-10:00
Complying with National and State Standards ................... 11:00-12:00
E-learning on a Budget: Introducing Interactive Tools in the Classroom ...................................................... 1:00-2:00
Recruiting Students into Welding Programs ..................... 2:00-3:00
Techniques for Developing Accurate and Fair Welding Assessments .......................................................... 3:00-4:00
Developing a Welding Curriculum ................................ 4:00-5:00

**Educators’ Program**
*Thurs., Nov. 17*
Project and Community Based Curriculum Design ............. 9:00-10:00
Structuring the Welding Shop Experience ....................... 10:00-11:00
Implementing the SENSE Program ................................. 11:00-12:00
Keep up with all the AWS events at FABTECH with the free mobile app installed on your smartphone, with maps, schedules, alerts, networking tools, and much more.

www.aws.org/show
Electrodes Catalog Offered in Spanish and English

The company has issued its updated six-page condensed catalog in both English and Spanish editions. Detailed are the company’s complete lines of flux cored and metal cored welding electrode products. Included is a comprehensive list of carbon steel, low-alloy, stainless steel, nickel alloy, and hardfacing electrode products, and packaging options.

Select-Arc, Inc.
www.select-arc.com
(800) 341-5215

Linear Motion Guide Issued for Design Engineers

The 88-page Linear Motion Technology selection guide gives machine design engineers a comprehensive overview of the benefits and applications of linear motion products to help engineers determine which linear motion products meet their application requirements, as well as provide technical insights into cost savings through standardization and energy efficiency. Included are an overview of the structural design, operating principles, and characteristics of the company’s products, including precision modules, profiled rail, ball screw drives, miniature components, electromechanical actuators, and complete preconfigured linear motion systems with matching motors, and controls. Technical drawings illustrate how reducing friction can lower energy consumption without sacrificing machine performance or capacity, and how precision engineering and manufacturing of profiled rail systems can minimize downtime during changeovers and provide cost efficiency in logistics and installation, and lower the overall cost of ownership. The PDF literature can be downloaded from the Web site shown.

Bosch Rexroth AG
www.boschrexroth-us.com/linearmotion
(800) 739-7684

Bar Steels Manual Updated

This edition of the Bar Steels Products Manual has been reformatted and updated to include an expanded section on the manufacturing processes related to the production of hot rolled steel bar products, general technical product information on steel bars and bar product applications, a new section on the selection of bar products for an application, and some properties of steel bars and bar products for steel manufacturers and customers. It provides concise data pertaining to the manufacturing processes, product characteristics, and uses for bar, rod, and wire steels. The 110-page manual lists for $75, $40 for institute members. Visit

For info go to www.aws.org/ad-index
An eight-page, well-illustrated, full-color brochure displays and describes the company’s high-resolution CCD video-probes featuring interchangeable objective lenses with various fields of view, depth of focus, and aperture values. Also detailed is the AIT iRis DVR 360-deg industrial videoscope capable of high-speed digital video suitable for recording leaks, rotating fan blades, etc. The 3-lb system has working lengths from 5 to 25 ft. One page illustrates 16 accessories, including memory card, chargeable battery, case, sun shield, various objective lenses, side-view adapter, and several holding devices.

Advanced Inspection Technologies
www.aitproducts.com
(321) 610-8977

RW Equipment Web Site Is Now Multilingual

The company’s Web site has been upgraded to provide a full-featured product finder in Spanish, Chinese, and Portuguese, in addition to English. Offered are detailed descriptions of its lines of resistance welding equipment, laser processing systems, reflow soldering equipment, and a host of specifications, manuals, application references, and technical documentation.

Miyachi Unitek Corp.
www.miyachiunitek.com
(626) 303-5676

Fluid Recycling Products Pictured

A full-color brochure illustrates and describes the company’s Hydroflow® line of products for recycling various fluids to help metalworking companies maximize coolant effectiveness and longevity while improving productivity and reducing disposal costs. The applications include parts washing, machining, grinding, honing, superfinishing, and EDM where fluids from water-based coolants to straight oil lubricants are required. Visit the Web site to
Thermadyne® Appoints Product Manager

Thermadyne®, St. Louis, Mo., a supplier of metal cutting and welding products, has appointed Paul Eckhoff a senior product line manager for manual plasma cutting products, primarily marketed under the Thermal Dynamics® brand. Eckhoff, with 25 years’ experience in engineering, marketing and product management, has served with Stout Tool, Perceptron, Black & Decker, and Emerson Electric Tool Co.

Hobart Institute Elects Two Board Members

Hobart Institute of Welding Technology, Troy, Ohio, has elected Sundaram Nagarajan and Jennifer Monnin to serve on its board of directors. Nagarajan is executive vice president of Illinois Tool Works, Inc. (ITW), responsible for its global welding, cutting, and insulation businesses. He also serves as a trustee on the AWS Foundation. Monnin, general manager of the North American Tubular Div. of Hobart Brothers Co., has more than 17 years in the welding industry in various managerial and leadership positions. Long-time board member Scott Santi, vice chairman of ITW, has resigned his position on the board.

Chromalloy Hires VP

Chromalloy, Orangeburg, N.Y., a supplier of FAA-approved replacement parts, and maintenance and repair services for gas turbines for military and commercial, and industrial aviation and land-based applications worldwide, has hired Dennis Orzel as vice president and general manager serving the United States and United Kingdom. Prior to this appointment, Orzel was chief operating officer at PAS Technologies.

Kaman Industrial Appoints Director

Kaman Industrial Technologies, Windsor, Conn., a provider of motion control and automation products, has named Brian Lombardo senior director, business systems. Lombardo previously served as director, business systems planning. He replaces Carlos O. Ingram, vice president, business systems, who has retired.

Intelligrated® Names VP

Intelligrated®, Atlanta, Ga., a provider of conveyor and sorting systems, automated material-handling solutions, and robotics, has appointed Chris Barber vice president of southern operations, distribution and fulfillment. Previously, Barber served five years as senior sales engineer and sales manager for the company’s southwest operations.

Koike Announces New Employee

Koike Aronson, Inc./Ransome, Arcade, N.Y., has named Fernando Bertola Brazil manager. Bertola has a background in engineering, managing, and selling.

Two Promoted to VPs at Camfil Farr

Camfil Farr Air Pollution Control, Jonesboro, Ark., has promoted John Dauber to vice president of sales, U.S.A. and Canada; and Thomas Frungillo vice president of sales, Latin America and Focus Markets. Dauber joined the company in 1998 as a regional sales manager and served most recently as North American sales manager. Frungillo, with the company since 2000, previously served as a regional sales manager and special market management.

X-Ray Supervisor Named at Laboratory Testing

Laboratory Testing, Inc., Hatfield, Pa., a provider of failure analysis and calibration services, has promoted Jason Tucker to X-ray supervisor. With the company for seven years, Tucker, a certified Level II inspector in X-ray inspection, formerly served as a technician in the Nondestructive Testing Dept.

Seconn Fabrication Builds Its Management Team

Seconn Fabrication, Waterford, Conn., a provider of precision sheet metal, has named Todd Gigliotti vice president of sales and Skip Swift vice president of business development. Gigliotti has 31 years of experience in the welding and distribution business in the New England region. Swift has 35 years of experience in the industry, specializing in automation and robotics.

IMS Confers Honorary CFO

The International Metallographic Society (IMS), Lake Bluff, Ill., has named David Rollings to serve as chief financial officer. The honorary position becomes effective August 6. In this post, Rollings will be responsible for developing the IMS annual budget, making financial projections, and managing its corporate support program. Rollings currently is vice president of sales at Buehler.

SME Presents Faculty Advisor Awards

The Student Relations Committee of the Society of Manufacturing Engineers (SME), Dearborn, Mich., has awarded its inaugural Faculty Advisor Professional Development Award to recognize the service of faculty advisers to SME and its student chapters in advancing manufacturing knowledge, education, and the society’s strategic plan. Receiving $1000 awards were Christopher Gallagher, Olympic College, Bremerton, Wash.; and
Bahram Asisbanpour, Texas State University, San Marcos, Tex. Receiving $2000 recognitions were Ross Monroe, Edmonds Community College, Lynnwood, Wash.; and Daniel Kandray, University of Akron, Akron, Ohio.

Eriez® Fills Two Manager Positions

John Mackowski  Andrew Kloecker

Eriez®, Erie, Pa., has promoted John Mackowski to the newly created position of metalworking product manager, responsible for Magnamation products and integrating the recently acquired Hydroyflow® filtration systems and fluid recycling equipment. Mackowski previously worked in engineering and sales. Andrew Kloecker was promoted to manager, metalworking distributor sales. Previously, Kloecker served as a technical sales representative.

Obituaries

Jerry L. McManus Sr.

Jerry Lynn McManus Sr., 64, died at his home, April 22. A long-time member of the New Orleans Section, and an AWS member since 1978, he received the District Educator of the Year Award in 1988 and served the New Orleans Section in various positions including first vice chairman. McManus was a native of Gilbert, La., a former longtime resident of St. Bernard Parish, and a resident of Mandeville, La., for the past five years. He was a medical gas inspector, installer, and instructor for National Inspection, Testing & Certification Corp. (NITC). He retired from the Plumbers and Steamfitters Local #60 where he served as business manager for many years. He was a member of the United Association and Louisiana State Building & Construction Trades Council, The International Association of Plumbering and Mechanical Officials, American Society of Sanitary Engineering, Grand Lodge of the State of Louisiana F. & A.M., Andrew Jackson #428, Shriners International, South East Building Trades, AFL-CIO, and St. Timothy United Methodist Church. He is survived by his wife, Janice; a son, Jerry Jr.; a daughter, Debra Blackwell; four brothers; and three grandsons. Memorial donations may be made to the Shriners or American Cancer Society.

Richard F. Glascock II

Richard E. Glascock II, 59, died April 30 following a motorcycle accident. Glascock, an AWS member since 2002 with the Nashville Section, was a professional civil engineer, licensed in 44 states. He received his engineering degree from Tennessee Technological University. Most of his professional career of more than 30 years was specifically involved with engineering commercial signs. He was the owner and operator of Elrod & Co., LLC, based in Murfreesboro, Tenn. The company's main focus is site-specific sign design and engineering. He enjoyed hiking, travel, biking, and chocolate. Glascock is survived by his life partner, Betty Ralph; and a brother.

NEW PRODUCTS — continued from page 23

in process database to simplify plasma and oxyfuel torch setup. The machine’s offered with a choice of 200, 360, 450, or 600 A m3 plasma systems.

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www.esabcutting.com

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AlumiSeal™ is a brush-on methacrylate compound formulated for sealing porosity in aluminum parts and welds that will contain liquids or gases under pressure. The product’s chemistry and low dynamic viscosity enable it to wick deeply into pores or seams and between close-fitting nonferrous metal surfaces. Once cured, any excess material on the surface of the part is rinsed away with water. The compound does not alter critical surface dimensions and comes packaged in a 250-mL kit. Mixing the sealant’s two components creates a VOC-free, pale-blue liquid. Curing in the absence of air, it forms a pressure-tight seal that withstands continuous service temperatures of up to 180°F.

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www.impco-inc.com

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Ceramic Abrasives Detailed in Literature

A four-page, full-color brochure details the company’s Saber Tooth™ line of ceramic abrasives for faster cutting of stainless steels, aluminum, and other hard-to-grind metals. The line includes flap discs, blending disks, resin fiber discs, and belts. The ceramic abrasives permit grinding and finishing in one step for weld blending, grinding, deburring, deflashing, surface finishing, and edge chamfering. Described are abrasive belts, a trimmable AVi-in. flap disc that can be custom-sized for a specific application, and resin fiber discs in various sizes and grits from 24–80. Call the toll-free number for a copy.

Weiler® Corp.
www.weilercorp.com
(800) 835-9999

NEWS OF THE INDUSTRY

The release allows procuring long lead-time components that will support the planned official construction start later this year on the as-yet-unnamed submarine at Electric Boat and its team-mate, Huntington Ingalls Industries, Newport News, Va.

“From the engineers and designers who reduced the cost of the Virginia Class, to the shipbuilders who have delivered the submarines ahead of schedule and under budget, to the vendors who worked with us on cost-containment strategies, and of course the Navy, which has managed the program now recognized as a model for Pentagon procurement, this has truly been a collective effort,” said John D. Holmander, Electric Boat’s vice president for the Virginia Program.

Industry Notes

• The Navy Metalworking Center is leading a Navy ManTech project developing a prototype tool to minimize the amount of manual grinding on large steel plates. A mechanized system is expected to save $2.5 million per DDG 1000 Class hull.

• The Navy Metalworking Center is leading a Navy ManTech project developing a prototype tool to minimize the amount of manual grinding on large steel plates. A mechanized system is expected to save $2.5 million per DDG 1000 Class hull.

• Koike Aronson, Inc./Ransome is in the process of incorporating a company in Brazil. Plans are to start with a sales office and eventually establish an assembly operation.

• Tennessee Governor Bill Haslam and Tennessee Dept. of Labor & Workforce Development Commissioner Karla Davis awarded $31,697 to Gestamp Chattanooga, LLC. This grant will provide training to 14 employees in Fanuc robot training.

• Harold Bushong, president of Arc Welders, Inc., Richmond, Va., donated two Miller MR-V robotic welding systems to Eastern Shore Community College, Melfa, Va., for students in the electronics and computer science programs.

• May 19 marked 1000 days that employees at Eriez® headquarters in Erie, Pa., a technology company for magnetic and inspection applications, worked without a lost-time accident.

• Seconn Fabrication, Waterford, Conn., has been awarded the Sustainability Award from Legrand | Ortronics for its pursuit of energy-efficient solutions.

• Worthington Industries, Inc., signed an agreement with International Tooling Solutions, LLC (ITS), to combine its automotive body panels subsidiary, The Gerstenslager Co., with ITS in a 50/50 joint venture. ArtiFlex Manufacturing, LLC, will offer a solution for engineering, tooling, stamping, and assembly.

World Class Benefits for Your World Class Members

NEW FOR 2011

World Class Benefits has five new enhancements to your association's member benefits program. Here is a brief summary of each plan:

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<td><strong>CoreHealth Insurance</strong></td>
<td>- Guaranteed-acceptance, individual and family health insurance plans</td>
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<td>- No medical questions or exams required</td>
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<td>- Low-cost, affordable rates – Plans start at just $92 per month</td>
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<td>- Freedom to choose any doctor or hospital</td>
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<td>- Next day coverage available</td>
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<td>- Benefits include: doctor office visits, routine checkups, hospital and emergency room benefits, surgery, anesthesia, accident medical benefits, prescription drug discount card and more!</td>
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| **BioIQ Home Diagnostic Tests**           | - At home testing for cholesterol, triglycerides, and diabetes          |
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| **HR Mentor – On Demand Human Resource Services for Small Businesses** | - Free Initial 20-minute consultation for members |
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9th Annual Image of Welding Awards Program recognizes outstanding achievement in the following categories:

- **Individual**
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- **Section**
  (AWS local chapter)

- **Large Business**
  (200 or more employees)

- **Educational Facility**
  (Any organization that conducts welding education or training)

- **Distributor**
  (welding products)

- **Educator**
  (welding teacher at an institution, facility, etc.)

- **Small Business**
  (less than 200 employees)

Entry deadline is **July 31, 2011**

For more information and to download the PDF nomination form online, visit [www.aws.org/awards/image.html](http://www.aws.org/awards/image.html) or call 800-443-9353.
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- and more...

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American Welding Society
Development Engineer

Select-Arc, Inc., is seeking a Development Engineer to work at its Fort Loramie, Ohio, facility. The primary job responsibility entails developing new products for the welding of carbon and low-alloy steels, stainless steels, nickel alloys, and for hardfacing. Candidates should have a Bachelor of Science degree in Metallurgy or Materials Science. Degrees in other related fields with a background in materials will be considered. Welding experience is a plus.

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Effect of Tool Geometries on Thermal History of FSW of AA1100

The peak temperatures measured, which have major influence on the overall welding process, were found to be in very good agreement with the calculated values

BY P. BISWAS AND N. R. MANDAL

ABSTRACT

In the present work, three-dimensional finite element (FE) transient thermal analysis of friction stir welding (FSW) was presented for different tool geometries and different process parameters. The source of heat generation was assumed to be pure friction between the tool and workpiece interface. Thermal history of FSW of 6-mm-thick AA1100 plates for different tool geometries was calculated. The estimated thermal profiles compared well with those of the experimental results, thus validating the various assumptions made in the work. It was observed that in FSW of AA1100 with SS310 tool, friction is the major contributor to heat generation. Tool geometry with concave shoulder and conical pin was found to be preferable for FSW of AA 1100. It is preferable to keep the tool pin diameter as small as possible to avoid occurrence of a wormhole defect. Tool plunging force reduced significantly with an increase in tool rotational speed; however, the increase in heat generation was marginal.

Introduction

Friction stir welding (FSW) is a solid-state joining technique. The welds are created by the combined action of frictional heating and mechanical deformation due to a rotating tool. The majority of the heat generated from the friction, i.e., about 95%, is transferred into the workpiece and only 5% flows into the tool (Ref. 1). The maximum temperature created by the FSW process ranges from 80 to 90% of the melting temperature of the material being welded.

The localized heating softens the material around the pin. Tool rotation and translation leads to movement of material from the front of the pin to the back of the pin. As a result of this process, a joint is produced in the solid state. Plastic flow in FSW is a complex phenomenon due to the interaction of the variation of strain rates and flow stress leading to variation in viscosity, which affects the flow (Ref. 2). Because of various geometrical features of the tool, the material movement around the pin can be quite complex (Ref. 3). Design of tools based on quantitative understanding of material flow is just beginning (Ref. 2). Colegrove and Shercliff (Refs. 4, 5) suggested that Trivex™ tools with their convex surfaces avoid sticking to the material, thus reducing the shear force at the tool-metal interface, leading to reduction in traverse force. However, at the same time, they observed that the heat generated, as well as the power requirement, remained unchanged by different tool designs. During FSW, the material undergoes intense plastic deformation at elevated temperature, resulting in generation of fine and equiaxed recrystallized grains (Ref. 6). The fine microstructure in friction stir welds results in improved mechanical properties.

In FSW, there are two sources of heat generation. One through friction and the other due to plastic deformation at the tool-workpiece interface and at the thermomechanically-aFFECTed zone (TMAZ) (Refs. 7-9). The tool-workpiece interface can be further subdivided into shoulder-workpiece and tool-pin-workpiece interface. In most models (Refs. 10-16), heat generated from the tool pin was neglected.

Ulysse (Ref. 17) presented a 3D finite element model for determining the temperature profile using a commercial FEM (finite element method) code FIDAP. The heat generation rate was expressed as the product of the effective flow stress and the effective strain rate. Reasonable agreement between the predicted and the measured temperature was reported.

Chen and Kovacevic (Ref. 18) developed a 3D finite element model to study the thermal history and thermomechanical phenomena in butt-joint welding of aluminum Alloy 6061-T6 using a commercial FEM code ANSYS. Their model incorporated the mechanical reaction between the tool and the weld material. X-ray diffraction technique was used to measure the residual stress in the welded plate.

A few models did consider the effect of tool pin on heat generation (Refs. 19-21). For instance, in Colegrove et al. (Ref. 19) 20% of the total heat was attributed to the pin, yet, they concluded that the addition of heat due to the pin had little effect on the thermal profile produced from the modeling. However, tool pin geometry was not given in the report. The relative contributions of the heat generated from these two sources remained unknown.

Nandan et al. (Refs. 22, 23) combined viscoplastic flow with heat transfer to study the three-dimensional FSW process in 6061 aluminum alloy. They (Ref. 24) further expanded the study to mild steel. Although they claimed that the computed temperatures were in good agreement with the corresponding experimentally determined values, only temperatures at one...
Heat Generation

In FSW, heat is generated due to friction and plastic deformation at the tool-workpiece interface and at the TMAZ. The heat generation at the contact surfaces due to friction is the product of frictional force and the tangential speed of the tool with respect to the workpiece. The heat generated per unit area due to plastic deformation at the tool-workpiece interface is the product of shear stress and the velocity of the workpiece material sticking to the tool as it traverses. This velocity is actually the tangential speed of the tool.

The heat generation due to friction on an elemental area \(dA\) at the tool-workpiece interface, considering high rotational speed compared to traverse speed of the FSW tool, is given by

\[
dQ_f = \delta \omega r \mu pdA
\]  

(2)

Therefore, total heat due to friction and plastic deformation is given by

\[
dQ = dQ_f + dQ_p
\]

\[
= \omega r dF p \delta (\mu p - \delta\mu p) + \delta \tau
\]

Let \(\tau_{\text{contact}} = \left[ (\mu p - \delta\mu p) + \delta \tau \right] \)

Therefore, \(dQ = \omega r dA \tau_{\text{contact}} \)

(3)

There is no straightforward mechanism to estimate the extent of slip. At the same time, with the increase in temperature, the yield strength of the workpiece material decreases, resulting in reduction in heat generation from plastic deformation. In such a situation, it was felt more logical to consider pure friction and neglect the heat generation due to plastic deformation. In the case of pure friction \(\delta = 0\). Therefore, Equation 3 reduces to

\[
\tau_{\text{contact}} = \mu p
\]

(5)

Therefore, from Equations 4 and 5, the expression for heat generation on an elemental surface area \(dA\) at the tool-workpiece interface is given by

\[
dQ = \omega r \mu pdA
\]

where \(dF = \mu p \delta r dA\)

The three distinct tool-workpiece interface surfaces are tool shoulder, tool pin side, and tool pin tip. However, the contribution of tool tip surface is negligible (Ref. 30) toward the total heat generation required for welding. \(Q_1\) and \(Q_2\) are the components of the respective heat generated from the tool shoulder and tool pin side interfaces, as shown in Fig. 1. Therefore, the total heat generated is given by

\[Q_{\text{total}} = Q_1 + Q_2\]

Tool Shoulder - Workpiece Interface

The expressions were derived considering a concave shoulder surface. The purpose of this geometric feature is to act as an escape volume as the tool pin is plunged into the plate during the welding operation.

The concave shoulder surface is represented by its vertical and horizontal projected surfaces as \(A_s\) and \(A_w\), respectively. Therefore, for an elemental segment

\[
dA = r d\theta dz
\]

then

\[
dz = \tan \alpha dr
\]

and

\[
dA_s = r d\theta \tan \alpha dr
\]

(7)

From Equation 7 one can observe that the concave shoulder surface actually contributes to increased frictional area by a factor of \(\tan \alpha\).

Therefore, combining Equations 6 and 7, the heat generation from the elemental shoulder surface is given by

\[
dQ_s = \omega r dS
\]

\[
= \omega r^2 \mu_p \mu \delta r d\theta (1 + \tan \alpha)
\]

The heat generated through friction of the tool shoulder with the plate surface is obtained by integrating Equation 8 from the pin root radius to the outer radius of the shoulder surface.

\[
Q_t = \int \int_{R_p} \omega r^2 \mu_p \mu \delta r d\theta (1 + \tan \alpha)
\]

\[
= \frac{2\pi}{3} \mu_p \omega \rho \left( R_s^3 - R_f^3 \right) (1 + \tan \alpha)
\]

(9)

Tool Pin-Workpiece Interface

Heat generated from the cylindrical tool pin side surface is denoted by \(Q_2\). As the FSW tool traverses along the joint, the forward half of the tool pin experiences a reaction force \(F\) as shown in Fig. 2. It is the
product of the projected area of the tool pin and the yield stress of the aluminum alloy at the prevailing temperature of pin-plate interface as given in Equation 10. The temperature at the pin-plate interface was taken as about 80% of the melting temperature of the plate material, i.e., 530°C. 

\[ F = F_p \times h_p \times \left( \sigma_y \right)_{530°C} \tag{10} \]

Therefore, the frictional force experienced by the tool pin side vertical surface will be given as

\[ F_v = \left( \mu \right)_{530°C} \times F \tag{11} \]

Hence, the heat generated due to friction of the tool pin side surface will be

\[ Q_2 = \omega R_p F_v \tag{12} \]

Therefore, the total heat generation considering pure friction of tool shoulder and pin side surface will be given by

\[ Q_{total} = Q_1 + Q_2 \]
\[ = \frac{2}{3} \mu \rho \omega \left( R_S^3 - R_p^3 \right) \cdot \left( 1 + \tan \alpha \right) + \omega R_p F_v \tag{13} \]

In case of a flat shoulder, the heat generation expression simplifies to

\[ Q_{total} = \frac{2}{3} \mu \rho \omega \left( R_S^3 - R_p^3 \right) + \omega R_p F_v \tag{14} \]

Using the parameters given in Table 1, the calculated values of \( Q_1 \) and \( Q_2 \) were found to be 1782 J/s (i.e., 89% of total heat input) and 219 J/s (i.e., 11% of total heat input), respectively. The percentage of heat generation obtained from the above formulation matched well with that of published results (Ref. 30).

### Three-Dimensional Finite Element Model

A three-dimensional FE transient thermal model was developed to determine the thermal history on the workpiece based on the \( Q_1 \) and \( Q_2 \) given by Equations 9 and 12, respectively. The following assumptions were made in the analysis:

1) All the thermal properties of AA1100 were considered as a function of temperature.
2) Linear Newtonian convection cooling was considered on all the surfaces.

<table>
<thead>
<tr>
<th>Table 1 — Typical FSW Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of Plates (mm)</td>
</tr>
<tr>
<td>6.0</td>
</tr>
</tbody>
</table>
3) 95% of the heat was transferred to the workpiece.

The governing differential equation is

\[ \frac{\partial}{\partial x} \left[ K \frac{\partial T}{\partial x} \right] + \frac{\partial}{\partial y} \left[ K \frac{\partial T}{\partial y} \right] + \frac{\partial}{\partial z} \left[ K \frac{\partial T}{\partial z} \right] = \rho C \frac{dT}{dt} \]

The boundary conditions below were applied in the present FE model.

Initial Condition
A specified initial temperature for the entire plate,

\[ T = T_\infty \text{ for } t = 0 \quad (16) \]

First Boundary Condition
A specific heat flow acting over weld surface for \( t > 0 \) representing the FSW heating source \( q_n = -q_{sup} \). The quantity \( q_{sup} \) is the heat flux supplied to the plate due to friction at the tool-plate interface. \( q_n \) is the normal component of heat flux vector. Here \( q_{sup} \) was given by Equation 17.

Second Boundary Condition
The convection loss due to convection over the weld surface at temperature \( T \). Considering \( h_f \) as convection coefficient, the heat loss \( q_{conv} \) is given by

\[ q_n = -q_{conv} = h_f (T - T_\infty) \quad (17) \]

Where \( h_f \) is the convective heat transfer coefficient.

Material Properties
The temperature-dependent thermal properties (Ref. 27) of the aluminum alloy used in this analysis are given in Table 2. Constant convection coefficient, 30 W/m²K was used (Ref. 28) in the analysis. The temperature-dependent friction coefficient of aluminum and steel combination (Refs. 26, 27) is given in Table 3. The melting temperature of AA1100 was taken as 660°C.

FE Results and Discussion
Transient thermal analysis of FSW of AA1100 was carried out considering two different sets of FSW tools having cylindrical- and conical-shaped tool pins as shown in Figs. 3 and 4, respectively. Brick elements with fine meshing in the weld zone were considered. The vertical tool plunging force was measured using a load pad. It was ob-
erved that the average plunging force required for cylindrical and conical tool pin varied with tool rotational speed. The measured values of plunging force for varying tool rotational speed are given in Table 4.

The peak temperatures obtained from the results of thermal analysis of FSW of AA1100 considering traverse speed of 112 mm/min and tool rev/min of 1400 for different tool geometries are given in Table 5. It can be observed that tools having a concave shoulder led to lesser temperature rise. At the same time, conical tool pins exhibited somewhat lesser peak temperature compared to that of a cylindrical pin having a pin diameter the same as the base diameter of conical pins.

The variations of calculated peak temperature distributions for two sets of three different tool geometries with cylindrical and conical tool pins at traverse speed of 112 mm/min and 1400 rev/min are shown in Figs. 5 and 6, respectively.

From Fig. 5 one can observe that with 1 mm increase in pin diameter peak temperature increased by about 10%. However, with the same pin diameter but with a concave shoulder surface there was about 4.6% reduction in the peak temperature compared to that of a flat shoulder surface.

As expected, welding with the tool pin having a higher base diameter led to higher temperature. Also, a reduction in temperature was observed in the case of the tool with concave shoulder.

Figure 7 shows the variation of peak temperature distribution along plate breadth perpendicular to the weld interface for varying tool rotational speeds for a tool having a 5-mm-diameter cylindrical pin with flat shoulder.

Here one can observe that with 100% increase in tool rev/min, i.e., from 1000 to 2000, the increase in peak temperature was only about 13%. It is important to note that although heat generation depends on tool rotational speed, its effect is rather marginal.

**Experimental Details**

Extensive experiments with excellent repeatability were carried out to test and val-

---

**Table 4 — Vertical Plunging Force at Varying Tool Rotational Speeds**

<table>
<thead>
<tr>
<th>Thickness of Plates (mm)</th>
<th>Rotational Speed (rpm)</th>
<th>Traverse Speed (mm/min)</th>
<th>Average Plunging Force on FSW Tool during Welding (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>1000</td>
<td>112</td>
<td>6450</td>
</tr>
<tr>
<td>6.0</td>
<td>1400</td>
<td>112</td>
<td>5090</td>
</tr>
<tr>
<td>6.0</td>
<td>2000</td>
<td>112</td>
<td>3800</td>
</tr>
</tbody>
</table>

**Table 5 — Peak Temperatures for Different Tool Geometries**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Tool Type</th>
<th>Peak Temperature (°C)</th>
<th>% of Melting Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flat shoulder, pin dia. 5 mm</td>
<td>490</td>
<td>74</td>
</tr>
<tr>
<td>2</td>
<td>Flat shoulder, pin dia. 6 mm</td>
<td>540</td>
<td>81.8</td>
</tr>
<tr>
<td>3</td>
<td>Cylindrical Pin Flat shoulder, pin dia. 8 mm</td>
<td>598</td>
<td>90.6</td>
</tr>
<tr>
<td>4</td>
<td>Concave shoulder, pin dia. 5 mm</td>
<td>462</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>Concave shoulder, pin dia. 6 mm</td>
<td>515</td>
<td>78.1</td>
</tr>
<tr>
<td>6</td>
<td>Concave shoulder, pin dia. 8 mm</td>
<td>577</td>
<td>87.4</td>
</tr>
<tr>
<td>7</td>
<td>Flat shoulder, pin base dia. 5 mm, tip dia. 2.5 mm</td>
<td>479</td>
<td>72.58</td>
</tr>
<tr>
<td>8</td>
<td>Flat shoulder, pin base dia. 6 mm, tip dia. 3 mm</td>
<td>528</td>
<td>80</td>
</tr>
<tr>
<td>9</td>
<td>Flat shoulder, pin base dia. 8 mm, tip dia. 3 mm</td>
<td>571</td>
<td>86.5</td>
</tr>
<tr>
<td>10</td>
<td>Concave shoulder, pin base dia. 5 mm, tip dia. 2.5 mm</td>
<td>457</td>
<td>70</td>
</tr>
<tr>
<td>11</td>
<td>Concave shoulder, pin base dia. 6 mm, tip dia. 3 mm</td>
<td>491</td>
<td>74.4</td>
</tr>
<tr>
<td>12</td>
<td>Concave shoulder, pin base dia. 8 mm, tip dia. 4 mm</td>
<td>554</td>
<td>84</td>
</tr>
</tbody>
</table>

Tool traverse speed = 112 mm/min, Tool rpm = 1400
idate the numerical model for calculating the thermal history of FSW of AA1100.

A vertical milling machine with only 7.5-hp motor capacity was used to carry out the FSW experiments. The tools were mounted in the vertical arbor using suitable collates. The edges of the test pieces were machined to obtain a neat square butt. They were clamped to the horizontal bed with zero root opening. The butt line was aligned with the centerline of the FSW tool. The clamping of the test pieces was done such that the movement of the plates was totally restricted under both plunging and translational forces of the FSW tools. The tool rev/min and translational speed of the bed were set prior to each run of welding. After plunging the rotating tool at the plate butt joint and visually ensuring full contact of the tool shoulder with the plate surface, the bed horizontal movement was switched on. A typical FSW setup is shown in Fig. 8. The FSW tools were fabricated in house using SS310.

For measuring temperature distribution during welding, thermocouples were used 5 and 20 mm away from the weld interface on bottom and upper surfaces of the plates respectively, as shown in Fig. 8. Thermocouples were used at the middle length of the plate along the longitudinal direction as shown in Fig. 8. Agilent data logger 34970A was used to record temperature data. For measurement of tool plunging force, a 5000-kg-capacity load pad was used.

Several test samples 300 mm long and 200 mm wide taken from 6-mm-thick AA1100 plate were welded with the above referred FSW tools.

**Experimental Results**

Several experiments with temperature measurements were conducted. The numerical and experimental temperature distribution for welding with flat shoulder tools having 5- and 6-mm-diameter cylindrical tool pins were plotted as shown in Fig. 9. The welding was carried out with tool traverse and rotational speed of 112 mm/min and 1400 rev/min respectively.

Figure 10 shows a sample result of numerical and experimental temperature distribution for welding with a conical tool having an 8-mm root diameter and 4-mm tip diameter with concave shoulder. The temperature was recorded 20 mm away from the center of the weld interface. The welding was carried out with tool rotational and transverse speeds of 1400 rev/min and 112 mm/min, respectively.

The measured thermal history compared well with the calculated ones as can be seen in Figs. 9 and 10. Some mismatch can be observed in the cooling rate below about 150°C. However, more importantly, the peak temperatures measured, which have major influence on the overall welding process, were found to be in very good agreement with the calculated ones. A variation of about 2.4 to 3.3% from the measured data was noted. Hence, it points to the fact that in FSW of AA1100 with a SS310 tool, friction is the major contributor to heat generation.

It was observed that the tendency of a wormhole defect to occur toward the bottom of the weld increased when the diameter of the tool pin increased in the case of cylindrical tools and increasing base diameter with conical tool pins, irrespective of tool rotational or traverse speed. A higher diameter tool pin implies a higher volume of material displacement, and thus, it may lead to inadequate material flow toward the bottom of the weld, causing a wormhole defect.

**Conclusions**

The thermal history obtained through the model developed in the present study compared fairly well with the experimentally measured thermal profile at two different locations. Variation in peak temperature at these two locations was found to be only about 2.4 to 3.3%. Hence, it points to the fact that in FSW of AA1100 with a SS310 tool, friction is the major contributor to heat generation.

It was observed that tools having a concave shoulder led to lesser temperature rise. At the same time, conical tool pins exhibited somewhat lesser peak temperature compared to that of a cylindrical pin having a pin diameter the same as the base diameter of conical pins. The calculated peak temperatures were all closer to or more than about 80% of the liquidus temperature of AA1100. Therefore, tool geometry with a concave shoulder and conical pin is preferable for FSW of AA1100.

For a particular welding parameter, the peak temperature increased only around 10% for the cylindrical pin when its diameter increased by 1 mm. Since the increase in pin diameter does not significantly contribute to heat generation, it is preferable to keep its diameter as low as possible providing for adequate bending and shearing strength of the tool pin. Extensive experiments were carried out and it was observed that a lower tool pin diameter resulted in good weld quality.

With 100% increase in tool rev/min, i.e., from 1000 to 2000 rev/min, the increase in peak temperature was only about 13%. Although heat generation depends on tool rotational speed, its effect is rather marginal. However, with a 100% increase in tool rev/min, the reduction of plunging force was more than 40%, which justifies use of higher tool rev/min.

**Acknowledgments**

The authors sincerely acknowledge the funding support from Naval Research Board to carry out the research, and also the generous help extended by Garden Reach Shipbuilders and Engineers Ltd., Kolkata, by providing AA1100 to carry out the experiments.

**References**


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Nomenclature

\( a = \) shoulder concavity angle

\( \delta = \) extent of slip

\( p = \) H density of plate material

\( \mu = \) coefficient of friction

\( \tau_y = \) shear yield stress

\( \omega = \) tool angular rotational speed

\( c = \) specific heat

\( dA = \) elemental area

\( k = \) thermal conductivity

\( p = \) tool plunging pressure applied on the element

\( A_H = \) horizontal projected surfaces area

\( A_V = \) vertical projected surfaces area

\( Q = \) heat input to the workpiece

\( Q_1 = \) heat generated under the tool shoulder

\( Q_2 = \) heat generated at the tool pin side

\( Q_3 = \) heat generated at the tool pin tip

\( Q_{total} = \) total heat generated

\( R_p = \) pin root radius

\( R_S = \) outer radius of shoulder surface

\( T_{\infty} = \) ambient temperature

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Virtual Reality Integrated Welder Training

A scientific evaluation was performed of training potential, cost effectiveness, and implication for effective team learning

BY R. T. STONE, K. WATTS, AND P. ZHONG

ABSTRACT

Training in the welding industry is a critical and often costly endeavor; this study examines the training potential, team learning, material consumption, and cost implications of using integrated virtual reality technology as a major part of welder training. In this study, 22 participants were trained using one of two separate methods (traditional training (TT) and virtual reality integrated training (VRI)). The results demonstrated that students trained using 50% virtual reality had training outcomes that surpassed those of traditionally trained students across four distinct weld qualifications (2F, 1G, 3F, 3G). In addition, the VRI group demonstrated significantly higher levels of team interaction, which led to increased team-based learning. Lastly, the material cost impact of the VRI group was significantly less than that of the TT group even though both schools operated over a full two-week period.

Introduction

Welding is a skill, and as such requires that its practitioners be trained to a standard; this kind of training requires time, money, and talent. For nearly as long as modern welding has existed, innovators have been exploring new ways to increase the effectiveness of its training.

Currently, computer-based virtual reality (VR) training (CS Wave) and immersive VR training systems (VRTEX™, ARC+) have generated interest because they have the potential to reduce training costs (Refs. 1–3). However, cost savings is only beneficial if the result is a competent welder who is trained in a timely manner.

Prior to this study, the direct training impact of using VR technology as an integrated part of weld training has not been evaluated. Published works pertaining to VR technology in welding focus primarily on the training technology and its development, not the development of the trainee (Refs. 4, 2). Many studies have focused on general use of VR in training operations and results are far from conclusive. Some studies have shown that the use of VR technology leads to reduced learning and transfer of skills (e.g., Refs. 5, 6). Other studies have shown that the use of VR technologies in training is not significantly different from real-world training (e.g., Refs. 7, 8). Many studies have found that the use of VR technologies leads to a superior transfer of skills when compared to traditional methods (Refs. 9–12). There are many reasons for this diversity of findings, like the methodology used for investigating the transfer of training (Ref. 13). More commonly, however, it is the fidelity of the different VR machines evaluated and the degree to which the individual technologies were suited to their tasks that account for the major sources of inter-study variation (Refs. 14, 15).

Modern technology has evolved to a point such that some VR systems have the ability to create high-fidelity immersive environments (due in large part to advanced physic engines and graphics-rendering capabilities) coupled with an ability to achieve realistic kinesthetic movements (due to magnetic displacement technologies allowing for 6 depth-of-field movements). These aspects of current VR welding simulators allow users to utilize kinesthetic and cognitive learning in a way never before available in the virtual environment. In addition, some VR systems such as the VRTEX™ 360 allow users to work in teams, with one member observing welding progress while the other conducts the actual VR welds. This kind of system further encourages team-based interaction and learning among users. It must be noted that the authors hold the VRTEX 360 as an example of a VR system capable of providing a level of realism and kinesthetic feedback appropriate for this study. The authors do not endorse this product over others that have the before-mentioned capabilities.

Prior to conducting this investigation, the authors hypothesized the following: 1) VR integrated training would result in superior training outcomes when compared to traditional methods, 2) the use of a state-of-the-art VR system would lead to increased levels of team interaction and learning, and 3) weld training conducted with VR integrated technology would be significantly less expensive than training conducted using traditional means.

Background

Transfer of Training Paradigm

The simplest way to evaluate the amount of learning that has taken place during the course of a training program is to measure performance prior to training and compare it with performance measures after training has taken place (Ref. 16). Often, training performance is measured in terms of both operation completion time and accuracy. These measures can be translated into training effectiveness ratios (TER) that enable comparison between training conditions.

The transfer of training paradigm requires a minimum of two groups of trainees, functioning as an experimental group and a control group (Ref. 17). The group(s) given a new instructional device (or alternative method of training) is the experimental group(s). The group given the standard training (or no training) is the control group. In this experiment, the experimental group used VR training technology 50% of the time and traditional training the remainder of the time (VRI), whereas the control group used traditional means of training 100% of the time (TT). To employ the transfer of training paradigm effectively, it is necessary to select appropriate

KEYWORDS

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measurements to determine the extent to which training has been effective. In the case of this study, the qualification rate (the number of welders qualified for a specific position) was used as the primary performance measure. The performance of the control group, measured in terms of time and qualification rate, was used as a baseline. A positive transfer effect occurs when the experimental group performs as well or better than the control group. In the transfer of training paradigm, the control group is automatically assigned a TER of zero. A TER greater than zero represents a positive transfer effect; while a TER less than zero indicates a negative transfer effect. The percent transfer is the absolute difference between control and experimental group performance. The transfer of training paradigm is an effective tool in the assessment of alternative training methods, and has commonly been used to determine the transfer effect between virtual reality, augmented reality, and real training environments (e.g., Refs. 15, 18-20) particularly in laparoscopic surgery (e.g., Refs. 21, 22) as well as in aircraft simulation (Refs. 23, 24).

Team Interaction and Learning

Team learning occurs when multiple individuals carry out activities that enhance the acquisition and development of competencies in all team members. Research has shown that students who learn in team situations have a stronger tendency to learn from past experiences and are more likely to take actions that lead to continuous development (Ref. 25). This has been documented many times in various settings including many college classrooms (Refs. 26, 27). In this study, the team learning questionnaire (TLQ) that was developed and validated by Breso et al. in 2008 formed the basis for our team learning evaluation (Ref. 28). The TLQ evaluation was modified so that the questions and content were specific to the domain of weld training. The TLQ method of evaluation tracked three key dimensions of team learning and interaction that were relevant to this study: 1) Continuous Improvement Seeking (the degree to which a team can learn from previous experiences); 2) Dialogue Promotion and Open Communication (the degree to which open and honest communication is encouraged and takes place within a team); and 3) Collaborative Learning (the degree to which team members are seen and used as sources of knowledge by the rest of the team). Each dimension consists of a series of questions, which the participant answers on a five-point scale (the higher the rating for a given question the more positive the participant feels about the team learning for that question). In addition to TLQ, the authors of this study used continuous video and auditory recordings to assess the amount of time students spent interacting within the weld booths.

Experiment

Training Facilities and Equipment

Both a traditional and a VR welding facility were constructed on the Iowa State University campus. The traditional facility housed six welding booths. Each booth was equipped with the following: a new Lincoln Electric Power MIG 350 MP welding machine with shielded metal arc welding (SMAW) attachments, two autodarkening welding helmets, multiple sets of welding jackets and gloves, power grinders, slag hammer, wire brushes, welding table, quenching buckets, and other miscellaneous welding equipment. The welding facility was stocked with an ample supply of runoff tabs, flat stock plates, groove plates, and 7018 electrodes.

The VR welding training facility was located one floor below the traditional facility and housed weld booths of the same size and dimensions as their traditional counterparts. Each booth contained a new VR welding trainer with SMAW attachments and multiple sets of welding jackets and gloves. The VRTEX 360 trainer was chosen because it is the highest fidelity VR simulator currently available, and has design features that the authors felt would greatly affect team-based learning.

Certified Welding Inspector

Achieving the rank of AWS Certified Welding Inspector (CWI) represents a base standard for instructor capability; as such, the CWI capability was considered to be a controlled variable. However, it is important to note that individual teaching styles and capabilities are an important influencing factor in knowledge acquisition. For this reason, the experimenters observed four different CWIs at three different welding schools so as to learn what individual differences existed between them. Analysis revealed that the major factor was overall experience in teaching (how long they have been instructing). For this reason, the experimental protocol of this study called for a CWI with at least 15 years of active teaching experience.

There was one paid CWI (who had 15 plus years of experience) used in this experiment to train participants in both the TT and VRI groups. All CWI activities were closely monitored by the experimenters to ensure that the same style of interaction and information exchange was maintained between the CWI and participants in both groups. Lastly, poststudy questionnaires sent to participants revealed that participants in the TW group rated their instructor's capabilities as a teacher at 4.2/5, participants in the VRI group rated their instructors as 3.8/5. This indicated that the perception of the interaction between the two groups was not significantly different. The controls for the CWI were appropriate; if an alternative CWI with similar experience were to have been used the overall outcome would be expected to remain the same.

Participants

There were 22 participants in total (21...
males and one female). All participants committed to 80 training hours over the course of two weeks. Participants were randomly assigned to one of two groups. Group one (VRI) subjects were trained with 50% VR + 50% traditional training, whereas group two (TT) subjects were trained using only the traditional training system. Participants in this study were screened to ensure little to no welding experience prior to the beginning of this study. The four participants with some previous experience were evenly distributed between the two experimental groups. Participants in the TT and VRI groups had an average age of 44 and 41 years, respectively.

Independent and Dependent Variables

The primary independent variable in this experiment was training type at two levels, representing the type of interface tested: Traditional Weld Training (TT) and 50% Virtual Reality Training (VRI).

There were five major dependent measures in this investigation: percentage transfer, training effectiveness ratio (TER), team learning, material consumption, and cost effectiveness. Percentage transfer and TER are both training potential measures. As such, both were based on the outcomes of participant qualification rates and training time. Qualification rates were evaluated for each of four different weld positions tested in this study, including the 2F, 1G, 3F, and 3G positions. Training time was defined as the total amount of time taken to train for a qualification. Team learning was measured using the TLQ questioner and follow-up video evaluation. Material consumption and cost effectiveness were functions of total plate and electrodes.

Experimental Procedure

Prior to experimentation, all participants gave informed consent, followed by individual screening tests to ensure that they possessed normal visual acuity, depth perception, and hearing. Upon completion of screening tests participants were randomly assigned to either the VRI or the TT experimental group. The TT group trained at ISU for two weeks, and then one week later the VRI group trained for two weeks.

In the traditional welding school (TT group), participants were trained in the principles and practical application of welding techniques starting with the simplest position (2F), and proceeding through to the most difficult (3G). The maximum amount of training time allotted for teaching was fixed; this time included formal lectures and practical lab training conducted by an AWS Certified Welding Inspector (CWI). The CWI was responsible for evaluating welds to determine whether or not a participant was ready to be tested prior to the end of his or her total allotted training time. Following the training for each qualification, participants were given their test plate. If the test plate for the qualification test passed the CWI’s visual inspection, it was sent to an independent laboratory for structural testing. Qualification for certification was based on the results of this structural testing. Immediately following the qualification tests for all four welds, participants were administered TQL evaluations.

In the VR integrated welding school (VRI), the experiment was conducted in the same basic manner as the previous group. Both TT and VRI groups were given the same overall training time opportunity for each weld type. The major difference between traditional training and VR integrated training was in the training system itself. Participants in the VRI group spent only 50% of their time training (lectures and practical lab training) under the direction of an AWS CWI for each weld type. The remaining 50% of their time was spent training on the VR system. During VR training time, the participants (in pairs) used the VR system to conduct virtual welds of each of the four weld types on which they would be tested. If the participants were able to earn a machine-generated quality score of 85% at least twice in a row for a weld, they were permitted to discontinue their VR training time early.

Results

Training Potential

Training potential is defined by both the percent transfer and the transfer effectiveness ratio (TER). These measures encompass both the differences in certification outcomes between the groups as well as the differences in absolute training time between the groups.

Figure 1 shows the training differences in terms of qualification rate and training time for the 2F position. Participants in the VR50 group (q. rate = 100%, M time = 12.27 h) outperformed the TW (q. rate = 81.8%, M time = 15.05 h) group in terms of both qualification rate and training time. The VRI group was found to have a 22.2% positive transfer and a TER of 1.81 when compared to the TT group.

Figure 2 shows the training differences in terms of qualification rate and training time for the 1G position. Participants in the VRI group (q. rate = 90.1%, M time = 11.72 h) outperformed the TT (q. rate = 54.5%, M time = 14.09 h) group in terms of both qualification rate and training time. The VRI group was found to have a 66.7% positive transfer and a TER of 5.68 when compared to the TT group.

Figure 3 shows the training differences in terms of qualification rate and training time for the 3F position. Participants in the VRI group (q. rate = 72.7%, M time = 11.60 h) outperformed the TT (q. rate = 45.5%, M time = 14.54 h) group in terms of both qualification rate and traini-
ing time. The VR50 group was found to have a 60% positive transfer and a TER of 5.17 when compared to the TW group.

Figure 4 shows the training differences in terms of qualification rate and training time for the 3G position. Participants in the VRI group (q. rate = 55.0%, M time = 12.25 h) outperformed the TT group (q. rate = 36.4%, M time = 15.31 h) in terms of both qualification rate and training time. The VRI group was found to have a 25% positive transfer and a TER of 2.04 when compared to the TT group.

Team Interaction and Learning

Team interaction and learning was assessed across three dimensions [1] Continuous Improvement Seeking, 2) Dialogue Promotion and Open Communication, and 3) Collaborative Learning, each representing a different aspect of cognitive capability. Interaction styles were evaluated using video-based interaction analysis.

The VRI (M score = 4.47) group was not found to be significantly distinctive from the TT (M score = 4.14) group in terms of continuous improvement seeking (T(0.05, 1, 20) = -1.617, P = 0.121). Hence, both groups demonstrated a very strong desire to learn from their experiences and to use what they learned to improve as individuals and as a team. This finding indicates that the participants in both groups were equally willing to learn in the team context.

The VRI (M score = 4.63) group was found to be significantly more developed in terms of Dialogue Promotion and Open Communication than was the TT group (M score = 3.85) (T(0.05, 1, 20) = -4.542, P < 0.001). Students in the VRI group were significantly more likely to engage in task-specific communication with their team member than were students in the TT group. Video analysis revealed that the VRI group spent an average of 32% of their shared-booth virtual reality training time engaged in training-relevant discussion (this discussion was primarily related to the screen-observing student directing the student performing a virtual weld). This can be compared to only 17% of the time spent in training-related discussion when sharing a booth in the real world training facility (this discussion occurred primarily when the team member was in between passes). Video analysis demonstrated that participants in the TT group engaged in training-relevant discussion an average of 10% of the time when sharing a booth in the real-world training facility (this discussion occurred when the team member had completed a pass or a full plate).

The VRI (M score = 4.73) group was found to be significantly more developed in terms of Collaborative Learning than was the TT group (M score = 3.30) (T(0.05, 1, 20) = -8.318, P < 0.001). Students in the VRI group viewed their team members as sources of knowledge to a greater extent than did students in the TT group. The higher the level of collaborative learning in a team the greater the likelihood that positive teamwork interaction took place and they learned from one another.

Material Consumption

Real-World Material Usage

The VRI group used significantly less flat plates than the TT group (T(0.05, 1, 20) = 4.607, P < 0.001). The VRI group used 210 flat plates compared to the TT group, which used 288.

Also, the VRI group used significantly less groove plates than did the TT group. The VRI group used 50 groove plates compared to 63 for the TT group (T(0.05, 1, 20) = 2.711, P = 0.013). Similarly, the VRI group used significantly less electrodes than did the TT group, 111.2 lb for the VRI group compared to 187.6 lb for the TT group (T(0.05, 1, 20) = 8.958, P < 0.001).

Virtual-World Stock Material Usage

The VRI group used a significantly larger amount of overall flat plates (when considering both virtual- and real-world plates) than the TT group. The VRI group used a total of 550 combined (real + virtual) flat plates compared to the 288 real plates the TT group used (T(0.05, 1, 20) = -12.343, P < 0.001). The VRI group used a significantly larger amount of overall groove plates than did the TT group. The VRI group used a total of 82 combined plates compared to the 63 real plates the TT group used (T(0.05, 1, 20) = -8.542, P < 0.001). However, the VRI group did not use a significantly larger number of electrodes than did the TT group. The VRI group used 205.2 lb of electrode vs. 187.6 lb used by the TT group (T(0.05, 1, 20) = -1.386, P = 0.181). The increased plate use in the VRI group reflects the fact that these students were able to conduct more overall welds due to the fact the virtual environment allows for focused welding time without the need for setup, tacking, etc. No difference in electrode usage was discovered primarily because the VR environment does not suffer from sticking and associated electrode abandonment, as does the real-world condition.

Material Costing

The material costs in this study reflect the consumables purchase prices; it must be noted that these prices may vary depending on a company's vendor and purchasing agreements. Additionally, prices reported in this study do not reflect shipping costs. Prices in this study are as follows: flat plate ($2.00 per foot), preassembled groove plate ($15.00 each), 7018 electrode ($4.09 per pound).

Real-World Cost Implications

When factoring in the costs for the material, the total dollar value of the flat plate used in the VRI group was $420; the flat plate used by the TT group was $576. Similarly, the total dollar value for the VRI groove plate was $750 while the groove plate cost for the TT group was $945. The total dollar value for the amount of electrode used was again less for the VRI group. The electrode dollar value for the VRI group was $343.61, compared to the TT group value of $779.71. When all materials usage is considered, the total materials training cost for the VRI group was $1513.61, compared to $2100.71 for the TT group. This equates to a per-student cost of $137.6 for participants in the VRI group and a per-student cost of $190.97 for participants in the TT group.

Virtual-World Cost Savings

The equivalent virtual cost represents the hypothetical materials cost that would be generated if the virtual machine actually charged for plates and electrodes. The equivalent virtual cost for the flat plate would have been $680. The equivalent virtual cost for the groove plate would have been $1710. The equivalent virtual cost for the 7018 electrodes would have been $290.46. The total equivalent virtual cost savings, when all factors are considered, equate to $2,680.46. That is a per-student savings of $243.68.

Discussion

The study described in this paper aimed to determine the effect of modern VR training technology in the domain of welding. The overall effectiveness of VR integrated training was examined in terms of training potential, team learning, material demand, and cost. These issues will be discussed by addressing the hypotheses of this paper.

The authors' first hypothesis was that VR integrated training would result in superior training outcomes when compared to traditional methods. In all cases, participants in the VRI group had a greater percent transfer and a far superior TER than participants in the TT group. The VRI group was not only able to surpass the TT group in terms of absolute effectiveness, but they were able to do so with a significantly shorter amount of training time.
This finding strongly supports the use of VR integrated training at the 50% level, and supports the first hypothesis.

The second hypothesis stated that the use of the VR system would lead to increased levels of team interaction and learning. The results from the team interaction and learning analysis showed that for the continuous-improvement-seeking dimension there was no significant difference between the two groups. This indicates that there was no difference in participants’ desire to perform well and to learn from their experience between the VRI and TT groups. However, the VRI group did have significantly higher values for the dialog and open communication as well as the collaborative learning dimensions. These results confirm this second hypothesis. Moreover, these results indicate participants in the VRI group were much more willing to communicate and learn from their cohorts. The VR machine provided a conduit by which participants not only were more likely to communicate, but were more likely to value the communication and use it to improve their skills. Team learning was a positive factor in the superior training outcomes associated with VR integrated training.

The third hypothesis was that the weld training conducted with VR integrated technology would be significantly less expensive than training conducted using traditional means. The results of cost analysis clearly confirm this hypothesis. For each type of consumable used in this investigation, the total cost of the material was less for the VRI group compared to the TT group. The VR machine allowed students to practice welds without the need to invest time in setup and material-gathering procedures. As such, the students in the VRI group had the opportunity to utilize more plates. If the virtual machine had charged for the consumables, the VRI would have cost twice as much, this despite costing markedly less in terms of the real cost of the physical goods. Further, the ability (afforded by the virtual training system) to abandon a poor weld and start over without the consequence of wasted materials could have been greatly beneficial to the welding students. For example, it was often observed that when students in the VRI group were told (by the partner relaying the machine’s score) they had a bad root pass, they would often start over with a new plate. From the students’ perspective there was no need to worry about wasting steel or losing the time involved in assembly and re-tacking.

Conversely, students in the TT group were less likely to be aware they had a bad root pass, and even when aware they would retain the plate to avoid setup and wasted plate/money. The increased number of practice welds created by students in the VRI group was a likely contributor to their superior percent transfer and TER. The VR system also allowed the participants to focus on the areas of a weld they needed to practice the most. For example, if they needed to practice the root pass, they could start over on a new piece every single time. This activity could not be feasibly replicated using traditional means of training.

Analysis of the VR system’s impact on the human operators indicate that there were at least three major attributes that contribute to the success of the VR weld trainer. The first being the fully immersive environments that allow for the manipulation of physical weld tools. This allows the user to develop sensory motor memories that were appropriate for use in real-world welding situations. Second was the use of feed-forward visual overlays and postweld feedback in the VR system that allowed users to improve specific aspects of their welds during training. This level of oversight and guidance is simply not possible during normal weld training due to environmental factors and time constraints. The third and final attribute was the increased volume of practice weld achievable in the VR environment. By eliminating material transfer and setup times, participants in the VRI group were able to gain more practical experience by spending more time in the commission of a weld than their real-world counterparts. Hence, a successful VR solution should incorporate these key characteristics.

The authors’ future work will include a 100% VR weld school. The experiment will be conducted in a similar fashion to the current study, with the exception being that the CWI will only oversee testing as opposed to conducting instructional operations. This study will aid in further understanding of the effectiveness of VR for weld training.

Conclusions

The results of this study clearly show the direct benefits of using virtual reality integrated training in the domain of welding. The students in the VRI group demonstrated vastly superior training outcomes when compared to their traditionally trained (TT) counterparts. Following are two factors that are associated with this outcome: 1) the significantly higher levels of team learning and interaction between VRI students, and 2) the significantly greater amount of welds performed by VRI students in the VRI environment. In addition to fostering greater learning success, the use of VR integrated training greatly reduces training-associated costs.

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